APPENDIX E-4

GRASSLAND BIRD ASSEMBLAGE CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

"As a group, grassland birds in general and endemic grassland birds specifically have shown steeper, more consistent, and more geographically widespread declines than any other behavioral or ecological guild of North American species (Knopf 1996)." The U.S. Goelogical Survey (USGS) North American Breeding Bird Survey Species Group Summary (Sauer et al. 2011) shows statistically significant downward trends for 11 grassland bird species based on survey data collected between 1966 and 2009. Conversion of habitat to other uses and degradation of habitat due to a variety of factors have been identified as principal factors in the decline of grassland birds.

This assemblage is comprised of the following 5 species: Baird's sparrow (*Ammodramus bairdii*), chestnut-collared longspur (*Calcarius ornatus*), McCown's longspur (*Rhynchophanes mccownii*), Sprague's pipit (*Anthus spragueii*), and swift fox (*Vulpes velox*). These species were approved by the Assessment Management Team (AMT) as an assemblage conservation element (CE) because they are representative of large, intact landscapes across the Northwestern Plains ecoregion.

Swift fox (*Vulpes velox*) was added to this assemblage of grassland bird species; it was previously included in the black-tailed prairie dog (BTPD) assemblage. The AMT felt the swift fox was more of a grassland generalist rather than dependent on BTPD colonies for their habitat, so the species was moved to the grassland bird assemblage. This presents a challenge for trying to rename this assemblage to something other than 'grassland birds' as it was originally constructed to represent birds that favor varying grassland types from short to mixed grasslands. At present it will be continued to be referred to as grassland birds assemblage.

A variety of the management questions (MQs) apply to this assemblage. Many of the MQs can be summarized into four primary questions:

1) Where are the habitats that support breeding grassland bird species?
2) Where are the key habitat areas that support regionally significant concentrations of grassland bird assemblage species?
3) Where are areas that have potential for restoring grassland bird assemblage species habitat or habitat connectivity, currently and in the future?
4) Where are regionally significant grassland bird assemblage habitat areas at greatest risk from CAs including climate change (connectivity, small population size), disturbance, or development?

The intent of the process described herein is to answer the MQs applicable to this assemblage. The central focus of these four overarching MQs is to document the current status of selected CEs at the ecoregional scale and to evaluate how this status may change over a future time period. The first step is to identify suitable habitat for the CE within the ecoregion. Then, these areas are assessed relative to current and potential future CA threats.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The focal species selected to represent this assemblage include the Baird's sparrow (*Ammodramus bairdii*), McCown's longspur (*Calcarius mccowni*), chestnut-collared longspur (*Calcarius ornatus*), and Sprague's pipit (*Anthus spragueii*). The species that comprise this assemblage were selected because their habitats range from short-grass to tall-grass prairies. The swift fox (*Vulpes velox*) is included as part of this assemblage because of its strong association with short-structured grasslands. The nests of the grassland birds in this assemblage are typically constructed in a depression on the ground, are well-concealed, and, constructed primarily with native grasses but in areas of varying cover and height.

All of the avian species included in this assemblage are species endemic to the Northern Great Plains. The avian species migrate to the north-central United States and Canada to breed, arriving beginning in mid-April and departing by October to winter in the southern United States and northern Mexico.

2.1 BAIRD'S SPARROW

The presence of Baird's sparrow is considered a defining feature of summer bird life for mixed-grass and fescue prairies of the northern Great Plains of North America; its presence is an indication of being in or near high-quality prairie (Green et al. 2002).

Once considered among the most common of prairie birds, Baird's sparrow is now rare throughout its range and only locally abundant depending on the condition of grasslands. Agriculture has eliminated much of its former range and continues to reduce remaining grassland tracts. Areas of potentially suitable prairie can become unsuitable when overgrown with woody or exotic vegetation because natural patterns of fire and grazing are lacking. This species was formerly thought an exclusive denizen of native grasses, but recent research reveals an acceptance of formerly cultivated lands with structural components resembling native prairie, as well as lands in agricultural use such as hayfields or pastures with strong incursions or plantings of non-native grasses. However, actively cultivated lands, while used to some degree, are clearly unproductive for this species and are likely responsible for population declines in this and several other grassland species.

Fitting the pattern of some other grassland birds, Baird's sparrow appears partially nomadic, sometimes exhibiting dramatic shifts in population densities from one year to the next. Such behaviors are likely an evolved response to shifting habitat suitability due to the unpredictable but common influences of fire, drought, and the movements and grazing of bison (*Bison bison*) herds. Their nests are well-hidden and difficult to find.

Baird's sparrow breeds in the Northwestern Plains ecoregion of the United States and Canada. The breeding range includes localities in central and eastern Montana, North Dakota (most common in the glaciated hill region east of the Missouri River), and northwestern and north-central South Dakota. The breeding range of the species in Canada includes localities in southern Alberta, Saskatchewan, and Manitoba.

In the Northwestern Plains ecoregion, Baird's sparrow habitat is characterized as mixed-grass and fescue prairie with scattered, low shrubs and residual vegetation from the previous year's growing season. In southern Alberta, this habitat is associated with undisturbed grassland comprised primarily of rough fescue (*Festuca scabrella*), sedge (*Carex obtusata*), porcupine grass (*Stipa spartea*), club moss (*Selaginella densa*), and spike oat (*Helictotrichon hookeri*). In North Dakota, this habitat is associated with club moss, pasture sage (*Artemisia frigida*), June grass (*Koeleria pyramidata*), and needle grass (*Stipa comata*). During dry years, Baird's sparrow may be restricted to dry, shallow ponds, depressions, and drainages. Traditionally described as a species of ungrazed to moderately-grazed tracts of native prairie with little shrub cover, heavy grazing typically makes habitat unattractive unless pockets of denser vegetation are available. Although uncommon in habitats comprised mostly of smooth brome grass (*Bromus inermis*) and other broad-leaved, exotic grasses, Baird's sparrow appears to accept formerly cultivated lands with exotic vegetation resembling native prairie. It has been found to occur as frequently in seeded pasture and hayland as in native pasture in southern Saskatchewan, where seeded pastures were characterized by crested wheatgrass, brome grass (*Bromus spp.*), bluegrass (*Poa spp.*), alfalfa (*Medicago spp.*), and tame hayfields characterized by mixtures of alfalfa, sweet clover (*Melilotus spp.*), crested wheatgrass, brome grass, and bluegrass. The species may benefit from agricultural programs in the United States and Canada that convert large amounts of cropland to perennial cover. However, determination of reproductive potential in exotic perennial cover is required to assess habitat quality.

As a grassland specialist endemic to the northern Great Plains, conversion of native prairie to cropland and exotic vegetation, invasion of native grasslands by exotic plant species, proliferation of shrubs due to fire suppression in moist portions of species distribution, and poor range management of some remaining tracts have greatly reduced Baird's sparrow populations from presettlement numbers. In all, total area of mixed-grass prairie has declined 60-99 percent in the Prairie Provinces and North Dakota. Little is known about habitat requirements during the migration and non-breeding seasons.

2.2 McCOWN'S LONGSPUR

Characteristic of grasslands with little litter and low vegetation cover, the McCown's Longspur favors the open wind-swept plains and sparse vegetation provided by native shortgrass prairie, or structurally similar habitats such as overgrazed pastures.

Although this is one of the few grassland species that may actually benefit from grazing, other disruptions of habitat (plowing, use of pesticides, and control of grassland fires that maintain shortgrass prairie) have reduced the species numbers and its distribution.

Some aspects of the biology and natural history of the McCown's longspur have received study and are reasonably well-known, including growth and development of young, habitat associations, diet and foraging behavior, breeding behavior, nest-site selection and reproductive success, territoriality, and breeding density.

Other aspects of the life history of this species remain much less well-known. There have been few attempts to investigate the impact of human disturbances on longspurs, for example, including pesticide, land-management practices, and physiological stress. According to With (2010), such information is crucial given the substantial declines this species has seen in its historical range and population levels. No formal demographic analysis has been performed to evaluate population viability or to uncover factors contributing to ongoing declines. Such efforts will be hampered by a lack of data on dispersal and demographic rates, especially survivorship. Little is known about this species' migratory ecology.

McCown's longspur is restricted to open habitat and sparse vegetation provided by the semi-arid shortgrass steppe of the Central Plains and Canadian Prairie Provinces, or to structurally similar habitats such as overgrazed pastures. Typical breeding habitat is a matrix of perennial shortgrass species (e.g., blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*) interspersed with cactus (e.g., *Opuntia polyacantha*), and limited cover of midgrasses (e.g., *Aristida longiseta*, *Agropyron smithii*, *Stipa comata*) and shrubs (e.g., *Gutierrezia sarothrae*, *Chrysothamnus nauseosus*, *Artemisia frigida*).

There are two distinct breeding populations; both are primarily restricted to the shortgrass prairie of the northwestern Great Plains and the southern fringe of the Canadian Prairie Provinces. One population extends northward from north-central Colorado into Wyoming and reaches extreme western Nebraska and southwestern South Dakota along its eastern edge. A second breeding population is centered primarily in Montana, southern Alberta, and southern Saskatchewan. This population also extends into southwestern North Dakota and extreme northwestern South Dakota. The breeding range formerly extended to northeastern North Dakota, southwestern Minnesota, and south to the Oklahoma Panhandle.

Nests are constructed in a shallow depression in the ground, are lined with grasses and other organic material, and are similar to the nests of horned larks in appearance and habitat.

2.3 CHESTNUT-COLLARD LONGSPUR

Like McCown's longspur, the chestnut-collared longspur is native to North American prairies, although it favors native mixed-grass and shortgrass uplands (whereas McCown's longspur is more characteristic of shorter grasslands with low vegetation cover) (Gould 1997). Historically, Chestnut-collared longspurs have been known to breed at sites recently grazed by bison (*Bison bison*) or disturbed by fire. Even today, this species avoids nesting in areas protected from grazing, instead preferring pastures and mowed areas such as airstrips, as well as grazed native prairie habitats. Breeding territories are sometimes clumped together, so this bird may at times be locally abundant; however, as native prairie has disappeared, so has the Chestnut-collared longspur. Breeding populations in Nebraska and Minnesota, for example, have been greatly reduced; the species no longer breeds in Kansas, where it was described as abundant in the 1870s.

The breeding range of chestnut-collared longspur is restricted to short- and mixed-grass prairie regions of the Great Plains and Canadian Prairie Provinces. The northern limits of the breeding range include southeastern Alberta, southern Saskatchewan, and southwestern Manitoba. In the United States, its breeding range overlaps most of the Northwestern Plains ecoregion, extending slightly beyond the ecoregion boundaries in western Minnesota and northeastern Colorado. Within the ecoregion, it breeds in Montana east of the Rockies, throughout most of North Dakota (especially the Missouri Plateau), and throughout most of South Dakota, except for the Black Hills. It breeds only locally in easternmost and southernmost South Dakota. It also breeds in eastern Wyoming and northwestern Nebraska.

A native-prairie specialist, typical breeding habitat of the chestnut-collared longspur is arid, short- to mixed-grass prairie that has been recently grazed, burned, or mowed, with vegetation height <20-30 centimeters (cm). It also uses grazed or mowed tallgrass prairie (Wyckoff 1986b). It prefers areas where litter accumulation is minimal (Wyckoff 1986b; Anstey et al. 1995). Dominant plant species in breeding habitat within the Northwestern Plains ecoregion include blue grama grass (*Bouteloua gracilis*), needle-and-thread grass (*Stipa comata*), northern wheatgrass (*Agropyron dasystachyum*), club moss (*Selaginella densa*), pasture sage (*Artemisia frigida*), and cactus (*Opuntia spp.*). Compared to McCown's longspur, Chestnut-collared longspur is found in areas with taller grass species (e.g., needlegrass, wheatgrass).

The species breeds in greater abundance in native grasslands than in "tame" pastures (e.g., planted with crested wheatgrass). Within native grasslands, higher densities of breeding birds were present in grazed compared to ungrazed areas, and the species is more likely to be present in native grasslands with high range-condition scores compared to pastures with low scores.

2.4 SPRAGUE'S PIPIT

One of the least-known birds in North America because of its highly cryptic plumage and habits, Sprague's pipit is one of a handful of birds endemic to the North American grasslands (Hill and Gould 1997). Most information on this species comes from more general studies of northern prairie avian communities.

This pipit often goes undetected during migration through the Great Plains, and almost nothing is known about its behavior on the wintering grounds in the southwestern and south-central United States and northern Mexico. Since its discovery near Fort Union, North Dakota, in June 1843, it has suffered dramatic declines in numbers throughout its range as prairie has disappeared via cultivation, overgrazing, and invasion by exotic plants.

Present-day breeding is primarily in native prairie of the Northern Great Plains of Alberta, Saskatchewan, and southwestern Manitoba, as well as in northern and central Montana, east of the Rockies, and nearly throughout North Dakota. The species also breeds locally in northern South Dakota. It winters in grasslands in northern Mexico and the southern United States.

Native grass is preferred over non-native grasses including smooth brome (*Bromus inermis*) and crested wheatgrass (*Agropyron cristatum*). Dominant grasses in native mixed-grass prairie at Matador, southwestern Saskatchewan, included northern wheatgrass (*Agropyron dasystachyum*), western wheatgrass (*A. smithii*), junegrass (*Koeleria gracilis*), and green needle grass (*Stipa viridula).* Northern wheatgrass and junegrass, along with slender wheatgrass (*A. trachycaulum*), blue grama (*Bouteloua gracilis*), and Canby blue (*Poa canbyi*), dominated at Last Mountain Lake, Saskatchewan. At Lostwood NWR, the pipit bred in native hilltops dominated by blue grama (*B. gracilis*), threadleaf sedge (*Carex filifolia*), junegrass, and plains muhly (*Muhlenbergia cuspidata*).

Virtually no pipits were encountered in surveys of hayed grasslands in North Dakota. In Manitoba, although native hayland was more attractive than brome/alfalfa hayland or idle native grassland, it was less attractive than pasture. In Alberta, however, hayed native fescue was less attractive to pipits than idle fescue, but more attractive than grazed fescue. Soil moisture and between-season regrowth may explain differences between the Manitoba and Alberta results.

Prescribed fire is now important for controlling encroachment of woody vegetation both on breeding grounds, especially in the eastern portion of the range, and on wintering grounds. In Saskatchewan, although negatively affected the first year following prescribed burns (0.11-0.14/ha), the second (0.61/ha, mixed grassland); or third year (0.25/ha, native fescue) pipit densities were greater than or similar to those in unburned areas. Pipits were most abundant 2-3 years postfire, but sometimes up to 7 years; none present on native prairie that had not been burned or grazed in >8 year. In drier portions of the range, abundance remained high in native grasslands undisturbed for up to 15 to 32 years, at two different locations.

Preferred management method(s) and frequency vary with location, soil type, and condition of habitat. Disturbance may be less intense and/or frequent on well-drained soils, drier sites, or where habitat has little shrub. Intense/frequent disturbance may be needed to restore sites in poor condition. Burning reduces shrub encroachment as well as residual grass cover and may reduce or restrict invasion of exotic plants. Grazing reduces residual grass cover and may stimulate growth of native plants and prevent or slow invasion by non-native plants.

2.5 SWIFT FOX

The swift fox (*Vulpes velox*) is a small prairie fox that was once common in the shortgrass and mixed-grass prairies of the Great Plains of North America. The swift fox depends on short and mixed-grass prairies to detect and evade predators. Suitable swift fox habitat was generally defined as extensive in size (preferably over 100,000 acres), with relatively level topography, and with greater than 50 percent of the area undisturbed by agriculture (Montana FWP 2012). Swift fox are primarily nocturnal; however, limited daytime activity may occur near den sites. The swift fox use dens on a daily basis year-round for shelter, protection from predators, and to rear young, swift fox breed when they are 1-2 years old; breeding occurs in February and early March, with a gestation period of 52-53 days. The young will stay with the adults about 4 or 5 months. Swift fox can live up to 10 years in the wild.

The conversion of native prairies, accidental trapping, shooting, and poisoning campaigns aimed at wolves and coyotes have contributed to the decline in the fox's habitat and numbers. Swift fox populations have naturally recovered somewhat since the 1950s, but overall abundance and distribution have been reduced to about 40 percent of their former range. Today, swift foxes thrive in the plains of Colorado, Kansas, Oklahoma, New Mexico, and Wyoming. Small native populations of swift foxes occur in Nebraska, South Dakota, and Texas, but are isolated from core populations, as are reintroduced (but expanding) populations in Canada, Montana, and South Dakota. The northward expansion of the swift fox into Montana, South Dakota, and southern Canada has been facilitated by reintroduction programs (Sovada et. al 2009). Recent surveys have documented swift fox in many of the counties bordering Canada in north-central Montana (Montana FWP 2012). In a 1995 assessment of the species' status under the U.S. Endangered Species Act (ESA), the U.S. Fish and Wildlife Service (USFWS) concluded that a designation of threatened or endangered was warranted, but the species was "precluded from listing by higher listing priorities." The swift fox is a state threatened species in South Dakota, a state endangered species in Nebraska. North Dakota and Wyoming have defined the swift fox as a species of concern (North Dakota Game and Fish Department 2012; Wyoming Game and Fish Department 2010).

3.0 GRASSLAND BIRD ASSEMBLAGE DISTRIBUTION MAPPING

In order to answer the MQs regarding the location and status of this assemblage across the Northwestern Plains ecoregion, a variety of data sources were used for mapping known and potential habitat for the grassland bird assemblage. State wildlife agencies, Natural Heritage Programs (NHPs), and Bureau of Land Management (BLM) field offices collect geographic information system (GIS) data on grassland birds and swift fox within their respective jurisdictions, the latter primarily for use with grazing allotment management and other rangeland concerns. The goal was to obtain data to determine the current distribution and status of each species throughout the ecoregion for critical periods (territory establishment, mating, nesting).

3.1 DATA IDENTIFICATION

Table E-4-1 lists the types of data and data sources that were proposed for use in the Rapid Ecoregional Assessment (REA) as part of the pre-assessment data identification effort in Task 2, for each of the focal species.

Table E-4-1. Data Sources for the Grassland Bird Assemblage Distribution Mapping

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	GAP Habitat Models	USGS	Raster (30-m)	Acquired	No
	Maxent Modeled Habitat	Occurrence data used in model listed under point occurrence	Raster	Modeled assemblage, BLM NOC Wildlife Spatial Analysis Lab modeled individual species.	Yes
Point Occurrences	State Natural Heritage Databases	NHPs of MT, WY, ND, SD, NE	Point	Not acquired for all species for all states	Yes
	USGS Breeding Bird Survey	USGS/MT FWP	Point	Acquired	Yes
	Glaciated Plains Bird Thesis	Frank Quamen (BLM)	Point	Acquired	Yes
Sensitive Areas	Audubon Important Bird Areas	Audubon	Polygon	Acquired	No

Although habitat models for most of the avian species and the swift fox were available from NatureServe and Gap Analysis Program (GAP) (GAP is the only model available for the Sprague’s pipit), it was determined that Maxent would be used to develop updated modeled habitat maps for the species of this assemblage. The BLM National Operations Center (NOC) Wildlife Habitat Spatial Analysis Lab in Denver used Maxent to model each assemblage species independently, and a composite Maxent model of all the assemblage species was then created.

Point occurrence data that were provided through the state’s NHPs or fish and game agencies were used to develop the Maxent models. Point occurrence data from observations made from May to August, 1990 to present, were used to develop the models. After completion of the initial Maxent models for the avian species, it was determined that not all of the species were represented accurately and that data from some recent research would help provide more complete models for each of the species. Point occurrence data from a recent research project was used to supplement the models (Quamen 2007).

As described, a variety of data were used to develop the Maxent models. Table E-4-2 illustrates the number of points by state that were used in development of the Maxent models.

Table E-4-2. Point Occurrence Data used in the Maxent Models

	Baird's Sparrow	Chestnut-collared Longspur	McCown's Longspur	Sprague's Pipit	Swift Fox	Total Points
Montana	1,249	2,186	947	1,481	368	6,231
Nebraska	0	2	0	0	0	2
North Dakota	112	170	0	81	0	363
South Dakota	3	154	0	4	33	194
Wyoming	8	7	8	0	51	74
Total Points	1,372	2,519	955	1,566	452	6,864

3.2 DISTRIBUTION MAPPING METHODS

Maxent modeling consists of using presence-only species occurrence data and a series of environmental raster layers (soil, temperature, elevation, etc.) to attempt to determine modeled habitat. During a model run, the species occurrence data are compared to the individual values within the environmental raster layers to evaluate the commonality among observations (training the model). Once these commonalities are established, the model can expand beyond locations of occurrences to find suitable locations based on the commonalities between data. The Maxent model output is a value between 0-1; the higher the number, the higher the modeled area suitability. Maxent allows for testing the model to validate the accuracy of the predictions based on occurrence data and also provides various validation measures. Since Maxent is a standalone tool, GIS process models were used to extract, project, and format the data into required formats for the model inputs and also to convert them back to a GIS format for additional processing.

Maxent models are based on observation data, which can vary greatly in distribution within a state or within states of the ecoregion; this can create some uncertainty that must be acknowledged when viewing the resulting modeled habitat and corresponding maps. Some areas of the ecoregion without observations may still contain potential habitat for species of the grassland birds assemblage. Some areas of the ecoregion that have been intensively studied may also overemphasize modeled habitat. Because this ecoregion is so large, it can also be difficult to account for variance in the environmental variables as well as the ranges of individual species. This assemblage is not a collection of all grassland birds, but of four selected birds, each with its own range and habitats that can be found within the ecoregion. These factors and the uncertainty in the resulting modeled habitat should be taken into consideration when viewing the modeled habitat and its use in making management decisions.

The intent of the REA modeling effort was to identify modeled habitat of an assemblage of species that rely on grasslands for their habitats. Because Maxent uses species occurrence data, the Rolling Review Team determined that the occurrence data should be limited to 1990 to present to be consistent with timeframes used by other CEs being modeled with Maxent. The grassland bird observation data were also limited to those observations that were in the May to September timeframe to capture breeding populations. The swift fox didn't have any temporal limitations, but did have observations removed if there were attributes associated with 'road kill' or if the observation appeared on a road. These records were removed so that Maxent didn't consider roads to be modeled habitat.

A large portion of the species data received from state agencies consisted of studies from multiple years in which the same data were used and new observations were added to them. This created the problem of having a lot of duplicate records. To prevent overtraining of the Maxent model, duplicate records (based on spatial coordinates) were removed from the assemblage dataset.

The AMT wanted to look at Maxent models for both the assemblage and the individual species that make up the assemblage. SAIC completed the Maxent modeling of the assemblage, while the BLM NOC Wildlife Habitat Spatial Analysis Lab completed the Maxent modeling of the individual species (Baird's sparrow, chestnut-collared longspur, McCown's longspur, Sprague's pipit, and swift fox). The variety of data available for each state varied greatly, which made using Maxent modeling difficult for some of the individual species over such a large ecoregion. Table E-4-2 shows the individual species and occurrence data used by state. Figures E-4-1 through E-4-6 show the abundance of observations by state for each of the assemblage species, as well as the assemblage combined. The individual species Maxent outputs are included as Attachment A to this Appendix.

The raster output from the Maxent model provides cell values that provide information regarding the probability of modeled habitat. Several iterations of the model were run to determine the best fit for this assemblage. The main Maxent parameter that was modified was regularization. This parameter helps push the analysis out to areas without occurrence data so the model is not over-trained on areas with closely clustered occurrence data. Montana Fish, Wildlife, and Parks had previously carried out numerous Maxent modeling efforts and were able to assist in the determination of the Maxent output format that best described presence/absence raster data for the grassland birds assemblage. The resulting Maxent output consists of data values ranked 0-1. The higher the value, the higher the suitability based on the environmental layers used.

The Maxent modeling software generates output files that describe which environmental variables contributed the most to generating the output model. Table E-4-3 contains the 16 environmental variables used in the Maxent model and their contribution (listed in the 'Percent Relative Contribution' column). The grassland bird assemblage Maxent model had Parameter-Elevation Regressions on Independent Sloopes Model (PRISM) precipitation, PRISM max temperature, GAP, and LANDFIRE vegetation environmental layers as the highest contributors. Reviewing which layers contribute the most and least may allow the Maxent model to be fine-tuned by removing low contributing environmental layers. However, for the purposes of the REA, this was not done.

Table E-4-3. Maxent Environmental Variables for the Grassland Bird Assemblage

Environmental Variable	Maxent Variable Code	Percent Relative Contribution	Percent Permutation Importance
PRISM Precipitation	prsm_prcp90	37.6	31.9
PRISM Temperature (max)	prsm_maxt90	13.4	13.1
Solar Radiation (Winter Solstice)	sri_ws_nwp_90	13.3	12.8
LANDFIRE Vegetation	evt_nwp_90	11.2	10.1
GAP Vegetation	nwp_gap_90	9.7	12.3
Soils	soil_nwp_90	5	3.6
Geology	lith_nwp_90	3.1	2.7
PRISM Temperature (min)	prsm_mint90	2.8	0.8
Slope	slope_nwp_90m	1.8	4.8
Elevation	ned_nwp_90	1	3.5
Rugosity	vrm_nwp_90	0.4	0.8
Distance to Water	edw_nwp_90	0.3	1
Aspect (N/S)	aspns_nwp_90	0.3	0.5
Aspect (E/W)	aspew_nwp_90	0.2	0.6
Solar Radiation (Summer Solstice)	sri_ss_nwp_90	0.1	0
Solar Radiation (Equinox)	sri_eq_nwp_90	0.1	1.7

After initial review of the Maxent models, it was suggested that the ecoregion might need to be divided into sub-regions to improve the accuracy of the models. This work was not completed, but is something that could be done later as part of a step-down analysis.

A natural application of species distribution modeling is to answer the question of which variables matter most for the species being modeled. Table E-4-3 identifies the specific environmental variables used in the Maxent model, as well as two estimates (relative contribution and permutation importance) for each environmental variable and their importance to the Maxent model. Although these estimates can be used to understand the importance of the variable in modeling species distribution, the estimates for highly correlated environmental variables (e.g., monthly rainfall and annual rainfall) should be interpreted with caution (Philips 2010).

The next step was to separate the Maxent output into groups that best describe various thresholds between low, moderate, and optimal suitability. Through the advice of Montana Fish, Wildlife, and Parks and the BLM NOC Wildlife Habitat Spatial Analysis Lab, two possible methods were proposed for determining thresholds.

The first method was based on modeling done by Montana Fish, Wildlife, and Parks, which utilized a method that used validation generated by the Maxent model to determine where the model passed different thresholds. This method, based on work by Hirzel (Hirzel et al. 2006), focused on the location of where the predicted over expected frequency (P/E) ratio vs. logistic value crosses 1 (where the model started to do better than random selection). This threshold became the moderate suitability threshold. The optimal threshold was determined by analyzing the P/E vs. logistic value curve for the location where the increase in P/E is greater than the increase in logistic value. To help in determining these values, the BLM NOC Wildlife Habitat Spatial Analysis Lab wrote an 'R' script that was used to analyze the background predictions generated by Maxent. The R script generated a pdf output detailing the moderate and optimal thresholds (Figure E-4-7). The lowest suitability threshold was determined by calculating the 5 percent test omission rate. The test omission rate is another validation comma separated file created by the Maxent software. The Maxent output using the Hirzel method, with the low through optimal combined with observation points, is shown on Figure E-4-A-11.

The second method was based on Maxent modeling by the Wyoming Natural Diversity Database (WYNDD). The low and optimal suitability thresholds were calculated from the sample prediction comma separated file generated by the Maxent modeling. The thresholds were calculated by ranking the logistic prediction of the samples used to train the model using the 5th percentile (low suitability) and 50th percentile (optimal suitability). This method uses actual training data, the thresholds are based on real data and everything below the 5th percentile will be classified as unsuitable. The moderate threshold was the 'maximum training sensitivity plus specificity' calculated by the Maxent software. The Maxent output using the WYNDD method, with the low through optimal combined with observation points, is shown on Figure E-4-A-12.

The primary difference between the two methods lies in how each method sets the lowest threshold. The WYNDD method considers the 5th percentile the point at which low suitability begins and considers anything below that to be an outlier or unsuitable. The MT/Hirzel method uses the Pearson's lowest presence threshold, focusing on the lowest scoring occurrence data and considering anything below that low. Based on two methods of determining thresholds, the modeling team (SAIC; BLM NOC Wildlife Habitat Spatial Analysis Lab; and Montana Fish, Wildlife, and Parks) determined that the WYNDD thresholds were the best to use for the REA (Figure E-4-8). Table E-4-4 lists the thresholds calculated for the grassland bird assemblage by both methods.

Table E-4-4. Maxent Thresholds Calculated for Grassland Bird Assemblage

Method	Measurement	Threshold	Value
MT / Hirzel	Test Omission Rate (0.05)	Low	0.033
MT / Hirzel	P/E =1 (R Script)	Moderate	0.346
MT / Hirzel	Δ P/E Ratio > Δ Logistic Value (R Script)	Optimal	0.575
WYNDD	5% Training Value	Low	0.188
WYNDD	Max. Training Sen. + Spec.	Moderate	0.355
WYNDD	50% Training Value	Optimal	0.577

To establish a modeled habitat map, the Maxent model output requires a binary display of which areas are modeled habitat and which areas did not result in a Maxent output. The Rolling Review Team (RRT) decided that combining the low, moderate, and optimal thresholds would be the best representation of grassland birds assemblage modeled habitat. These three thresholds were combined because it was the most inclusive. The Maxent output was then reclassified to show two classes, modeled and not potential habitat, as shown on Figure E-4-9).

The Maxent output distribution model (Figure E-4-10) was overlain with the observation points to visually inspect the relative accuracy of the model. The RRT, consisting of state and BLM specialists, reviewed the accuracy of the model based on their experience, regional knowledge, and the validation output generated by Maxent (e.g., area under the curve [AUC]). The AUC for this assemblage was relatively high, at 0.8; the higher the score (closer to 1), the better. Threat analysis outputs were correlated to reporting units that spatially contained distribution data.

The RRT also wanted to see a combination of the individual species to see where species modeled habitat overlaps for both the optimal, moderate, and low thresholds. The optimal areas of overlap with the highest number of species would represent the best of the best grassland birds assemblage areas (Figures E-4-11 and E-4-12).

The geospatial modeling was based on the availability and quality of reference data layers for the states included in the ecoregion. Because the Maxent models utilize point occurrence data that drives the selection of the most suitable environmental conditions, an evaluation of the point occurrence data were also conducted. Figure E-4-13 shows that the majority of the point occurrence data for this assemblage is from the states of Montana, South Dakota, and Wyoming in areas that are noted as having optimal suitable habitat for this CE, as compared to Nebraska and North Dakota, where, although point occurrence data exists, most of the area indicated minor habitat for this assemblage in those states. Based on RRT discussion, it was determined that for the CA analyses, the Maxent output would be reclassified so that all suitable habitat (low, moderate, and optimal) would be combined to represent the CE distribution (Figure E-4-9).

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4.0 CONCEPTUAL MODELS

Conceptual models were developed as part of the pre-assessment phase to assist with the determination of the key factors that are important to the life cycles of the species in this assemblage. In addition, these models were also developed to understand the relationships that all of the potential CAs could have on the assemblage regardless of the availability of data.

The current status and potential future threat analyses were based on an analysis of the key attributes of the CE-specific ecological conceptual model, selection of key ecological attributes (KEAs) likely to result from the CAs, and most importantly, the availability of data. The CAs initially considered in this CE analysis included development, climate change, wildfire, and invasive species. However, after review of the data available for the CA analysis, only development could be represented in a geospatial format relative to the Maxent output for this assemblage. Although maps for climate change were developed, the scale of the models was not conducive to comparing the output in a quantitative manner.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model (Figure E-4-14) was developed to identify and link the key life cycle processes to specific ecological factors, or KEAs, that have the greatest potential to affect grassland bird habitat throughout the ecoregion. As noted in the species descriptions, the species of this assemblage all depend on various types of intact grasslands for nesting, protection from predators, and rearing young.

The key processes are identified in the model as green boxes. Following Unnasch et al. (2009), three broad headings or categories of ecological attributes (EAs) (size, condition, and context) are identified in the model as blue diamonds. Size refers to attributes related to habitat or patch size, condition refers to the condition of the habitat, and context refers to the spatial structure of the habitat. At the landscape level, the KEAs under the condition category will be the most challenging to spatially represent and primarily depended on the data available.

4.2 SYSTEM-LEVEL MODEL

The system-level conceptual model (Figure E-4-15) illustrates the interactions between the CAs and the primary habitat functions of this assemblage. The primary CAs for this CE are development, wildfire, climate change, invasive species, and insect outbreaks and disease (identified across the top of the figure in red). However, only development could be represented in a geospatial format. The important factors (or "drivers") affecting the abundance and distribution of grassland species include those that impact habitat availability, connectivity, and habitat quality. Overall, the single most important factor for the success of grassland birds is vegetation structure and is influenced by habitat size, condition, and landscape context at a large scale. At a smaller scale, vegetation structure is influenced by factors such as fire interval, invasive species, development, livestock grazing, and rainfall patterns. Variation in these factors within large blocks of habitat would lend to greater habitat heterogeneity and the capacity to support a greater variety of grassland species.

4.2.1 Development

Loss of habitat resulting from conversion of native prairie to agricultural production throughout the ecoregion has been identified as the primary cause of historic grassland bird declines (Leonard et. al. 2006). Species represented by the this assemblage are threatened by habitat loss resulting from fragmentation and conversion of land for agricultural, industrial, and human urban and exurban development, contributing to further grassland bird population declines. Agricultural and other types of secondary impacts from development reduce available habitat, increase fragmentation, and cause edge effects. Secondary impacts include predation (e.g., by domestic cats) and noise and human activity. Agriculture also causes direct habitat loss (e.g., tillage of native grassland); and degradation (seeding of non-native grasses, attracting nuisance species (e.g., to feedlots); mortality (hay cutting destroying nests;

other indirect effects). Increased trees associated with development support predators and brood parasites. Fire suppression associated with development, coupled with interruption of fuels by roads and right-of-ways, leads to decreased fire frequency and results in reductions in grass vigor and encroachment by woody species.

While urban development is focused more spatially, exurban development permeates outward into remaining habitat, causing additional fragmentation of grassland habitat and edge effects. For species that require relatively large grassland areas and avoidance of edges, habitat fragmentation is a threat throughout the population's breeding range. As more roads, oil and gas development, wind farms, and other features are constructed across the ecoregion, the fragmentation of the native prairie is expected to increase, further decreasing the amount of suitable habitat in large enough patches to be used by breeding pairs (USFWS 2011). For the purposes of this study, CRP land, if mapping is available, will be considered non-habitat for this assemblage.

4.2.2 Wildfire

In addition to the availability of habitat, habitat condition is also critical. Grassland habitats are well adapted to periodic wildland fire. Periodic wildland fires maintain high grass vigor, reduce the buildup of thatch, and prevent the encroachment of woody species. Large blocks of intact native prairie habitat are rare. Protecting these lands from conversion and other activities in conflict with historic disturbances (e.g., grazing and fire regimes that mimic the natural frequency and intensity) is critical to maintaining native prairie capable of supporting a diverse species assemblage (Leonard et al. 2006). Fire suppression associated with development, coupled with interruption of fuels by roads and right-of-ways, leads to decreased fire frequency, resulting in reductions of grass vigor and encroachment by woody and invasive species. Frequency of wildland fire is a major factor influencing the quality of habitat for grassland bird assemblage species. The Baird's sparrow, for example, reaches peak densities within 2-4 years after a fire, followed by a decline in density. Fire suppression has negatively impacted the composition and structure of native prairie, favoring the incursion of trees and shrubs in areas that were previously grassland. This change of structure negatively impacts Sprague's pipit, which avoids trees and is negatively associated with shrub cover on its breeding grounds (USFWS 2011). A heterogeneous prairie mosaic can support a greater number of grassland endemics.

4.2.3 Invasive Species

Prairie grasslands have evolved with natural disturbances, and changes or interruptions in these processes alter species composition by reducing native species and by increasing invasive species. This has led to a decline in the diversity and vigor of native plants. Without native plants for food and nesting cover, the populations of the grassland birds have declined. Human activity and disturbance related to agriculture and other development activities increase opportunities for invasive species to infest native habitat.

Research has shown that encroachment of woody vegetation into prairie grassland has a negative impact on the occurrence, density, and/or nesting success of game and non-game grassland nesting birds. Removing trees opens the landscape to provide more suitable habitat for birds that need large grassland blocks for breeding. The woody vegetation also attracts predators so removal of these plants gives nesting grassland birds a better chance to successfully rear their young (Duncan, 2012).

The Sprague's pipit has been documented to have a strong negative response to exotic grasses, and Sprague's Pipit populations have been documented as significantly more abundant in native prairie than in introduced vegetation (Jones 2010). Frequent fire and moderate rain appear to create the optimal habitat structure (National Audubon Society 2012).

4.2.4 Climate Change

Modeling and predictions of climate change indicate that the status of grassland birds in the United States and the lower third of Canada may be impacted due to increasing temperatures. Drought is likely to impact grassland areas, and there is potential for summertime temperatures greater than what the bird species may be able to tolerate. Areas for grassland birds may become unsuitable due to increased drought, invasive species, and encroachment by woody shrubs. Prolonged periods of cool and wet weather may impact local Sprague's Pipit populations by reducing productivity (Jones 2010).

Earlier research has suggested that, under predicted global climate change scenarios, a number of grassland bird species will need to shift their breeding ranges if they are to maintain identified climatic tolerances. It is recognized that bird distributions can shift rapidly, even from one year to another, in response to changes in climatic patterns. Habitat, such as grassland vegetation, cannot change nearly as rapidly. Furthermore, geological features, such as unsuitable substrate or soils, may preclude shifts of suitable vegetation; anthropogenic activities such as agriculture and urbanization may also preclude such shifts (Northern Prairie Wildlife Research Center 1999)

4.2.5 Insect Outbreak and Disease

Insect outbreaks and diseases only apply to this assemblage with reference to West Nile Virus (WNV) and grasshopper outbreaks, which could threaten grassland bird species or their habitats. Although grasslands are prone to insect outbreaks, and the BLM does monitor this in some locations, there are no ecoregion-wide records of insect outbreaks to include in this analysis. Similarly, as mentioned in Appendix C-4, there was no ecoregion-wide dataset for WNV; therefore, this CA was not included in the analysis.

4.3 CHANGE AGENTS PROPOSED FOR ANALYSIS

Although numerous attributes and indicators affecting this species assemblage were initially identified in the early phases of this REA, not all are included in this analysis. The specific indicators that could not be modeled are identified with an asterisk on Figure E-4-15. Analysis for the invasive species and insect outbreak and disease CAs are not included for this CE because the direct effect indicators were determined to be data gaps or because they were impractical to model at the ecoregional scale because appropriate geospatial data were not available. Further information on the data gaps for indicators are discussed in the respective CA analyses contained in Appendix C.

Analysis for the development, wildfire, and climate change CAs are included for this CE.

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5.0 CHANGE AGENT ANALYSIS

A current status and future threat assessment for this assemblage was conducted for the ecoregion using the 6th level Hydrologic Unit Codes (HUCs) as the analysis unit. Based on the ecological process and system level models, KEAs were identified for the current status and future threat analyses, with a specific emphasis on the ability to measure impacts using existing geospatial data. The CAs evaluated for current status include development and wildfire. The CAs evaluated for future threats include development and climate change.

Since the scale of the analysis is at the 6th level HUC, a layer of 6th level HUCs was extracted for the ecoregion. A GIS process was iterated through the KEA indicators and determined the metric values associated with some watersheds. In other instances, sufficient published data indicated cut-off points for these values. These values were added as an attribute to the 6th level HUC layer. Since the primary reporting units for final mapping outputs is at a minimum of the 6th level HUC for the CEs, the values from the final output maps need to be added as an attribute to the 6th level HUCs. In some cases, zonal statistics will be calculated to determine a value associated with each watershed. The final layers will be created by combining the 6th level HUCs (with ranked KEAs) with the final suitable habitat layer and the habitat layer from the current status CA layer.

5.1 CURRENT STATUS OF THE GRASSLAND BIRD ASSEMBLAGE

Table E-4-5 identifies the original KEAs proposed in Task 3 and which of these were used in the final current status analysis. Not all of the KEAs proposed were used, based on the rationale provided. Other KEAs were used but are not directly related to CAs. For example, the KEA related to the proportion of native habitat per HUC was excluded because the Maxent outputs provided answers to the MQ that this KEA was aiming to illustrate.

Table E-4-5. Key Ecological Attributes Retained or Excluded

Category	Key Ecological Attribute		Explanation
1. Size	a.	Extent of modeled habitat	Excluded from threat analysis, as modeled habitat was one large patch with many small tiny patches.
2. Condition	a.	Wildland fire frequency	Retained to include in threat analysis, to show the fire return interval (FRI) for the ecoregion.
	b.	Degradation from offsite effects related to human activity	Excluded from threat analysis, as this KEA was very similar to other anthropogenic KEAs and it could only be calculated for an entire watershed.
	c.	Distance to nearest road, power line, infrastructure or anthropogenic land cover (fragmentation)	Retained to include in threat analysis to show where the fragmentation could occur due to anthropogenic sources.
3. Context	a.	Proportion of HUC in modeled habitat	Excluded from threat analysis, showing the proportion of the HUC that contained Maxent modeled output.
	b.	Proportion of permanently developed areas in HUC 12 watershed	Excluded from threat analysis; calculating anthropogenic effects already in another KEA being carried forward for threat analysis.
	c.	Frequency distribution of modeled habitat patch size	Excluded from threat analysis, as the distribution of patch size was not a normal distribution. One large, the rest very small.
	d.	Distance to similar modeled habitat (connectivity)	Retained as an analysis to show connectivity but not included as part of the CA analysis.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

Table E-4-6 identifies the KEAs, indicators, and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion. Several indicators were used to assess the current status for this assemblage. Size and landscape context indicators (e.g., heterogeneity, distance to roads, fragmentation) of the applicable output will be incorporated into a GIS overlay analysis.

Table E-4-6. Key Ecological Attributes, Indicators, and Metrics for the Grassland Bird Assemblage

Ecological Attribute	Indicator	Metrics			Data Source	Citation	Weight
		Poor =3	Fair =2	Good =1			
Habitat condition	Wildland Fire Frequency: FRI (years)	>15	0-5 or 10-15	5-10	FRI	Professional judgment; Johnson 1996	10%
Fragmentation	Distance to nearest road, power line, other infrastructure, or anthropogenic land cover (m)	<500	500 to 1,000	>1,000	Linear features; power lines; oil and gas wells, GAP	Professional judgment; Herkert 1994; Johnson and Igl 2001	45%
Connectivity	Distance to similar habitat; Percent of Maxent output within 1 kilometer (km)	<15%	15-30%	>30%	GAP	Herkert 1994; Johnson and Igl 2001	45%

In most cases, the metrics used to identify attribute quality were based on available publications, coupled with expert analysis and professional judgment in association with data-driven metrics. This process was carried out through the establishment of a CE RRT comprised of BLM wildlife biologists and state-level experts. The RRT met periodically to contribute information and to analyze input attributes and outputs that were derived from various forms of spatial analyses in GIS. This process enabled the RRT to determine the efficacy of attributes, indicators, and metrics, as well as to ascertain the accuracy of each step of the modeling process. The KEA indicators were weighted, as noted in Table E-4-6, when evaluating the overall current status of the CE assemblage. Because FRI is not thought to be as representative of actual return intervals of fire in grassland systems versus forested systems, the RRT felt that the fire return interval (FRI) KEA should be weighted less than the other two KEAs (as connectivity and anthropogenic features were much more important).

5.1.1.1 Fire Return Interval

Grassland habitats are well adapted to periodic wildland fire. Periodic wildland fires maintain high grass vigor, reduce the buildup of thatch, and prevent the encroachment of woody species. Frequency of wildland fire is a major factor influencing the quality of habitat for grassland bird species. Baird's sparrow reaches peak densities within 2-4 years after a fire, followed by a decline in density. Sprague's pipits are most abundant in the first 2-3 years post-fire and, in portions of their range, may be absent from native prairie that has not been burned or grazed in more than 8 years. In drier portions of their range, Sprague's pipits may exhibit high abundance in undisturbed native prairie for longer periods. Fire suppression policies associated with residential and industrial development, along with an increase in road networks, reduce fire frequency.

Because no other data were available to spatially represent fire history across the landscape, FRI data from LANDFIRE's vegetation condition class (VCC) was used as the input data source for this KEA. The FRI data are modeled in spans of 5 years; therefore, the KEA metrics needed to be adjusted from a more detailed 3-8 years = good to 5-10 years = good.

For this analysis, the FRI data were downloaded from the LANDFIRE website and clipped to the ecoregion. Analysis was completed both at a pixel level and using zonal statistics to extract the majority or most common FRI value in an HUC 12 watershed. Figure E-4-16 classifies watersheds by good, fair, and poor, as well as areas that were outside the Maxent modeled areas.

The majority FRI for the watershed was assigned a relative rank of good, fair, or poor. The scoring system used for this indicator was adopted from Johnson (1996) and modified to fit within the bounds of the FRI modeled data attributes. For the grassland bird assemblage, poorest conditions were deemed as areas that have not burned in greater than 15 years, which could allow encroachment (or succession) of shrubs and woody vegetation into the grasslands. An FRI of 5-10 years was deemed good as a middle ground between recently burned and has not burned in a greater than 10 years (fair).

5.1.1.2 Fragmentation of Maxent Output

This KEA was established primarily to assist with the evaluation of anthropogenic disturbance relative to grassland bird habitat. Johnson and Igl (2001) found that Baird’s sparrows tend to avoid areas that contain extensive woody vegetation or are near roads. Herkert (1994) found that daily nest predation rates declined with increasing fragment size. In other words, the larger the patch of grasslands, the less nest predation occurred. Linnen (2008) found Baird’s sparrows may avoid areas within approximately 400 m of built-up oil wells, access roads, and associated activity. Sutter et al. (2000) also found that they tended to not establish territories adjacent to roads. This KEA was completed by merging roads, transmission lines, oil and gas wells, communication towers, human land uses, and agricultural areas into one layer. This layer was then extracted out to the assemblage Maxent output for scoring at the HUC level. The results of the anthropogenic distance analysis on protected lands assessment are shown on Figure E-4-17.

5.1.1.3 Connectivity of Maxent Output

This KEA was developed to show the connectivity of grassland bird habitat across the Maxent output. This KEA was completed using a moving window analysis with a window size of 1 km. The analysis determined what percent of the moving window was suitable habitat. The analysis was then rolled up to the HUC 12 level to show the percent of HUC 12 as connected habitat. Because the Maxent analysis was rolled up for all of the assemblage species, most of the Maxent output returned a good result for this KEA (>30 percent being contiguous Maxent output with the exception of some fragmented Maxent output in central South Dakota and southern Montana). The results of the grassland birds assemblage Maxent output connectivity analysis are shown on Figure E-4-18.

5.1.2 Current Status of Habitat

The grassland bird GIS process models are designed to create a series of intermediate data layers based on the KEA indicators that are scored according to the designated metric (Table E-4-5). These CA layers were combined together to form a single layer outlining areas that may negatively affect suitable grassland bird assemblage habitat. The grassland bird assemblage distribution model can be used as a standalone layer, but has also been draped over the composite CA model to show the Maxent output relative to the combined set of CAs.

The individual KEA analyses provide the basis for the compilation of an overarching data layer that defines the current status of grassland bird habitat for each HUC across the Northwestern Plains ecoregion. In order to create a current status data layer, an overall score for each HUC unit was calculated. Based on each KEA rating of good, fair, or poor, an HUC quality rank score was subsequently assigned to the KEA. If the KEA rating was good, then the HUC quality rank score of 1 was assigned; fair was assigned a score of 2, while poor was given a score of 3. The HUC quality rank score was calculated by performing a weighted sum overlay that factors in the weights assigned in Table E-4-6 when summing the individual KEAs.

The overall score for each HUC was assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. The natural breaks for the combined CA analysis were 0.33-0.55 (good), 0.56-0.76 (fair), and 0.77-1.0 (poor). A higher overall threat score would result in a rating of poor for the HUC, indicating there are existing threats to the grassland bird assemblage habitat based on the KEA metrics.

The results of the current status analysis for the ecoregion are presented on Figure E-4-19. Based on a review of this map, it appears that the majority of the modeled grassland bird habitat is in the fair category for current status. The assessment of fragmentation of habitat based on distance from anthropogenic features did include habitat reductions due to fragmentation (Figure E-5-17). In contrast, the assessment of connectivity, based on percentage of anthropogenic features within the HUC, was good overall (Figure E-5-18). FRI was good throughout the region of grassland bird Maxent distribution (Figure E-5-16).

A summary of the current status ratings based on the CE distribution is provided in Table E-4-7. The CE distribution layer was used to calculate the total number of square miles of CE habitat and a percentage of the total number of square miles per HUC that were rated as good, fair, or poor. The results of the current status assessment indicate that only one-third or approximately 33.4 percent of the 6th level HUCs that intersect the grassland bird assemblage distribution received an overall good rating.

Table E-4-7. Summary of Current Status Ratings for the Grassland Bird Assemblage

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	8,067	33.4
Fair	12,412	51.4
Poor	3,673	15.2

[a] These values include only the area of HUCs that intersect with the CE distribution layer.
[b] Values rounded to one decimal place.

5.2 FUTURE THREAT ANALYSIS

The system-level model (Figure E-4-15) was used to create a series of intermediate layers that are primarily based on the geospatial data that was available on the future projections for the development and climate change CAs. Future threats were evaluated for development for a short-term time horizon (5 to 10 years) and for climate change for a long-term time horizon (50-year; 2050 to 2069).

Because of the inherent inaccuracies of the temporal scale of the future data, it is only possible to infer information pertaining to a subjective future period (rather than a specific time period) for some of these attributes. However, because of the limits placed on these data outputs, it is fair to assume that this model predicts the overall future potential for these attributes within this ecoregion. It is an upper limit of potential growth and should therefore be carefully applied to future estimates of their effect on this assemblage.

5.2.1 Development Change Agent

Future spatial data for development was limited to potential energy development, modeled urban growth, and potential agricultural development, as discussed in the development CA analysis presented in Appendix C-1.

Figures C-1-1 through C-1-8 illustrate the future threats to grassland bird species habitats. Based on a qualitative assessment of the grassland bird habitat relative to the future potential for fossil and renewable energy development, it does not appear that the majority of grassland bird habitat is at high risk. However, fossil fuel energy development in the Bakken Shale areas of western North Dakota and eastern Montana could pose a risk to this CE in the future.

5.2.1.1 Agricultural Growth

As mentioned under the current status discussion, agricultural conversion of grassland bird habitat is the single most important current and future threat to this CE. As world-wide populations increase, so will the demand for additional crops.

Since no future agricultural models exist for use within this ecoregion, a model was created using surrogate data to derive potential agricultural areas. State Soil Geographic (STATSGO) data were used to identify potential agricultural soil types suitable for conversion. The appropriate soil types for use in this classification are types 1 through 4, which are shown on the agriculture potential map (Figure C-1-1 in Appendix C-1).

Although this information can be portrayed spatially, there is no way to temporally show this future threat. The politics of government-subsidized agriculture programs are uncertain and dictate the temporal nature of this CA. Alternatively, this analysis considered the maximum potential for future agricultural areas within this ecoregion.

Figure C-1-1, Future Agricultural Potential, shows the results of the analysis, indicating where the future potential for agriculture occurs relative to the Maxent output for this assemblage. In the Northwestern Plains ecoregion, most of the agricultural areas (current and future) are located within the heart of where the Maxent models predict this assemblage to occur. The majority of Maxent output intersects with current and future agricultural areas located in northern Montana and northwestern North Dakota. Areas along the Missouri River in South Dakota and Nebraska returned high results for the agricultural output, but these areas were not the most suitable areas for the grassland bird assemblage based on the Maxent output.

5.2.1.2 Future Growth of Urban Areas

The effects of urban growth on this assemblage are similar to those of agricultural activities. In the Northwestern Plains ecoregion, the majority of urban growth is anticipated around existing urban areas. The Integrated Climate and Land Use Scenarios (ICLUS) model is a universally accepted model created by the USEPA for use in future climate change modeling that provides spatial data that can be used to determine the future extent of urban areas for various time periods. The model uses U.S. Census data to predict urban growth. The ICLUS future urban extent for the year 2060 was used in this analysis. This corresponds more closely to the data and scenarios used to perform the modeled habitat and wind turbine analyses than a near-term time period. The ICLUS urban area footprint for 2060 was used to calculate the proximity to modeled grassland bird assemblage habitat. Figure C-1-8, Future Urban Growth Potential, shows the results of the analysis. Although the urban areas around Rapid City, South Dakota, and Sheridan, Wyoming, are projected to increase, it is not anticipated that this would adversely affect this assemblage as a whole. A small area around Havre, Montana, is expected to increase in development, but again, this does not appear to threaten grassland birds on a landscape scale. However, exurban development (such as the construction of houses on large properties) could negatively the species of this assemblage. Based on review of the map, it does not appear that urban growth needs to be considered as great of a threat to this CE as agriculture.

5.2.1.3 Wind Turbine Potential

The potential risk of wind energy development on wildlife and habitats has been a topic of concern for the last 10 years; as the number of wind turbines across the landscape increases so does the concern about their impacts. Very preliminary data suggest that grasshopper sparrow avoid turbines, whereas western meadowlark and chestnut-collared longspur do not avoid turbines. In addition to turbines, construction of roads may negatively impact grassland birds by fragmenting habitat (Martin et al. 2009).

The USFWS wind turbine data contained attribute information for current and future wind turbine locations. However, the future turbine locations dataset was very limited in number as most turbines will presumably be erected in the very near future. Therefore, an alternative dataset was used to determine the potential areas for erecting wind turbines over a long-term period. The future wind energy development layer was based on the location of documented wind speeds suitable for turbines.

Data characterized by the National Renewable Energy Laboratory (NREL) were used to create the potential future wind energy development data layer. A full description of the methods and processes implemented to create this data layer and its corresponding scoring system can be found in Appendix C-1.

The potential risks to modeled grassland bird assemblage habitat relative to future wind energy development are presented on Figure C-1-7. Higher elevations within this ecoregion are more susceptible to the risk of future wind turbines due to the higher wind speed levels within these areas. However, limited accessibility to higher elevations may limit the range of wind turbine distribution to lower-elevation areas. Much of the area encompassed by the grassland birds modeled habitat is labeled as moderate risk to wind development. The areas that are characterized as high risk for wind development are located in east central South Dakota where the Maxent output for this assemblage is not as dense as other areas in central Montana or northwestern North Dakota.

5.2.1.4 Oil and Natural Gas Production Risk

The potential for oil and gas development throughout the Northwestern Plains has the potential to affect the grassland bird assemblage modeled habitat. This topic is currently being studied as part of the plains and prairie potholes landscape conservation cooperative research efforts. It is recognized that oil and gas development in North Dakota is occurring at a rapid pace and agencies do not have a full understanding of the potential risk of these activities to grassland bird species.

This future analysis characterized the future potential for oil and natural gas development, rather than actual well locations (Figures C-1-3 and C-1-4). These larger potential production extents were used to qualitatively assess the potential effect of future oil and gas production activities. Although these areas are based on oil and gas density data, the application of these data to future potential well site activity is unknown. Therefore, a carefully considered approach should be taken when assessing the effect of potential oil and gas production areas on grassland bird assemblage modeled habitat.

Although the majority of potential oil and gas production is located in northeastern Wyoming, a large future energy development area in northeastern Montana/northwestern North Dakota poses a moderate risk to grassland bird habitats.

It is important to note that the Energy Policy and Conservation Act (EPCA) oil and gas data used in this assessment are based on the maximum potential for oil and gas reserves within the Northwestern Plains. As a result, these data are likely overly represented in these figures, and care should be taken in assessing the effects of oil and gas production within the constraints of this analysis.

5.2.1.5 Future Risk for Solar Development

This risk analysis for future potential for solar development is based on the solar potential maps developed by NREL. Although these maps are very crude (see Figure C-1-6), the areas at highest risk for solar development occur in northeast Wyoming and southeast Montana. Although the Maxent models for this assemblage did indicate some modeled habitat in southeastern Montana, the majority of the modeled habitat in northern Montana and North Dakota does not appear to be at risk for solar development.

5.2.1.6 Overall Development CA Future Threats

Most of the potential future risks to the grassland bird assemblage modeled habitat in the ecoregion would potentially result from future agricultural conversion. Although the future development of fossil fuel poses a moderate risk, it is not on the level of agriculture.

A future potential renewable energy development layer was created to address the MQs associated with future renewable energy production. This layer was created by averaging the NREL wind speed data layer with the NREL solar energy data layer (Figure C-1-8).

This output layer gives equal weighting to potential wind and solar energy production areas, and could therefore mischaracterize the effects of each. Unlike oil and gas, wind and solar energy are not necessarily closely associated with one another spatially. Photovoltaic solar arrays threaten the assemblage through a decrease in habitat availability and habitat fragmentation. Solar arrays are diverse in scope and size and it is therefore difficult to create a clear correlation between habitat loss and solar energy production. As a result, it might be beneficial for managers to consider wind and solar energy production as separate entities when determining the effects of renewable resources on this assemblage.

Because of the intricacies involved in the assessment of renewable energy production with regard to grassland bird assemblage modeled habitat, a limited approach must be taken in this analysis. The majority of the grassland bird modeled habitat in the Northwestern Plains ecoregion is considered to be at low risk from the development of renewable energy facilities.

5.2.2 Climate Change Future Threats

5.2.2.1 Ecoregion Climate Change Analysis

From a climate change perspective, the relationship between temperature, precipitation, and the re-distribution of vegetation communities through agricultural conversion, changes to historic wildfire regimes, and invasive species across the landscape are the factors that will provide the greatest potential risk to this assemblage.

All of the species in the assemblage rely on intact grasslands as habitat. If vegetation communities substantially change as a result of increased temperatures and decreased precipitation, it is likely that fire regimes will change and invasive species will negatively affect this assemblage. However, attempting to illustrate these potential impacts in a geospatial format is very difficult.

A constant overall increase in temperature (1.9 degrees Celsius [°C] to 2.3°C) is expected across the assemblage modeled habitat within the Northwestern Plains. Increased fire potential is the most likely result of temperature increase that would directly affect assemblage habitat quality. Across the Northwestern Plains ecoregion annual precipitation is predicted to be highly variable around the 2060 timeframe. Most of the region is expected to experience a mild increase (25-75 millimeters [mm]) in annual precipitation or no annual change in precipitation. Climate models indicate that July and August precipitation could decrease moderately in the Power River Basin as well as in southern South Dakota and Nebraska.

5.2.3 NatureServe Climate Change Vulnerability Index

The NSCCVI tool was utilized to assess Baird's sparrow as a representative of the overall vulnerability of the grassland bird assemblage to future climate change. Using annual raster datasets from NatureServe to perform climate change calculations in ArcGIS (through the Predicted Temperature 2040-2069 [Fahrenheit] and the Predicted Hamon ratio between actual evapotranspiration and potential evapotranspiration [AET : PET] Moisture Metric 2040-2069 datasets), the NSCCVI calculator was applied and produced an Index score of Insufficient Evidence. The NSCCVI tool indicated that the available information (within the geographical area assessed) about the species' vulnerability is inadequate to calculate an Index Score. Data gaps for Baird's sparrow's specific response to climate change were identified. The assessment rating was largely based on "unknown" scores calculated when assessing factors that influence vulnerability such as distribution to barriers, dispersal and movements, sensitivity to temperature and moisture changes (historical thermal/hydrological niche), reliance on interspecific interactions to generate habitat, and dietary versatility.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the grassland bird assemblage include those defined as part of the Landscape Species/Species Richness category (Appendix A). The overall MQ was: Where are the key habitat types (seasonal, refuges, corridors/connectivity, migration routes, concentrations of regionally significant species, etc.) for landscape species, keystone species, regionally significant species, and regionally significant suites of species? This MQ was considered in implementing the GIS analyses. Emphasis was placed on the spatial relationship of attributes mentioned in the MQs and the grassland birds distribution models for each focal species. Several examples of how the REA can be used to answer MQs (as noted in Appendix A) are provided below to demonstrate the functionality of the REA and to provide an opportunity to discuss data gaps that were identified during the REA.

6.1 WHERE ARE THE HABITATS THAT SUPPORT GRASSLAND BIRDS?

The response to this MQ was required to perform all of the additional analysis and data comparisons for each species within the assemblage and the assemblage as a whole. The Maxent habitat models are presented as Figures E-4-1 through E-4-12. Although there are potential limitations to the accuracy and precision of these models, all efforts were made, including expert review, to ensure that these were accurate representations of grassland bird modeled habitat in the Northwestern Plains ecoregion.

6.2 WHERE ARE THE KEY HABITAT AREAS THAT SUPPORT REGIONALLY SIGNIFICANT CONCENTRATIONS OF GRASSLAND BIRDS?

The Maxent distribution models used a variety of factors, including point occurrence data, to model potential habitat of each species and the assemblage as a whole. These models created probability ranges of potential grassland bird habitat that ranged from 0-1. In this analysis the output value was limited to areas that provided potential for grassland bird habitat, but could easily be reclassified to create revised thresholds based purely on the environmental variables associated with the Maxent model. Similarly, the analysis used to create the current status of grassland birds by 12-digit HUC provides this result. The figure (Figure E-4-19) portraying the current overall score specifically answers this MQ by scoring HUCs within the grassland bird Maxent output area.

6.3 WHERE ARE AREAS THAT HAVE POTENTIAL FOR RESTORING HABITAT OR HABITAT CONNECTIVITY FOR GRASSLAND BIRDS?

Several of the figures present data layers that could be used to answer this MQ. Habitat quality is identified both as a sum and individually across the ecoregion. These attributes can be analyzed by managers at the 12-digit HUC level to determine areas that are preferential for restoring grassland bird habitat based on their proximity to good quality habitat.

6.4 WHERE ARE REGIONALLY SIGNIFICANT GRASSLAND BIRD HABITAT AREAS AT GREATEST RISK FROM CHANGE AGENTS INCLUDING CLIMATE CHANGE (CONNECTIVITY, SMALL POPULATION SIZE), DISTURBANCE OR DEVELOPMENT?

The full range of figures and analyses described in this appendix can be used to answer this complex MQ. The models created throughout this process were created to directly address the effects of CAs on grassland birds. All of the CAs that had sufficient data were addressed spatially and described in this appendix, and all of the CAs were spatially attributed to the distribution of the grassland birds. Climate change was addressed separately because of data issues, but the spatial relationship between climate change and grassland bird distribution was described in detail.

6.5 WHERE ARE AREAS OF EXISTING, PLANNED, AND POTENTIAL FUTURE DEVELOPMENT, INCLUDING ROADS (BASED ON EXISTING WILDLAND URBAN INTERFACE LITERATURE, INCLUDING THEOBALD AND OTHERS)?

The effect of CAs on grassland birds was limited by data availability, but in most cases surrogate data were available for use in this analysis. Therefore, although the data were limited in quality, assumptions were made in order to address this question. The future CA figures in Appendix C provide a spatial display of the effects of these future CAs on areas where the Maxent predicted optimal habitat.

6.6 WHICH CORE CONSERVATION ELEMENTS ARE THREATENED BY SOD-BUSTING, ENERGY DEVELOPMENT, GRAVEL MINING, FRAGMENTATION, LOSS OF CONNECTIVITY, AND OTHER DEVELOPMENT PRESSURES?

This MQ was addressed in the future CA analysis. The results of the analysis (Section 5.2) indicate there could be a potential negative effect on future grassland bird populations in some areas as a result of agricultural activity and oil and gas development.

7.0 REFERENCES

Anstey, D. A., S. K. Davis, D. C. Duncan, and M. Skeel. 1995. Distribution and habitat requirements of eight grassland songbird species in southern Saskatchewan. Saskatchewan Wetland Conservation Corporation, Regina, Saskatchewan. 11 pages.

Brennan, L. and W. Kuvlesky, Jr. 2005. North American Grassland Birds: An Unfolding Conservation Crisis? J. Wildlife Management 69(1):1-13.

Carlson, John C. (2006). McCown's Longspur, *Calcarius mccowni* Montana Outdoors, July–August 2006 Montana Fish, Wildlife & Parks Available at http://fwp.mt.gov/mtoutdoors/HTML/articles/portraits/longspur.htm. Accessed on July 10, 2012.

Coppedge, B. R., D. Engle, R. Masters, and M. Gregory. 2001. Avian Response to Landscape Change in Fragmented Southern Great Plains Grasslands. Ecological Applications 11(1):47-59.

Dale, B. C. 1984. Birds of grazed and ungrazed grasslands in Saskatchewan. Blue Jay 42:102-105.

Dale, B. C., P.A. Martin, and P.S. Taylor. 1997. Effects of hay management on grassland songbirds in Saskatchewan. *Wildlife Society Bulletin*, 25:616-626.

Davis, S.K. 1994. Cowbird parasitism, predation, and host selection in fragmented grassland of southwestern Manitoba. M.S. Thesis, University of Manitoba, Winnipeg, Canada.

Dowd Stukel, E., ed. 2011. Conservation assessment and conservation strategy for swift fox in the United States – 2011 Update. South Dakota Department of Game, Fish and Parks, Pierre, South Dakota. Available at http://wildlife.state.co.us/SiteCollectionDocuments/DOW/WildlifeSpecies/Grasslands/2011SwiftFoxConservationAssessmentStrategy.pdf. Accessed on July 10, 2012.

Duncan, Celestine. 2012. *US Fish and Wildlife Service Manages Invasive Woody Plants, Techline*. Spring 2012. Available at http://techlinenews.com/2012prairie.pdf.

Grant, T.A., E. Madden, and G.B. Beerkey. 2004. Effects of woody vegetation on grassland birds: tree and shrub invasion in northern mixed-grass prairie: implications for breeding grassland birds. *Wildlife Society Bulletin*, Vol. 32, No. 3 (Autumn, 2004), pp. 807-818.

Green, M. T., P. E. Lowther, S. L. Jones, S. K. Davis and B. C. Dale. 2002. Baird's Sparrow (*Ammodramus bairdii*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/638

Harris, R. D. 1944. The Chestnut-collared Longspur in Manitoba. Wilson Bulletin 56:105-115.

Herkert, J.R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. *Ecological Applications*, Vol. 4, No. 3 (August, 1994), pp. 461-471.

Hill, Dorothy P. and Lorne K. Gould. 1997. Chestnut-collared Longspur (*Calcarius ornatus*), The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/288.

Hirzel A. H., G. Le Lay, V. Helfer, C. Randin, and A. Guisan. 2006. Evaluating the ability of habitat suitability models to predict species presences. Ecological Modeling 199, 142-152.

Johnson, D.H. 1996. Effects of Fire on Bird Populations in Mixed-Grass Prairie, pp. 181-206. In: F.L. Knopf and F.B. Samson (eds.). Ecology and Conservation of Great Plains Vertebrates. Springer: New York, New York.

Johnson, D.H. and L.D. Igl. 2001. Area Requirements of Grassland Birds: A Regional Perspective. The Auk 118(1):24-34.

Jones, S. L. and M. T. Green. 1998. "Baird's Sparrow status assessment and conservation plan." May, 1998. Administrative Report. U.S. Dept. of Interior, Fish and Wildlife Service, Denver, CO. Updated June 2010.

Jones, S. L. 2010. Sprague's Pipit (Anthus spragueii) Conservation Plan. U.S.Department of Interior, Fish and Wildlife Service. Washington, D.C. Available at http://www.fws.gov/mountain-prairie/species/birds/spraguespipit/
SpraguesJS2010r4.pdf.

Kantrud, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Canadian Field-Naturalist 95:404-417.

Knopf, F.L. 1994. Avian assemblages on altered grasslands. *Studies in Avian Biology*, 15: 247-257.

Knopf, F.L. 1996. Mountain Plover. *In*: A. Poole and F. Gill, editors. The Birds of North America, No. 211. Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Knopf, F.L. and F.B. Samson, eds. 1997. *Ecology and Conservation of Great Plains Vertebrates*. Springer: New York, New York.

Leddy, K., K. F. Higgins, and D. E. Naugle. 1999. Effects of wind turbines on upland nesting birds in conservation reserve program grasslands. Wilson Bulletin 111:100-104.

Lenard, S., J. Carlson, P. Hendricks, and C. Currier. 2006. Grassland Bird Surveys in North Valley County, Montana: Progress Report. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena. 22 pp. plus appendices. Available at http://mtnhp.org/Reports/Grassland_Birds_Progress.pdf

Linnen, C. G. 2008. Effects of Oil and Gas Development on Grassland Birds. Prepared for Petroleum Technology Alliance Canada.

Madden, E.M., R.K. Murphy, A.J. Hansen, and L. Murray. 2010. Models for guiding management of prairie bird habitat in Northwestern North Dakota. *American Midland Naturalist*, Vol. 144, No. 2 (Oct., 2000), pp. 377-392.

Martin, B., A. Pearson, B. Bauer. 2009. BAn Ecological Risk Assessment of Wind Energy Development in Montana.

Montana Fish, Wildlife and Parks (2012). Swift Fox — Vulpes velox. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on July 10, 2012, from http://FieldGuide.mt.gov/detail_AMAJA03030.aspx.

National Audubon Society. 2012. *Baird's Sparrow Ammodramus baird*ii http://birds.audubon.org/ species/baispa. Accessed on July 9, 2012.

Niemuth, N., M. Estey, C. Loesch, and R. Reynolds. Landscape-Level Benefits of Waterfowl Conservation to Non-Game Birds in the Prairie Pothole Region. USFWS HAPET Office presentation, Bismarck North Dakota.

Niemuth, N., R. Reynolds, M. Estey, F. Quamen, and D. Naugle. Effect of the Conservation Reserve Program on Grassland Bird Populations in the Prairie Pothole Region of North Dakota and South Dakota. USFWS HAPET and the University of Montana presentation.

North Dakota Game and Fish Department 2012. Species of Conservation Priority. Accessed from http://gf.nd.gov/conservation-nongame-wildlife/species-conservation-priority July 10, 2012.

Northern Prairie Wildlife Research Center 1999. Global climate change and range shifts of grassland birds: will the habitat be there? Research Progress, Highlights of the 1999 Fiscal Year. U.S. Geological Society. Updated October 11, 2006. Accessed on August 10, 2012 from http://www.npwrc.usgs.gov/news/highlights/fy99/research.htm#grass

Peterson, T.A. 2003. Projected climate change effects on Rocky Mountain and Great Plains birds: generalities of biodiversity consequences. *Global Change Biology*, 9:647-655.

Peterson, T.A. 2003. Subtle recent distributional shifts in Great Plains bird species. *The Southwestern Naturalist*, Vol. 48, No. 2, pp. 289-292.

Quamen, F.R. 2007. A landscape approach to grassland bird conservation in the Prairie Pothole Region of the Northern Great Plains. Doctoral dissertation. Missoula: University of Montana.

Robbins, Mark B. and Brenda C. Dale. 1999. Sprague's Pipit (*Anthus spragueii*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/439

Samson, F.B. and F.L. Knopf, eds. 1996. *Prairie Conservation: Preserving North America's Most Endangered Ecosystem*. Island Press: Washington, D.C.

Samson, F.B. and F.L. Knopf, eds. 1996. *Ecosystem Management, Selected Readings*. Springer: New York, New York.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2009. Version 3.23.2011* USGS Patuxent Wildlife Research Center, *Laurel, MD* Species Group Summary Results. Species Group: Grassland Breeding; Period 1966-2009. Central North America. Patuxent Wildlife Research Center. http://www.mbr-pwrc.usgs.gov/cgi-bin/guild09.pl

Sedgwick, J.A. 2004. Chestnut-collared Longspur (*Calcarius ornatus*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. December 13. Available: http://www.fs.fed.us/r2/projects/scp/assessments/chestnutcollaredlongspur.pdf. Accessed on July 10,2012.

Sovada, Marsha A., Robert O.Woodward, and Lawrence D. Igl. 2009. Historical range, current distribution, and conservation status of the Swift Fox, *Vulpes velox,* in North America. Canadian Field-Naturalist 123(4): 346–367. http://wildlife.state.co.us/SiteCollectionDocuments/DOW/WildlifeSpecies/Grasslands/SwiftFoxHistoricalRange2011SovadaWoodwardIgl.pdf.

Stewart, Robert E. 1975. Breeding Birds of North Dakota. Tri-College Center for Environmental Studies, Fargo, ND. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/birds/bbofnd/index.htm (Version 06JUL2000).

Sutter, G.C., S. K. Davis, and D. C. Duncan. 2000. Grassland songbird abundance along roads and trails in southern Saskatchewan. Journal of Field Ornith. 71(1):110-116.

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2008. The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System. Report to the National Park Service.

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2009. *The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System***.** Report to the National Park Service. Version 1.0. January.

USFWS 2011. *Species Assessment And Listing Priority Assignment Form for Anthus spragueii Sprague's Pipit.* USWFS. May 31. Available at http://ecos.fws.gov/docs/candidate/assessments/2012/r6/B0GD_V01.pdf

Weaver, J.E. 1954. *North American Prairie*. Johnson Publishing Company: Lincoln, Nebraska.

Weaver, J.E. and F.W. Albertson. 1956. *Grasslands of the Great Plains, Their Nature and Use*. Johnson Publishing Company: Lincoln, Nebraska.

Wiggins, D.A. (2006, June 9). Baird’s Sparrow (*Ammodramus bairdii*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/bairdssparrow.pdf Accessed on July 9, 2012.

With, Kimberly A. 2010. McCown's Longspur (*Rhynchophanes mccownii*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/096.

Wyckoff, A.M. 1986. A relict population of Chestnut-collared Longspurs in western Minnesota. Loon 58:3-11.

Wyoming Game and Fish Department 2010. State Wildlife Action Plan 2010. http://gf.state.wy.us/web2011/Departments/Wildlife/pdfs/SWAP_2012_FULL0002194.pdf

Wyoming Partners in Flight. 2002. Growing Grassland Birds: Best Management Practices for Grasslands to Benefit Birds in Wyoming. Wyoming Game and Fish Department, Lander.

APPENDIX E-4

FIGURES

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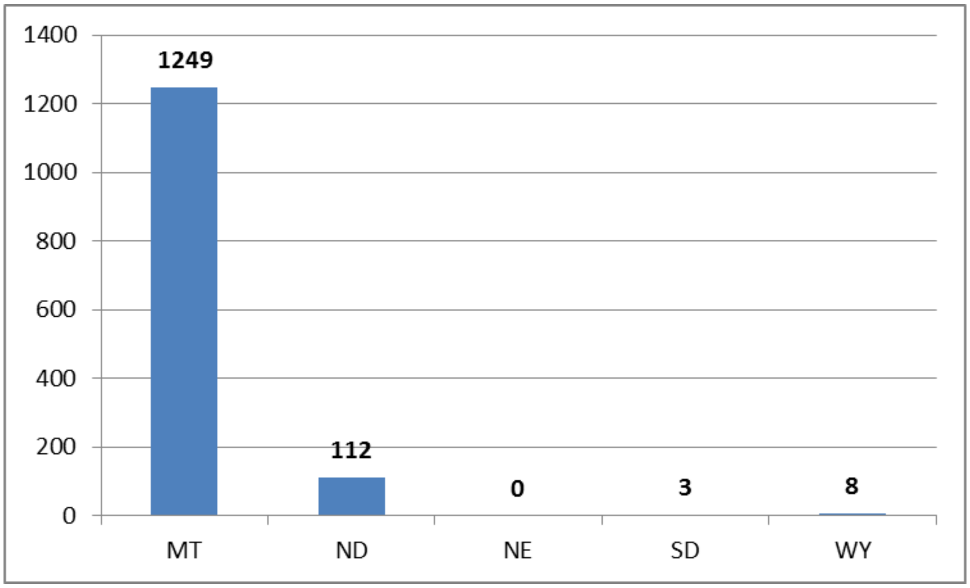


Figure E-4-1. Baird's Sparrow Observations by State used in Maxent Modeling

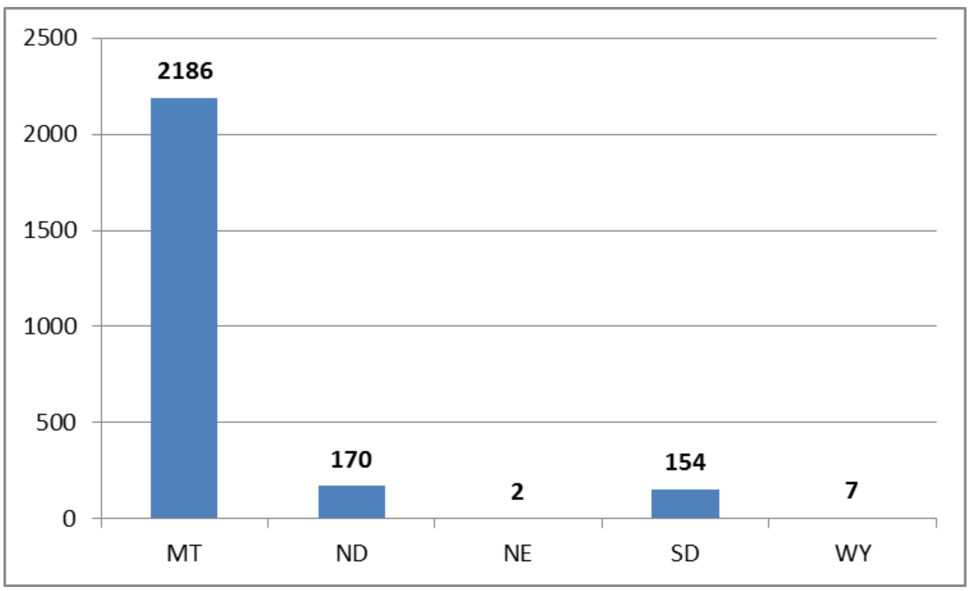


Figure E-4-2. Chestnut-collared Longspur Observations by State used in Maxent Modeling

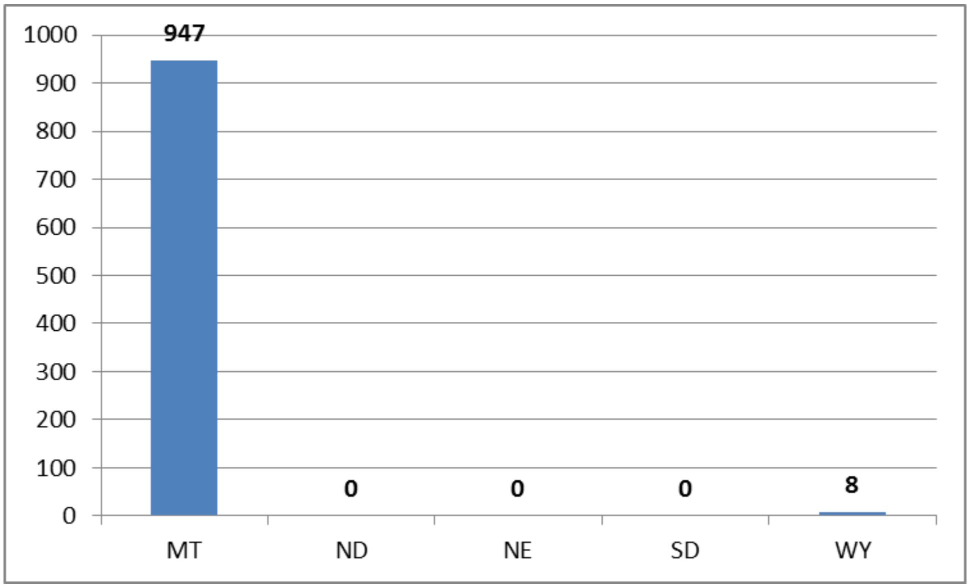


Figure E-4-3. McCown's Longspur Observations by State used in Maxent Modeling

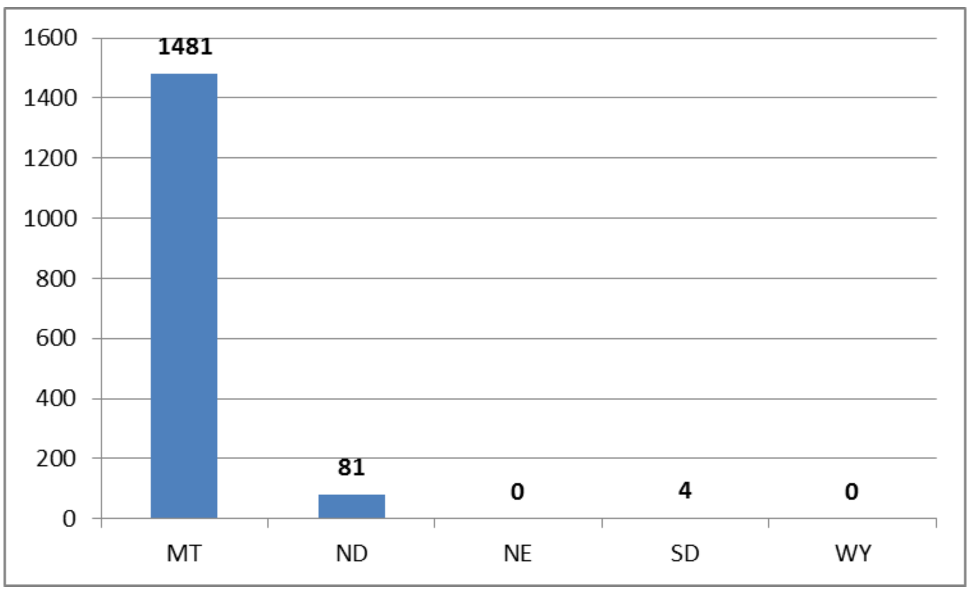


Figure E-4-4. Sprague's Pipit Observations by State used in Maxent Modeling

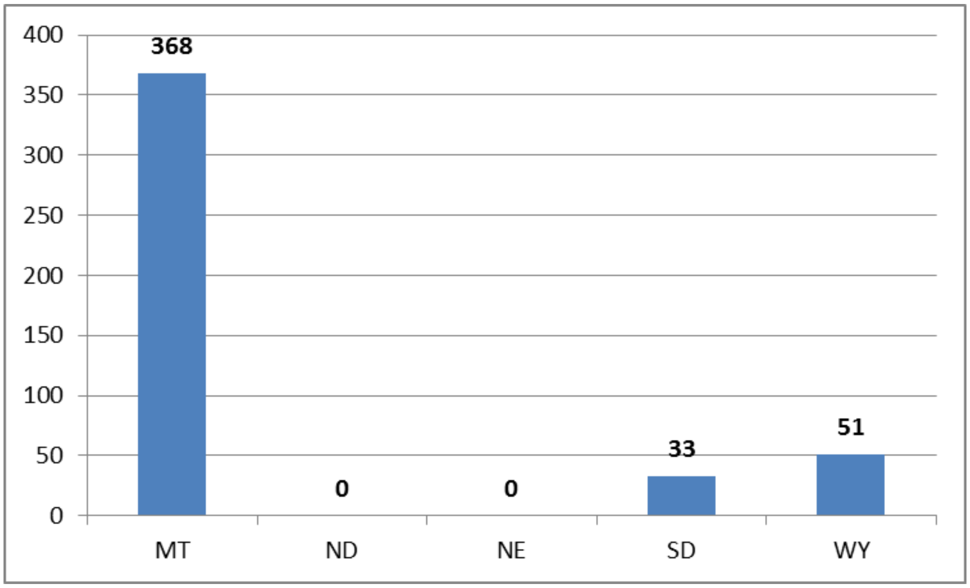


Figure E-4-5. Swift Fox Observations by State used in Maxent Modeling

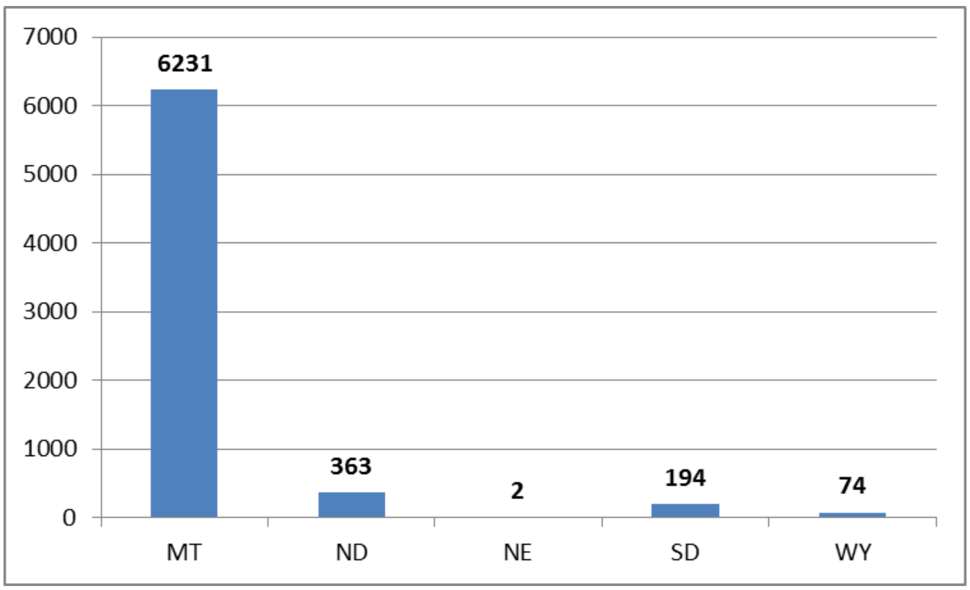


Figure E-4-6. Combined Grassland Bird Assemblage Observations by State used in Maxent Modeling

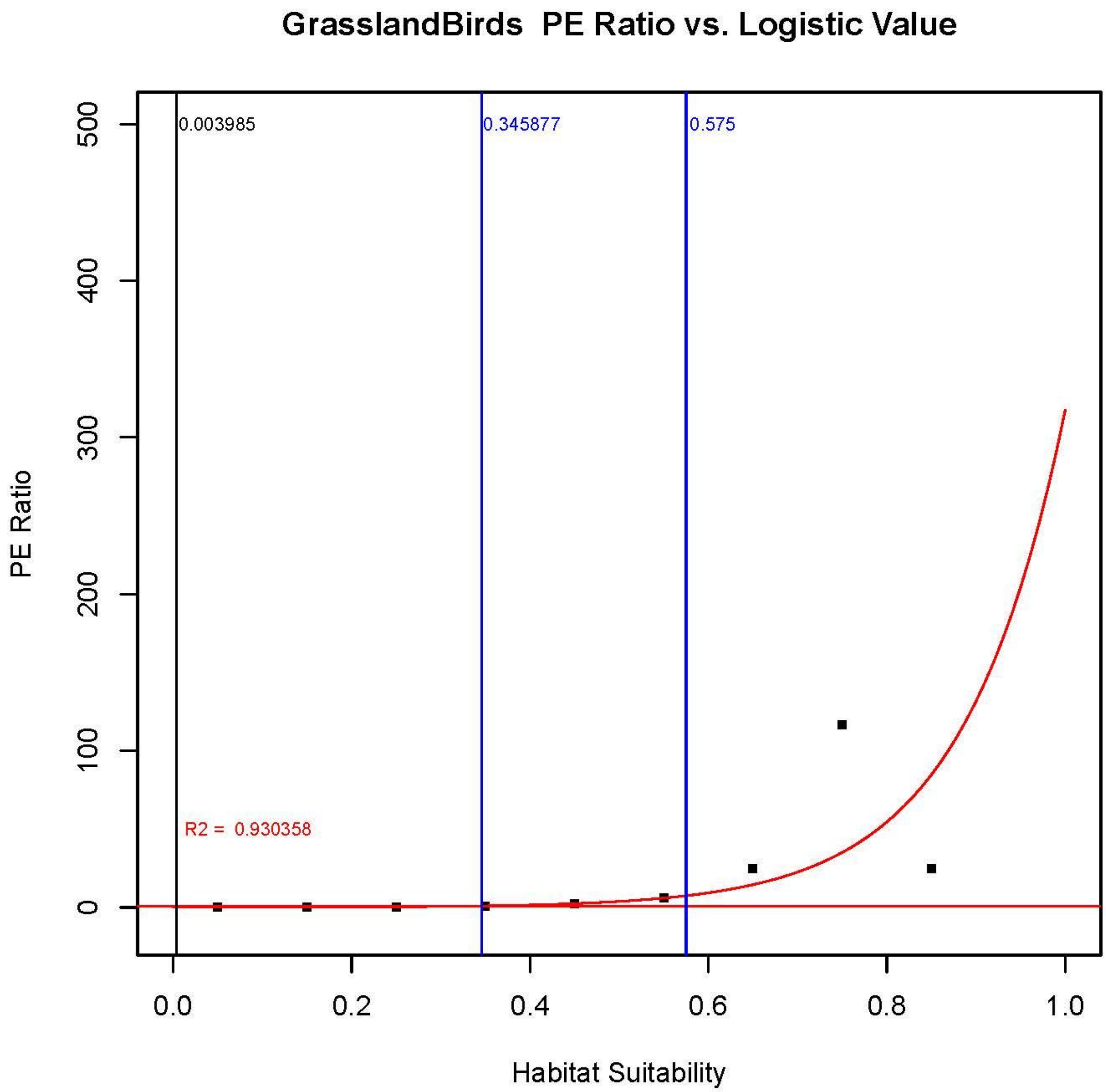


Figure E-4-7. R script PDF output for Grassland Bird Assemblage in the Northwestern Plains Ecoregion

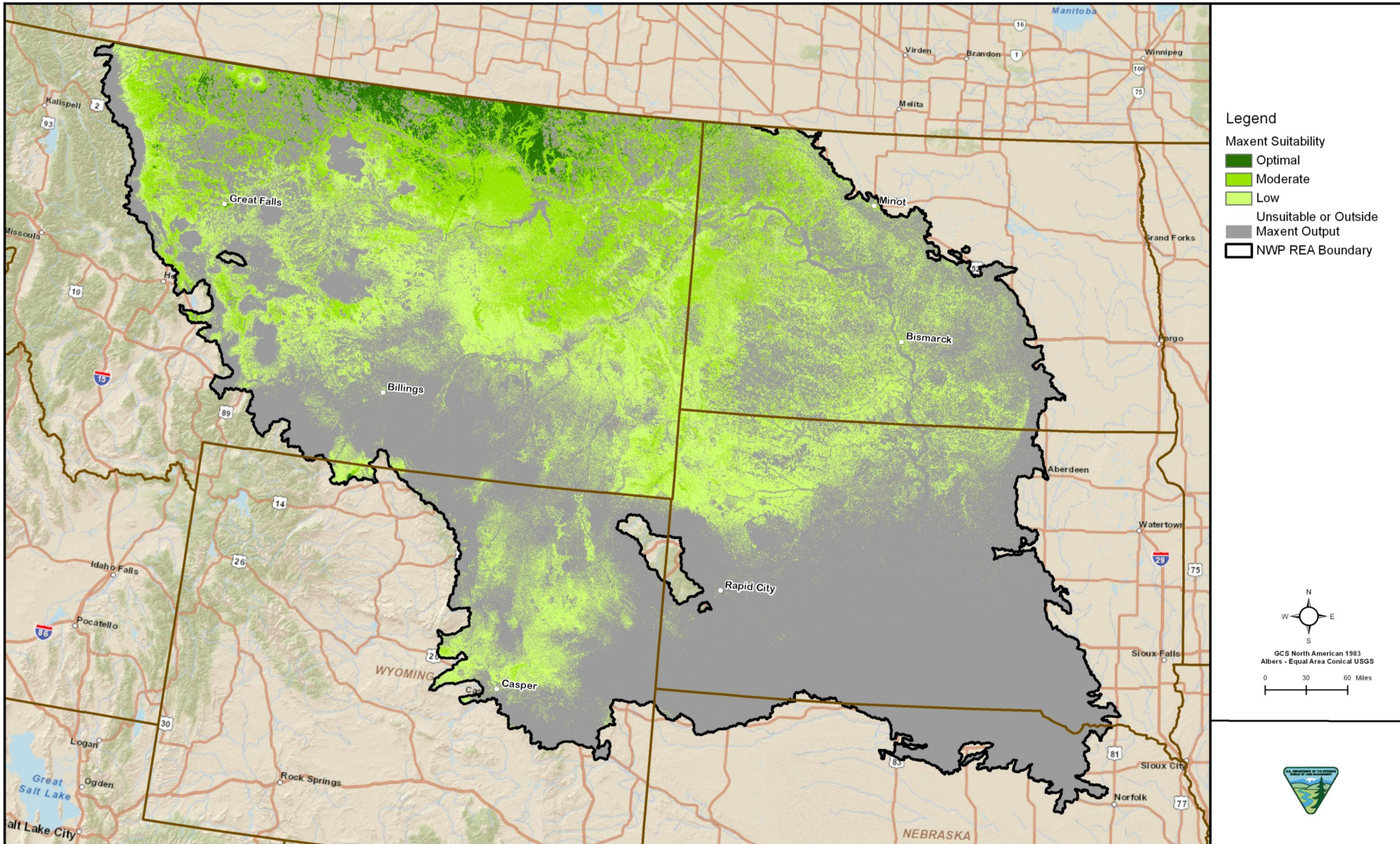


Figure E-4-8. Grassland Bird Assemblage Maxent Modeled Habitat

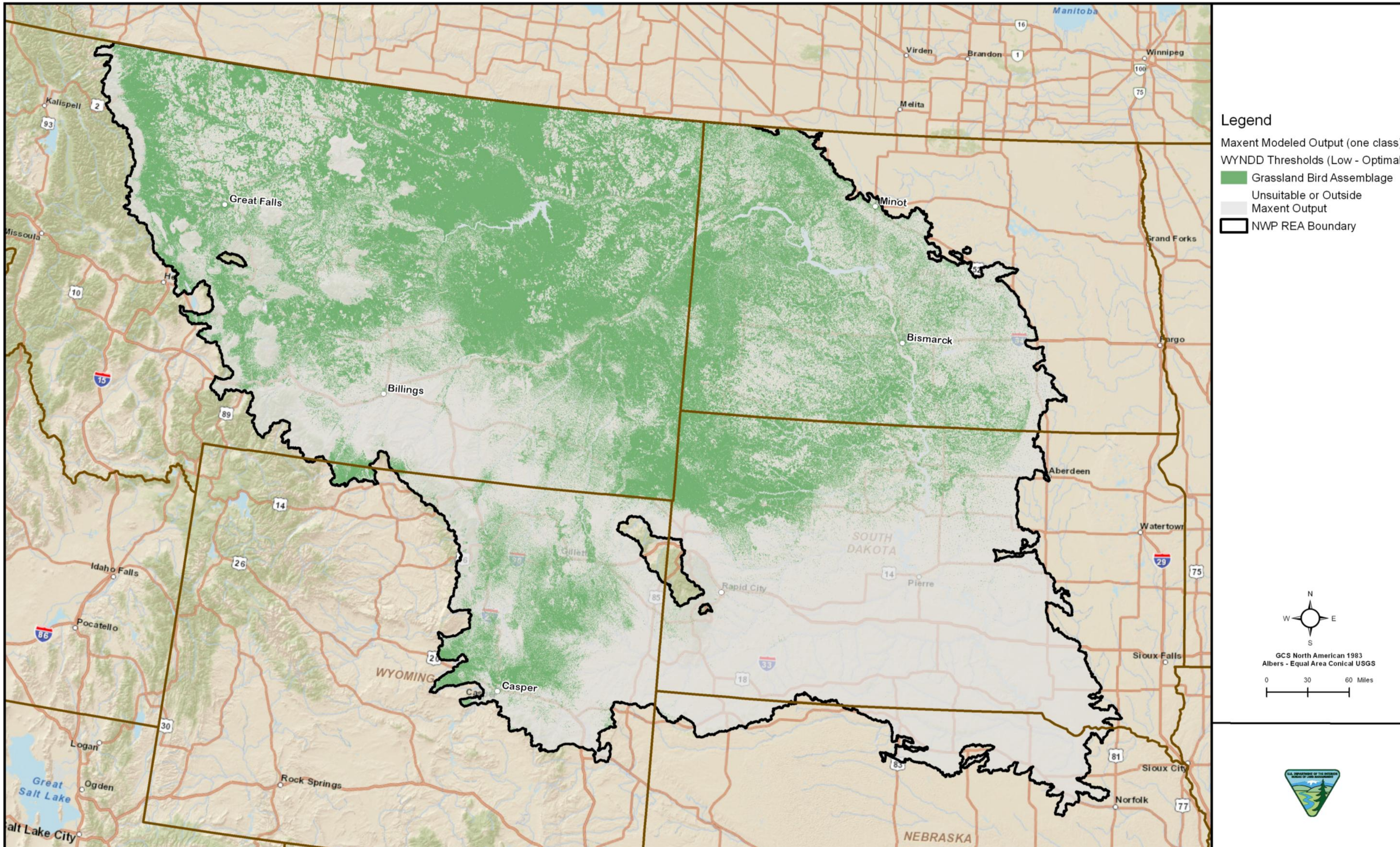


Figure E-4-9. Grassland Bird Assemblage Maxent Assemblage Combined Thresholds

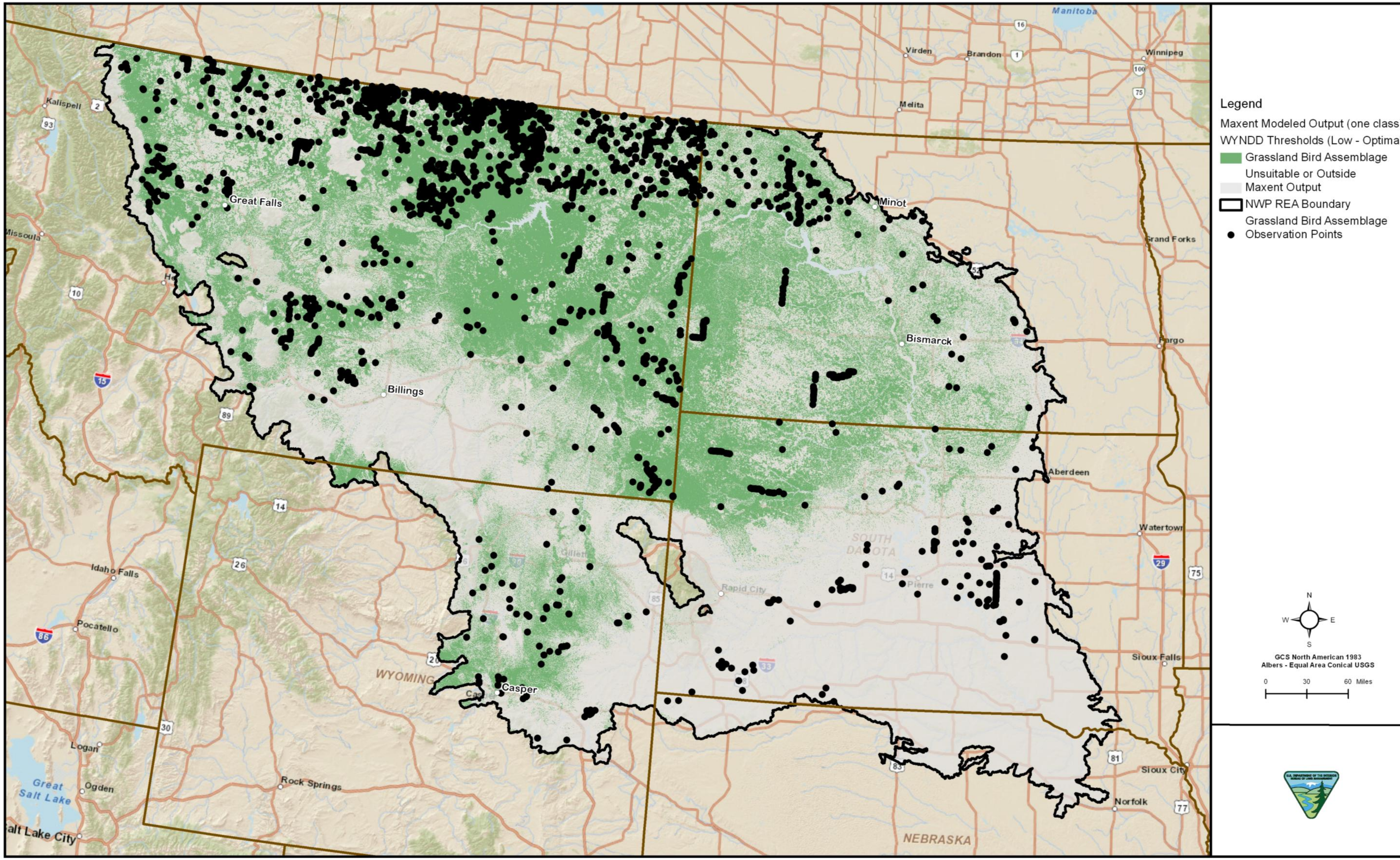


Figure E-4-10. Grassland Bird Assemblage Maxent Output with Point Occurrences

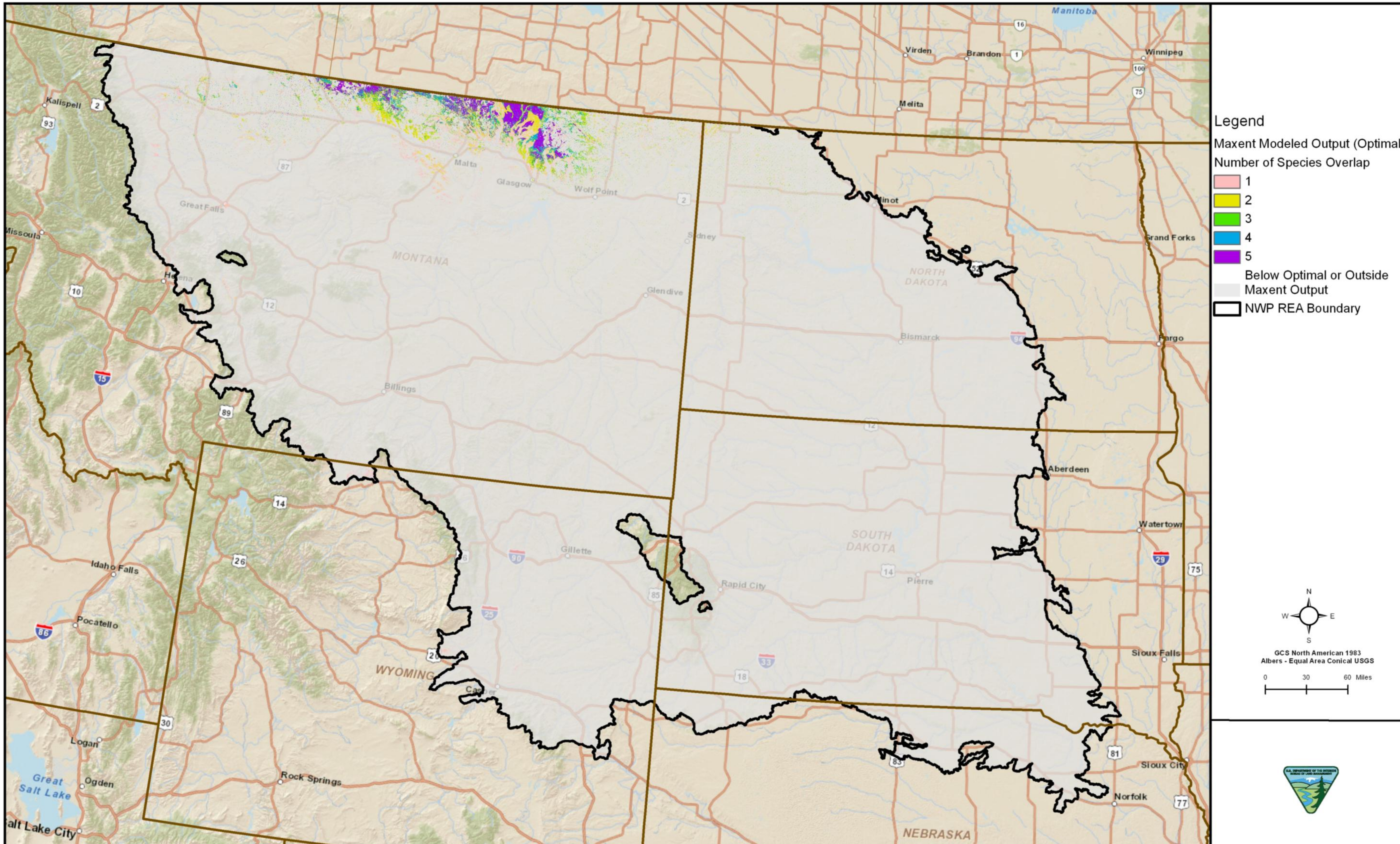
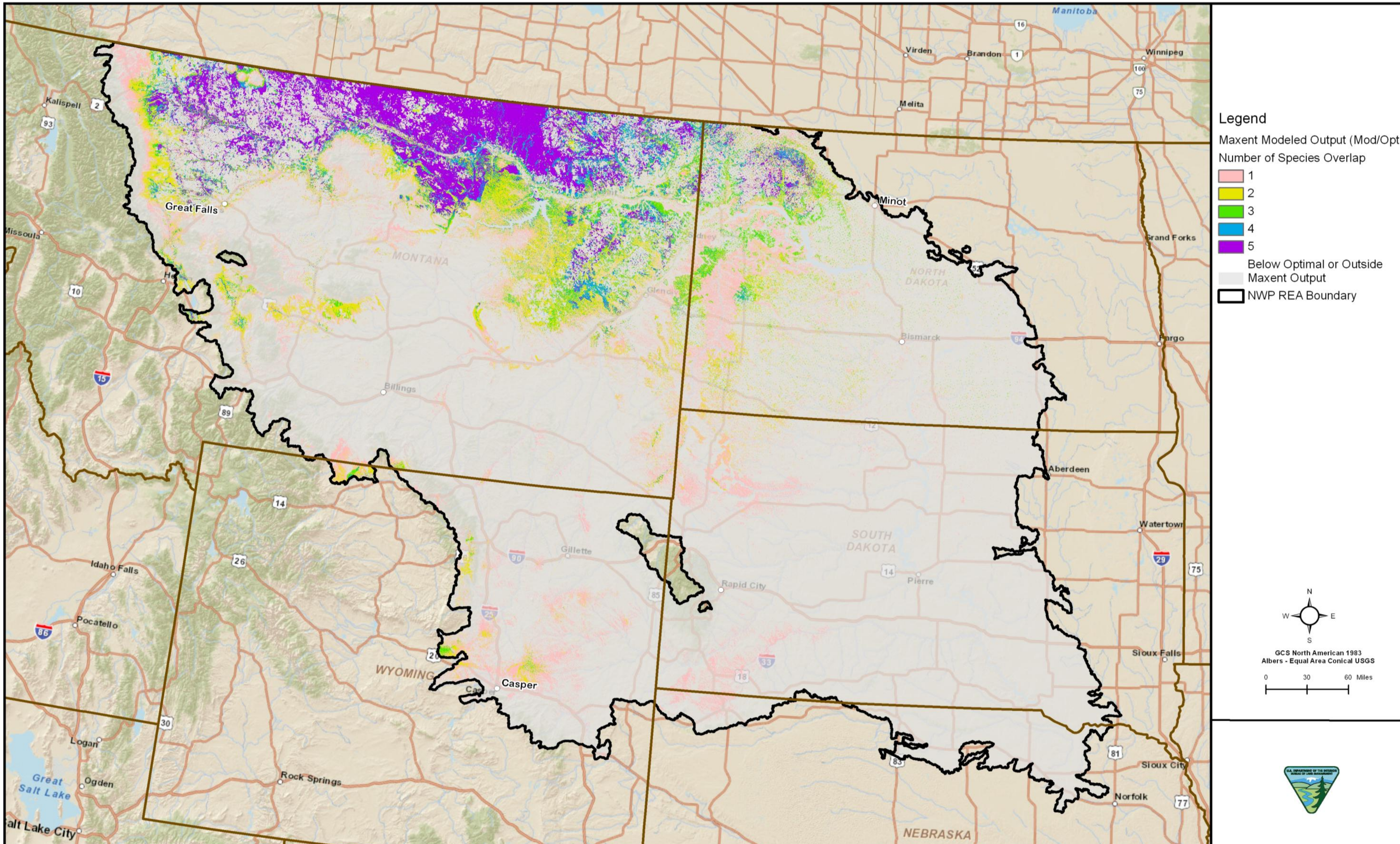


Figure E-4-11. Grassland Bird Assemblage Maxent Output Overlap with Optimal



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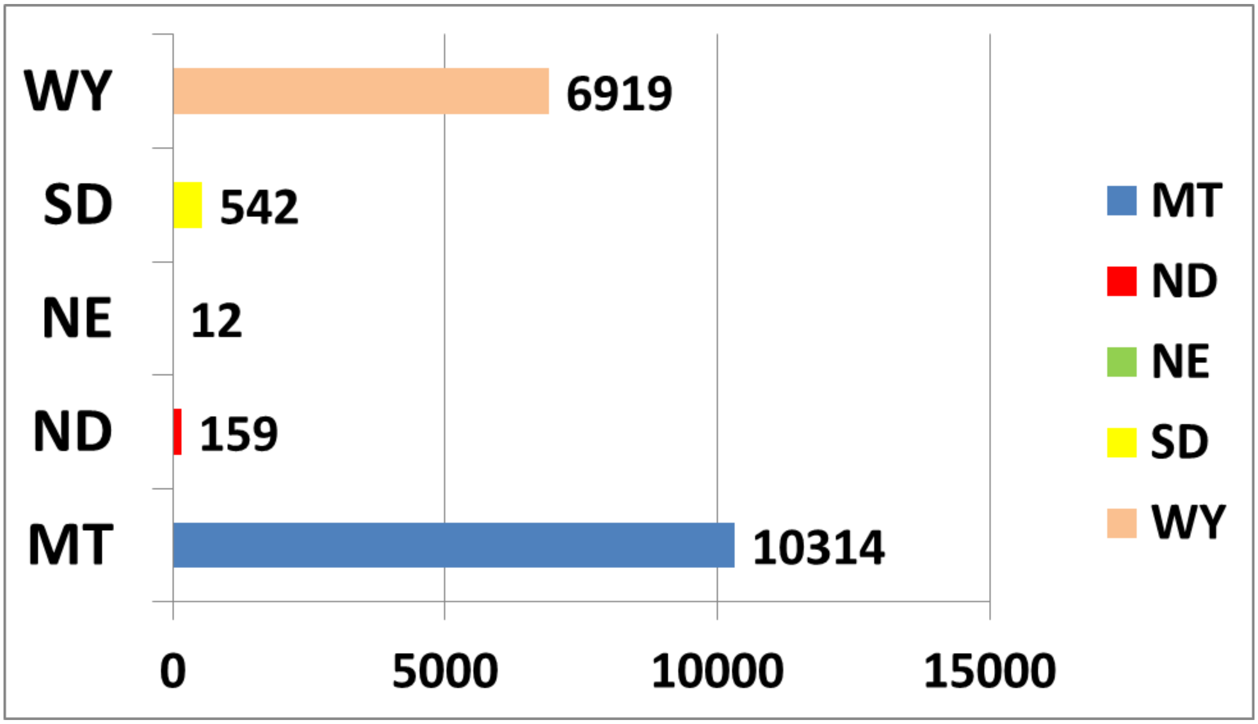

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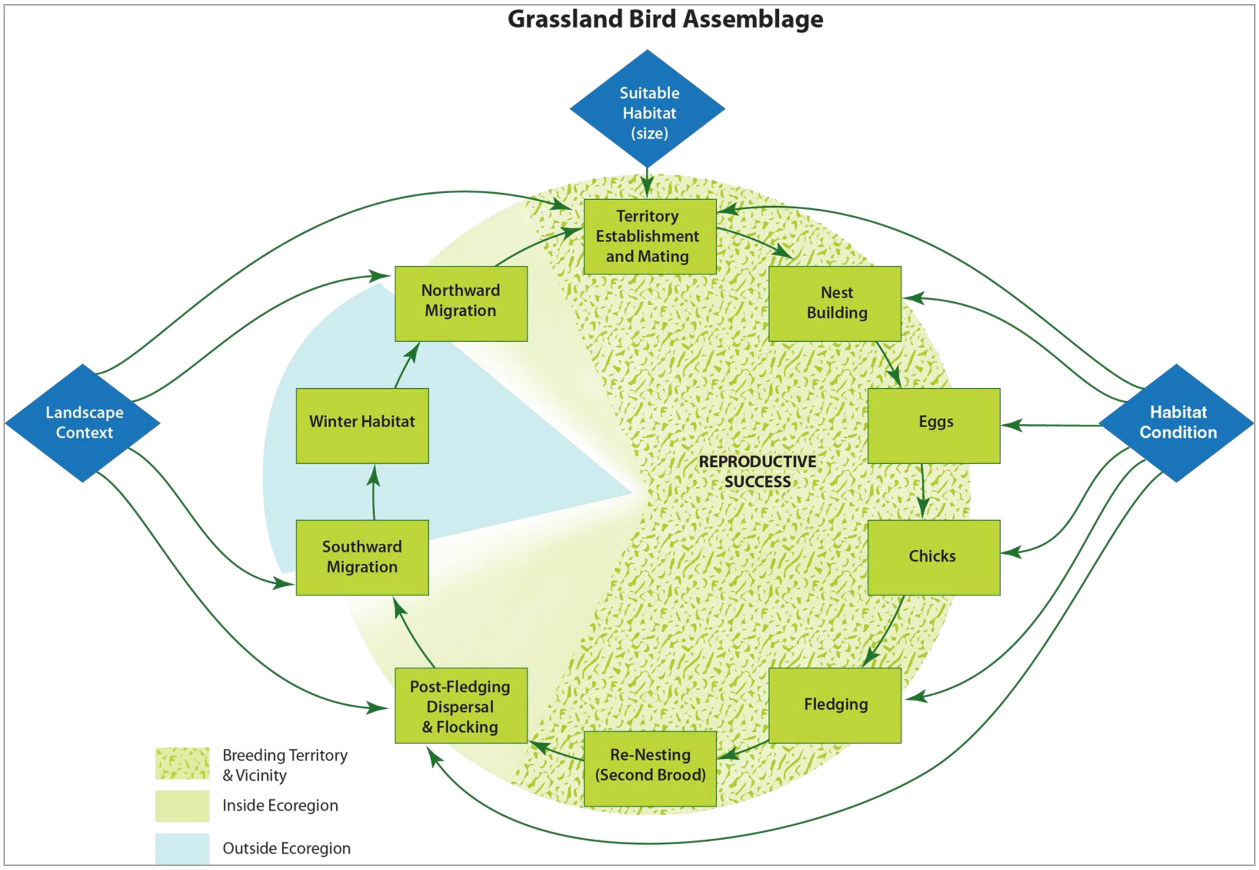

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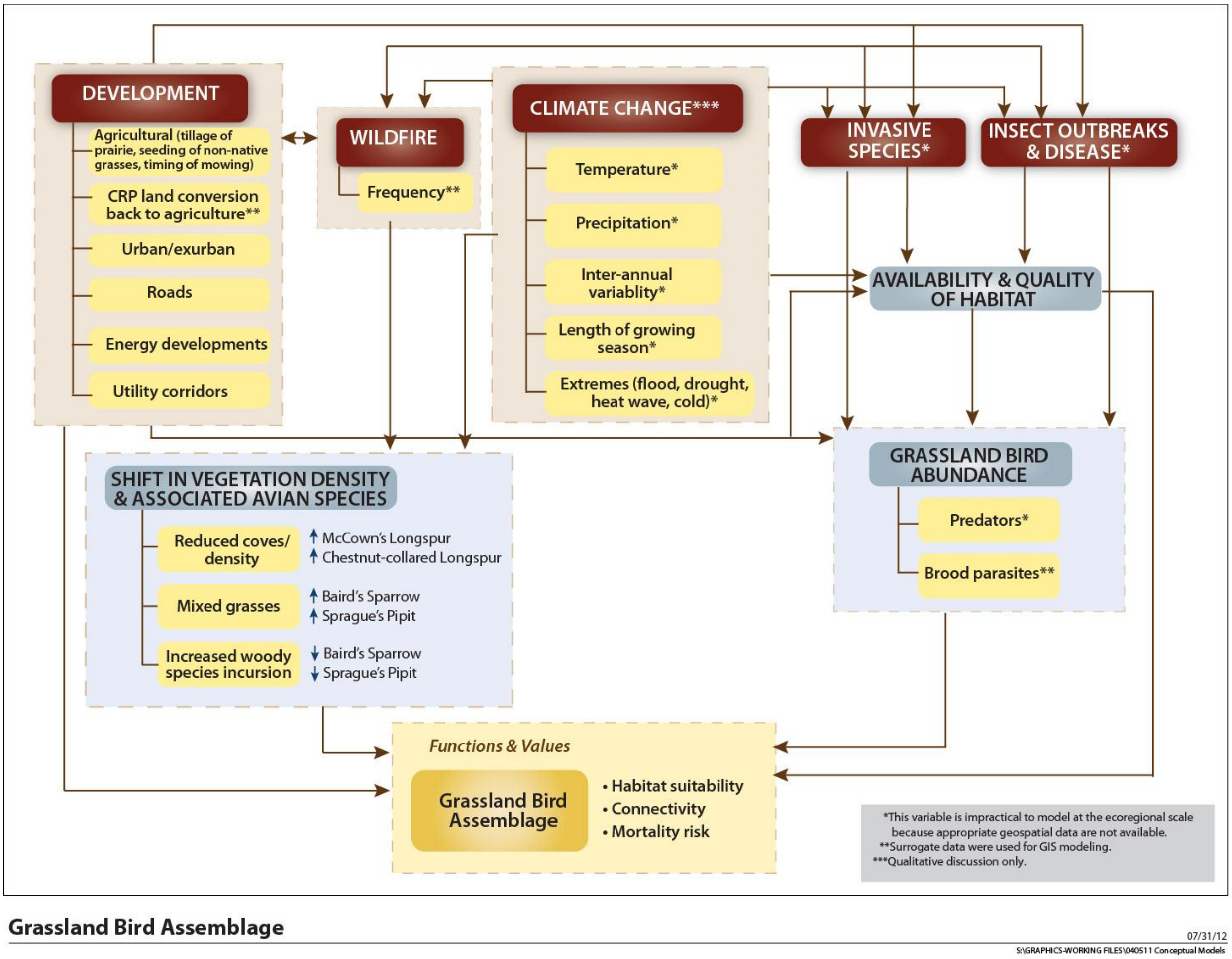

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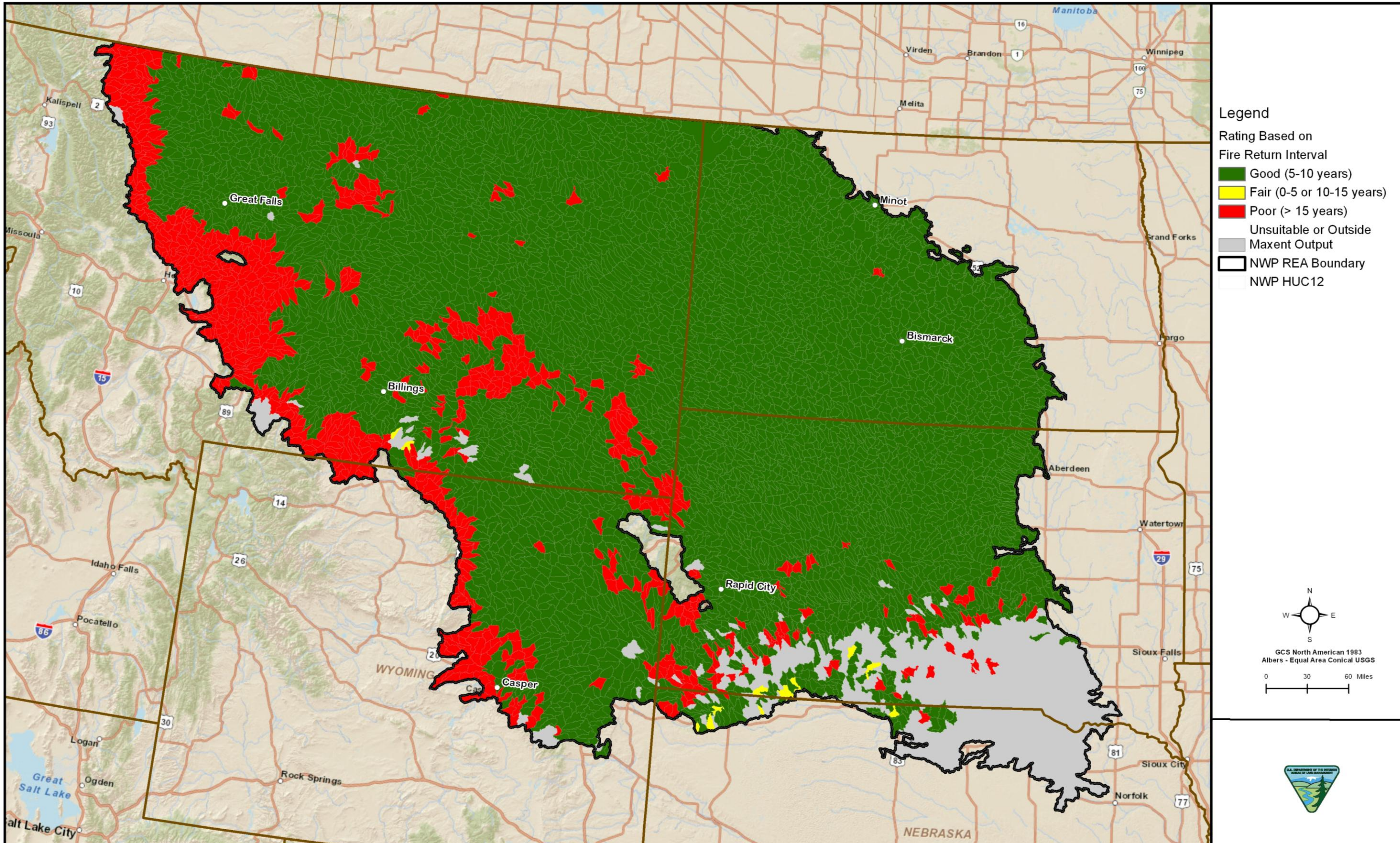

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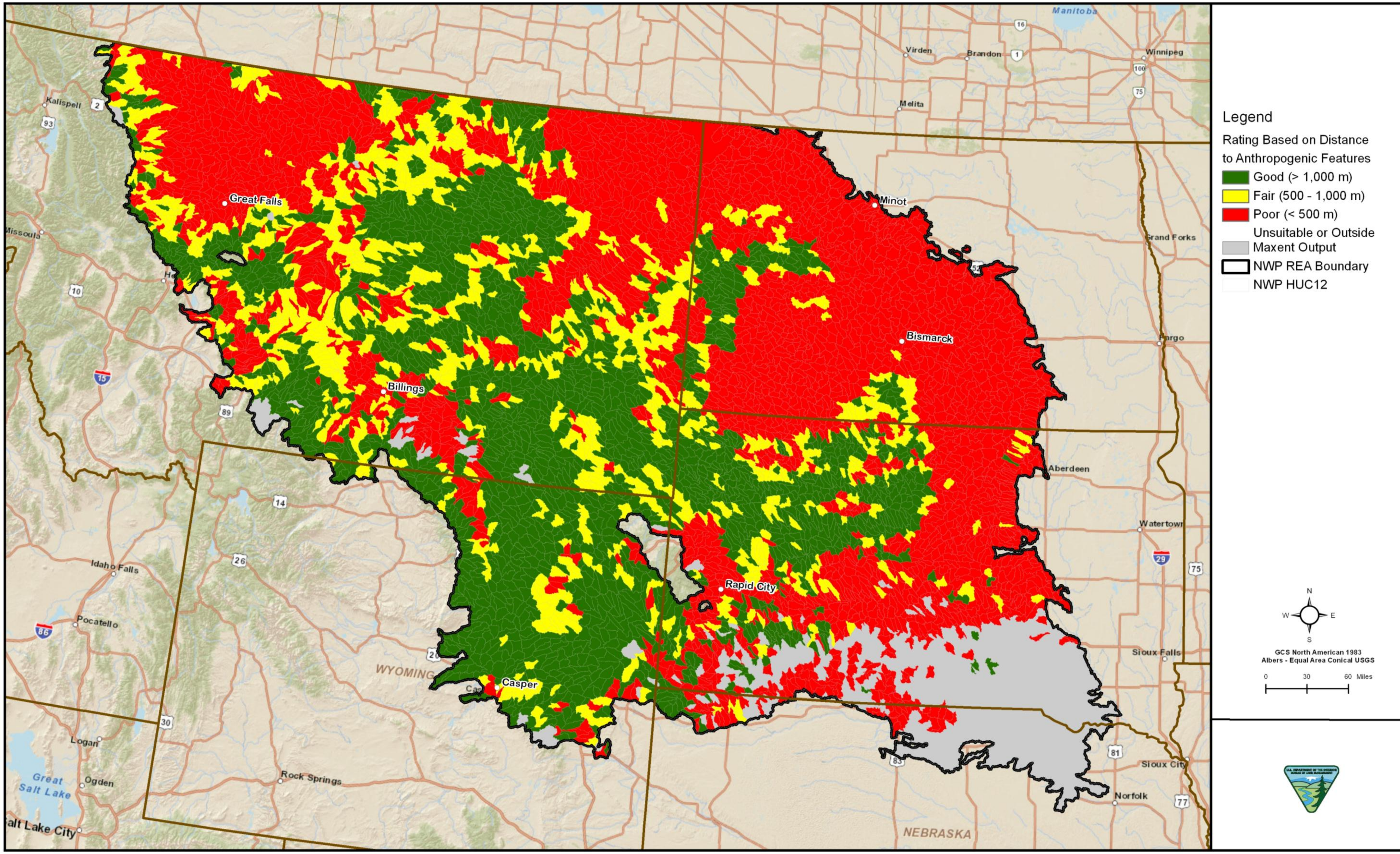

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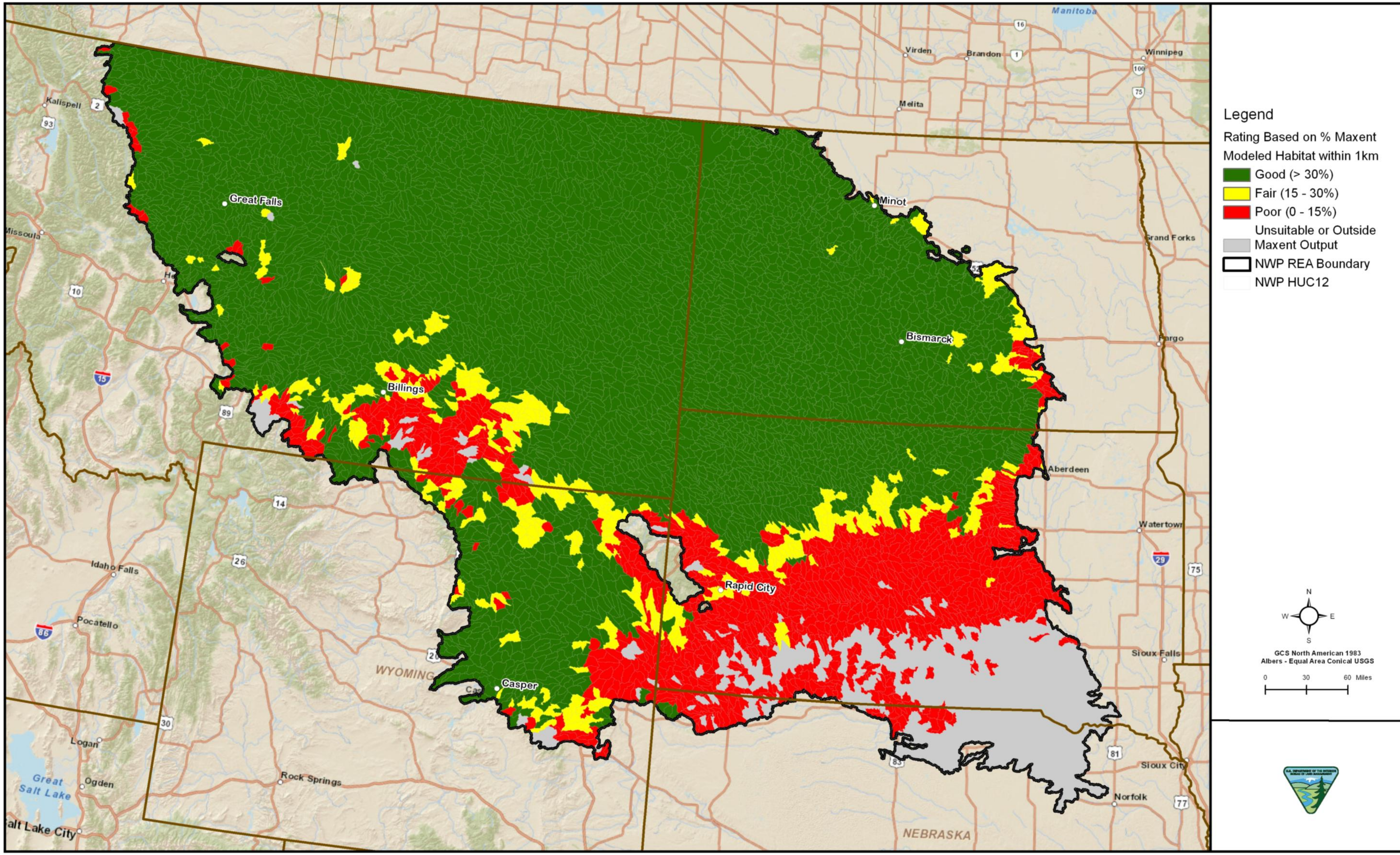

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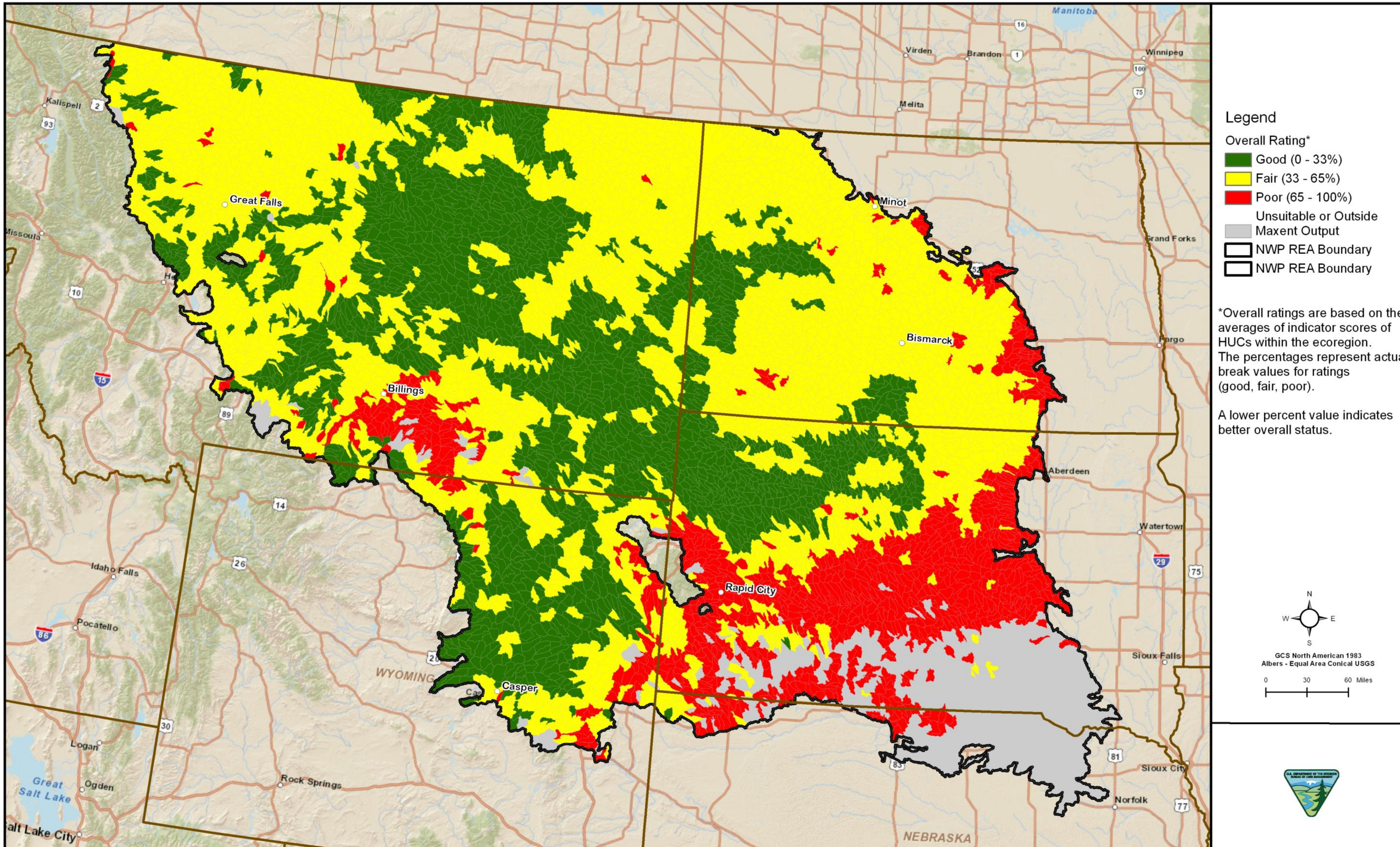

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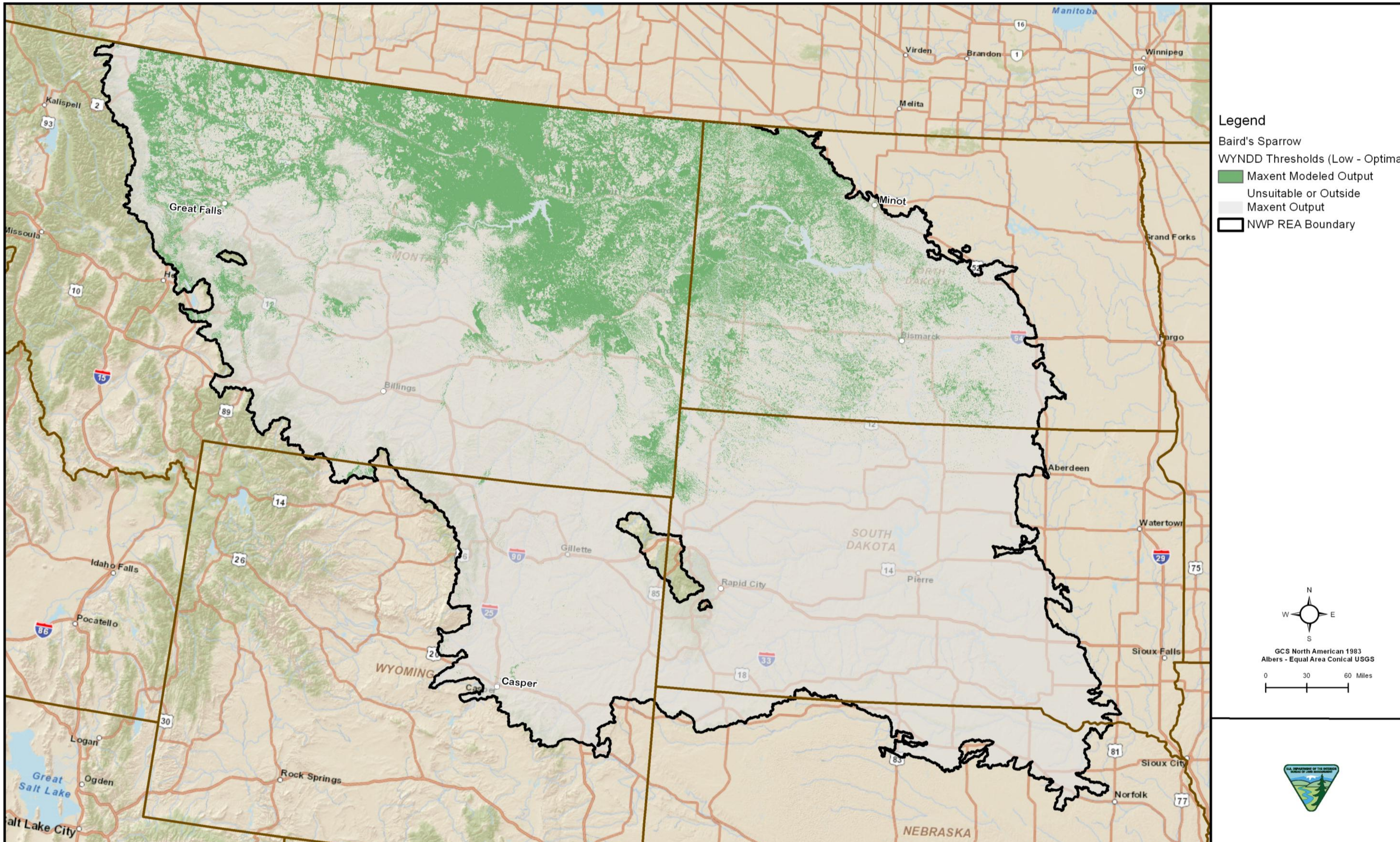

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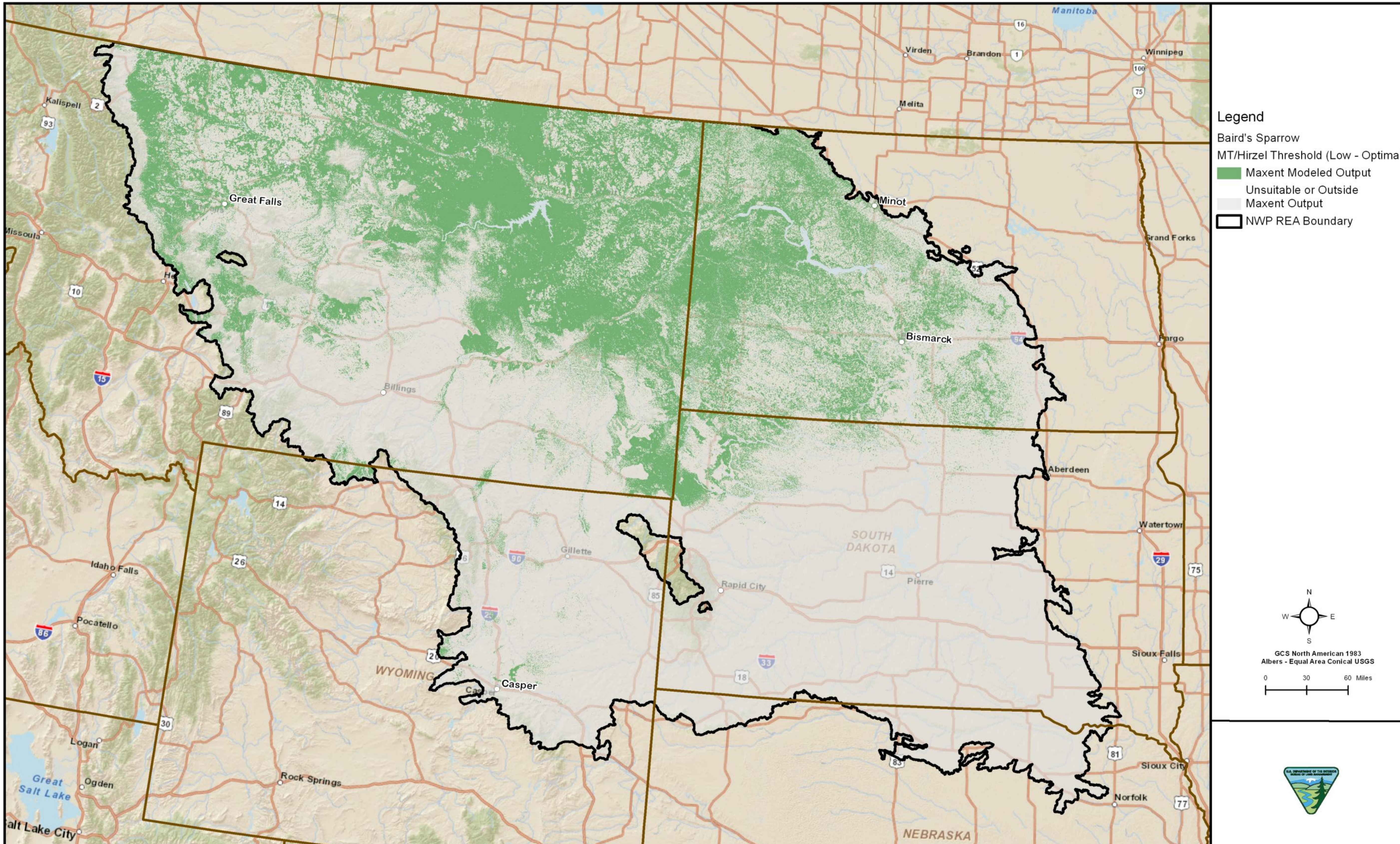

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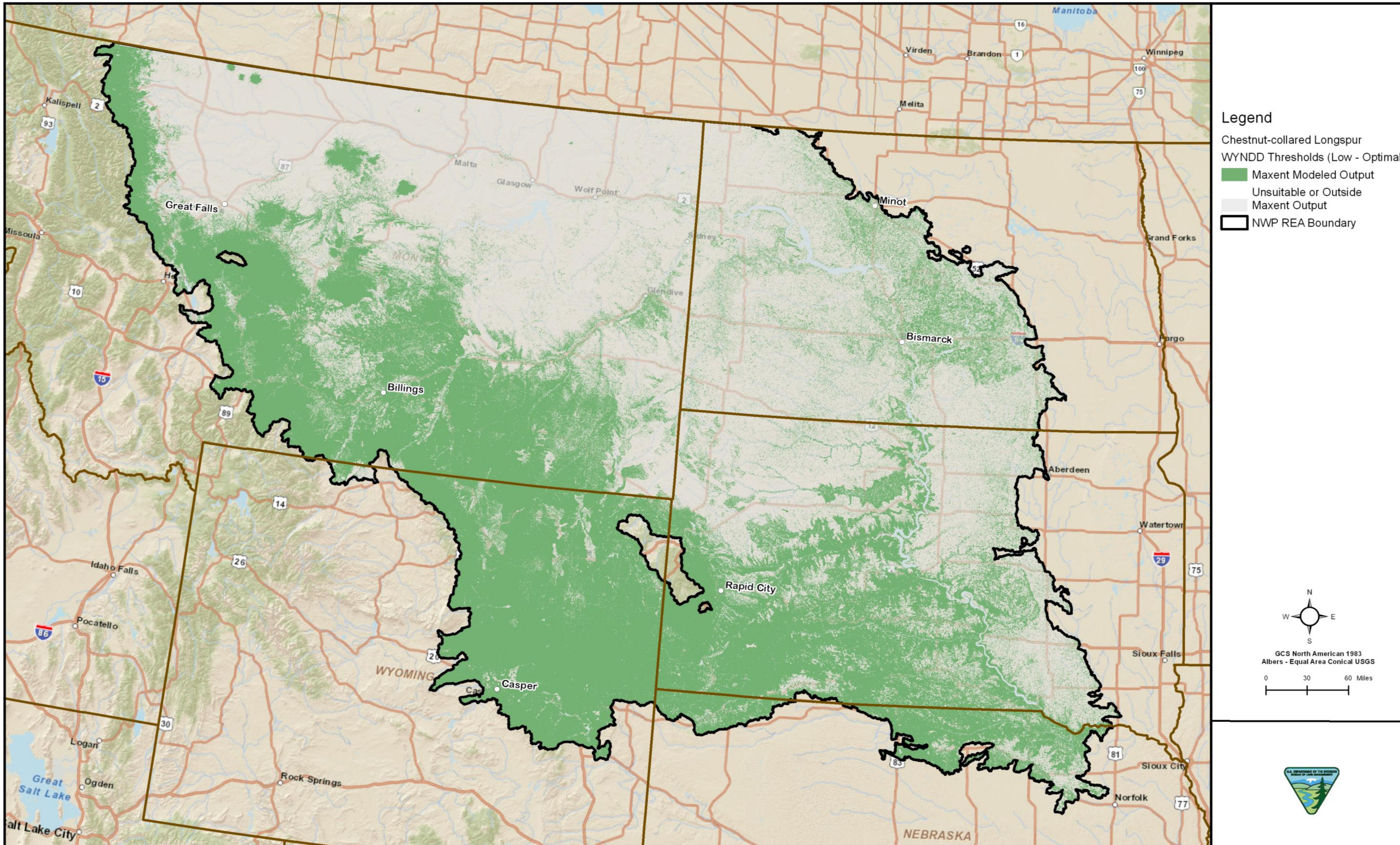

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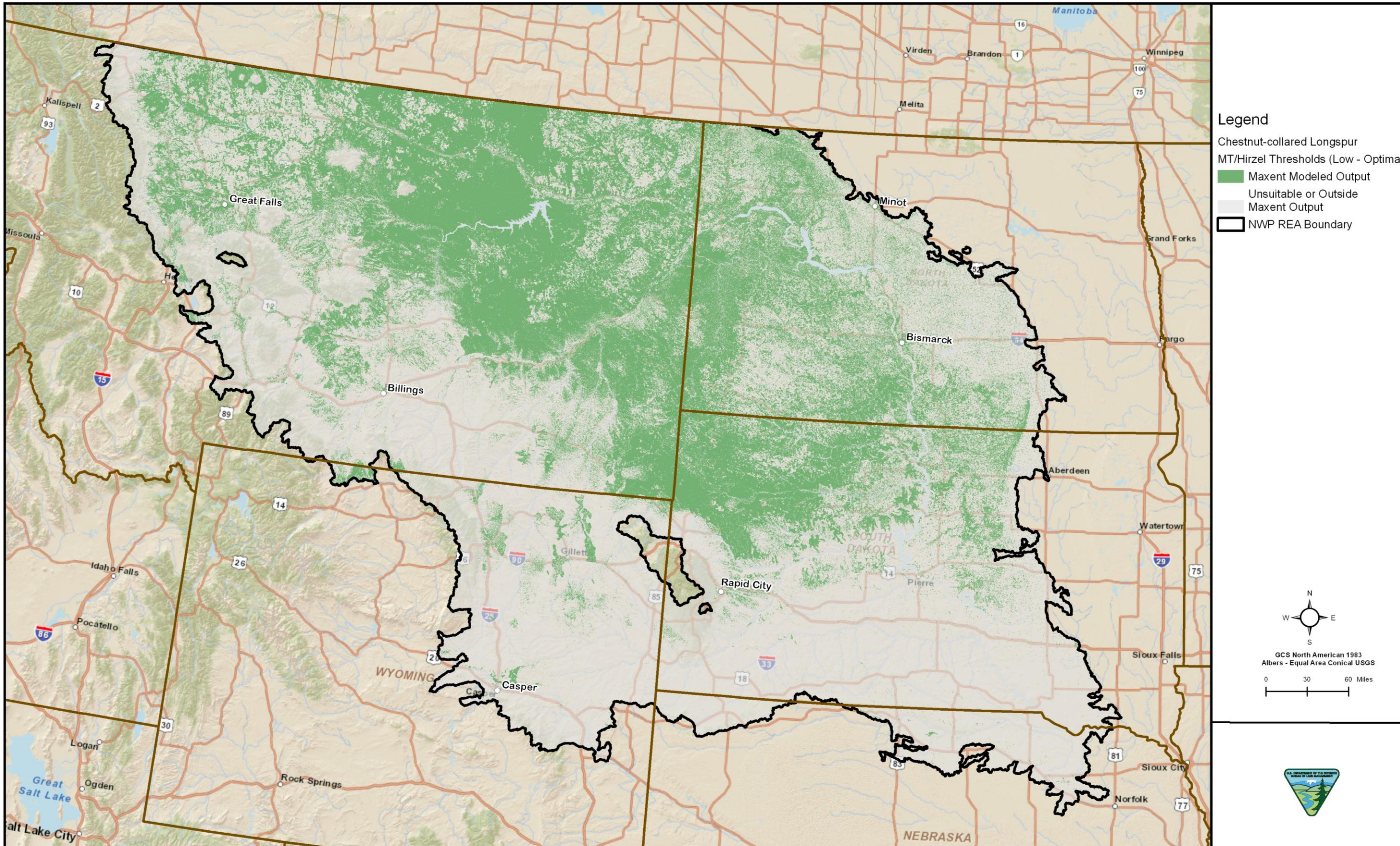

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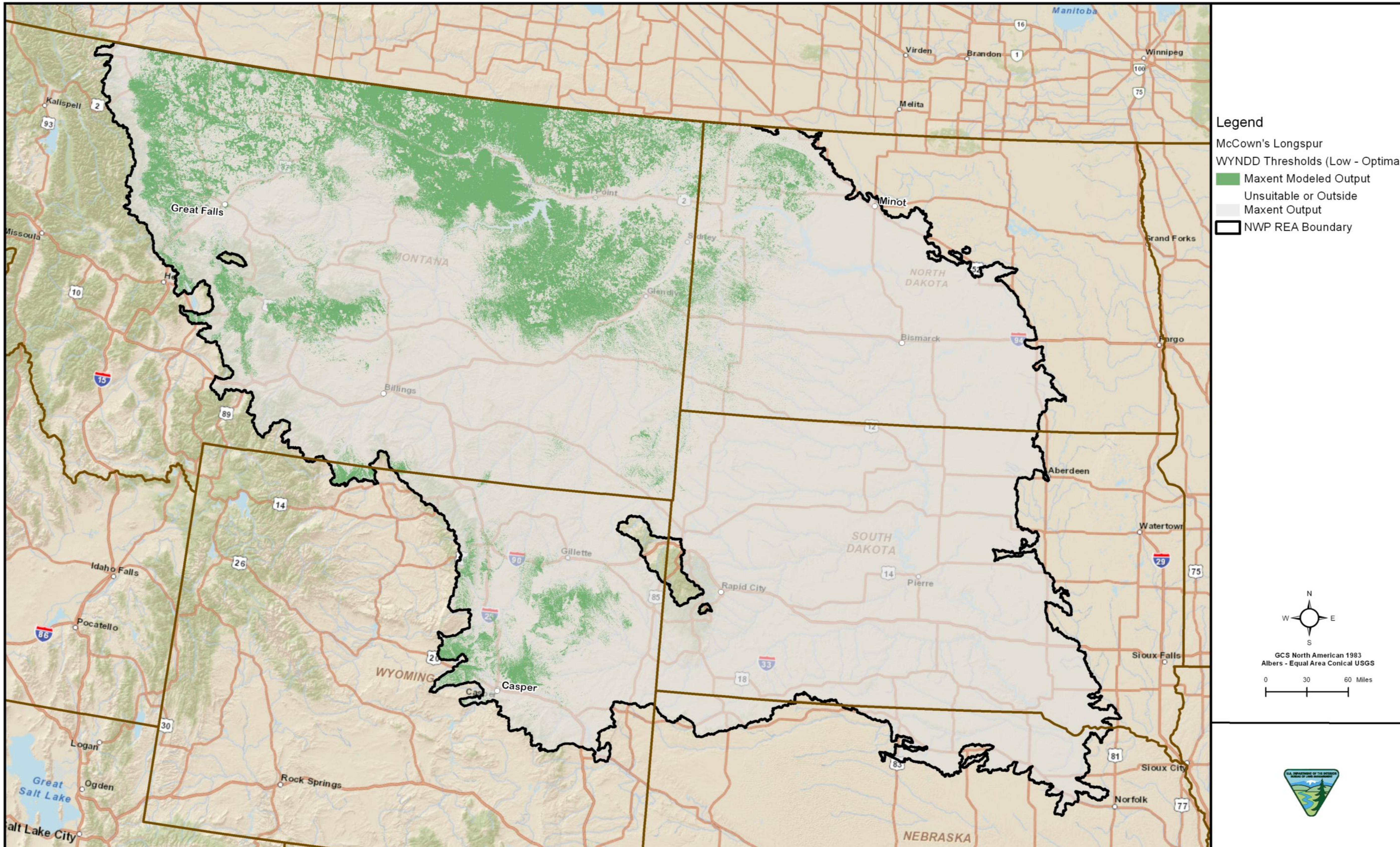

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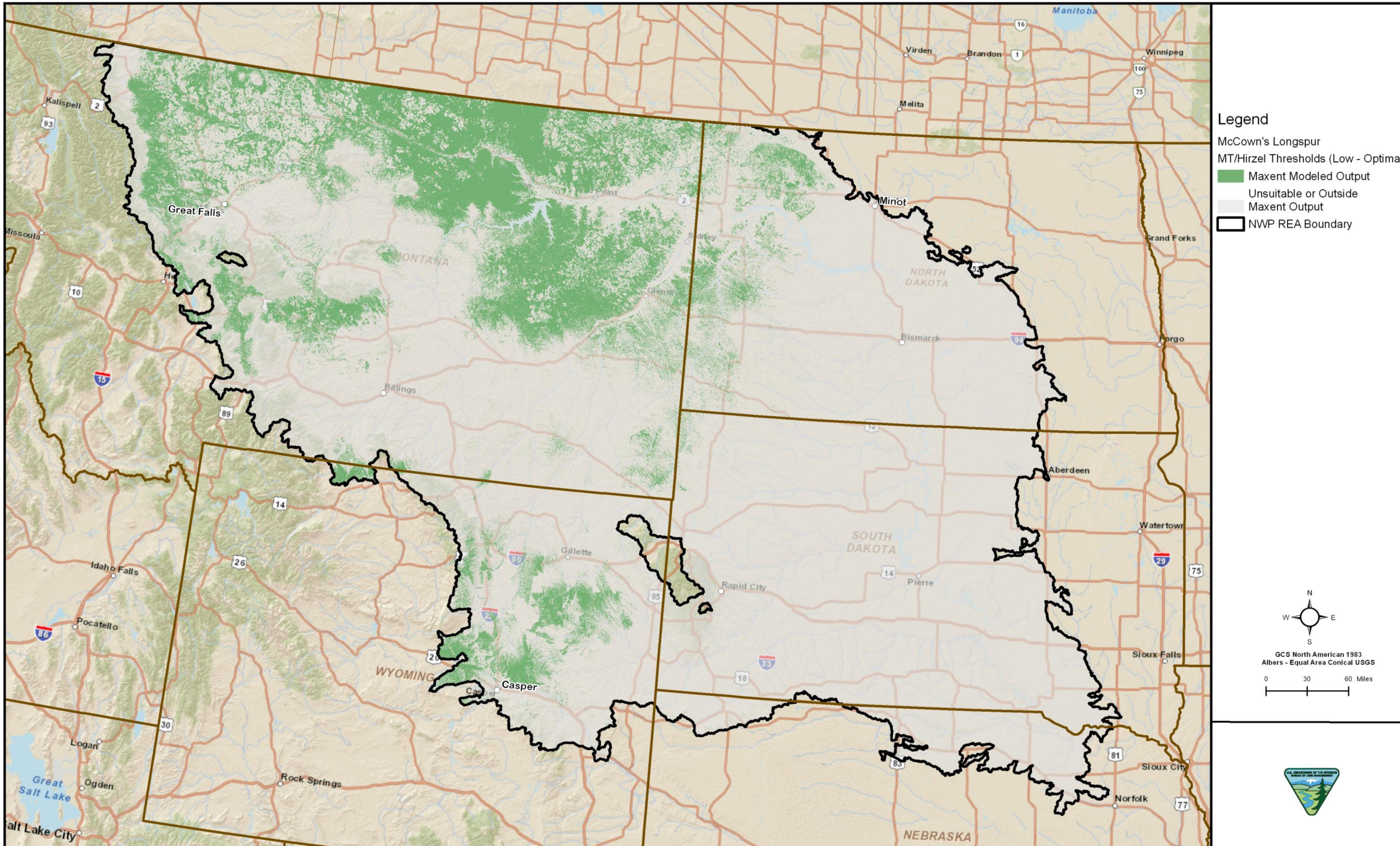

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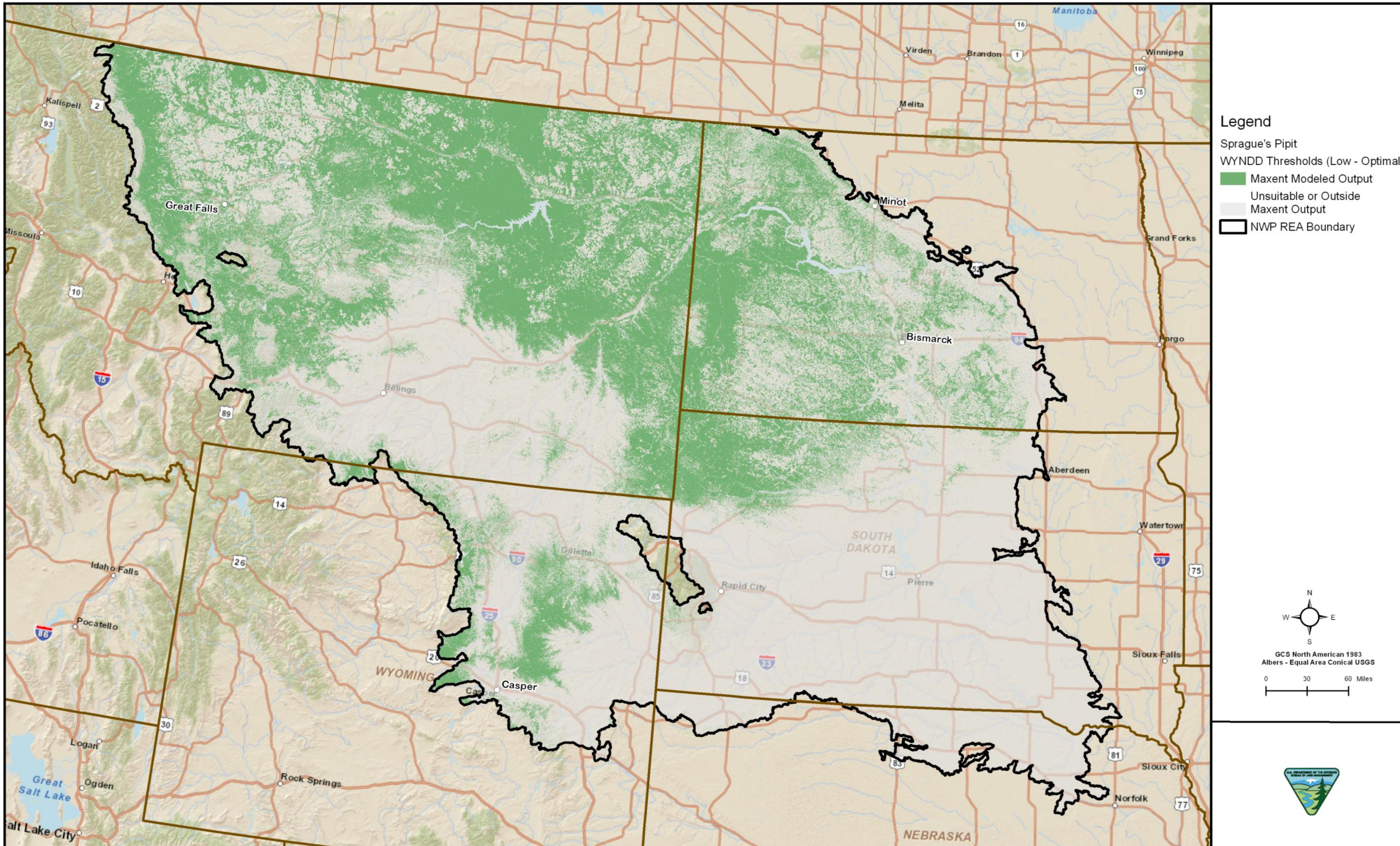

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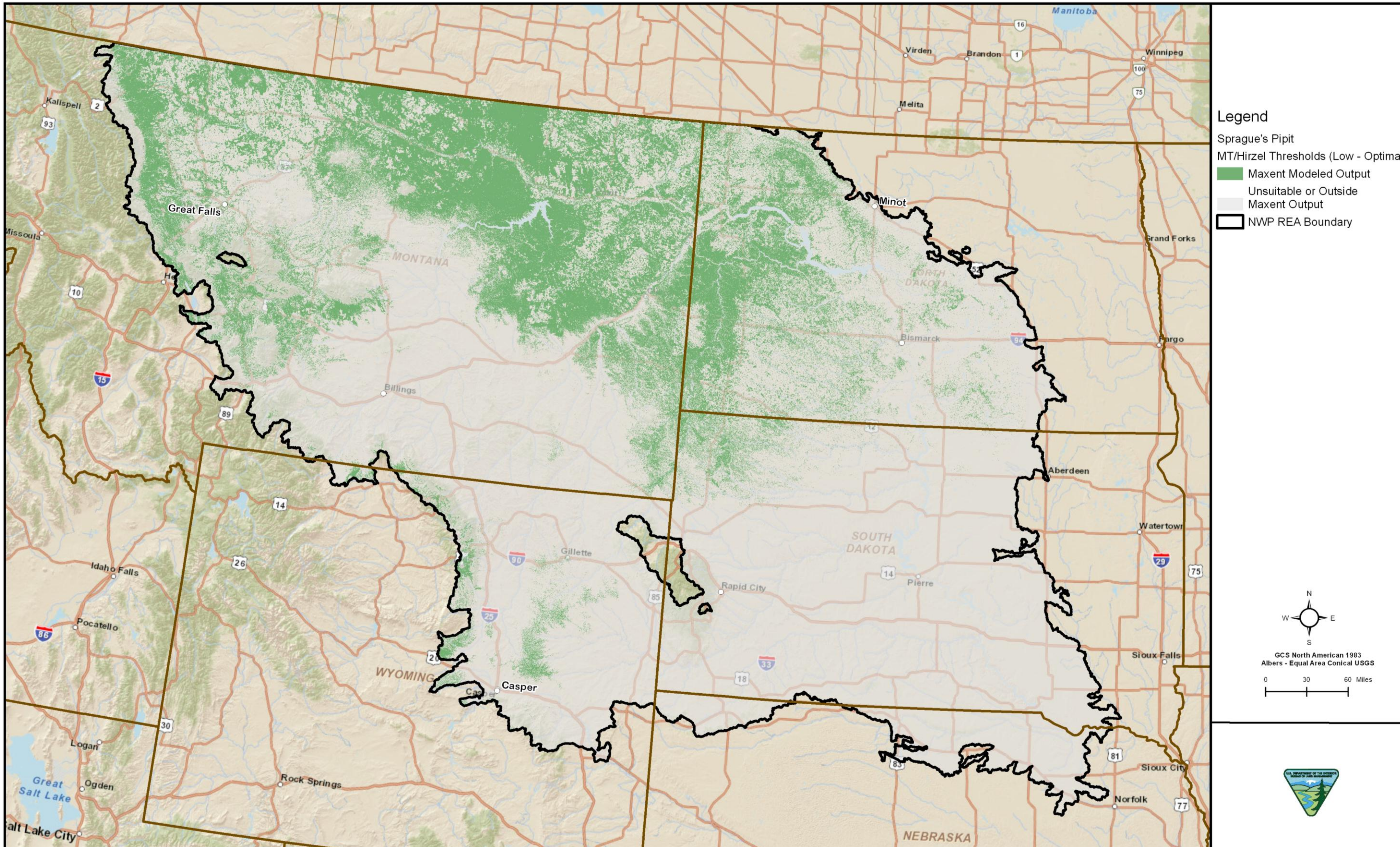

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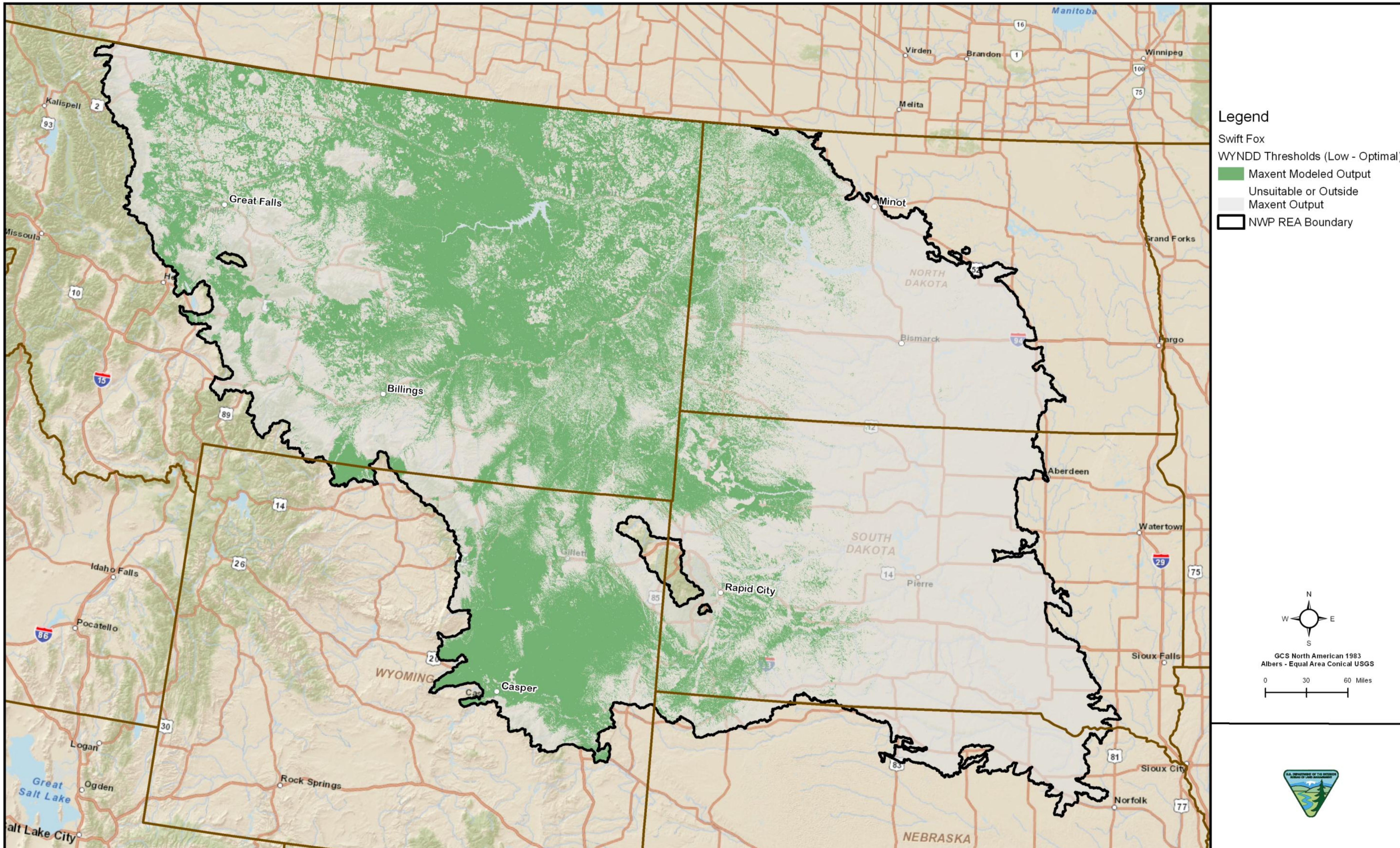

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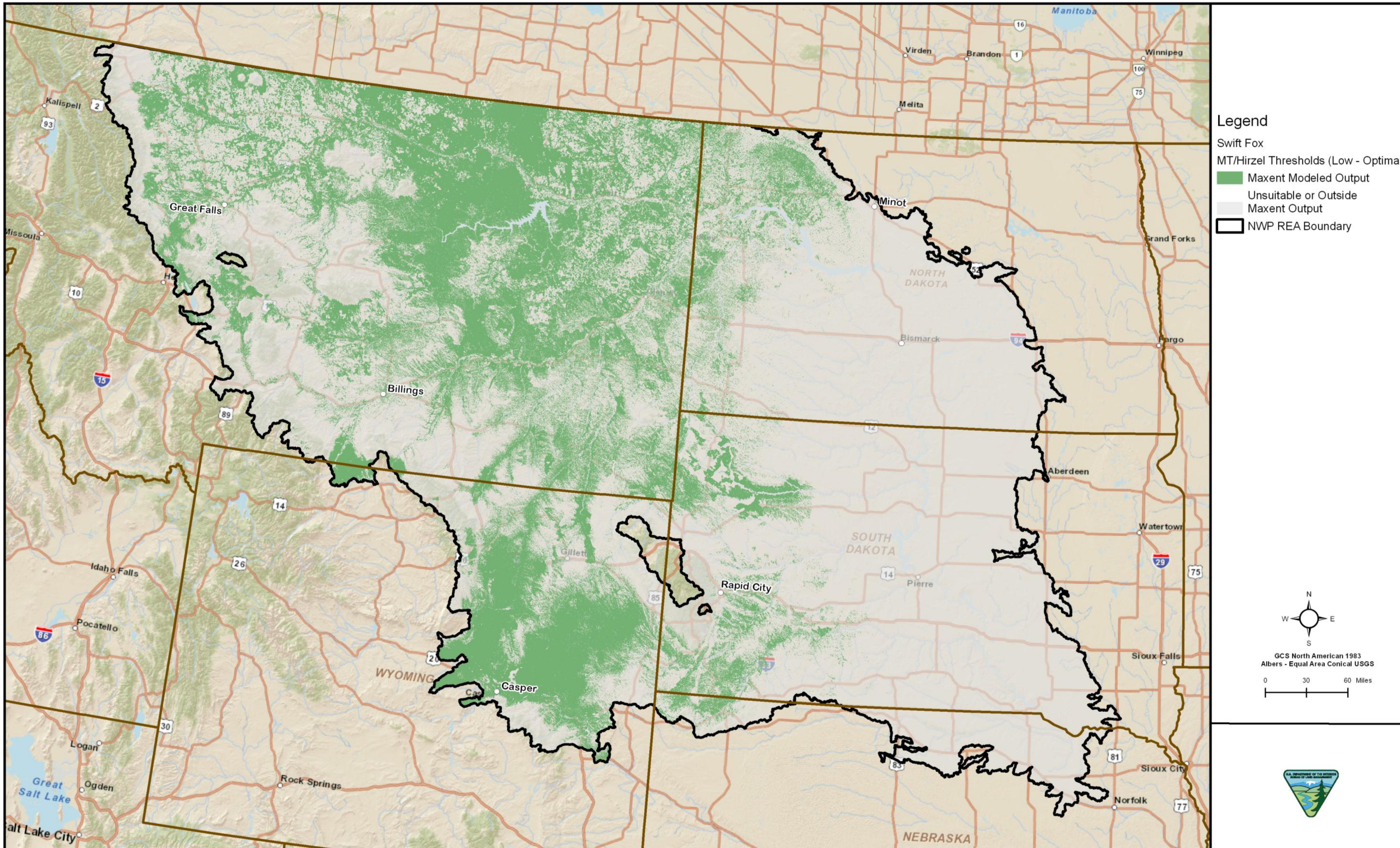

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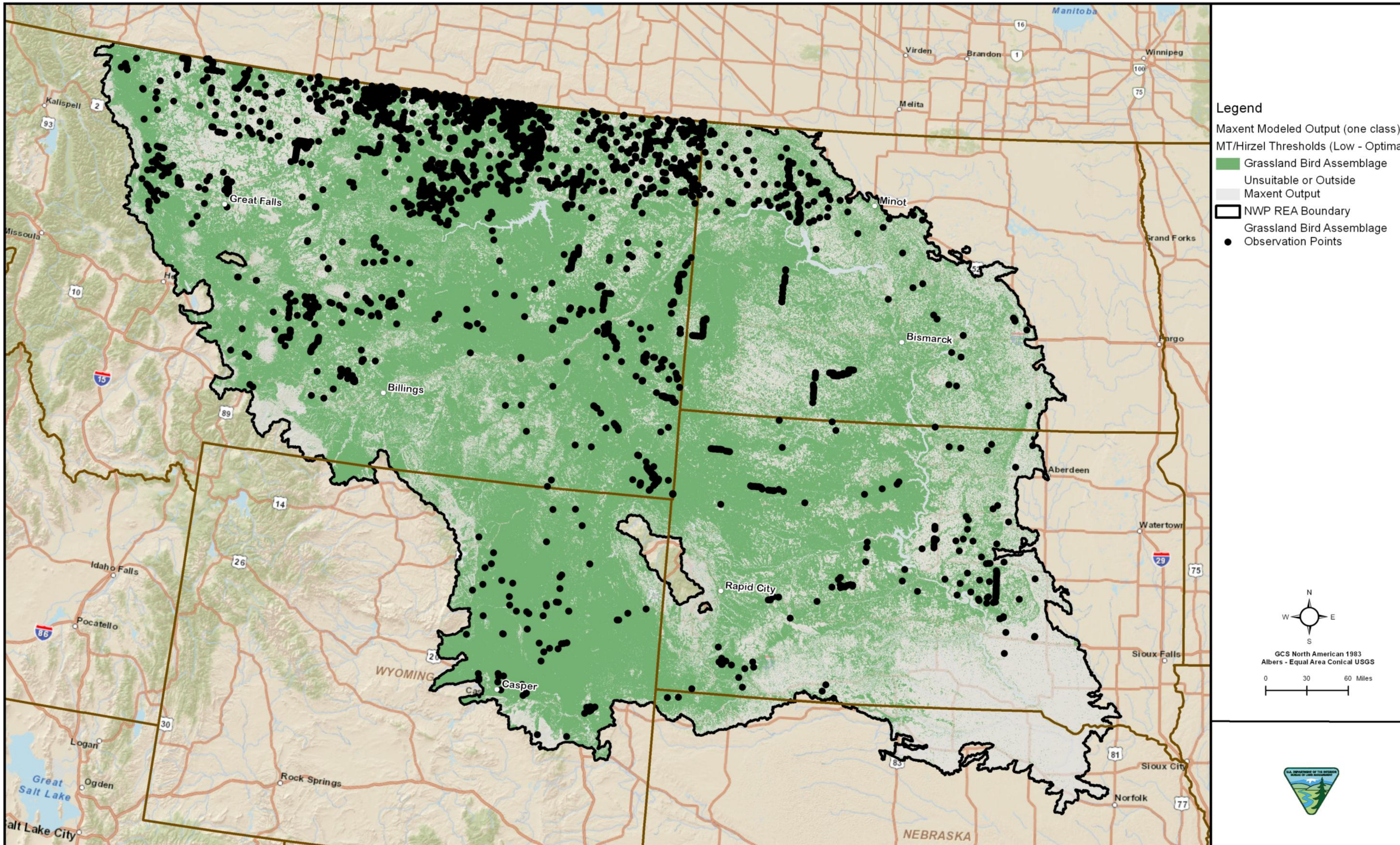

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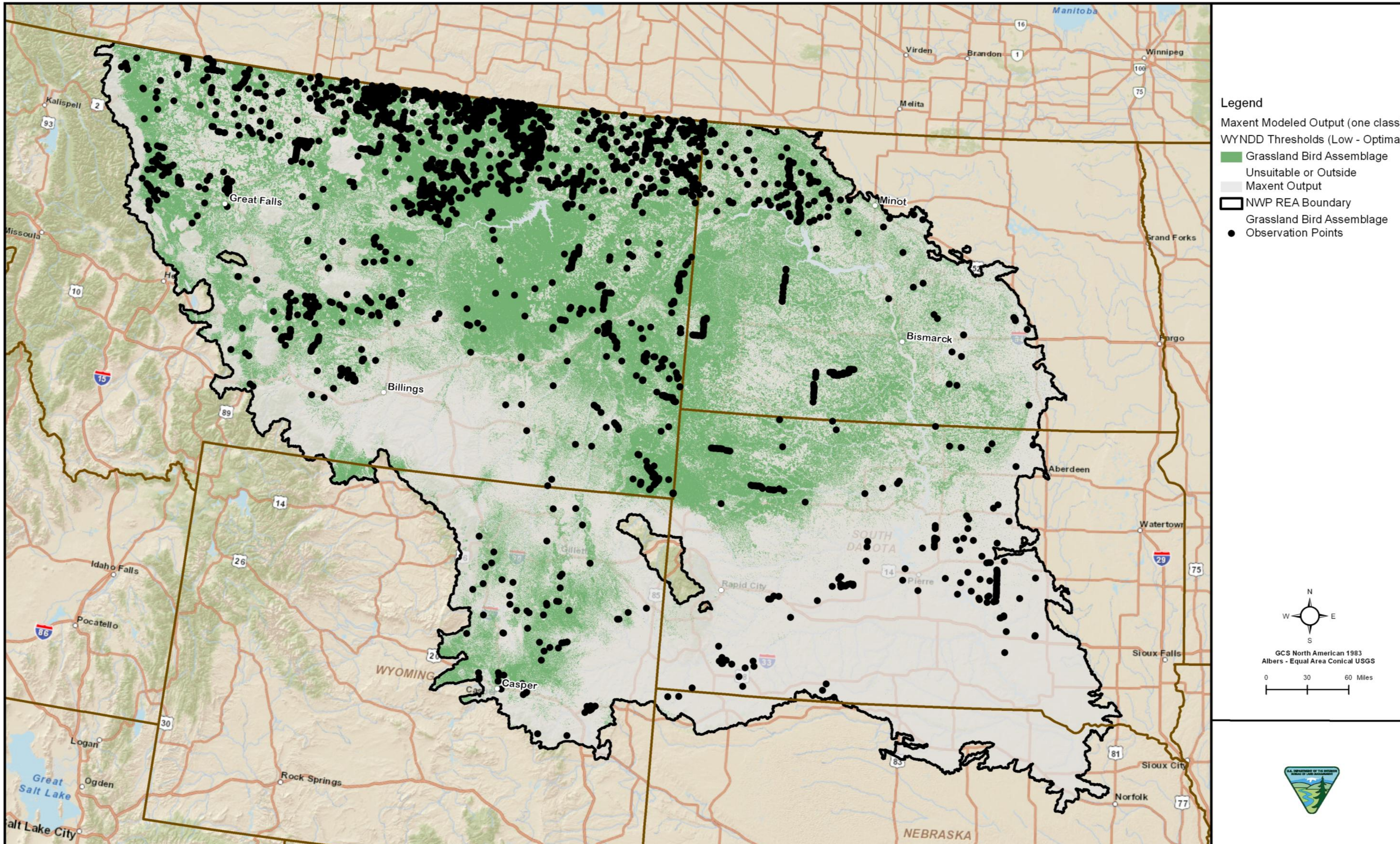

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APPENDIX E-5

BLACK-TAILED PRAIRIE DOG ASSEMBLAGE CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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Attachment A. Individual Assemblage Species Maxent Outputs

1.0 INTRODUCTION

This assemblage is comprised of the following five species: black-tailed prairie dog (BTPD) (*Cynomys ludovicianus*), ferruginous hawk (*Buteo regalis*), burrowing owl (*Athene cunicularia*), mountain plover (*Charadrius montanus*) and black-footed ferret (BFF) (*Mustela nigripes*). These species were approved by the Assessment Management Team (AMT) as an assemblage conservation element (CE), because they are representative of large, intact landscapes across the Northwestern Plains ecoregion. Although there are many BTPD colonies throughout the western United States, the focus of this analysis was on larger BTPD colonies that have the potential to provide habitat for not only the associated assemblage species but also many other species. However, through the analysis it was recognized that the smaller colonies are also important, because colony size fluctuates with plague epizootics, and, as a management priority, small colonies can be better treated for plague than large colonies.

A variety of the management questions (MQs) apply to this assemblage. Many of the MQs can be summarized into three primary questions: 1) where are the important areas for this assemblage? 2) where are healthy assemblages protected or where are those that can be restored and/or protected? and 3) what is happening to these areas? The central focus of these three overarching MQs is to document the current status of selected CEs at the ecoregional scale and to evaluate how this status may change over a future time period. The first step is to identify suitable habitat for the CE within the ecoregion. Then, these areas are assessed relative to current and potential future change agent (CA) threats. The CAs that were initially considered include development, climate change, wildfire, and invasive species.

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2.0 CONSERVATION ELEMENT DESCRIPTION

2.1 BLACK-TAILED PRAIRIE DOG

BTPDs are associated with and provide unique habitat for a variety of prairie wildlife species throughout the Northwestern Plains. These associations are based upon use of prairie dogs as a prey species, vegetation conditions resulting from prairie dog occupancy, or the presence of burrows created by prairie dogs. The U.S. Fish and Wildlife Service (USFWS) completed a status review of the BTPD in 2009 and determined that it did not warrant protection as a threatened or endangered species under the Endangered Species Act (ESA). Although they are identified as an important species, they are also classified as pests and are commonly hunted in all of the states of this ecoregion. BTPDs were abundant and widely distributed throughout grassland and shrub/grassland habitats east of the Continental Divide during the 1800s (Cooper 1869a, 1869b; Coues 1878; Messiter 1890; Stuart 1902; Chittenden and Richardson 1905; Cameron 1907; and Burroughs 1961). Historic BTPD declines can be attributed to intensive eradication programs (Anderson et al. 1986) and agricultural conversion of native rangelands (Lesica 1995). Recent declines are attributed to a combination of sylvatic plague (FaunaWest 1998), urbanization (Knowles and Weggenman 1998), and recreational shooting (Vosburg and Irby 1998).

2.2 FERRUGINOUS HAWK

The ferruginous hawk is a ground-nesting grassland bird of prey that occurs primarily east of the Continental Divide in the Northwestern Plains. The ferruginous hawk was petitioned for listing under the ESA in 1991, but the petition was denied by the USFWS. Ferruginous hawks concentrate on mammals as prey and are particularly adept at taking prairie dogs, ground squirrels, and pocket gophers. They will sometimes hunt birds, reptiles, and insects. Diet varies depending on distribution of prey species. Threats include habitat loss to agriculture development and urbanization; livestock grazing; and reduction in prey populations either through habitat loss, poisoning, shooting, or human disturbance. The effects of wildfire and the spread of invasive species in nesting habitat have contributed to population declines.

2.3 BURROWING OWL

Burrowing owls are known to occur throughout the Northwestern Plains ecoregion. They are considered to be a Bird of Conservation Concern by the USFWS at the national level and in the five states included in this Rapid Ecoregoinal Assessment (REA). They are primarily associated with open grasslands, where they prey on small mammals such as moles and mice during late spring and early summer. However, during late summer and into fall they switch to insects, especially grasshoppers and beetles. Burrowing owls are also known to eat birds, amphibians, and reptiles. The primary threats to this species are habitat loss due to land conversions for agricultural and urban development, and habitat degradation and loss due to reductions of burrowing mammal populations. The elimination of burrowing mammals through control programs and habitat loss has been identified as the primary factor responsible for declines of burrowing owls (Klute et al 2003).

2.4 MOUNTAIN PLOVER

The mountain plover is a disturbed-prairie or semidesert species rather than a grassland species, and it is often characterized as a breeding bird of high plains and desert tablelands. They prefer disturbed habitats for nesting, including areas formerly occupied by bison and prairie dogs, and agricultural fields (Dinsmore 2003). In 2011, the USFWS determined that the mountain plover is not threatened or endangered throughout all or a significant portion of its range and did not list them on the endangered species list. However, they are listed as a species of concern in Montana, listed as threatened in Nebraska, listed as a species of greatest conservation need in Wyoming, and considered extirpated from North and South Dakota. Several threats, particularly the loss of nesting habitat and threats to prairie dogs, are the focus of broader conservation efforts in this ecoregion that will benefit the mountain plover. The conservation of mountain plovers hinges on the protection of high-quality nesting habitat, the conservation of prairie dogs, and the use of proactive plover management with fire, rotational grazing, and protection of known nesting sites (Dinsmore 2003).

2.5 BLACK-FOOTED FERRET

The BFF is the only ferret native to North America and was once found on BTPD colonies across the Great Plains (from southern Canada to northern Mexico) and on white-tailed and Gunnison’s prairie dog colonies across the intermountain West. By 1986, the BFF was completely gone from the wild. Today, the BFF has been reintroduced to 15 locations within its former range in Arizona; Colorado; Montana; Kansas; South Dakota; Utah; Wyoming; and Chihuahua, Mexico. The BFF spends the majority of its time in vacant prairie dog burrows, venturing above ground at night to hunt for prey from one burrow to the next. The BFF was one of the original animals placed on the endangered species list in 1967. Loss of habitat and susceptibility to plague and canine distemper has contributed to decline over the years.

3.0 CONSERVATION ELEMENT DISTRIBUTION MODELING

In order to answer the MQs regarding the location and status of this assemblage across the Northwestern Plains ecoregion, a variety of data sources were used for mapping known and potential habitat for the BTPD assemblage. State wildlife agencies, natural heritage programs, and the Bureau of Land Management (BLM) field offices collect geographic information system (GIS) data on BTPD colonies within their respective jurisdictions, the latter primarily for use with grazing allotment management and other rangeland concerns.

3.1 DATA IDENTIFICATION

Table E-5-1 lists the types of data and data sources that were proposed for use in the REA as part of the pre-assessment data identification effort. Suitable habitat models, point occurrence data, nest sites, and sensitive habitat data were proposed for use in defining distribution of the assemblage species in the Northwestern Plains ecoregion.

Table E-5-1. Data Sources for the Conservation Element Distribution Mapping

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	NatureServe Habitat Model	NatureServe	Polygon	Acquired	No
	State-Derived Models	MT, WY, SD State Agencies	Raster	Not acquired for all species	Yes
Point Occurrence	State Natural Heritage Databases	Natural Heritage Programs – MT, WY, ND, SD, NE	Point	Not acquired for all species	Yes
Sensitive Areas	Audubon Important Bird Areas	Audubon	Polygon	Acquired	No
Nest Sites	Nests and Roosting Areas	BLM, MT, WY, ND, SD, NE State Fish and Game Agencies	Point	Acquired with the point occurrence data	Yes

An evaluation of the available data was conducted to determine which data would be used for the Maxent modeling. State-derived distribution models for all of the assemblage species were not available for all states within the ecoregion. In some cases, data were acquired but it was determined that other data were more representative for use in the REA (e.g., Christmas Bird Count, Breeding Bird Surveys).

All of the data that were obtained varied greatly in accuracy, with some data providing an estimate of the spatial quality of the data collection method. This attribute information was used to further remove data that appeared to show poor spatial accuracy. The initial datasets (Table E-5-1) provided by the state agencies reflected a variety of spatial attributes, so some data culling and aggregation was required to create a uniform dataset.

3.2 DISTRIBUTION MAPPING METHODS

Maxent modeling consists of using presence-only species occurrence data and a series of environmental raster layers (soil, temperature, elevation, etc.) to attempt to determine modeled habitat. During a model run, the species occurrence data are compared to the individual values within the environmental raster layers to evaluate the commonality among observations (training the model). Once these commonalities are established, the model can expand beyond locations of occurrences to find suitable locations based on the commonalities between data. The Maxent model output is a value between 0-1; the higher the number, the higher the modeled area suitability. Maxent allows for testing the model to validate the accuracy of the predictions based on occurrence data and also provides various validation measures. Because Maxent is a standalone tool, GIS process models were used to extract, project, and format the data into required formats for the model inputs and also convert them back to a GIS format for additional processing.

Maxent models are based on observation data, which can vary greatly in distribution within a state or within states of the ecoregion; this can create some uncertainty that must be acknowledged when viewing the resulting modeled habitat and corresponding maps. Some areas of the ecoregion without observations may still contain potential habitat for CEs that are comprised within the BTPD assemblage. Some areas of the ecoregion that have been intensively studied may also overemphasize modeled habitat. Since the Northwestern Plains ecoregion is so large, it can also be difficult to account for variance in the environmental variables. The climate in northwestern Wyoming could vary greatly from North Dakota, but both could have potential BTPD habitat. These factors and the uncertainty in the resulting modeled habitat should be taken into consideration when viewing the modeled habitat and when using it in making management decisions.

The intent of the REA modeling effort was to identify modeled habitat for the assemblage of species that rely on BTPD colonies for their habitats. Because Maxent uses species occurrence data, the Rolling Review Team (RRT) determined that the occurrence data should be limited to 1990-present to be consistent with timeframes used by other conservation elements being modeled with Maxent. Of the five states making up the Northwestern Plains ecoregion, Montana, South Dakota, and Wyoming contributed the most occurrence data, while Nebraska and North Dakota contributed the least. Figure E-5-1 shows the amount of occurrence data collected for each state.

Looking at the variety of species data, the BTPD occurrences were the highest contributor of observations to the BTPD assemblage (more than three times the total of the other species combined). Figure E-5-2 breaks out the occurrence data by assemblage species.

Much of the species data received from state agencies consisted of studies from multiple years during which the same data were used and new observations were added to it. This created the problem of having a lot of duplicate records. To prevent overtraining of the Maxent model, duplicate records (based on spatial coordinates) were removed from the assemblage dataset.

The AMT requested Maxent models for both the assemblage and the individual species that make up the assemblage. Science Applications International Corporation (SAIC) completed the Maxent modeling of the assemblage, while the BLM National Operations Center (NOC) Wildlife Habitat Spatial Analysis Lab at the completed the Maxent modeling of the individual species (BTPD, burrowing owl, ferruginous hawk, and mountain plover). The variety of data available for each state varied greatly which made using Maxent modeling difficult for some of the individual species over such a large ecoregion. Figures E-5-3 through E-5-6 show the individual species and occurrence data used by state.

The raster output from the Maxent model provides cell values that provide information regarding the probability of modeled habitat. Several iterations of the model were run to determine the best fit for the BTPD assemblage. The main Maxent parameter that was modified was regularization. This parameter helps push the analysis out to areas without occurrence data so that the model is not over-trained on areas with closely clustered occurrence data. Montana Fish, Wildlife, and Parks had previously carried out numerous Maxent modeling efforts and were able to assist in the determination of the Maxent output format that best described presence/absence raster data for the BTPD assemblage. The resulting Maxent output consists of data values ranked 0-1. The higher the value, the higher the suitability based on the environmental layers used.

The Maxent modeling software generates output files that describe which environmental variables contributed the most to generating the output model. Table E-5-2 contains the 16 environmental variables used in the Maxent model, with their contribution listed in the 'Percent Relative Contribution' column. The BTPD assemblage Maxent model had Parameter-Elevation Regressions on Independent Slopes Model (PRISM) maximum temperature, Gap Analysis Program (GAP), and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) vegetation environmental layers as the highest contributors. Reviewing which layers contribute the most and least may allow the Maxent model to be fine-tuned by removing low contributing environmental layers. However, for the purposes of the REA this was not done.

Table E-5-2. Maxent Environmental Variables for Black-Tailed Prairie Dog Assemblage

Environmental Variable	Maxent Variable Code	Percent Relative Contribution	Percent Permutation Importance
PRISM Temperature (max)	prsm_maxt90	54.1	39.7
GAP Vegetation	nwp_gap_90	18.3	10.6
LANDFIRE Vegetation	evt_nwp_90	10.3	10.6
PRISM Temperature (min)	prsm_mint90	3.2	4.5
Geology	lith_nwp_90	2.4	2.1
Rugosity	vrm_nwp_90	2.3	7.5
Aspect (N/S)	aspns_nwp_90	2.3	5
Soils	soil_nwp_90	1.9	1.7
Aspect (E/W)	aspew_nwp_90	1.5	2
PRISM Precipitation	prsm_prcp90	11	2.7
Slope	slope_nwp_90m	1	4.8
Elevation	ned_nwp_90	0.5	1
Solar Radiation (Winter Solstice)	sri_ws_nwp_90	0.5	3.7
Distance to Water	edw_nwp_90	0.3	0.8
Solar Radiation (Equinox)	sri_eq_nwp_90	0.3	3.3
Solar Radiation (Summer Solstice)	sri_ss_nwp_90	0.2	0

The next step was to separate the Maxent output into groups that best describe various thresholds between low, moderate, and optimal suitability. Through the advice of Montana Fish, Wildlife, and Parks and the BLM NOC Wildlife Habitat Spatial Analysis Lab, two possible methods were proposed for determining thresholds.

The first method was based on modeling done by Montana Fish, Wildlife, and Parks, which utilized a method that used validation generated by the Maxent model to determine where the model passed different thresholds. This method, based on work by Hirzel (Hirzel et al. 2006), focused on where the predicted over expected frequency (P/E) ratio vs. logistic value crosses 1 (where the model started to perform better than random selection). This threshold became the moderate suitability threshold. The optimal threshold was determined by analyzing the P/E vs. logistic value curve for the location where the increase in P/E is greater than the increase in logistic value. To help in determining these values, the BLM National Operations Center (NOC) Wildlife Habitat Spatial Analytical Lab wrote an 'R' script that was used to analyze the background predictions generated by Maxent. The R script generated a portable document format (PDF) output detailing the moderate and optimal thresholds (Figure E-5-9). The lowest suitability threshold was determined by calculating the 5 percent test omission rate. The test omission rate is another validation comma-separated file created by the Maxent software. The output using the Hirzel method is shown on Figure E-5-7.

The second method was based on Maxent modeling by the Wyoming Natural Diversity Database (WYNDD). The low and optimal suitability thresholds were calculated from the sample prediction comma-separated file generated by the Maxent modeling. The thresholds were calculated by ranking the logistic prediction of the samples used to train the model using the 5th percentile (low suitability) and 50th percentile (optimal suitability). This method uses actual training data, thus the thresholds are based on real data and everything below the 5th percentile will be classified as unsuitable. The moderate threshold was the 'maximum training sensitivity plus specificity' calculated by the Maxent software. The output using the WYNDD method is shown on Figure E-5-8.

Based on two methods of determining thresholds, the modeling team (Science Applications International Corporation [SAIC]; BLM NOC Wildlife Habitat Spatial Analysis Lab; and Montana Fish, Wildlife, and Parks) determined that the WYNDD thresholds were the best to use for the REA (Figure E-5-8). Table E-5-3 list the thresholds for the BTPD assemblage for both methods.

To establish a modeled habitat map, the Maxent model output requires a binary display of which ones resulted in modeled habitat and whicht areas did not result in a Maxent output. The RRT decided that combining the low, moderate, and optimal thresholds would be the best representation of BTPD assemblage modeled habitat. These three thresholds were combined because it was the most inclusive. The Maxent output was then reclassified to show two classes, modeled and not potential habitat.

Table E-5-3. Maxent Thresholds Calculated for BTPD Assemblage

Method	Measurement	Threshold	Value
MT / Hirzel	Test Omission Rate (0.05)	Low	0.159
MT / Hirzel	P/E =1 (R Script)	Moderate	0.434
MT / Hirzel	Δ P/E Ratio > Δ Logistic Value (R Script)	Optimal	0.505
WYNDD	5% Training Value	Low	0.378
WYNDD	Max. Training Sen. + Spec.	Moderate	0.477
WYNDD	50% Training Value	Optimal	0.519

The Maxent output distribution model (Figure E-5-8) was overlain with the observation points to visually inspect the relative accuracy of the model. The RRT, consisting of state and BLM specialists, reviewed the accuracy of the model based on their experience, regional knowledge, and the validation output generated by Maxent (such as area under the curve [AUC]). The AUC was relatively low (0.61) for this assemblage. This is probably due to the high number of BTPD observation points and the adaptability of the BTPD to a variety of environmental conditions across a large ecoregion. The CA analysis outputs were correlated to reporting units that spatially contained distribution data.

The last set of assemblage distribution figures requested by the RRT included the Maxent distribution output showing the number of assemblage species that overlap. Two figures are included in Attachment A to illustrate the overlap. Figure E-5-A9 provides the optimal Maxent output with the overlap of species. Figure E-5-A10 provides the combined moderate and optimal Maxent output with the overlap.

4.0 CONCEPTUAL MODELS

Conceptual models were developed as part of the pre-assessment phase to assist with the determination of the key factors important to the life cycles of the species in this assemblage. These models were also developed to understand the relationships that all of the potential CAs could have on the assemblage regardless of the availability of data.

The current status and potential future threat analyses were based on an analysis of the key attributes of the CE-specific ecological conceptual model, selection of key ecological attributes (KEAs) likely to result from the CAs, and most importantly, the availability of data. The CAs initially considered in this CE analysis included development, climate change, wildfire, disease, and invasive species. However, after review of the data available for the CA analysis, only development and wildfire could be represented in a geospatial format relative to the Maxent output for this assemblage. Although maps for climate change were developed, the scale of the models was not conducive to comparing the output in a quantitative manner.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model (Figure E-5-10) was developed to identify and link the key life cycle processes to specific ecological factors, or KEAs, that have the greatest potential to affect BTPD assemblage habitat throughout the ecoregion. As noted in the species descriptions, this assemblage requires intact blocks of native grasslands combined with active BTPD colonies.

The key processes are identified in the model as green boxes. Following Unnasch et al. (2009), three broad headings or categories of ecological attributes (EAs) (size, condition, and context) are identified in the model as blue diamonds. Size refers to attributes related to habitat or patch size, condition refers to the condition of the habitat, and context refers to the spatial structure of the habitat. At the landscape level, the EAs under the condition category will be the most challenging to spatially represent and will primarily depend on the data available.

This model illustrates a portion of the burrowing owl, mountain plover and ferruginous hawk life cycles that are not included in the REA because the AMT emphasis for this CE was focused on the portions of the life cycles that occur in the Northwestern Plains ecoregion.

4.2 SYSTEM-LEVEL MODEL

The system-level conceptual model (Figure E-5-11) illustrates the interactions between the CAs and the primary habitat functions of the species in this assemblage. The three primary CAs for this CE are development, climate change, and wildfire, which are identified across the top of the figure in red. The important factors (or “drivers”) affecting the abundance and distribution of the assemblage species include those that cause risk to the expansion of BTPD colonies throughout the ecoregion.

Although numerous attributes and indicators affecting this assemblage were initially identified in the early phases of this REA, due to the limitations and availability of the geospatial data, not all are included in this analysis. For some of the CAs, it was determined that either the attribute or indicator was not suitable for a landscape-level analysis or data were not available to support the analysis. The specific indicators that could not be modeled are identified with an asterisk on Figure E-5-11. Further information on the data gaps for these indicators is discussed in the respective CA analysis contained in Appendix C.

Each of these CAs may directly or indirectly affect the total acreage of natural communities in the ecoregion, some of which are currently grassland suitable for BTPDs, and other areas contain woody or non-native vegetation type that have the potential to become grasslands under climate change effects or as a result of fire. Grassland habitat availability and quality are the most important factors affecting species of the BTPD assemblage. Changes caused by development, climate change, wildfire, invasive species, and insect outbreak and disease all affect BTPD assemblage habitat. In order to provide data gap information, the system-level model includes not only attributes that are anticipated to be represented geospatially, but also those that represent data gaps or are at a scale that is not suitable for use in the REA. The attributes are labeled in the model accordingly.

Figure E-5-11 illustrates the interactions between habitat functions and values of the BTPD assemblage, CAs, and potential landscape effects of changes to the system. The CAs may affect natural community succession and the rate of loss or creation of grassland. Finally, some CA effects focus directly on individual species rather than the amount and quality of habitat.

4.2.1 Climate Change

Climate change has the potential to change habitat availability and quality directly as well as indirectly through its influence on local precipitation and temperatures affecting fire frequency, invasive species, and insect outbreaks and disease. Locations of habitats are expected to change under many climate change scenarios. Some models have projected dramatic spatial shifts in specific grassland habitat conditions, which could prove problematic for BTPDs and associated species that establish large, perennial colonies in suitable shortgrass prairies where the fewest conflicts with human land uses allow their proliferation. Precipitation has a pronounced effect on colony size, causing BTPDs to expand their colonies during dry years and to maintain or shrink colony size when precipitation is near normal or during extended wet periods (NPS 2006). However, conflicts between land use and BTPD colonies remain at high levels across the species' range and colony expansion may only be possible on large, protected areas such as national grasslands.

4.2.2 Development

Various studies have shown documented or potential impacts of development on three wildlife species in the BTPD assemblage. For example, the ferruginous hawk has been shown to be sensitive to human disturbance around nests. In one study, 35 percent of disturbed nests were abandoned by the nesting pair, and disturbed nests fledged significantly fewer young than undisturbed nests (White and Thurow 1985). An increase in the number of transmission lines may provide additional nesting habitat structure but can also result in mortality by collision with or electrocution by energized wires (Bechard and Schmutz 1995, Cartron et al. 2000). This CA was incorporated into the metrics under connectivity by using the lateral distance to nearest road, infrastructure, or anthropogenic land cover present.

4.2.3 Wildfire

Grassland habitats are well adapted to periodic wildland fire, which is a natural characteristic of grassland ecosystems. Periodic wildland fires are required to maintain high grass vigor, reduce the buildup of thatch, and prevent the encroachment of woody species. Frequency of wildland fire is a major factor influencing the quality of grassland habitats. A combination of fire suppression efforts and networks of roads associated with urban, exurban, energy, and agricultural development that act as 'fire breaks" tend to reduce fire frequency and extent leading to reduced vigor of grasses and encroachment of woody species. Optimal fire frequencies are likely to be in the neighborhood of 5-15 years for Northwestern Plains grassland habitats. Very frequent fires (return interval less than two years) can select against the perennial grasses by exhausting their stored food reserves, allowing the potential invasion of non-native species or annual grasses, and resulting in habitat degradation. Woody vegetation encroachment and build-up of thatch may occur when the interval between fires is too long. Both of these conditions result in reduced suitability of grasslands for the BTPD assemblage.

Once the ecological process and system-level models were developed, indicators for the KEAs were identified, with a specific emphasis on the ability to measure the KEA using existing geospatial data. The indicators will assist with answering the MQs that relate to what is happening to the CE across the ecoregion.

4.3 CHANGE AGENTS PROPOSED FOR ANALYSIS

Analysis for the climate change, wildfire, and invasive species CAs were not included for this CE, because the direct effect indicators were determined to be data gaps, or because they were impractical to model at the ecoregional scale because appropriate geospatial data were not available. Further information on the data gaps for these indicators is discussed in the respective CA analysis contained in Appendix C. Analysis for the development and climate change CAs are included for this CE.

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5.0 CHANGE AGENT ANALYSIS

Current status and future threat assessments for the BTPD assemblage were conducted for the Northwestern Plains ecoregion using both 30-meter (m) pixels and the 12-digit hydrologic unit codes (HUCs) as the analysis units. Based on the ecological process and system-level models, KEAs were identified for the current status and future threat analyses, with a specific emphasis on the ability to measure risks using existing geospatial data. The CAs evaluated for current status include development and wildfire. The CAs evaluated for future threats include development, wildfire, and climate change.

Since the scale of the analysis is at the HUC 12, a layer of 6th level watersheds was extracted for the ecoregion. A GIS process was iterated through the KEA indicators and determined the metric values associated with some watersheds. In other instances, sufficient published data indicated cut-off points for these values. These values were added as an attribute to the HUC 12 layer. The intermediate CA layers were then combined together to form a single layer outlining the current status or future threat status for each HUC.

5.1 CURRENT STATUS OF CONSERVATION ELEMENT

Table E-5-4 identifies the original nine KEAs proposed in Task 3 and which of these were used in the final current status analysis. Not all of the KEAs proposed were used, based on the rationale provided. Other KEAs were used but are not directly related to CAs. For example, the KEA related to BTPD colony size was mapped to show the location of large, medium, and small colonies throughout the ecoregion but is not used in the composite current status map.

Table E-5-4. Key Ecological Attributes Retained or Excluded

Category	Attribute	Explanation
1. Size	a. Extent of suitable habitat patches	Retained to show the large patches of grassland habitat.
	b. BTPD colony size	Analysis completed but not included as part of the CA analysis.
2. Condition	a. Wildland Fire Return Interval (FRI)	Retained to show the FRI for the ecoregion.
	b. Proportion of anthropogenic within 1 kilometer (km)	Retained as the anthropogenic layer; merged roads, transmission lines, oil and gas wells, wind and communication towers, and human land uses.
	c. Proportion of suitable habitat on protected lands	Retained to show where the colonies occur relative to protected lands.
3. Context	a. Proportion of HUC in native grassland	Retained to show the proportion of the HUC in agricultural lands.
	b. Distance to anthropogenic features	Retained to show the anthropogenic risk.
	c. Fragmented Maxent habitat	Retained to show the fragmentation throughout the ecoregion.
	d. Distance to other colonies	Retained as an analysis to show connectivity but not included as part of the CA analysis.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

Table E-5-5 identifies the KEAs, indicators, and metrics used to evaluate the current status and pathways affecting this CE across the ecoregion (as illustrated on Figure E-5-21). A GIS process model was designed to create a series of intermediate layers that are primarily based on the available geospatial data.

For each of the KEAs listed in Table E-5-5 and used in the current status analysis, a discussion of the indicator, metric, metric rank and value, data source(s), and references is provided. Several indicators were used to assess the current status for this assemblage, although the analysis was limited to size and landscape context based on spatially available attributes and key factors affecting the assemblage species in the ecoregion.

Table E-5-5. Black-Tailed Prairie Dog Assemblage Key Ecological Attributes, Indicators, and Metrics for Current Status Assessment for the Northwestern Plains Ecoregion

Ecological Attribute	Indicator	Metrics			Data Source	Reference
		Poor =3	Fair =2	Good =1		
1. Size	a. Patch Size (acres)	< 60	60-80	> 80	GAP	BLM 2005
2. Habitat Condition	a. Mean Fire Return Interval (MFRI)	> 20	<5 or 16 -20	6 -15	LANDFIRE	Professional Judgment
	b. Proportion of human land use within 1 km.	> 30%	10-30%	< 10 %	Human Footprint/ GAP	Professional Judgment
	c. Area of Maxent output protected vs. not protected	< 20%	20-60%	> 60%	GAP/Protected Areas Database of the United States (PAD-US)	Professional Judgment
3. Connectivity	a. Proportion of grassland habitat within 1 km	< 50%	50-80%	> 80%	GAP	Unnasch et al. 2008
	b. Distance (lateral) to anthropogenic features	> 226 feet = Good < 226 feet = Poor			Linear Feature/Human Footprint	Manning and White 2001
	c. Fragmentation of Maxent Output (10x10 moving window analysis)	< 20%	20-60%	60-100%	GAP/IRAs	Unnasch et al. 2008
	d. Distance to other colonies (km)	> 7 km = Good < 7 km = Poor			GAP/State Models	USFWS 1989
BTPD Colony Size (not included in analysis and only included to show colony sizes in ecoregion)						
Ecological Attribute	**Indicator**	**Size**			**Data Source**	**Reference**
		Small	**Medium**	**Large**		
Size	BTPD colony size (acres)	< 80	80-1,000	> 1,000	BLM	USFWS 1989

In most cases, the metrics used to identify attribute quality were based on available publications, coupled with expert analysis and professional judgment in association with data-driven metrics. This process was carried out through the establishment of a BTPD RRT comprised of BLM wildlife biologists and state-level BTPD experts. The RRT met three separate times to contribute information and to analyze input attributes and outputs that were derived from various forms of spatial analyses in GIS. This process enabled the RRT to determine the efficacy of attributes, indicators, and metrics, as well as to ascertain the accuracy of each step of the modeling process. Weights were attributed to each metric in order to provide an overall score for all metrics combined, based on the reporting unit.

With the exception of BTPD colony size, Table E-5-5 identifies the KEAs that were retained for further analysis, along with the indicators and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion. BTPD colony size was not included in the KEA analysis. The colony size map was only included to illustrate the relative size of colonies across the ecoregion. For each analysis, a series of intermediate data layers were created based on the KEA indicators that are scored according to a designated metric and then ranked (good, fair, or poor; or large, medium, or small). If necessary, data from multiple source datasets were combined. These metrics were derived from the literature, where possible; however, in some cases, best judgment was used following a review of the literature on the BTPD species.

5.1.1.1 Patch Size

This particular KEA was designed to identify where the largest patches of grassland occur in this ecoregion that are not currently affected by known anthropogenic disturbances. To complete this analysis, the GAP landcover was extracted out to the extent of the assemblage with Maxent output as the starting point. Once this extraction was complete, all anthropogenic features were removed and contiguous pixels of grassland were then grouped and categorized into the metrics shown in Table E-5-5. The metrics for this KEA were obtained from the Wyoming statewide biological assessment (BA) for the BFF (BLM 2005). Information in the Wyoming BA indicated that the minimum BTPD colony size that was considered habitat for the BFF was 80 acres. The results of the BTPD assemblage patch size assessment are shown on Figure E-5-12. Based on review of this figure, it appears that the majority of the Maxent output for this assemblage is rated in the good category (with the exception of large areas in northeastern Wyoming and central Montana).

5.1.1.2 BTPD Colony Size

The BLM provided BTPD colony size data for all of the states in the ecoregion. These data were not included in the current status analysis and were only used to illustrate where the different-sized BTPD colonies occur throughout the ecoregion. Originally, colony size was included in the analysis and scores of good, fair, or poor were used for the large, medium, and small-sized colonies, respectively. However, input from the RRT indicated that the small colonies are just as important as the large colonies for a variety of reasons but mainly for the treatment of plague epizootics. Therefore, colony size was excluded from the analysis and the metrics were changed to large, medium, or small. The break points for the metrics were obtained from a USFWS document that indicated colonies of 1,000 acres or more should be considered as possible locations for reintroduction of BFF (USFWS 1989). The results of the BTPD colony size assessment are shown on Figure E-5-13. Based on the metrics that were developed for this KEA, the majority of BTPD colonies ranked in the medium category, with some of the colonies in central Montana ranking in the large category and colonies in central South Dakota ranking in the small category.

5.1.1.3 Wildland Fire Frequency

This KEA was included to represent areas of the Northwestern Plains that have wildland fire frequencies conducive to BTPD assemblage habitat. The results of this analysis should be used with caution, as these metrics are not known to be as accurate for grassland and shrubland systems as they are for forested systems. Periodic wildland fire greatly influences the grassland habitat quality. Best professional judgment and input from the RRT were used to establish the breakpoints for this metric. The results of the mean fire return interval (MFRI) assessment are shown on Figure E-5-14. The majority of the ecoregion was classified in the good category for MFRI, with a few areas in central Montana and South Dakota ranking in the poor category.

5.1.1.4 Proportion of Human Land Use Relative to BTPD Maxent Output

Several of the KEAs attempted to identify areas of the ecoregion in which development disturbance could adversely affect this assemblage. For this KEA, a variety of anthropogenic layers were combined. These included exurban, housing density, industrial, agriculture, linear features, and wells. Once this layer was created, a moving window analysis with a window size of 1 kilometer (km) was completed to show proportion of the Maxent output within 1 km of human land uses. If greater than 30 percent of the area within the moving window was classified as anthropogenic, then those pixels were rated as poor; if less than 10 percent of the area within the moving window was classified as anthropogenic, then those pixels were rated as good. The results of the human land use proximity assessment are shown on Figure E-5-15. Based on review of this figure, most of the Maxent output for this assemblage ranked in the good category; however, a large area of the Maxent output in northwest Montana returned a poor result for this KEA.

5.1.1.5 Area of Maxent Output Protected versus Not Protected

This KEA was included to show the relative protection of the BTPD assemblage modeled habitat. The assumption used for this KEA was that if the modeled habitat occurred on a National Wildlife Refuge, National Grassland, or other protected area, those habitats would be less at risk from anthropogenic development or disturbance. For this analysis, the GAP status 1-3 lands were used to show the protection level of the Maxent output. The results of the assessment of Maxent output on protected lands are shown on Figure E-5-16. Based on review of this map, it does not appear that much of the BTPD assemblage Maxent-modeled habitat occurs on protected lands. With the exception of a fairly large area of land around Fort Peck, much of the Maxent output returned a poor result for this KEA.

5.1.1.6 Proportion of Grassland Habitat Relative to BTPD Maxent Output

This analysis was included to show the proximity of grassland habitat from the grassland coarse-filter CE relative to the BTPD assemblage-modeled habitat. For this KEA, a moving window analysis with a window size of 1 km was completed to show proportion of the Maxent output within 1 km of the coarse-filter grasslands. If greater than 80 percent of the area within the moving window included grasslands, then those pixels were rated as good; if less than 50 percent of the area within the moving window included grasslands, then those pixels were rated as poor. The results of the grassland proportion assessment are shown on Figure E-5-17. Much of the Maxent output in Montana and Wyoming returned a poor result for this KEA. Areas in northwestern South Dakota returned a good result for this KEA.

5.1.1.7 Lateral Distance to Anthropogenic Features

This KEA was established primarily to assist with the evaluation of anthropogenic disturbance relative to mountain plover. A study conducted by Manning and White (2001) on mountain plovers in Utah, where oil and gas wells are prevalent, found that plover nest sites were located on average approximately 226 feet from well pads and/or roadways. This KEA might not be suitable for a landscape-level analysis because 226 feet is not a far distance. The KEA was set up as a binary analysis to show areas of the Maxent output that were greater than 226 feet from anthropogenic features and areas that were less than 226 feet from anthropogenic features. The results of the assessment of anthropogenic distance analysis on protected lands are shown on Figure E-5-18. With the exception of some areas in northwestern Montana, most of the Maxent output in this ecoregion was categorized as good for this KEA.

5.1.1.8 Fragmentation of Maxent Output

This KEA was designed to show the relative fragmentation of the Maxent output across the ecoregion. For this KEA, a moving window analysis with a window size of 10x10 pixels was completed to show proportion of the Maxent output within 10 pixels of other Maxent-modeled habitat. If greater than 60 percent of the area within the moving window included Maxent output, then those pixels were rated as good; if less than 20 percent of the area within the moving window included Maxent output, then those pixels were rated as poor. The results of the fragmentation analysis are shown on Figure E-5-19. The metrics for this KEA returned fair to poor results for much of the Maxent output in Montana and Wyoming and returned good results for much of the Maxent output in South Dakota.

5.1.1.9 Distance to Other Colonies

This KEA was established because the USFWS determined that, at a minimum, potential habitat for BFF must include a single BTPD colony of greater than 200 acres, or a complex of smaller colonies within a 7-km radius (USFWS 1989). For this analysis, a 7-km buffer was placed around each of the colonies to graphically show the proximity of colonies across the ecoregion. This analysis did not include a score of good, fair, or poor, but rather a visual representation of how BTPD colonies are connected across the landscape. The results of the colony proximity analysis are shown on Figure E-5-20. Based on review of this analysis, there is a significant cluster of colonies in South Dakota that appears to be connected to colonies in northeastern Wyoming, which are somewhat connected to the colonies in Montana.

5.1.2 Current Status of Habitat

The individual KEA analysis provides the basis for the compilation of an overarching data layer that defines the current status of BTPD habitat for each HUC across the Northwestern Plains ecoregion. With the exception of the buffered colonies KEA, each of the seven KEAs were assigned a value of 1 (good), 2 (fair), or 3 (poor). If the KEA was a binary analysis, the value was completed as a 1 or a 3. The KEAs were then weighted to reduce the importance of some of them and enhance the importance of others. For example, the RRT did not believe that the wildland fire frequency and the protected lands KEAs would provide accurate metrics for this assemblage. As for the order of ranking, for these two KEAs, the RRT indicated that the fire frequency would return a less accurate result than protected lands. Therefore, it was arbitrarily determined that these two KEAs would equal 10 percent of the total weight with the fire frequency KEA accounting for 4 percent and the protected lands KEA accounting for 6 percent. The remaining five KEAs were weighted equally at 18 percent weight per KEA. It is important to note that these weights were arbitrarily applied with no scientific basis and can be adjusted for future analysis. The HUC quality rank score was multiplied by the weighting factor for the KEA and the total score was then averaged.

The overall score for each HUC was assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. The natural breaks for this analysis were: less than 49 percent equals a poor rating; 49.01 to 74 percent equals a fair rating; and greater than 74.01 equals a good rating. A higher overall threat score would result in a rating of poor for the HUC, indicating that there are existing concerns to the BTPD assemblage habitat based on the KEA metrics.

The results of the current status analysis for the ecoregion are presented on Figure E-5-21. Based on review of this map, it appears that the majority of the Maxent output for this assemblage in South Dakota is not currently at risk from the CAs used for this analysis. However, much of the assemblage Maxent output for Wyoming and Montana is rated as fair (at moderate risk from the CAs used for this analysis). Figure E-5-10 provides the results from the patch size analysis for BTPD habitat. The results indicate an overall rating of good for the majority of the ecoregion, with significant portions of northeastern Wyoming and central Montana rated as poor. BTPD colony size (Figure E-5-11) is predominately fair to poor across the ecoregion with only small, scattered areas across the ecoregion representing good scores. The MFRI (Figure E-5-12) and distance to anthropogenic features (E-5-16) both exhibited good scores across the majority of the ecoregion. The anthropogenic features attribute resulted in significant poor scores for areas within the Golden Triangle in northwestern Montana and the far eastern portion of the ecoregion. Additionally, the proportion of protected lands (Figure E-5-14) and the proportion of prairie (Figure E-5-15) both scored poorly across most of the ecoregion. Good scores for protected lands were limited to central Montana and northeastern Wyoming, with scattered good-scoring areas throughout the rest of the ecoregion. The proportion of prairie scored as good was limited to the southeastern section of the ecoregion. The proportion of land use (Figure E-5-13) results are much more heterogeneous than the other attributes. The majority of the ecoregion is characterized as fair to good. Notable exceptions occur in the Golden Triangle, eastern Montana, southern North Dakota, and central North Dakota.

A summary of the current status ratings based on the CE distribution is provided in Table E-2-6. The CE distribution layer was used to calculate the total number of square miles of CE habitat and a percentage of the total number of square miles per HUC that were rated as good, fair, or poor. The results of the current status assessment indicate that nearly 36 percent of the 6^{th} level HUC's that intersect the BTPD distribution received an overall rating of good. The majority of the watersheds were rated as fair, while approximately 19 percent were rated as poor.

Table E-5-6. Summary of Current Status Ratings for the Black-Tailed Prairie Dog Assemblage

Overall Rating by 6th Level HUC	Total Square Miles [a]	Percentage of Total Square Miles [a, b]
Good	81,052	35.6
Fair	103,241	45.3
Poor	43,459	19.1

[a] These values include only the area of HUCs that intersect with the CE distribution layer.
[b] Values rounded to one decimal place.

5.2 FUTURE THREAT ANALYSIS

The system-level model (Figure E-5-11) was used to create a series of intermediate layers that are primarily based on the geospatial data available on the future projections for the development and climate change CAs. Future threats were evaluated for development for a short-term time horizon (5 to 10 years) and for climate change for a long-term time horizon (50-year; 2050 to 2069).

Because of the inherent inaccuracies of the temporal scale of the future data, it is only possible to infer information pertaining to a subjective future period (rather than a specific time period) for some of these attributes. However, because of the limits placed on these data outputs, it is fair to assume that this model predicts the overall future potential for these attributes within this ecoregion. It is an upper limit of potential growth and should therefore be carefully applied to future estimates of their effects on the BTPD assemblage.

5.2.1 Development Change Agent

Future spatial data for development were limited to potential energy development area, modeled urban growth, and potential agricultural development, as discussed in the development CA analysis presented in Appendix C-1.

5.2.1.1 Agricultural Growth

Agricultural activities have the potential to threaten grasslands and other areas where this assemblage occurs. As human populations increase, it is expected that the demands of a larger human population will require additional agricultural landscape.

Since no future agricultural models exist for use within this ecoregion, a model was created using surrogate data to derive potential agricultural areas. State Soil Geographic (STATSGO) data were used to determine potential agricultural soil types. The appropriate soil types for use in this classification are types 1 through 4, which are shown on Figure C-1-1 in Appendix C-1. No specific future time period was considered in this analysis (e.g., 2025 or 2060). Alternatively, this analysis considered the maximum potential for future agricultural areas within this ecoregion.

Figure C-1-1 shows the results of the analysis, indicating where the future potential for agriculture occurs relative to the Maxent output for this assemblage. In the Northwestern Plains ecoregion, most of the agricultural areas (current and future) are located outside of the Maxent output for the BTPD assemblage. With the exception of a few areas in north-central South Dakota, there is minimal potential risk to the habitat of this assemblage from the effects of agricultural growth. In general, the majority of the modeled habitat is likely to remain unaffected.

5.2.1.2 Future Growth of Urban Areas

The effects of urban growth on this assemblage are similar to those of agricultural activities. In the Northwestern Plains ecoregion, the majority of urban growth is anticipated around existing urban areas. Although the urban areas around Rapid City, South Dakota and Sheridan, Wyoming are projected to increase, it is not anticipated that this would adversely affect this assemblage as a whole. However, exurban development (such as the construction of houses on large properties) could negatively affect mountain plovers and other species of this assemblage.

The Integrated Climate and Land Use Scenarios (ICLUS) model is a universally accepted model created by the U.S. Environmental Protection Agency (USEPA) for use in future climate change modeling; this model provides spatial data that can be used to determine the future extent of urban areas for various time periods. The model uses U.S. Census data to predict urban growth. The ICLUS future urban extent for the year 2060 was used in this analysis. This corresponds more closely to the data and scenarios used to perform the modeled habitat and wind turbine analyses than a near-term time period. The ICLUS urban area footprint for 2060 was used to calculate the proximity to modeled BTPD assemblage habitat. Figure C-1-2, Future Urban Growth Potential, shows the growth of urban areas occurring mostly outside of the BTPD assemblage observation points. Although there is very minimal overlap, there is likely no potential future threat on an ecoregional scale.

5.2.1.3 Wind Turbine Potential

The USFWS wind turbine data contained attribute information for current and future wind turbine locations. However, the future turbine locations dataset was very limited in number as most turbines will presumably be erected in the very near future. Therefore, an alternative dataset was used to determine the potential areas for erecting wind turbines over a long-term period. The future potential wind energy development layer was based on the location of documented wind speeds suitable for turbines.

Data characterized by the National Renewable Energy Laboratory (NREL) was used to create a potential future wind turbine area data layer. A full description of the methods and processes implemented to create this data layer and its corresponding scoring system can be found in Appendix C-1.

The potential threats to BTPD assemblage modeled habitat relative to future wind energy development are presented on Figure C-1-1. Higher elevations within this ecoregion are more susceptible to the threats related to future wind turbine development due to the higher wind speed levels within these areas. However, limited accessibility may affect the distribution of wind turbines at higher elevations, limiting the range of wind turbine distribution to lower-elevation mountainous regions. Fortunately for this assemblage, many areas at high risk for future wind development are located in east-central South Dakota where the Maxent output for this assemblage is not as dense as other areas in central Montana or northwestern South Dakota.

5.2.1.4 Oil and Natural Gas Production Potential

The BTPD modeled habitat does appear to be at risk from oil and gas production throughout the Northwestern Plains. The future analysis characterized potential oil and natural gas production areas rather than actual well locations (Figure C-1-5). These larger potential production extents could be used to qualitatively assess the potential effect of future oil and gas production activities. Although these areas are based on oil and gas density data, the application of these data to future potential well site activity is unknown. Therefore, a carefully considered approach should be taken when assessing the effect of potential oil and gas production areas on BTPD assemblage habitat.

The highest risk area for potential future oil and gas development is limited to northeastern Wyoming. However, this area represents a large part of Wyoming that is characterized as modeled BTPD assemblage habitat. There is potential for risk to this assemblage in northeastern Wyoming and southeast Montana, but the large areas of modeled habitat in South Dakota would appear to be less affected by oil and gas production. The oil and gas production potential in Wyoming appears to indicate the highest risk to this assemblage. It is important to note that the Energy Policy and Conservation Act (EPCA) oil and gas data used in this assessment are based on the maximum potential for oil and gas reserves within the Northwestern Plains. As a result, these data are likely over-represented in these figures, and care should be taken in assessing the effects of oil and gas production within the constraints of this analysis.

5.2.1.5 Future Potential for Solar Development

This future potential analysis characterized the future potential for solar development was based on the solar potential maps developed by NREL. Although these maps are very crude (see Figure C-1-6), the highest risk for solar development is shown to occur in northeast Wyoming and southeast Montana (where some of the highest density of BTPD assemblage modeled habitat is located). Again, the NREL solar maps are very crude and solar development is based on many other factors such as permitting requirements, land cover types, and topography.

5.2.1.6 Overall Development Change Agent Future Threats

A fossil fuel energy output layer was created to address the MQs associated with future fossil fuels production. This layer was created by averaging the EPCA oil data layer with the EPCA gas data layer (Figure C-1-5).

Most of the potential future risk to the BTPD assemblage modeled habitat in the ecoregion would potentially result from the effects of fossil fuels production and solar development. The majority of potential fossil fuels production is limited to northeastern Wyoming, western North Dakota, and eastern Montana. There is potential for risk to the modeled habitat in Wyoming, but the overall distribution of the species is expected to remain unaffected by fossil fuel production.

A renewable energy output layer was created to address the MQs associated with future renewable energy production. This layer was created by averaging the NREL wind speed data layer with the NREL solar energy data layer (Figure C-1-8).

This output layer gives equal weighting to potential wind and solar energy production areas, and could therefore mischaracterize the effects of each. Unlike oil and gas, wind and solar energy are not necessarily closely associated with one another spatially. Photovoltaic solar arrays threaten the assemblage through the decrease in habitat availability and habitat fragmentation. Solar arrays are diverse in scope and size, and it is therefore difficult to create a clear correlation between habitat loss and solar energy production. As a result, it might be beneficial for managers to consider wind and solar energy production as separate entities when determining the effects of renewable resources on this assemblage.

Because of the intricacies involved in the assessment of renewable energy production with regard to BTPD assemblage modeled habitat, a limited approach must be taken in this analysis. The majority of the Northwestern Plains ecoregion is considered to be at moderate risk from renewable energy development.

5.2.2 Climate Change Future Threats

5.2.2.1 Ecoregion Climate Change Analysis

From a climate change perspective, the relationship between temperature, precipitation, and the re-distribution of vegetation communities across the landscape is the factor that will have the greatest risk to this assemblage.

All of the species in the assemblage rely on the BTPD to continue to provide habitat. If vegetation communities substantially change as a result of increased temperatures and decreased precipitation, it is likely that fire regimes will change and invasive species will negatively affect this assemblage. However, attempting to illustrate these potential risks in a geospatial format is very difficult.

A constant overall increase in temperature (1.9-2.3 degrees Celsius [°C]) is expected across the assemblage modeled habitat within the Northwestern Plains. Increased fire potential is the most likely result of temperature increase that would directly affect assemblage habitat quality. Across the Northwestern Plains ecoregion annual precipitation is predicted to be highly variable around the 2060 timeframe. Most of the region is expected to experience a mild increase (25-75 millimeters [mm]) in annual precipitation or no annual change in precipitation. Climate models indicate that precipitation could decrease moderately in the Powder River Basin and in southern South Dakota and Nebraska for the months of July and August.

5.2.2.2 NSCCVI

The NatureServe Climate Change Vulnerability Index (NSCCVI) tool was utilized to assess the burrowing owl as a representative of the overall vulnerability of the BTPD assemblage to future effects of climate change. Using annual raster datasets from NatureServe to perform climate change calculations in ArcGIS (through the Predicted Temperature 2040-2069 (Fahrenheit [F]) and the Predicted Hamon ratio of actual evapotranspiration to potential transpiration [AET : PET] Moisture Metric 2040-2069 datasets), the NSCCVI calculator was applied and produced an index score of Insufficient Evidence. The NSCCVI tool indicated that the available information (within the geographical area assessed) regarding the species' vulnerability is inadequate to calculate an index score. Data gaps for the burrowing owl's specific response to climate change were identified. The assessment rating was largely based on unknown scores calculated when assessing factors that influence vulnerability, such as distribution to barriers, dispersal and movements, sensitivity to temperature and moisture changes (historical thermal/hydrological niche), reliance on interspecific interactions to generate habitat, and dietary versatility.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the BTPD assemblage include those defined as part of the Landscape Species/Species Richness. The overall MQ was: Where are the key habitat types (seasonal, refuges, corridors/connectivity, migration routes, concentrations of regionally significant species, etc.) for landscape species, keystone species, regionally significant species, and regionally significant suites of species? This MQ was considered in implementing the GIS analyses. Emphasis was placed on the spatial relationship of attributes mentioned in the MQs and the distribution map for the CE. Several examples of how the REA can be used to answer MQs (as noted in Appendix A) are provided below; those examples demonstrate the functionality of the REA and provide an opportunity to discuss data gaps that were identified during the REA.

6.1 WHERE ARE AREAS THAT HAVE POTENTIAL FOR RESTORING REGIONALLY SIGNIFICANT SPECIES HABITAT OR HABITAT CONNECTIVITY FOR REGIONALLY SIGNIFICANT SPECIES?

The habitat patch size assessment (Figure E-5-12) can be used to identify general areas in which habitat patch size is rated as good and would likely continue to support these species through conservation efforts.

6.2 WHERE ARE THE HABITATS THAT SUPPORT THE BLACK-TAILED PRAIRIE DOG ASSEMBLAGE SPECIES?

This MQ was answered with a variety of different GIS outputs. The individual species Maxent outputs (Attachment A), along with the combined assemblage Maxent output (Figure E-5-8) and the figures that show the Maxent species overlap (Figures E-5-A9 and E-5-A10), provide relevant answers to this MQ. In addition, Figure E-5-17 was completed to show habitats that support the assemblage species. The habitat patch size (Figure E-5-12) indicates that habitat size is good (>80 acres) within most of the Maxent output. However, there are some areas in the central and southern portions of the Maxent output that returned poor scores for habitat patch size.

6.3 WHERE ARE CURRENT REGIONALLY SIGNIFICANT LANDSCAPE/KEYSTONE SPECIES AND THEIR HABITATS, INCLUDING SEASONAL HABITAT AND MOVEMENT CORRIDORS, AT GREATEST RISK FROM CHANGE AGENTS, INCLUDING CLIMATE CHANGE (CONNECTIVITY, SMALL POPULATION SIZE)?

Several of the geospatial outputs could be used to answer this MQ. There are two anthropogenic outputs that display areas in which the assemblage could be at risk from effects of development. Much of the Maxent output is outside of the areas potentially at risk from effects of anthropogenic development. The primary future threats to this assemblage are from energy development. Review of the overall current status map (Figure E-5-21) shows that the majority of the BTPD Maxent output is rated as fair or good. The northwestern portion of the Maxent output was rated as poor, which is obviously reflective of the amount of human land uses in that area of the Maxent output.

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7.0 REFERENCES

Anderson, E., S. C. Forrest, T. W. Clark, and L. Richardson. 1986. Paleo-biology, biogeography, and systematics of the black-footed ferret, *Mustela nigripes* Audubon and Bachman (1851). Great Basin Naturalist Memoirs 8:11-62.

Bechard, M. J., and J. K. Schmutz. 1995. Ferruginous Hawk (*Buteo regalis*). *In* A. Poole and F. Gill (eds.), The Birds of North America, No. 172. The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists' Union, Washington, DC.

BLM (U.S. Bureau of Land Management). 2005. FINAL Statewide Programmatic Biological Assessment: Black-footed Ferret (*Mustela nigripes*). Wyoming State Office Cheyenne, Wyoming. August 25.

Burroughs, R.D. 1961. *The Natural History of the Lewis and Clark Expedition.* East Lansing: Michigan State University Press.

Cameron, E. S. 1907. The birds of Custer and Dawson counties, Montana. Auk 241241-270.

Cartron, J.-L. E., G. L. Garber, C. Finley, C. Rustay, R. P. Kellermueller, M. P. Day, P. Manzano Fischer, and S. H. Stoleson. 2000. Power-pole casualties among raptors and ravens in northwestern Chihuahua, Mexico. Western Birds 31:255-257.

Chittenden, H.M., and A.T. Richardson, eds. 1905. *Life, letters, and travels of Father DeSmet among the Indians 1801-1873,* vol. 1 (4 vols.), New York: Harper.

Cooper, J.G. 1869a. The fauna of Montana Territory. *American Naturalist*. 3:73-84.

Cooper, J.G. 1869b. Notes on the fauna of the upper Missouri. *American Naturalist 3:294-99.*

Coues, E. 1878. Field notes on birds observed in Dakota and Montana along the forty-ninth parallel during the seasons of 1873 and 1874. In *Bulletin of the US Geological and Geographical Survey,* 4:545 661. Washington, DC: US Government Printing Office.

Dinsmore, S.J. (2003, December 8). Mountain Plover (*Charadrius montanus*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/mountainplover.pdf.

FaunaWest. 1998. Status of the black and white-tailed prairie dog in Montana. Helena: Montana Fish, Wildlife and Parks.

Hirzel A, Lelay G, Helfer V, Randin C, Guisan A. 2006. Evaluating the ability of habitat suitability models to predict species presences. Ecol Model 199: 142−152.

Klute, D. S., L. W. Ayers, M. T. Green, W. H. Howe, S. L. Jones, J. A. Shaffer, S. R. Sheffield, and T. S. Zimmerman. 2003. Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States. U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP-R6001-2003, Washington, D.C.

Knowles, C.J. and M. Weggenman. 1998. Relocation of the Fort Harrison prairie dog colony. Paper present at the Montana Chapter of The Wildlife Society 1998 annual meet, 4-6 March.

Lesica, P. 1995. 'Endless sea of grass'...No longer. Kelseya 8:8-9.

Manning, A.E.E. and C.M. White. 2001. Breeding Biology of Mountain Plovers (*Charadrius montanus*) in the Uinta Basin. Western North American Naturalist 61(2), pp. 223–228.

Messiter, C.A. 1890. *Sport and Adventure among the North American Indians.* London: R.H. Porter.

National Park Service (NPS) 2006. U.S. Department of the Interior, Wind Cave National Park, South Dakota. Black-tailed Prairie Dog Management Plan Draft Environmental Assessment. January.

Stuart, J. 1902. The Yellowstone expedition of 1863. In *Contributions to the Historical Society of Montana*, 2d ed., 1: 162-79. Helena, MT: Independent Publishing Company.

Unnasch, R.S., D.P. Braun, P.J. Comer, and G.E. Eckert. 2009. The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System. Report to the National Park Service. Version 1.0. January.

USFWS. 1989. Black-Footed Ferret Survey Guidelines for Compliance with the Endangered Species Act. Available on internet at: http://www.fws.gov/montanafieldoffice/Endangered_Species/Survey_Guidelines/Ferret_Survey_Guidelines.pdf. Accessed May 20, 2011.

Vosburght, C., and L. R. Irby. 1998. Effects of recreational shooting on prairie dog colonies. The Journal of Wildlife Management 62:363-372.

White, C. M. and T. L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.

APPENDIX E-5

FIGURES

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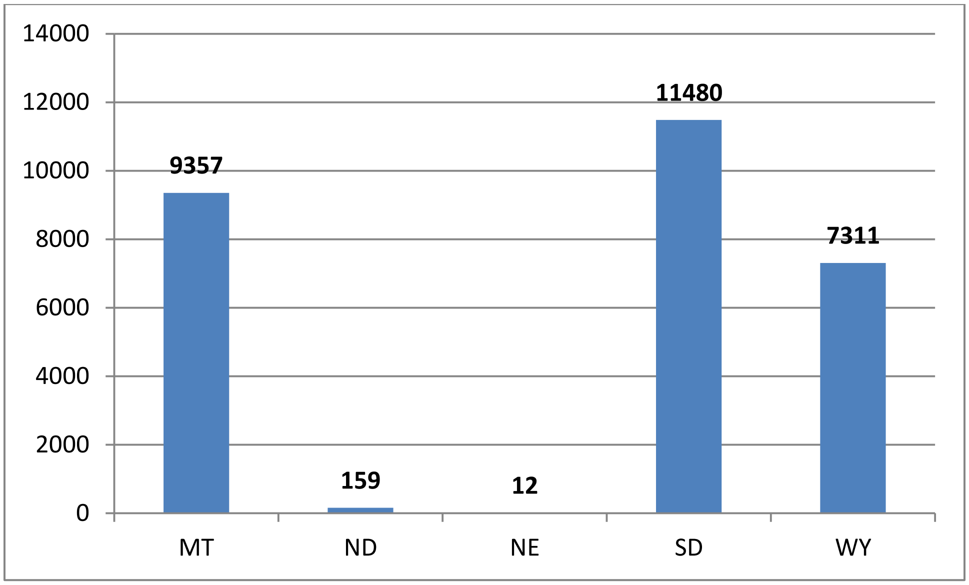

Figure E-5-1. Individual State Contribution to BTPD Assemblage

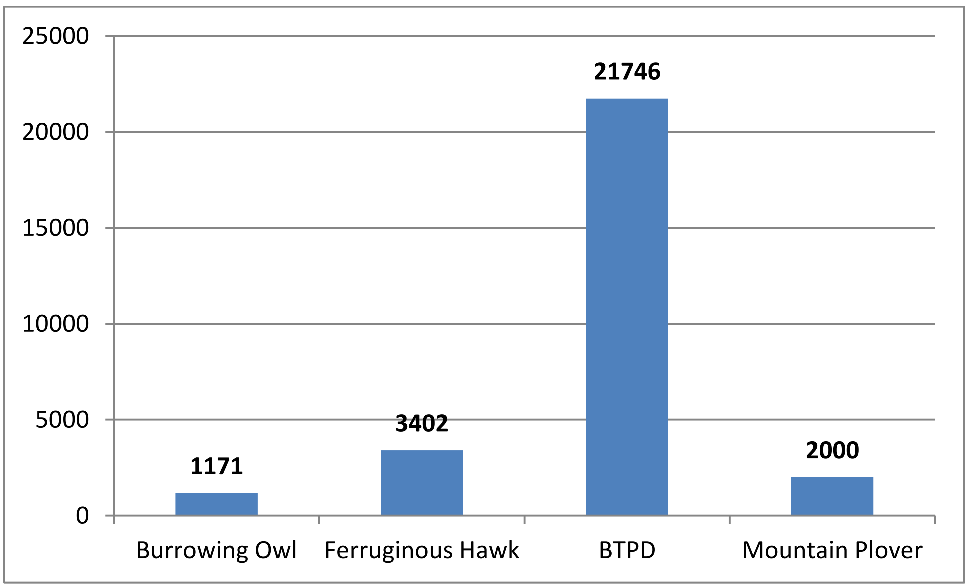

Figure E-5-2. Occurrence Data by Species used in the BTPD Assemblage

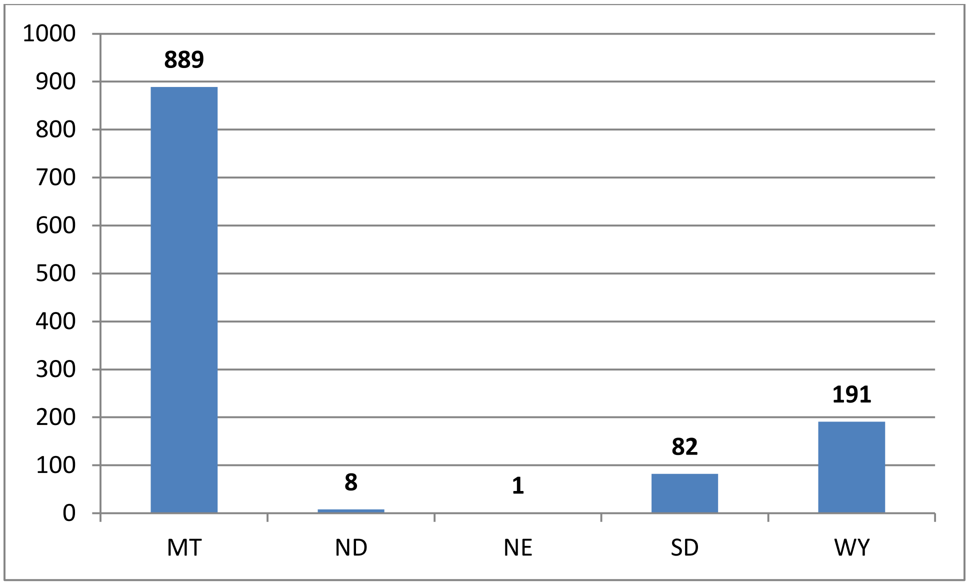

Figure E-5-3. Burrowing Owl Occurrence Data used in Maxent Modeling by State

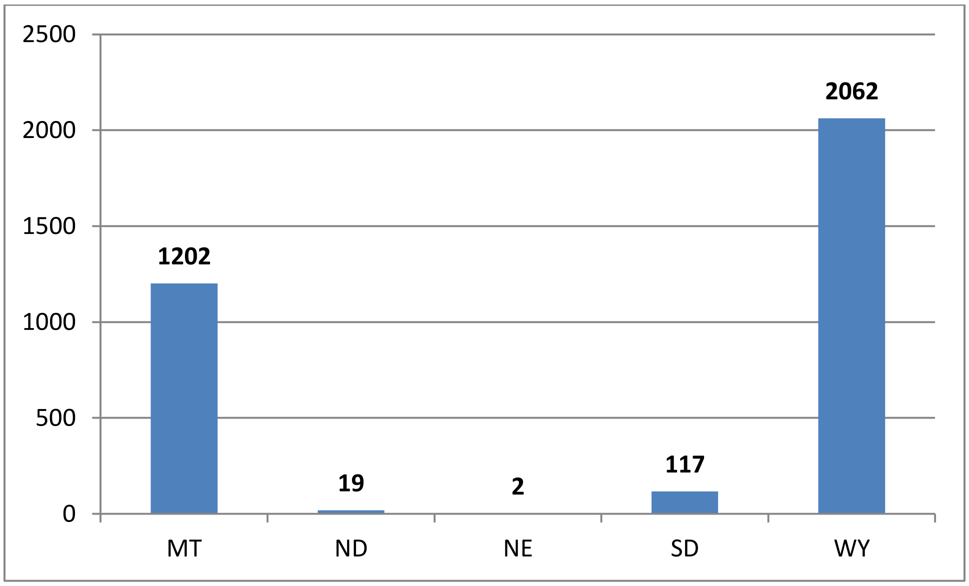

Figure E-5-4. Ferruginous Hawk Occurrence Data used in Maxent Modeling by State

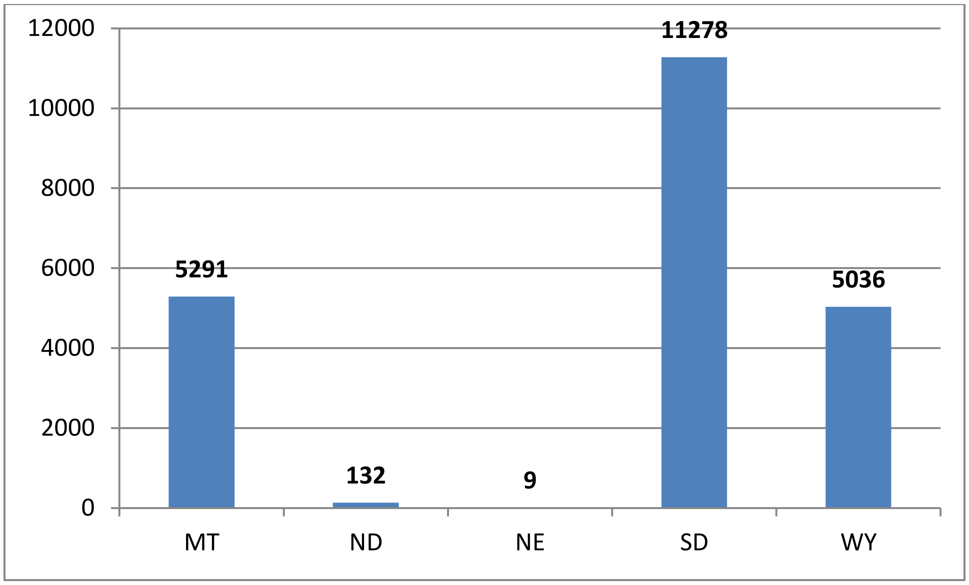

Figure E-5-5. BTPD Occurrence Data used in Maxent Modeling by State

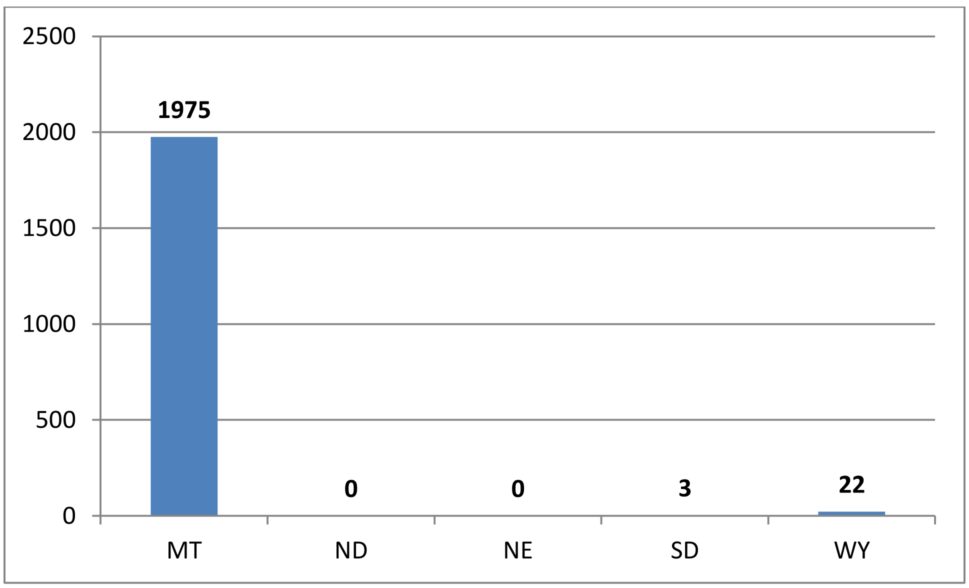

Figure E-5-6. Mountain Plover Occurrence Data used in Maxent Modeling by State

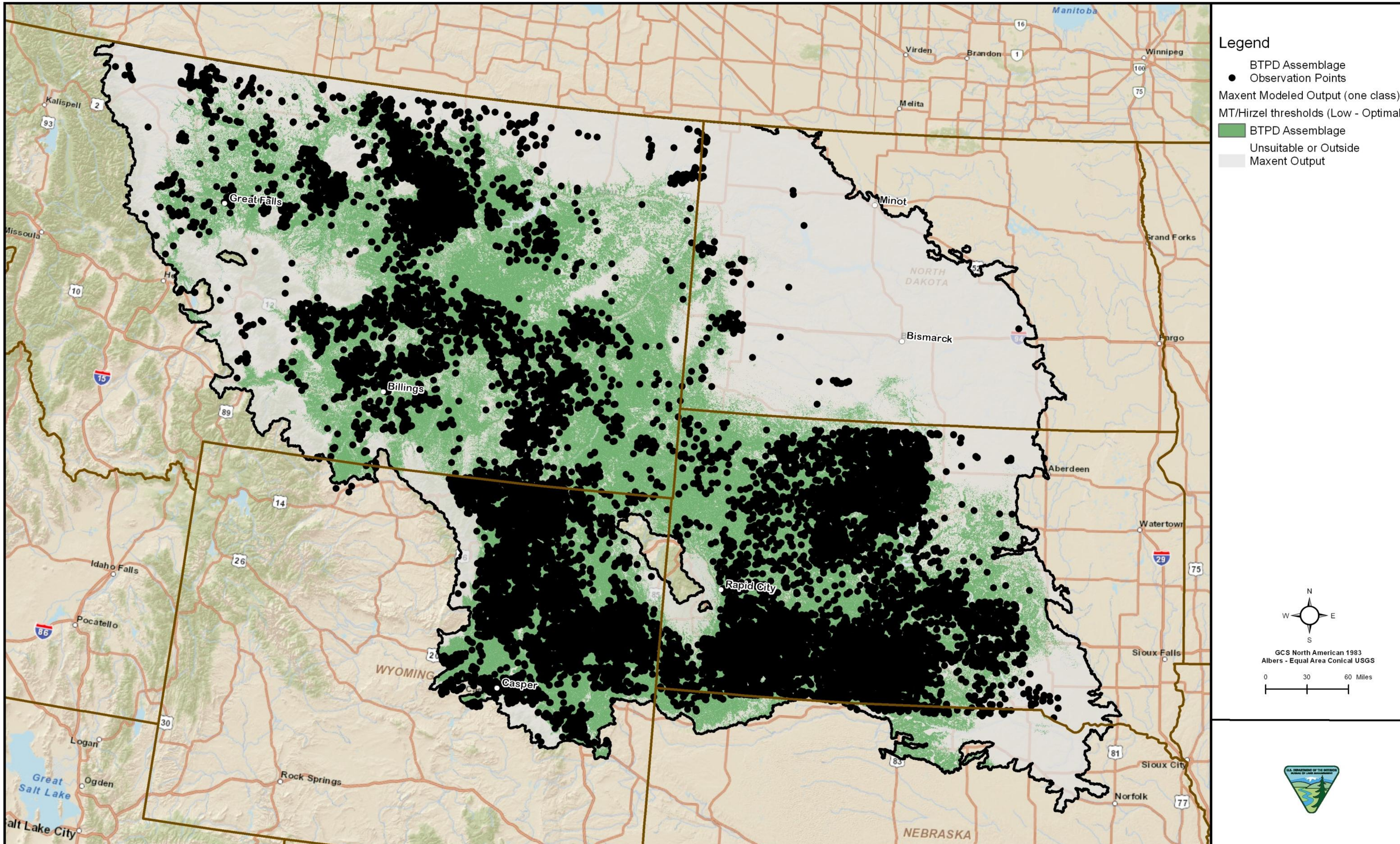

Figure E-5-7. BTPD Assemblage Distribution Map using Hirzel Method

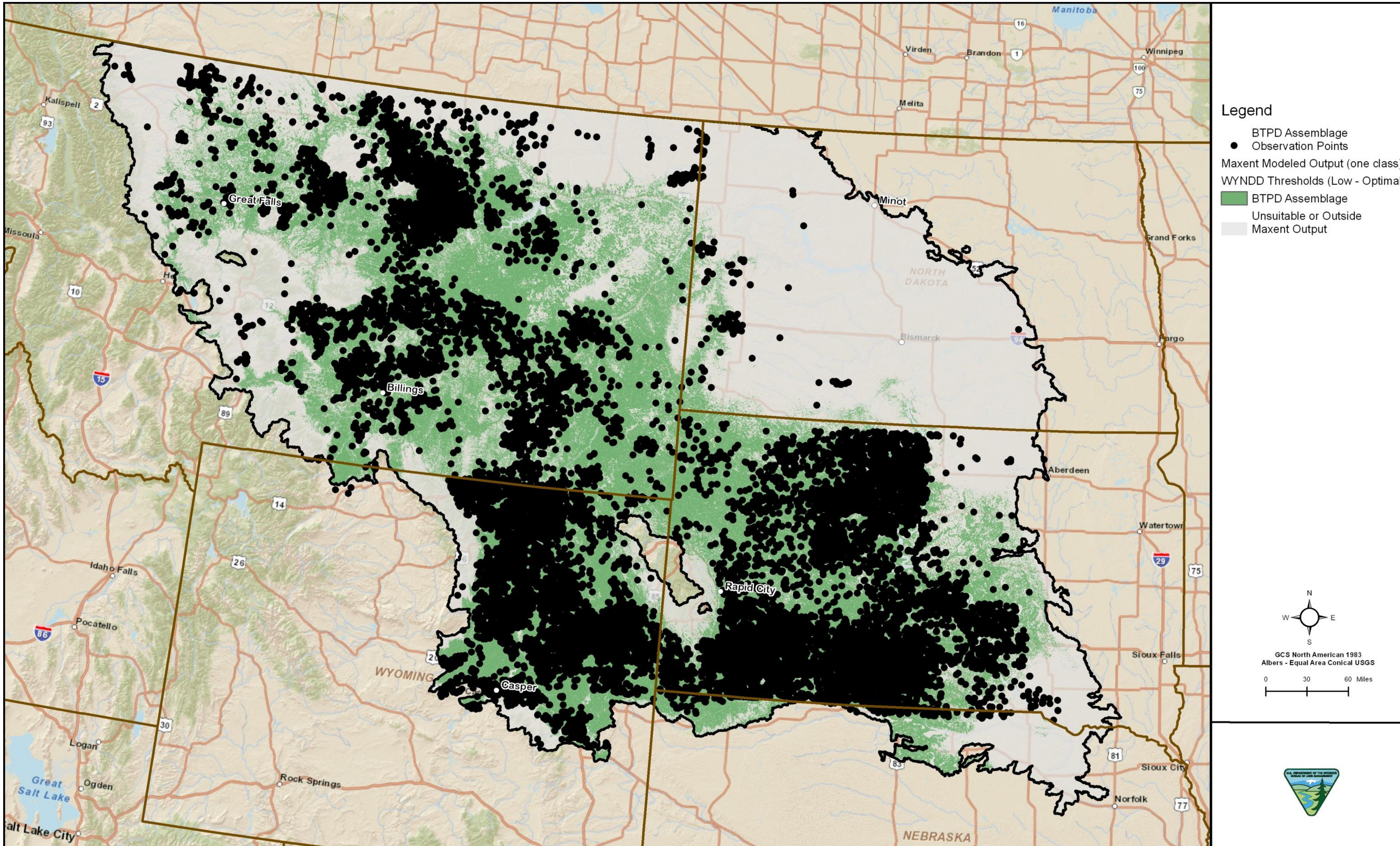

Figure E-5-8. BTPD Assemblage Distribution Map using WYNDD Method

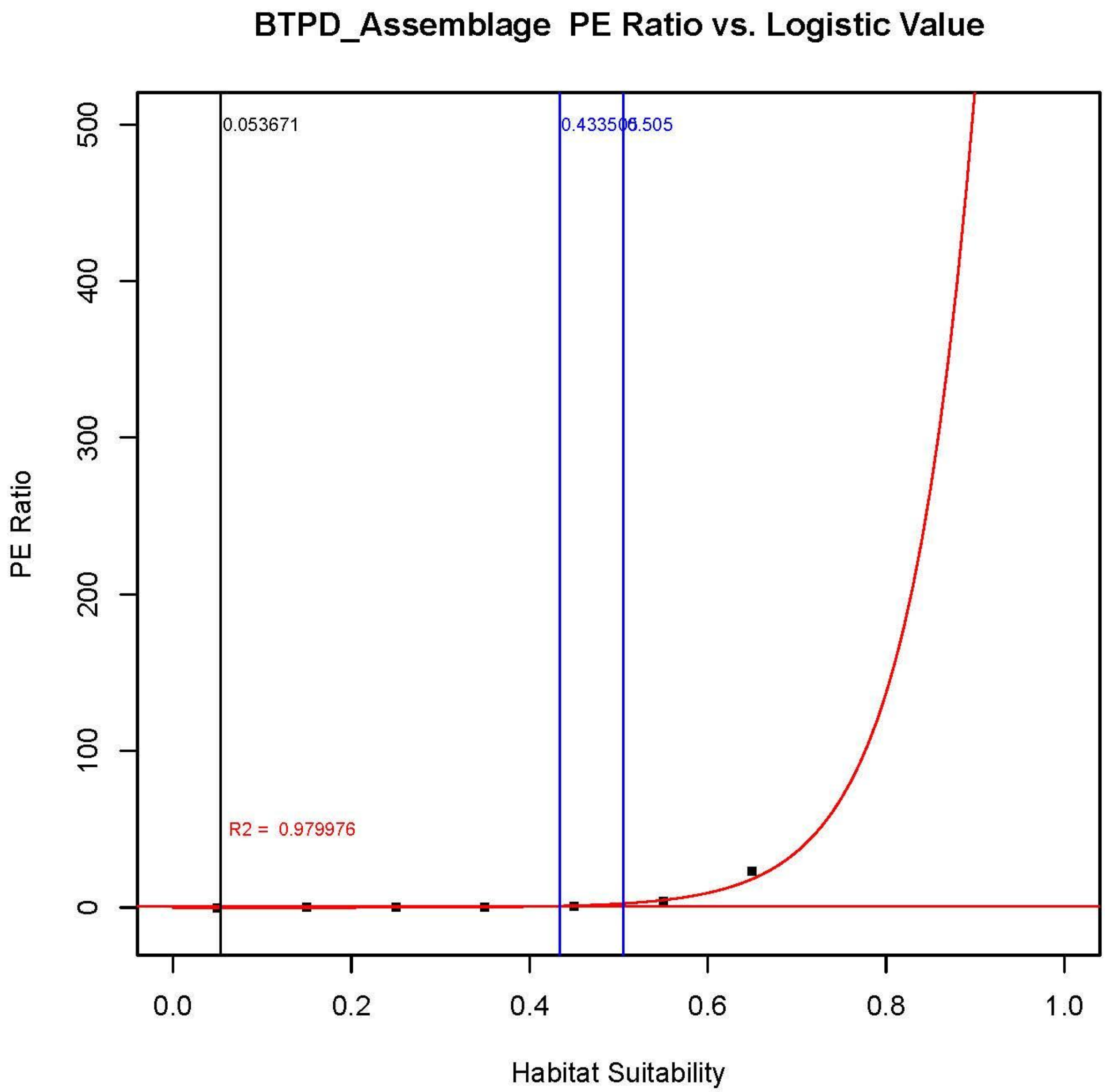

Figure E-5-9. R script PDF output for BTPD Assemblage in the Northwestern Plains Ecoregion

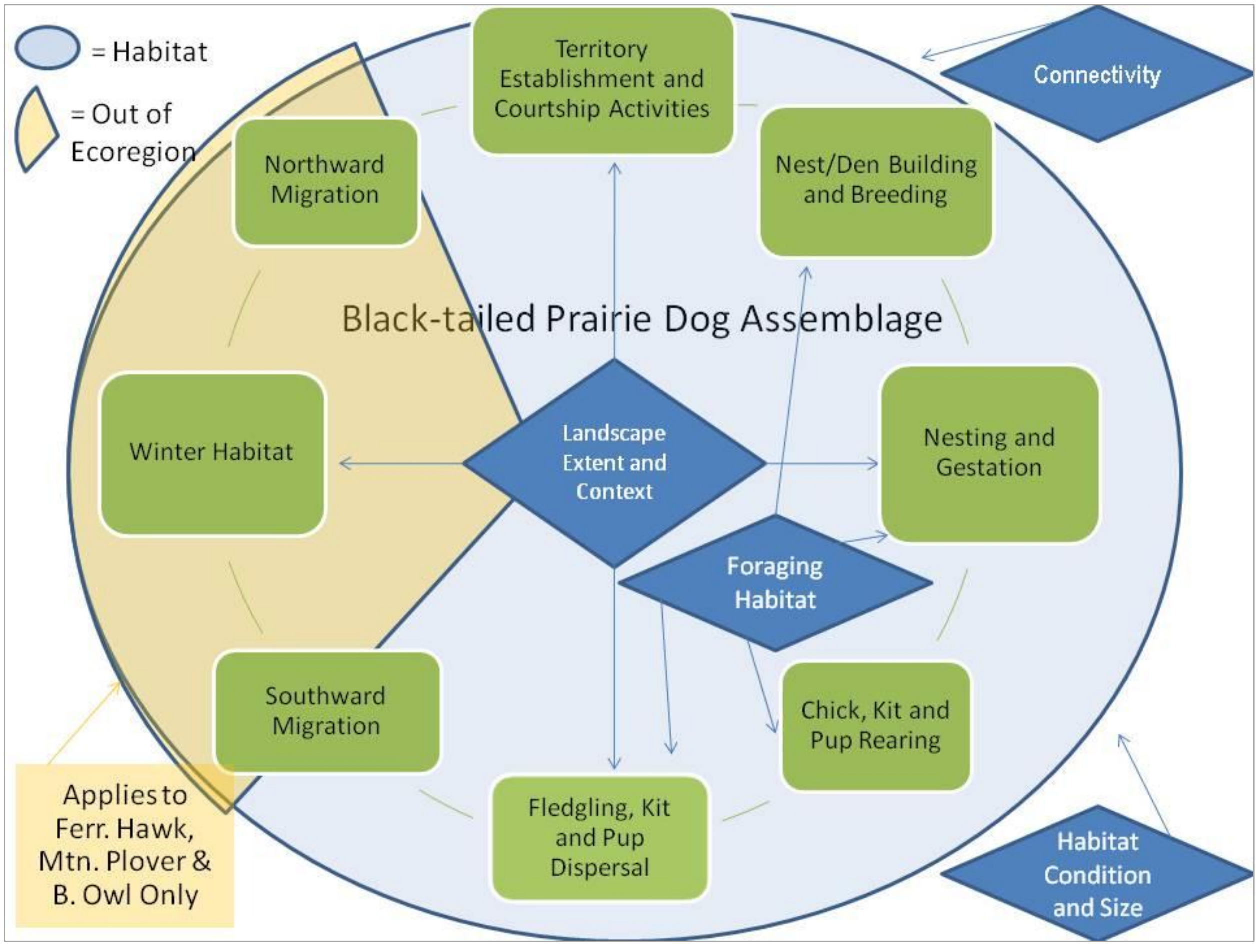

Figure E-5-10. Black-tailed Prairie Dog Assemblage Ecological Process Model

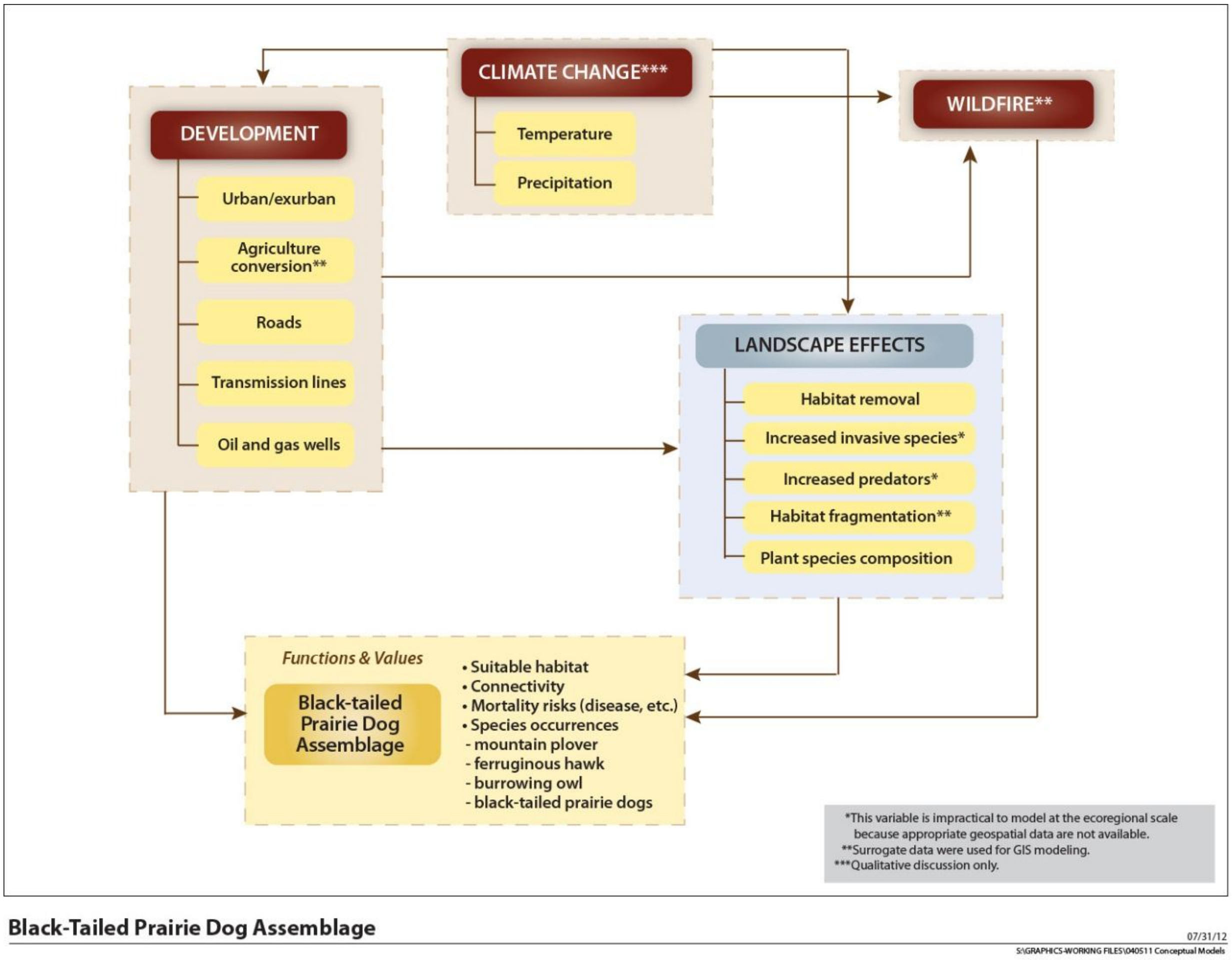

Figure E-5-11. Black-tailed Prairie Dog Assemblage System-Level Conceptual Model

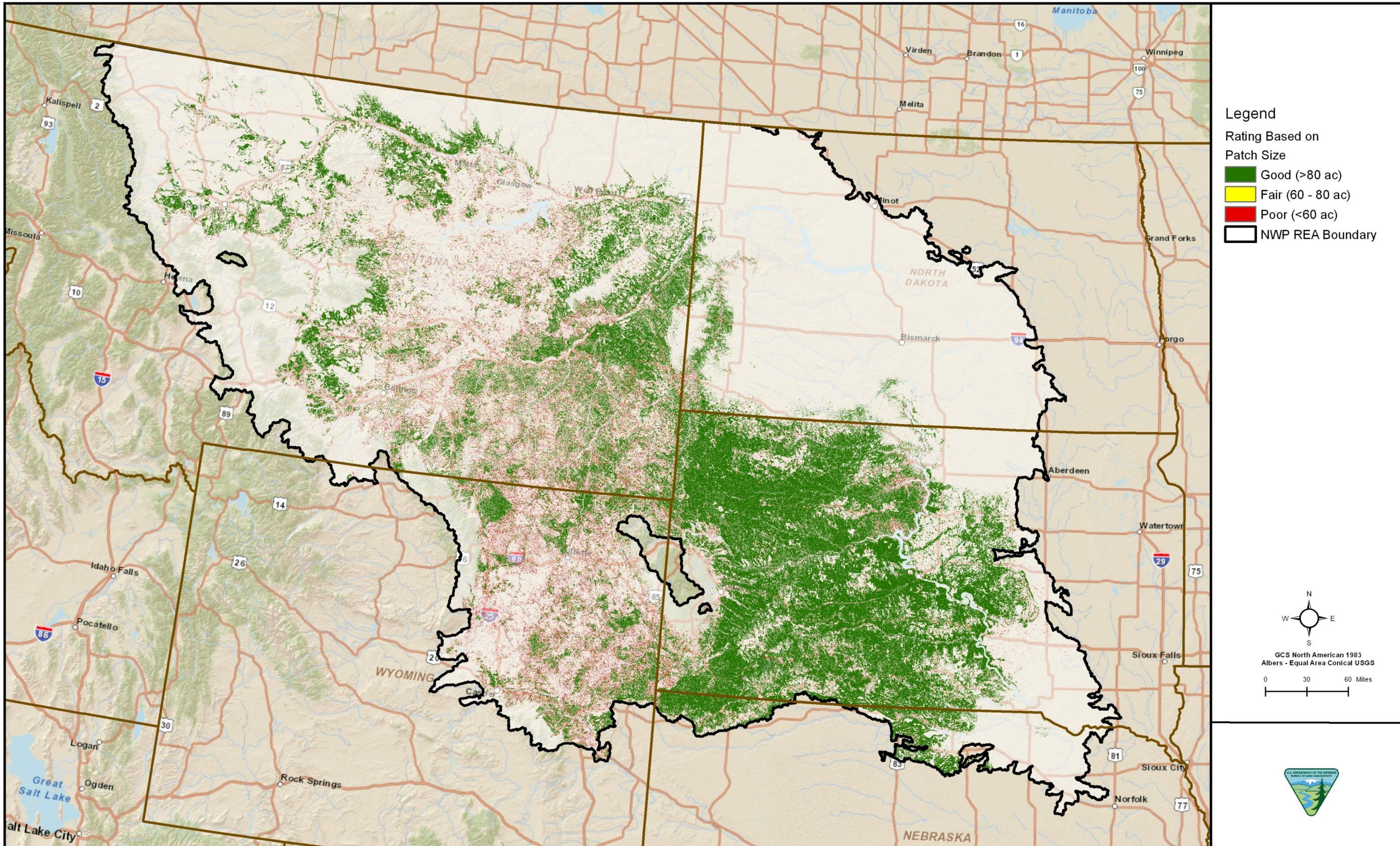

Figure E-5-12. BTPD Assemblage Patch Size Assessment

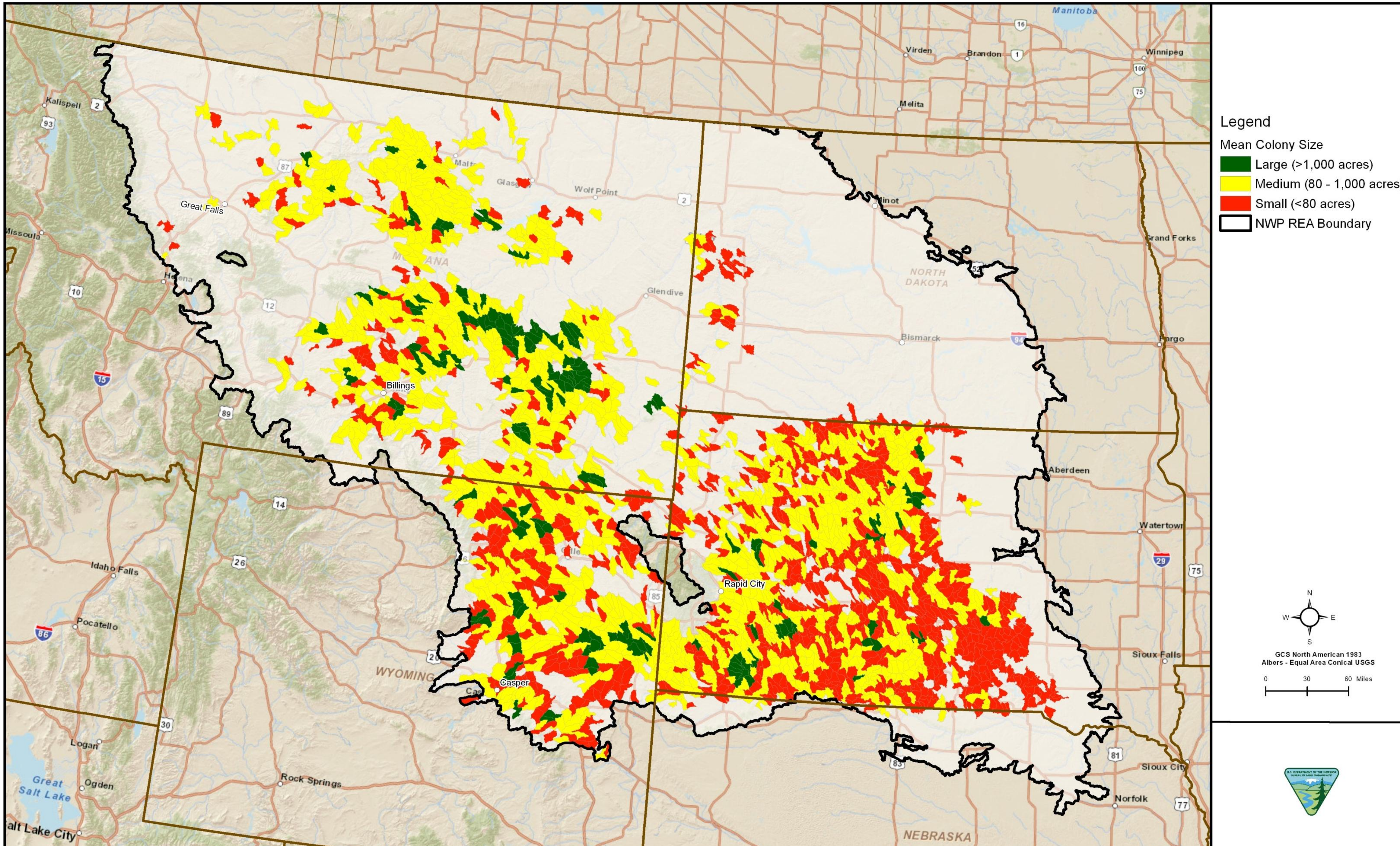

Figure E-5-13. Black-tailed Prairie Dog Colony Size Assessment

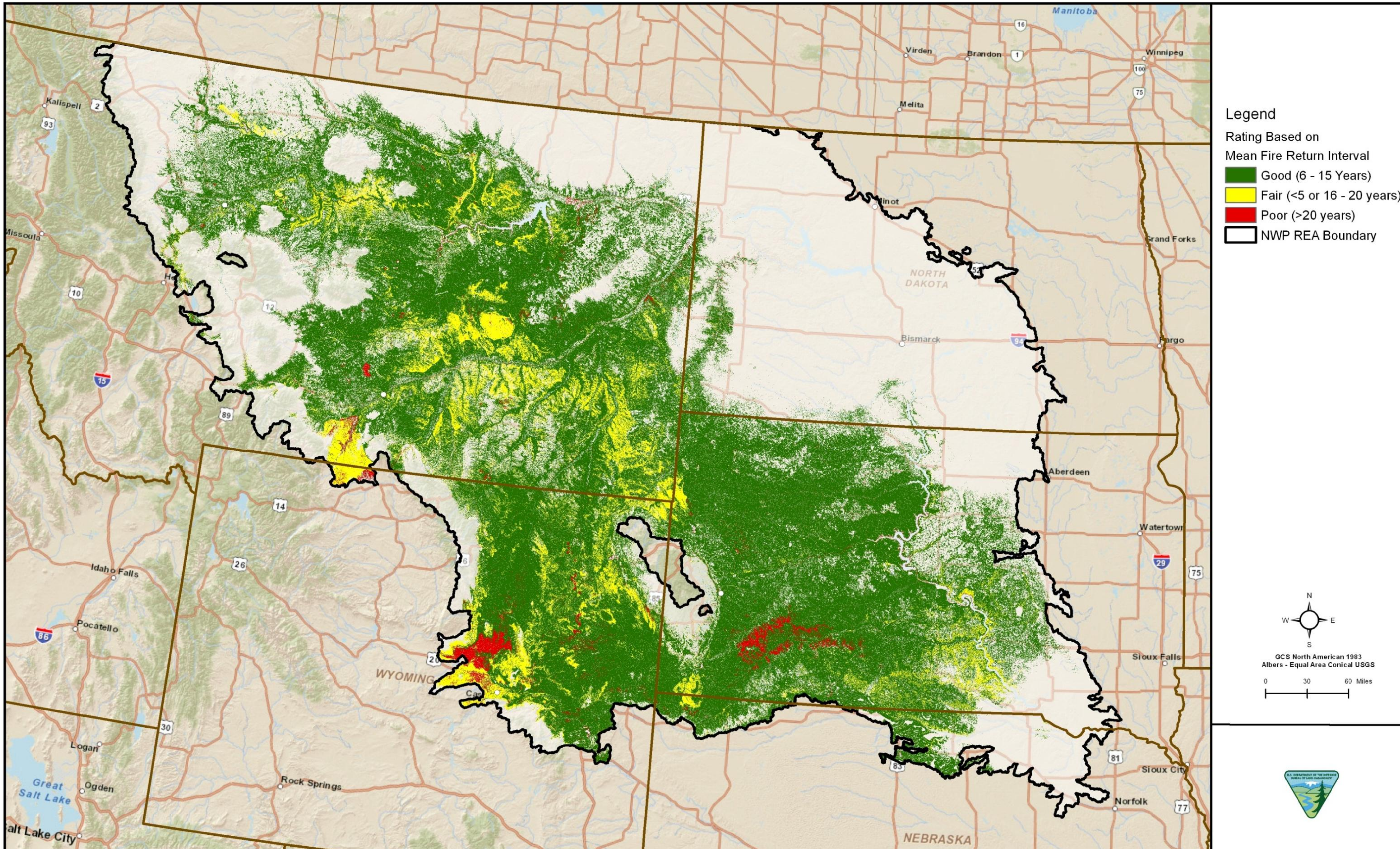

Figure E-5-14. Mean Fire Return Interval Relative to BTPD Maxent Output

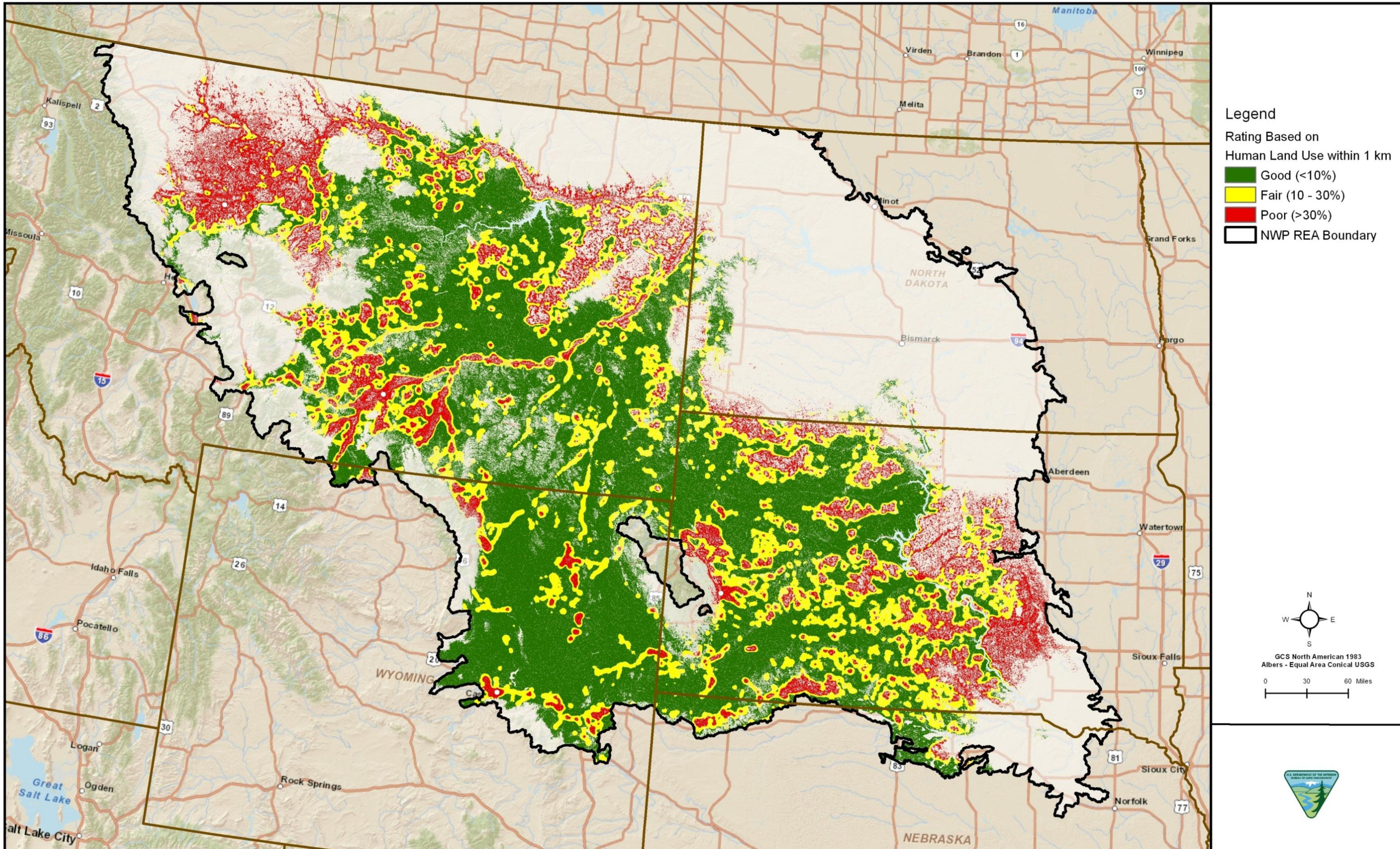

Figure E-5-15. Human Land Use Proximity Analysis

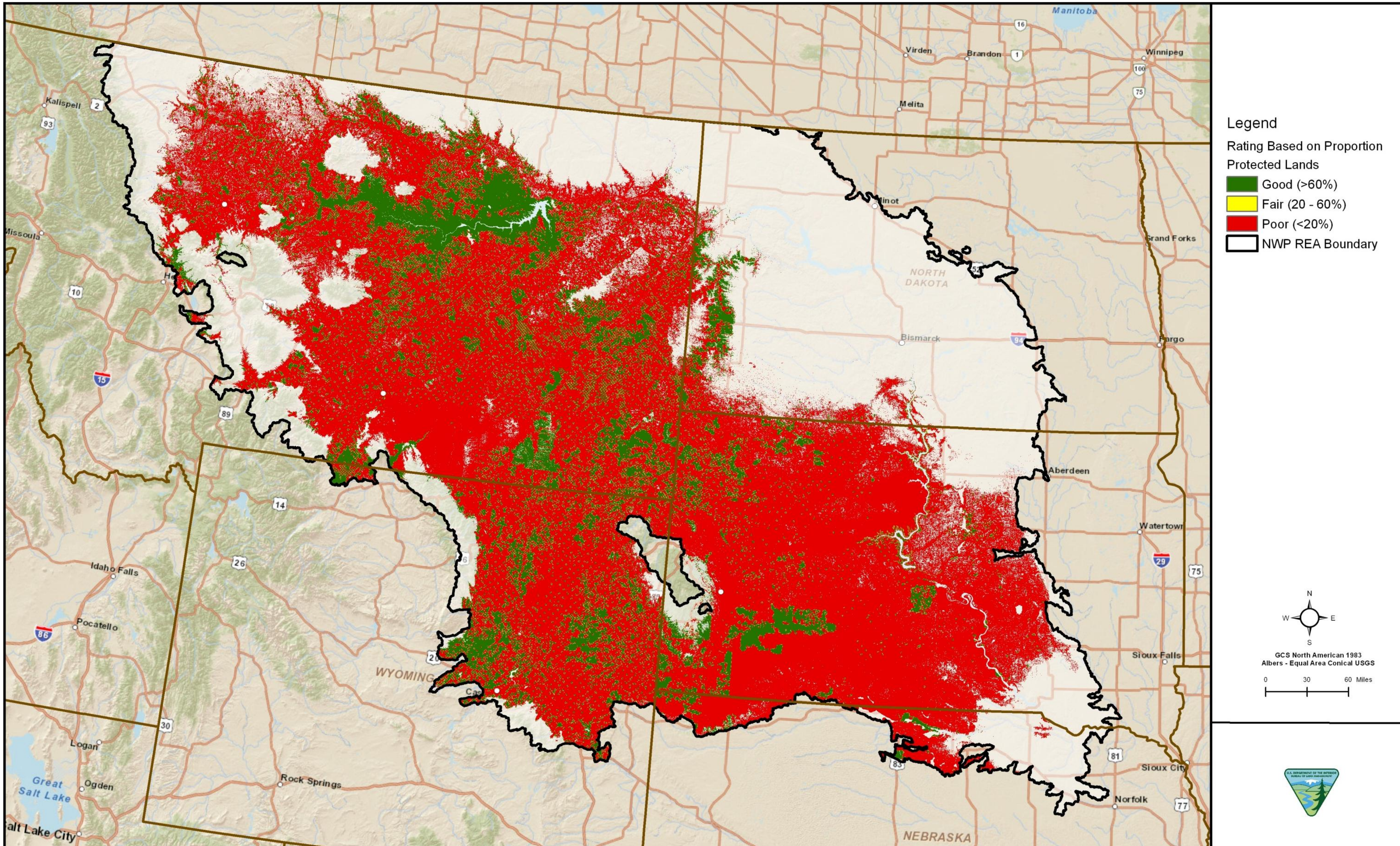

Figure E-5-16. BTPD Maxent Output on Protected Lands

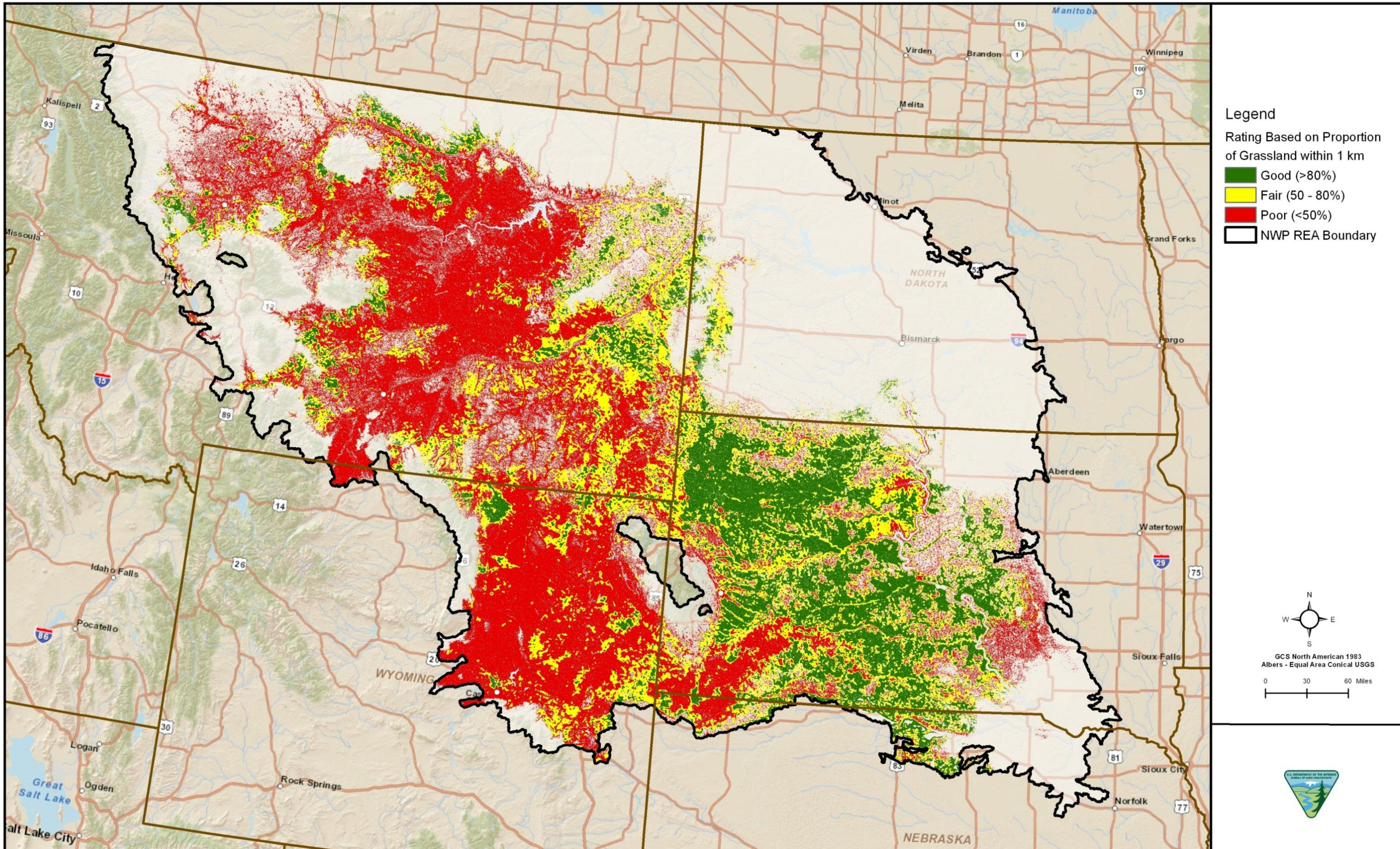

Figure E-5-17. Proportion of Grassland Habitat Relative to BTPD Maxent Output

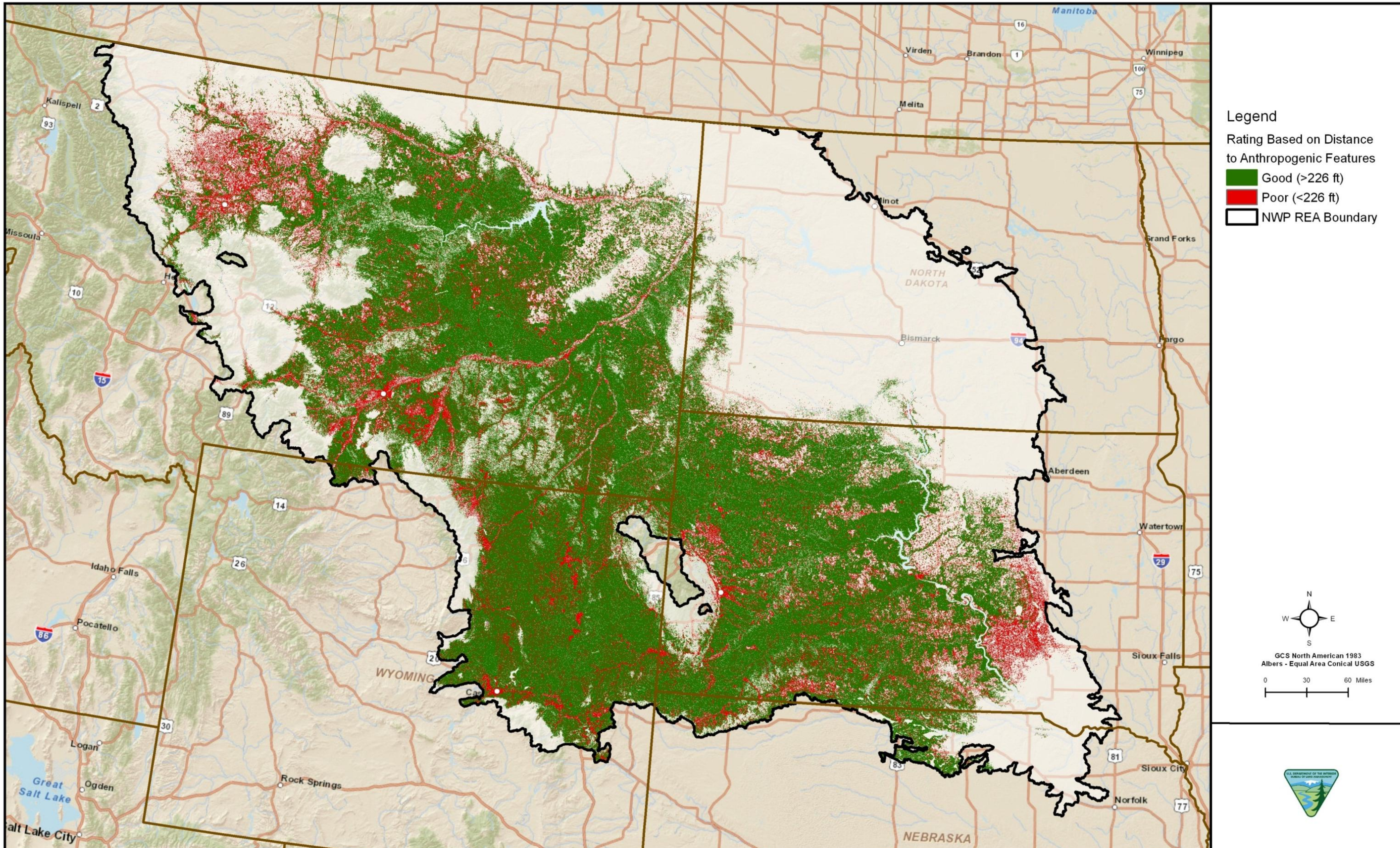

Figure E-5-18. BTPD Anthropogenic Proximity Analysis

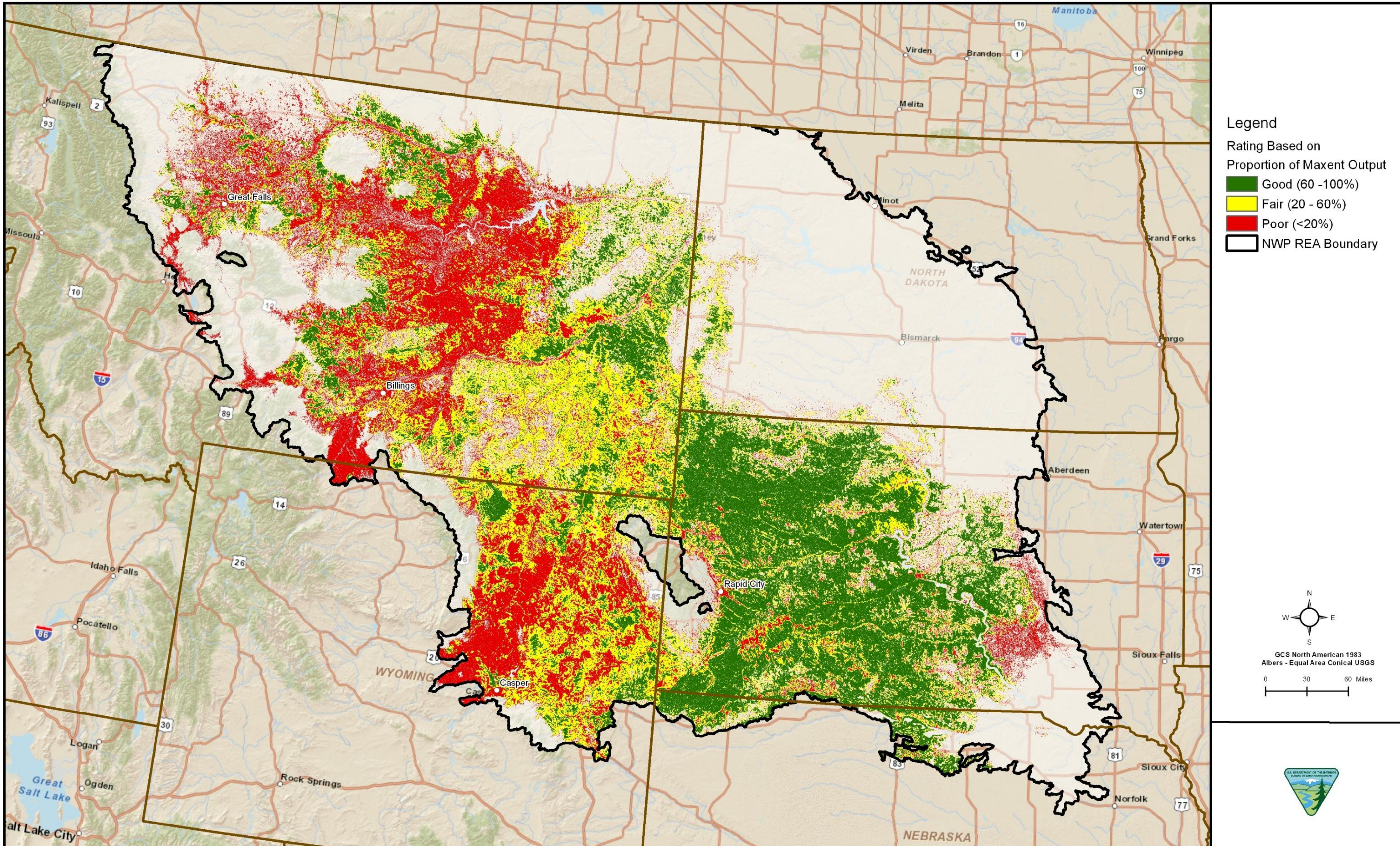

Figure E-5-19. Fragmentation of BTPD Maxent Output

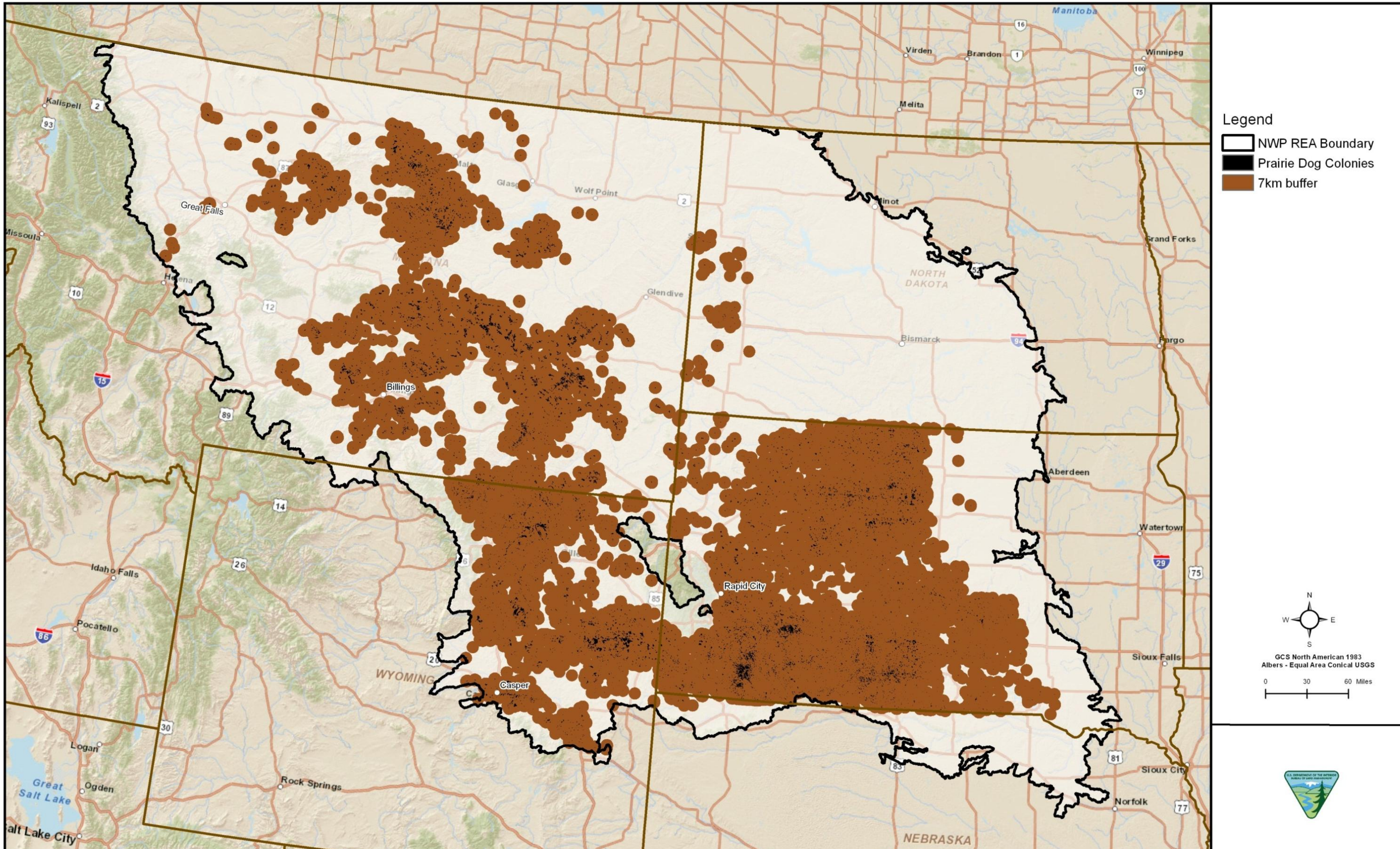

Figure E-5-20. BTPD Colony Proximity Analysis

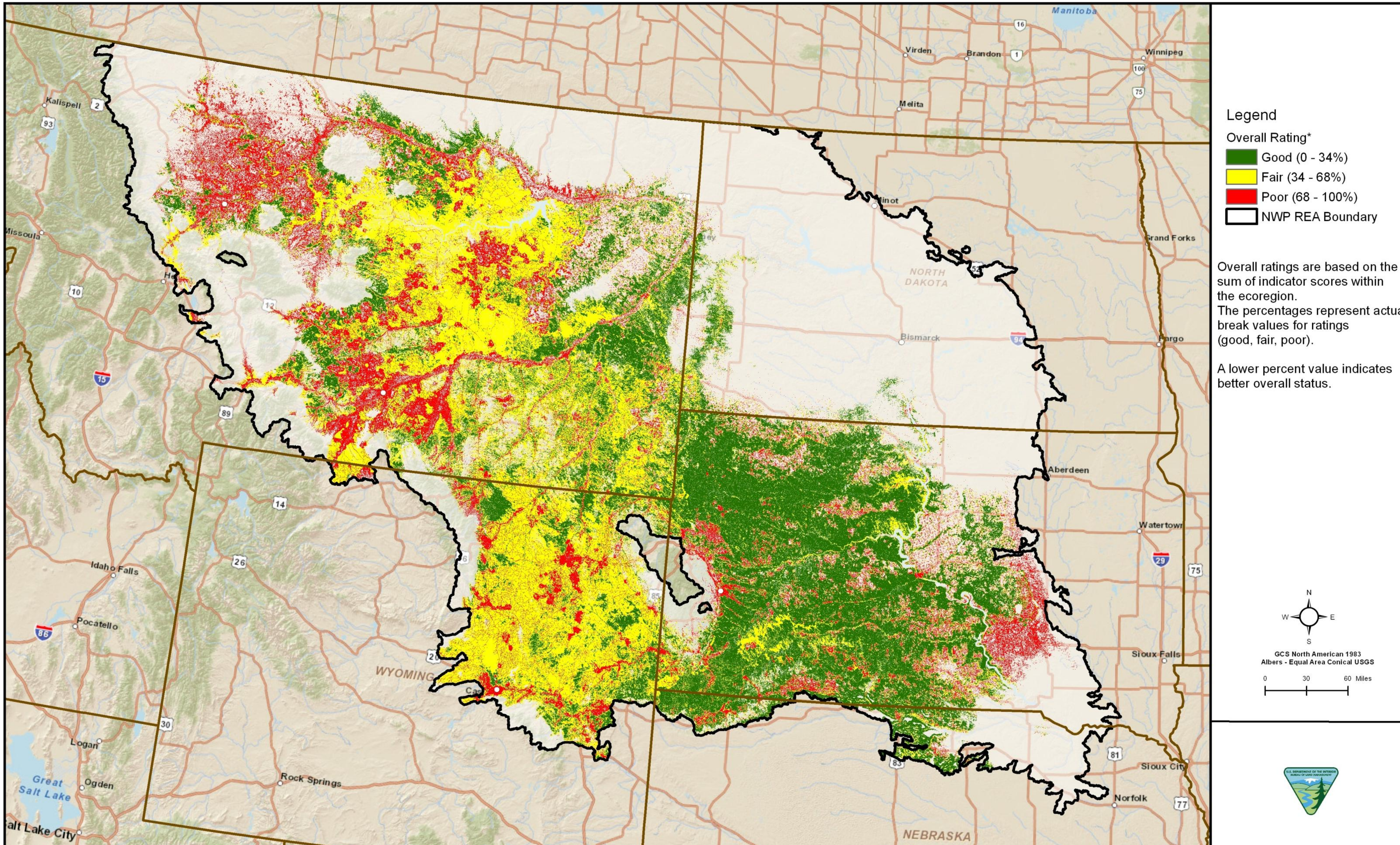

Figure E-5-21. Overall Current Status Score for the BTPD Assemblage Displayed by Pixels

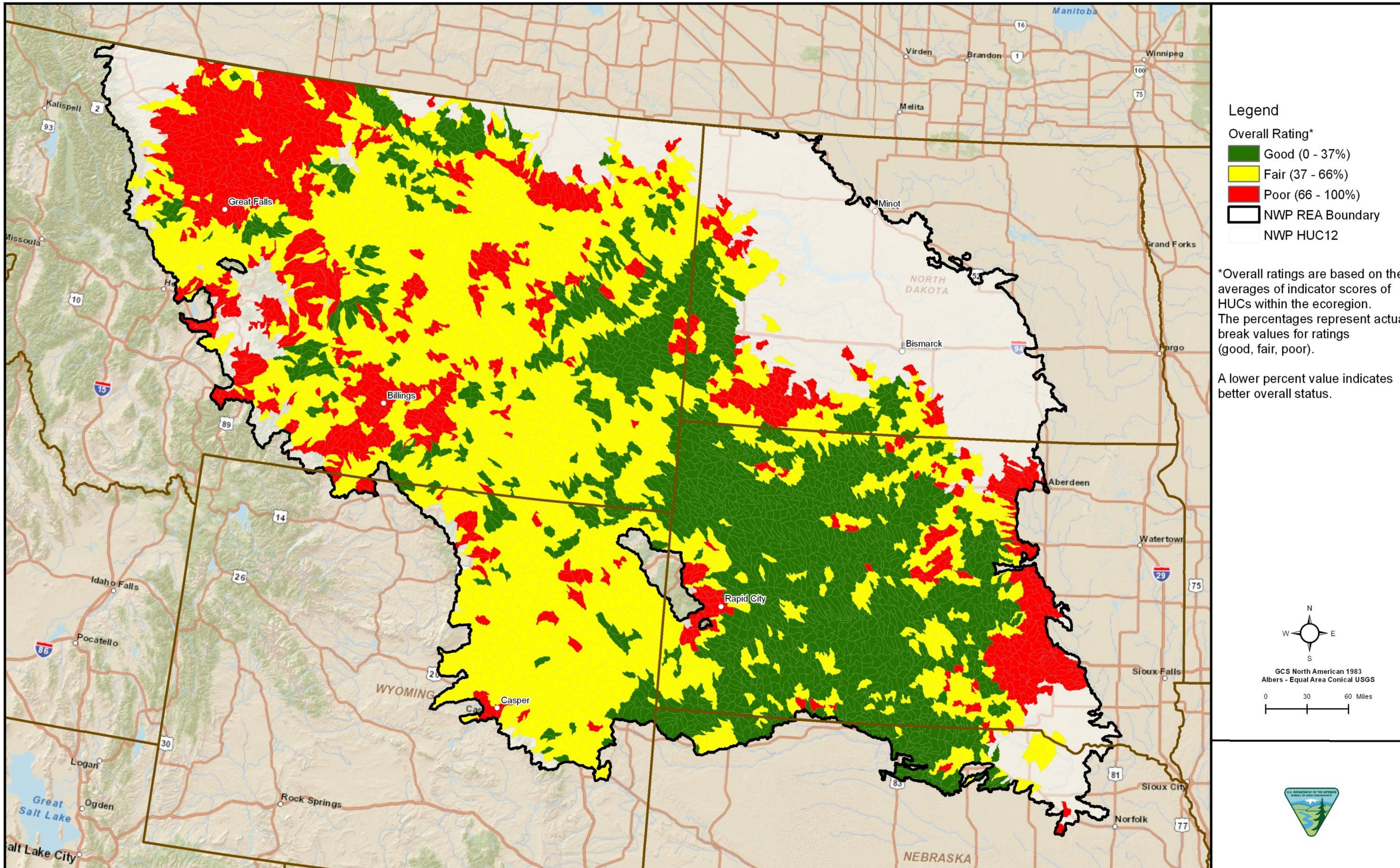

Figure E-5-22. Overall Current Status Score for the BTPD Assemblage by 6th Level HUC

ATTACHMENT A

INDIVIDUAL ASSEMBLAGE SPECIES MAXENT OUTPUTS

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LIST OF ATTACHMENT A FIGURES

Figure E-5-A1. Burrowing Owl Maxent Output WYNDD
Figure E-5-A2. Burrowing Owl Maxent Output Hirzel
Figure E-5-A3. Black-tailed Prairie Dog Maxent Output WYNDD
Figure E-5-A4. Black-tailed Prairie Dog Maxent Output Hirzel
Figure E-5-A5. Ferruginous Hawk Maxent Output WYNDD
Figure E-5-A6. Ferruginous Hawk Maxent Output Hirzel
Figure E-5-A7. Mountain Plover Maxent Output WYNDD
Figure E-5-A8. Mountain Plover Maxent Output Hirzel
Figure E-5-A9. Maxent Output (Optimal) Showing the Number of Species Overlapping
Figure E-5-A10. Maxent Output (Moderate and Optimal Combined) Showing the Number of Species Overlapping

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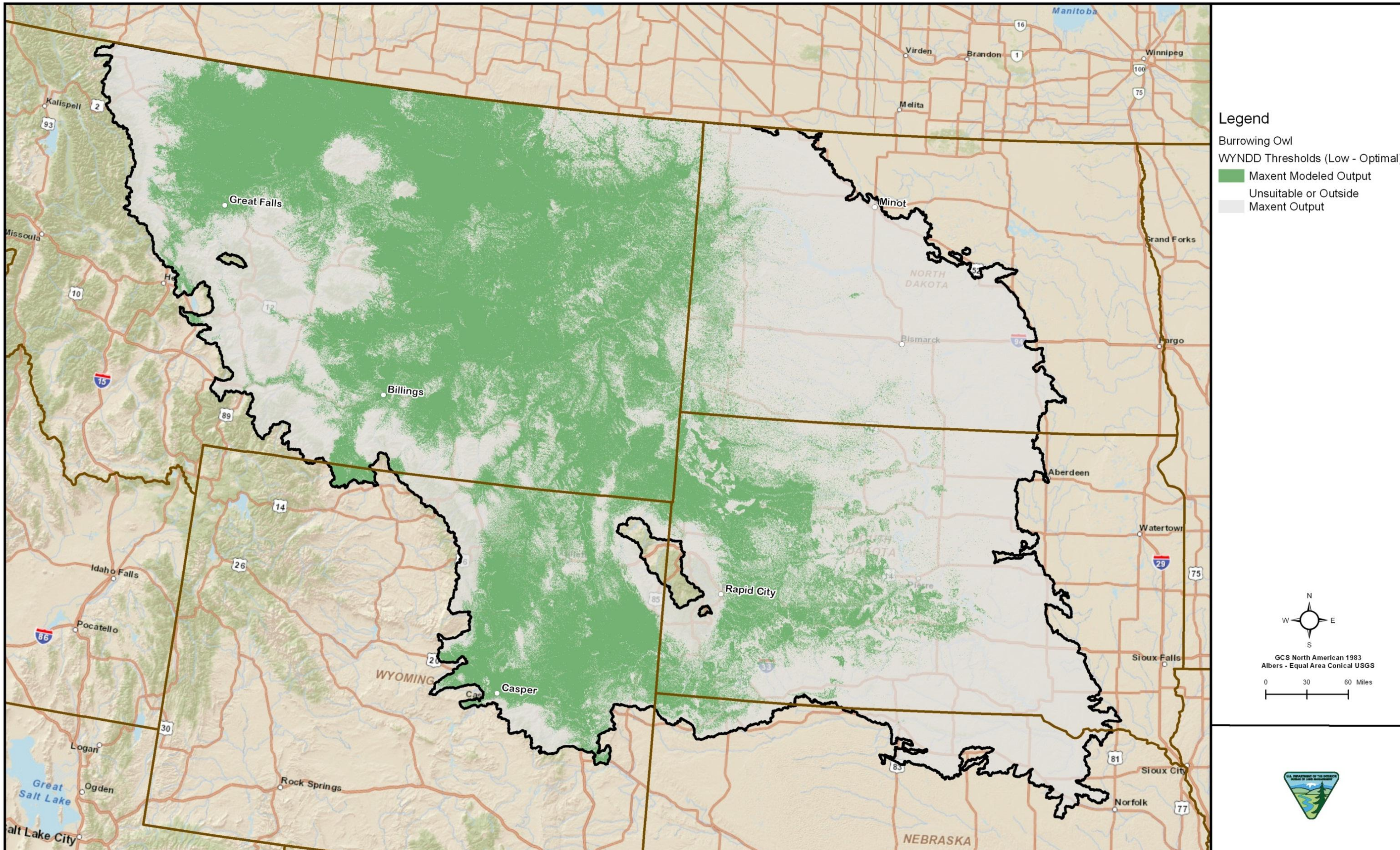

Figure E-5-A1. Burrowing Owl Maxent Output WYNDD

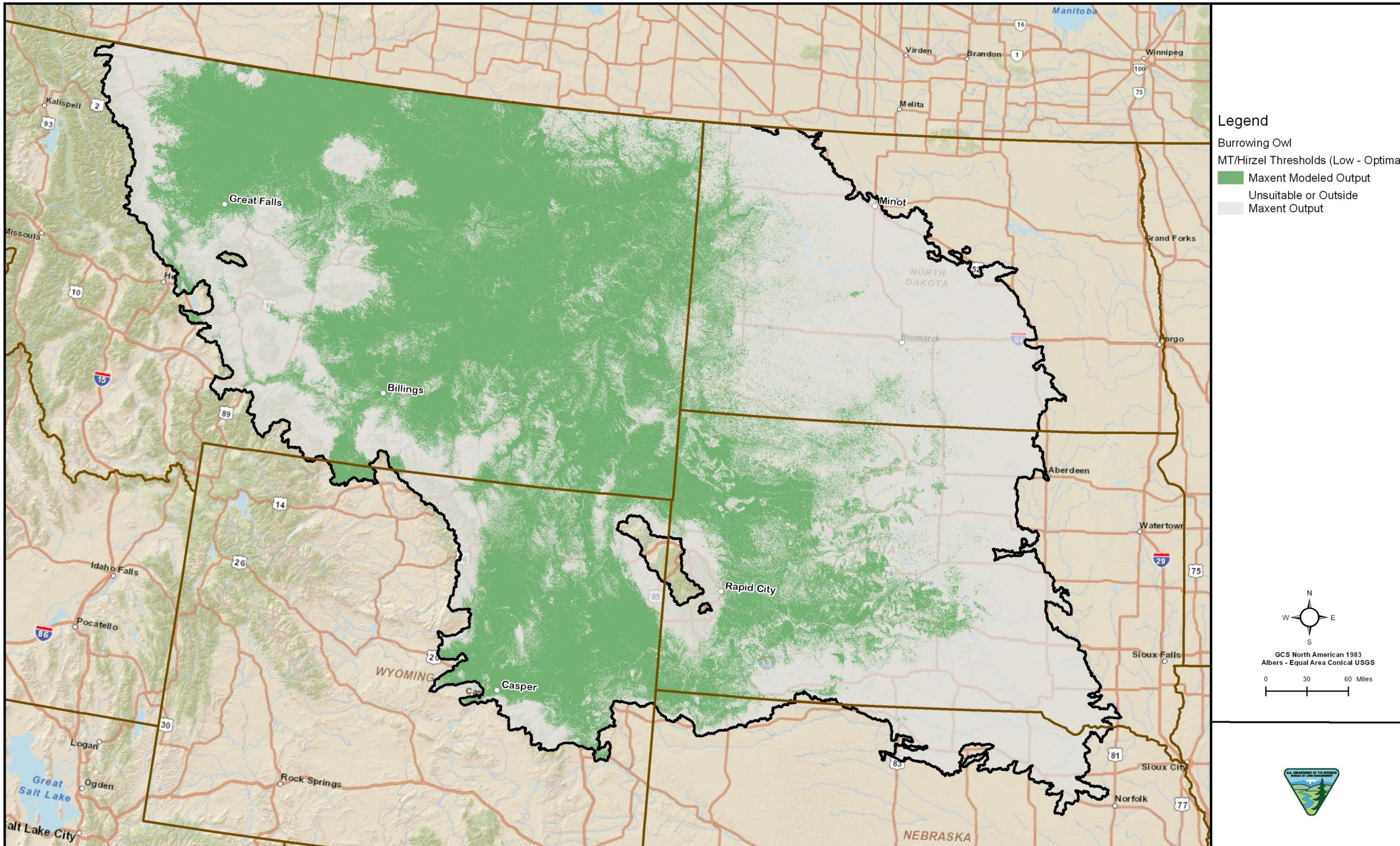

Figure E-5-A2. Burrowing Owl Maxent Output Hirzel

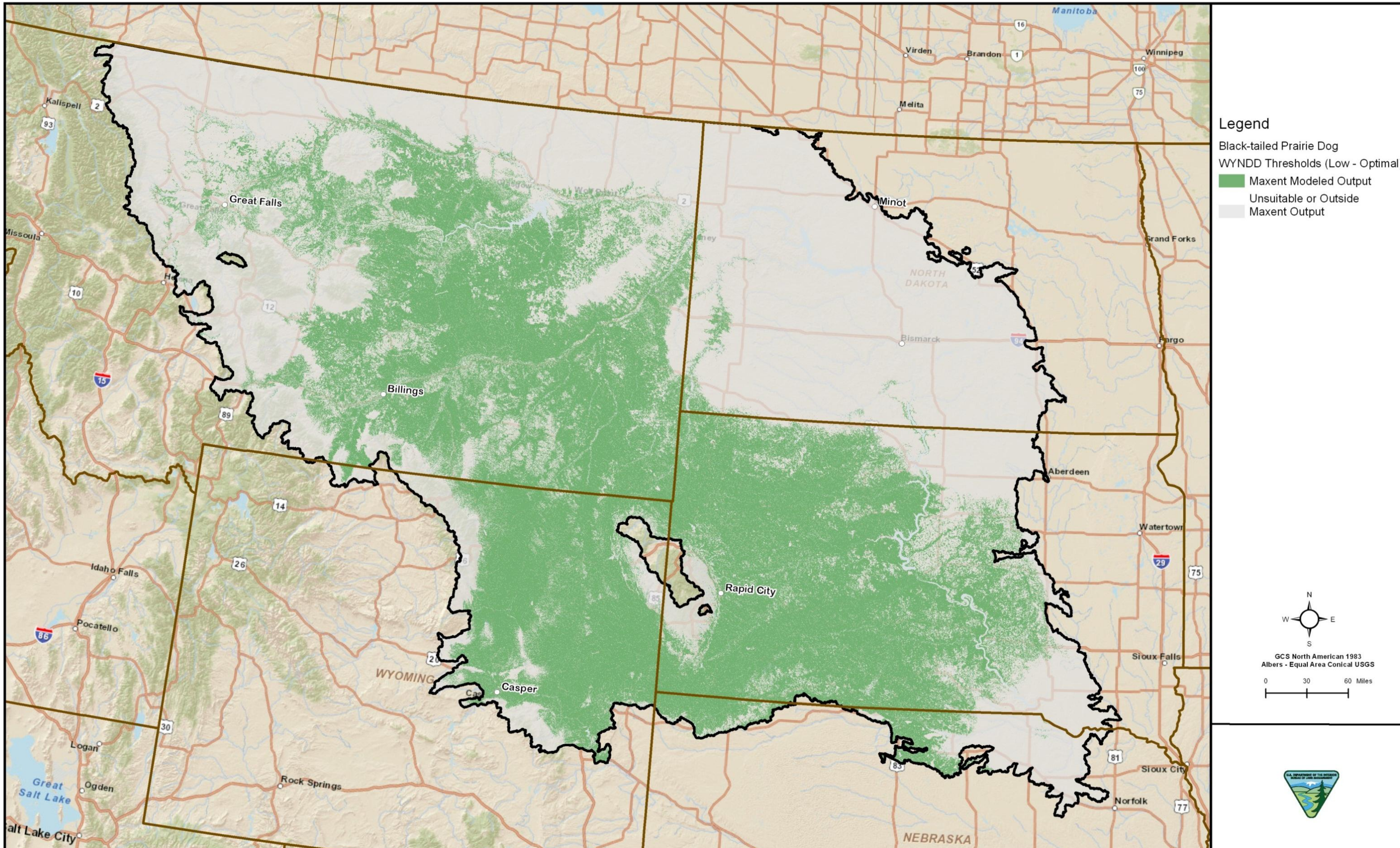

Figure E-5-A3. Black-tailed Prairie Dog Maxent Output WYNDD

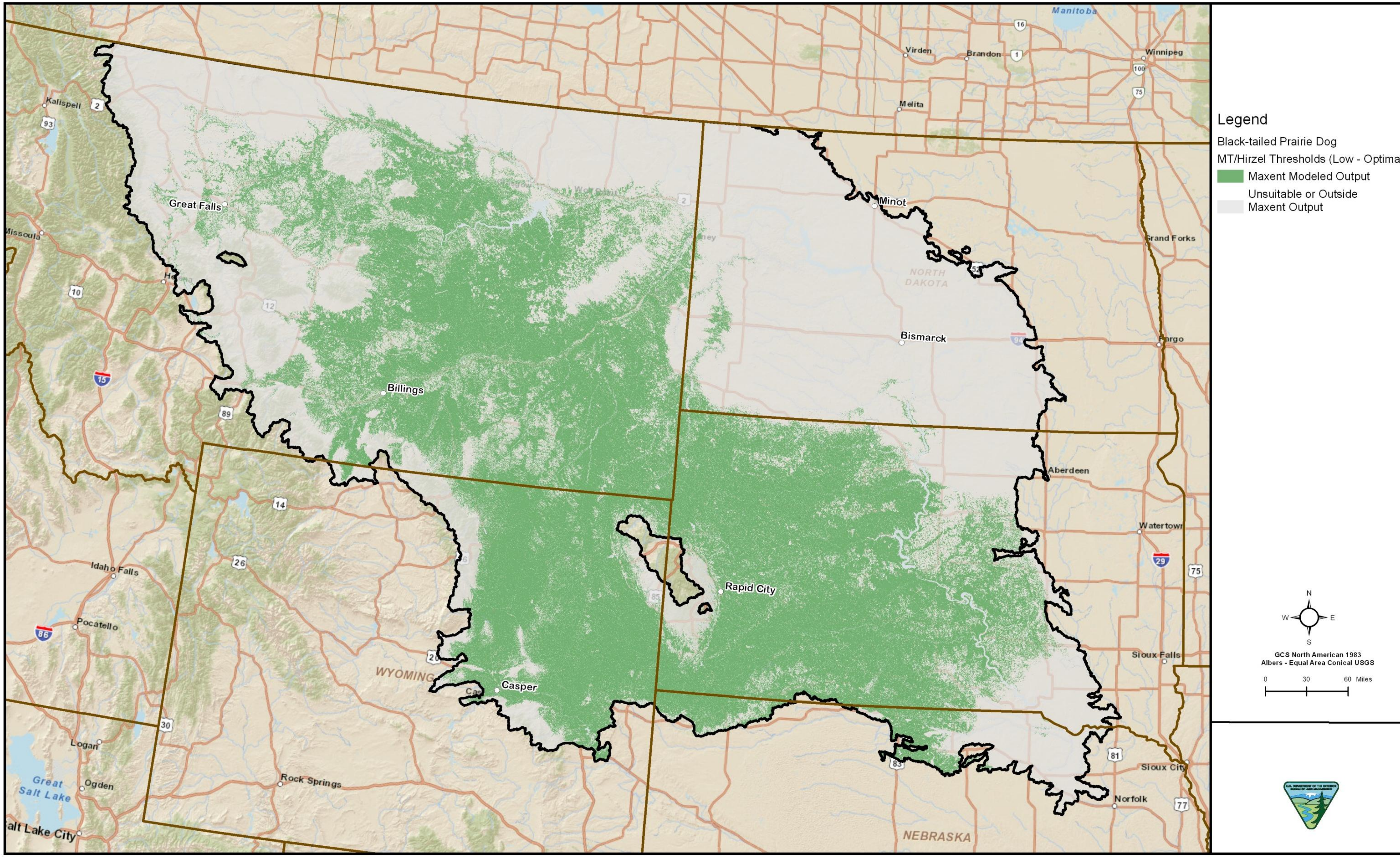

Figure E-5-A4. Black-tailed Prairie Dog Maxent Output Hirzel

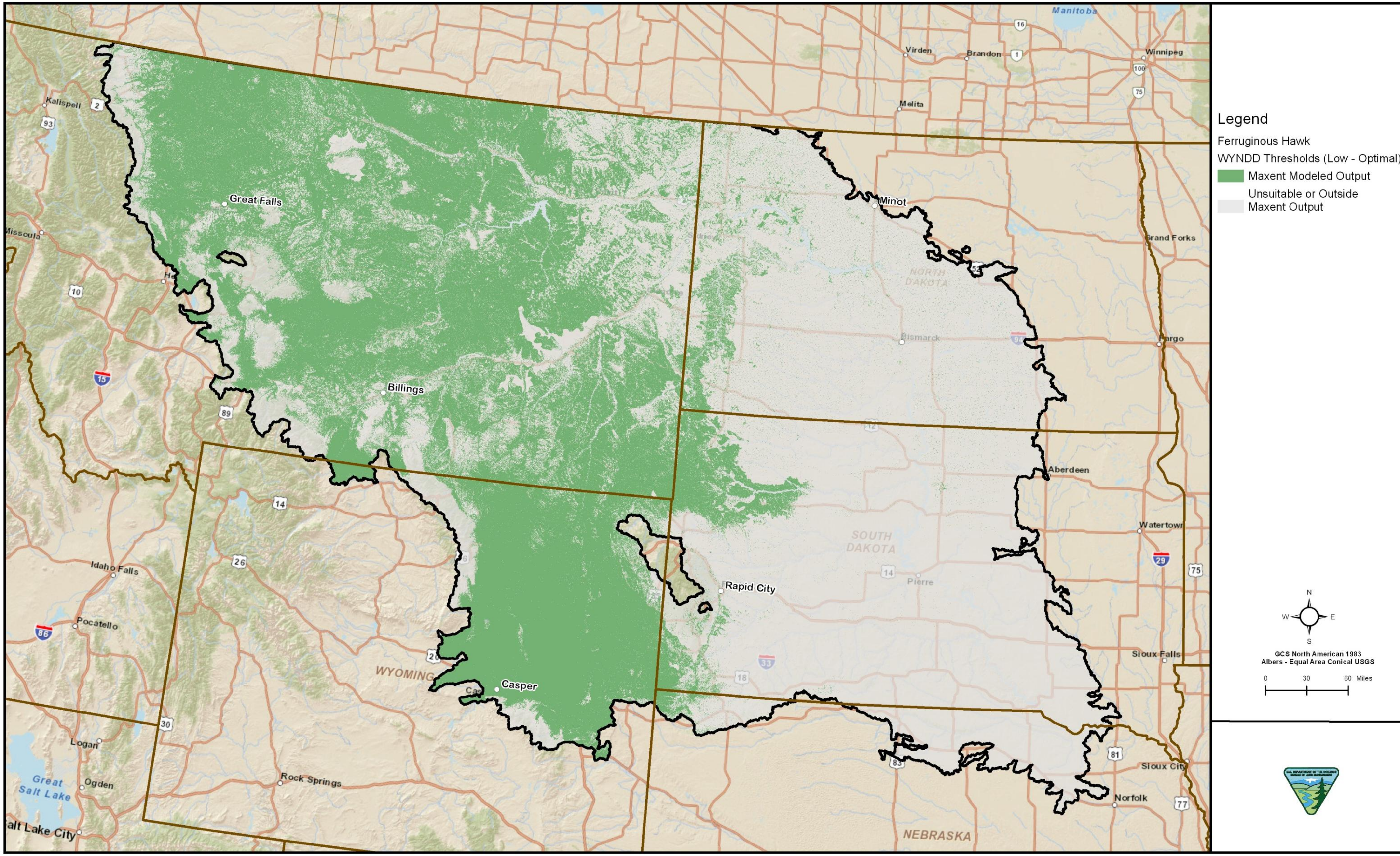

Figure E-5-A5. Ferruginous Hawk Maxent Output WYNDD

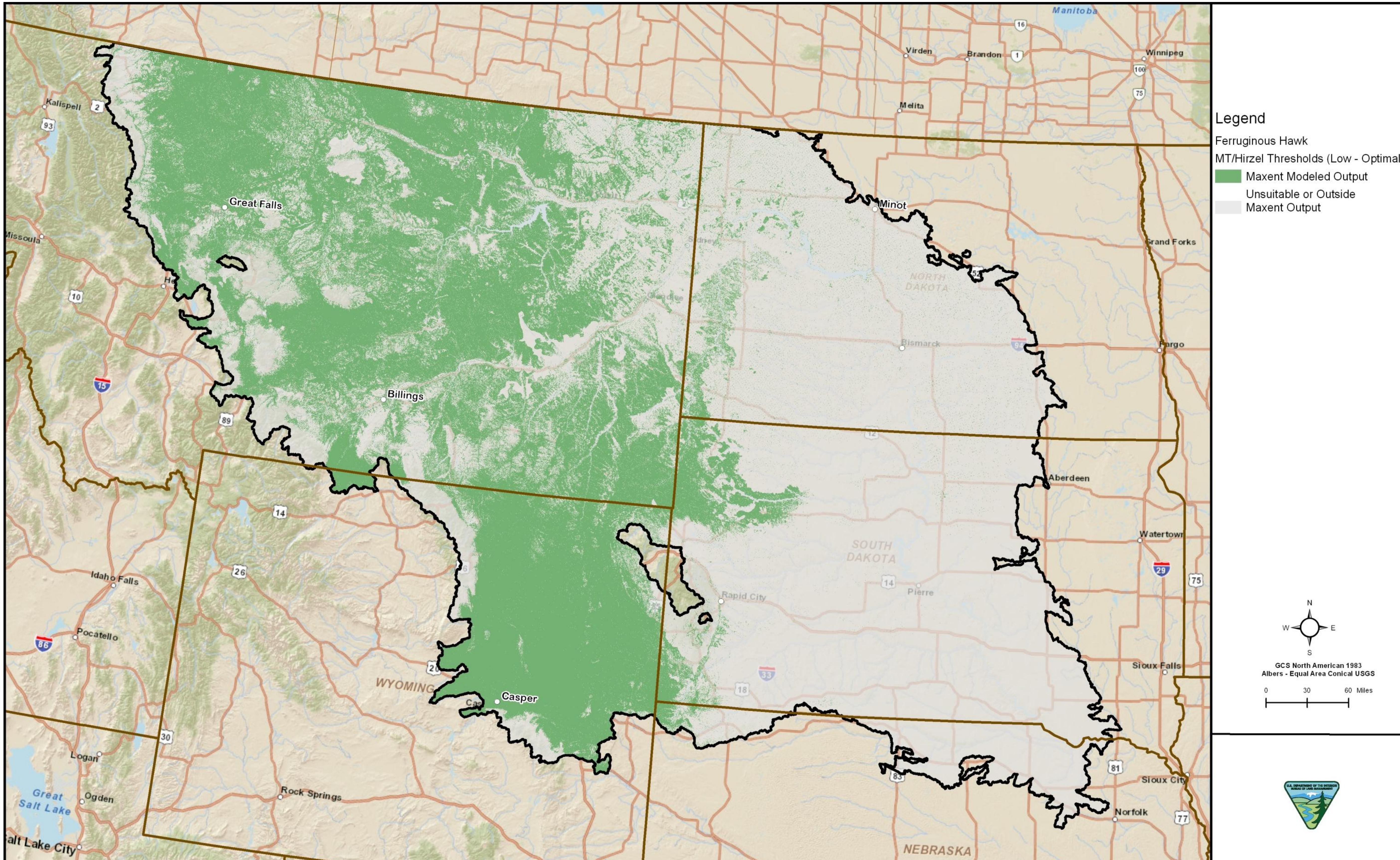

Figure E-5-A6. Ferruginous Hawk Maxent Output Hirzel

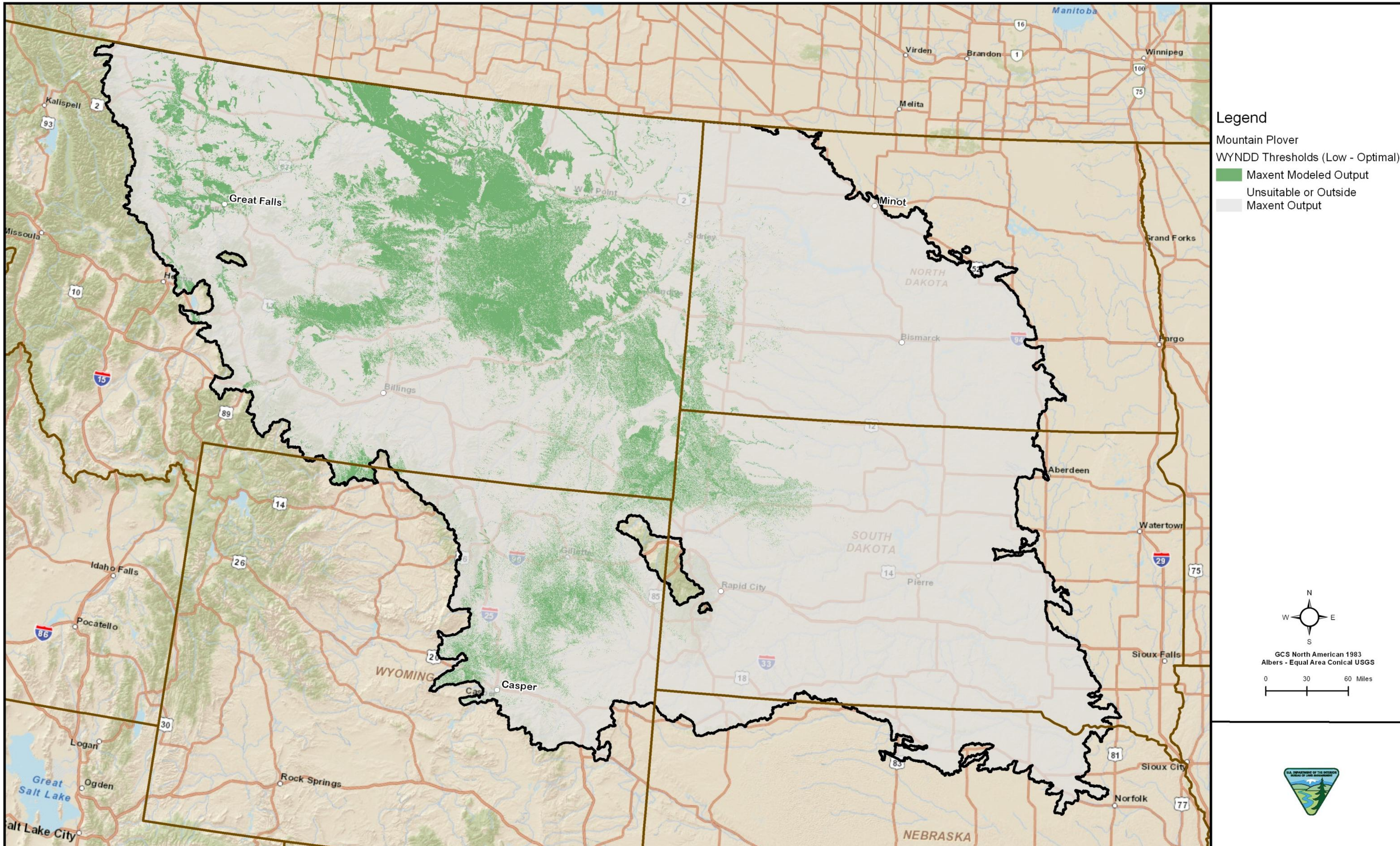

Figure E-5-A7. Mountain Plover Maxent Output WYNDD

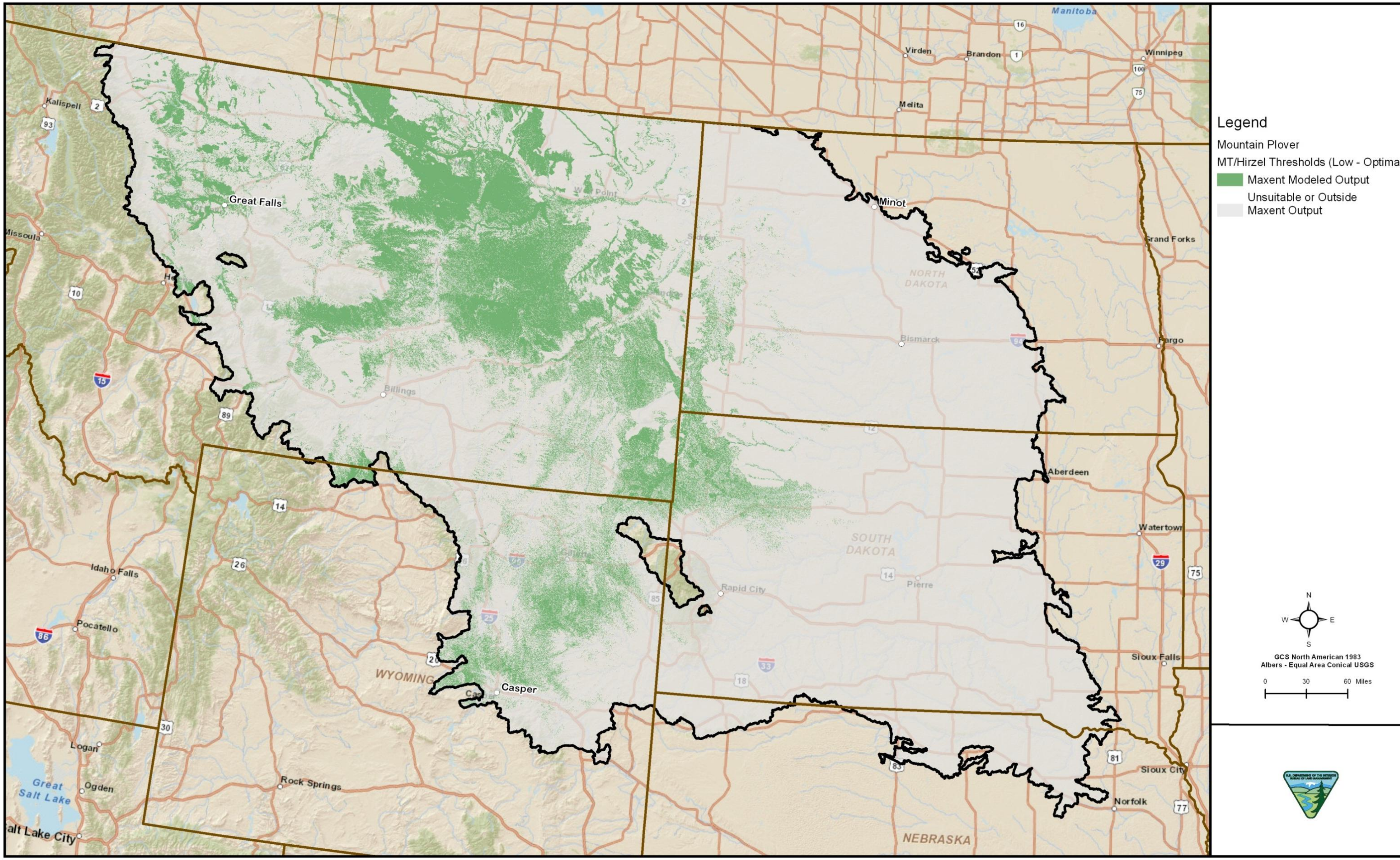

Figure E-5-A8. Mountain Plover Maxent Output Hirzel

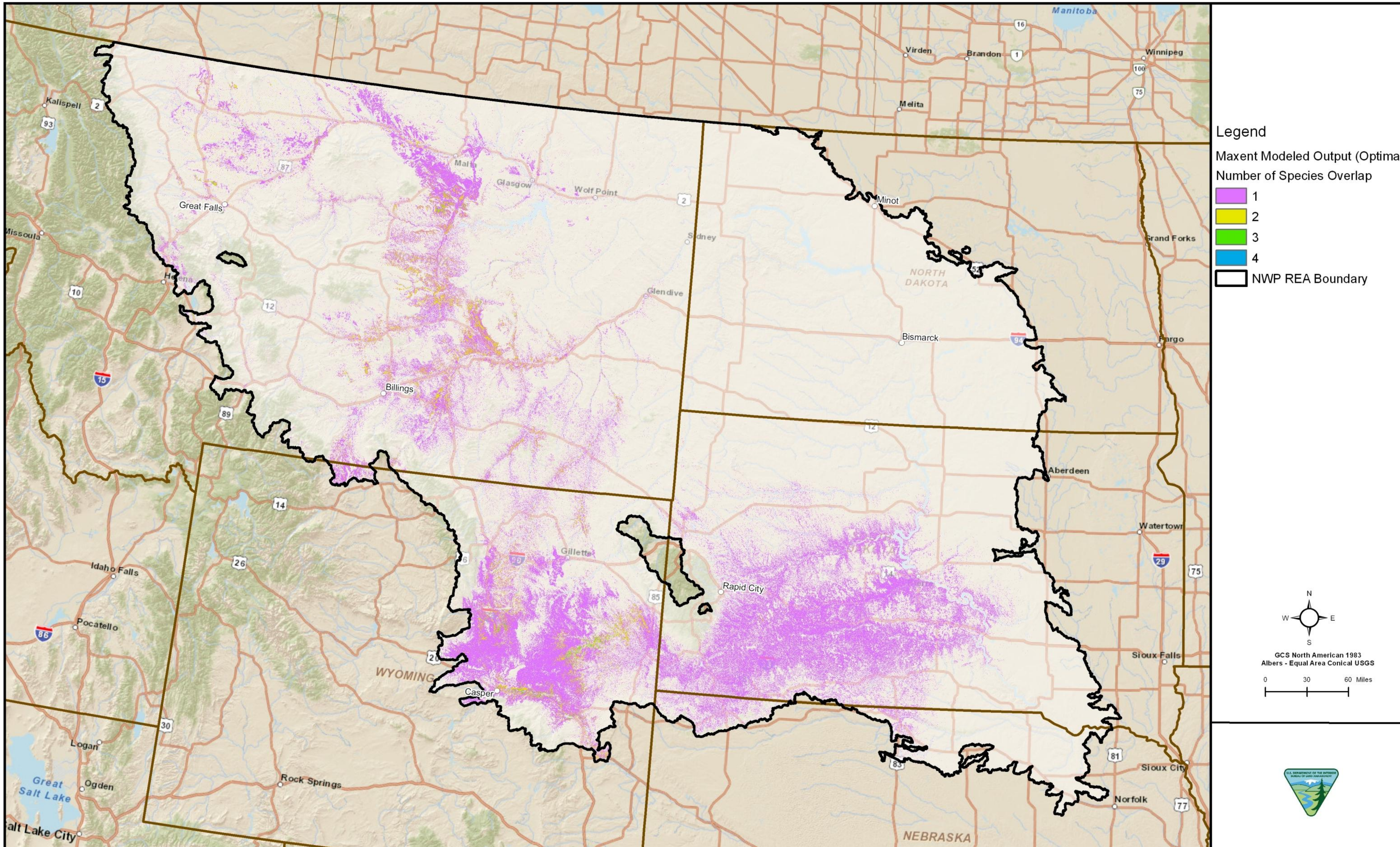

Figure E-5-A9. Maxent Output (Optimal) Showing the Number of Species Overlapping

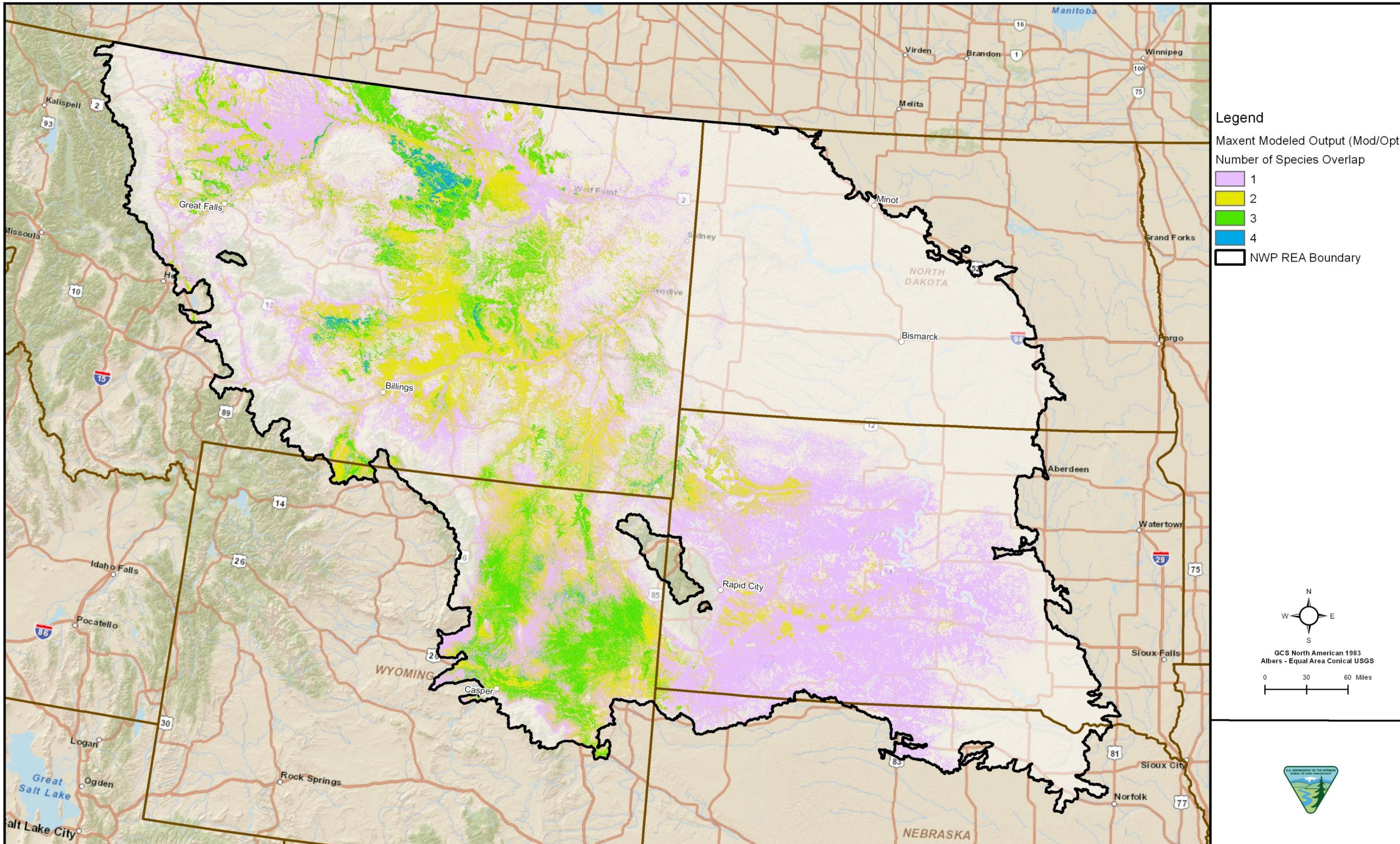

Figure E-5-A10. Maxent Output (Moderate and Optimal Combined) Showing the Number of Species Overlapping

APPENDIX E-6

PRAIRIE POTHOLE CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

Prairie potholes were identified in the original statement of work (SOW) as a potential conservation clement (CE) for this ecoregion. At Assessment Management Team (AMT) Workshop 1, it was recognized that potholes in the formerly-glaciated terrain of the northern and eastern part of the ecoregion are essential for waterfowl and shorebird breeding and migratory stopovers along the North American Central Flyway. These potholes form a part of a system of international importance. However, because they comprise such a small percentage of the ecoregion area, there was concern that they would be underrepresented in this coarse-filter analysis. Given this concern and the importance of their resources in the ecoregion, they were included as a fine-filter CE.

A variety of the management questions (MQs) identified in Task 1 apply to this CE. Many of the MQs can be summarized into three primary questions: 1) where are the important areas for this CE? 2) where are these areas currently at risk from anthropomorphic influences? and 3) where are prairie pothole strongholds that are intact, protected, and likely sustainable? The intent of the process described herein is to answer the MQs applicable to this CE.

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2.0 CONSERVATION ELEMENT DESCRIPTION

Geologic processes from the last ice age generated extensive areas of pothole wetlands throughout the northwestern glaciated portion of this ecoregion. Various ice sheets, originating in Canada, provided the dominant forces for the creation of potholes. Wetlands in these landforms have evolved in response to biotic and abiotic processes that continue to the present, providing the wetland systems that in turn provide habitat for abundant waterfowl and other wildlife.

Prairie potholes encompass millions of depressional wetlands of glacial origin that constitute one of the richest wetland systems in the world and occur over 300,000 square miles of prairies in the north-central United States and south-central Canada. These highly productive systems support an incredible diversity of bird life, including breeding habitat for many wetland and grassland birds, and support significant numbers of spring and fall migrants. Once a vast grassland, the prairie pothole region is now an agrarian system dominated by cropland (PPJV 2010). With much of the wetlands and grasslands of the Midwest converted to agriculture and just 2 percent protected within the National Wildlife Refuge System, the prairie pothole region still produces 50 percent of North America’s breeding waterfowl population (USFWS 2011).

Because of their value to the environment, prairie potholes have been the focus of in-depth evaluation for many years. A wide variety of literature specific to measuring the value of wetlands is available. However, many of the metrics used are not applicable at a landscape scale and are directed toward small-scale evaluations. For example, the presence of vegetated buffers surrounding wetlands is one of the metrics that is commonly used to determine the quality of the wetland. However, at a landscape scale, and with the sheer number of units that occur in the Rapid Ecoregional Assessment (REA) buffer, determination of every pothole would not be practical for this process.

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3.0 CONSERVATION ELEMENT DISTRIBUTION MODELING

In order to answer the MQs regarding the location and status of this CE across the Northwestern Plains ecoregion, a variety of the sources were used for mapping prairie potholes. The modeling for this CE was dependent upon the data available from state and federal agencies. Because no boundary of the potholes area of this ecoregion was provided, we used the boundary of the Northwest Glaciated Plains as the extent of the potholes area in the Northwestern Plains ecoregion. This boundary provided a starting point for the identification of data to support this analysis.

3.1 DATA IDENTIFICATION

As part of the pre-assessment process, a thorough search for a comprehensive wetland dataset for the ecoregion was completed. The only standard comprehensive dataset that currently exists is the National Wetlands Inventory (NWI). Fortunately, the NWI is complete and in digital format for the area of potholes in the Northwestern Plains ecoregion.

Table E-6-1 lists the types of data and data sources that were originally proposed for use in the REA as part of the pre-assessment data identification effort. This table lists the need for the data, the general name of the dataset, if the dataset was acquired, and if the data were used.

Table E-6-1. Data Sources for the Change Agent Analysis

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
GIS mapping	Ecoregion	U.S. Environmental Protection Agency (USEPA) National Health and Environmental Effects Research Laboratory (NHEERL)	Area	Acquired	Yes
Watersheds	5th level Hydrologic Unit Codes (HUCs)	U.S. Geological Survey (USGS)	Polygons	Acquired	Yes
Water habitats	Water	Gap Analysis Program (GAP)	Raster	Acquired	Yes
	National Hydrological Database (NHD)	USGS		Acquired	Yes
	NWI	U.S. Fish and Wildlife Service (USFWS)	1:24,000	Acquired	Yes

3.2 DISTRIBUTION MAPPING METHODS

In order to answer the MQs regarding the locations of prairie potholes across the Northwestern Plains, a variety of data sources were needed. The portion of the prairie potholes region considered for this REA occurs across northern Montana, through northwestern and central North Dakota, and through central South Dakota. To define the extent to be used for our analysis, we first obtained geographic information system (GIS) mapping of defined ecoregions from the U.S. Environmental Protection Agency (USEPA) National Health and Environmental Effects Research Laboratory (NHEERL) Level III classification system (2003). We merged the layer for the Northwest Glaciated Plains with the fifth level Hydrologic Unit Codes (HUCs), our unit of analysis for this CE, to create an outline of the study area extent. After defining the boundary of the potholes area, it was important that a process for identifying pothole wetlands be developed. Montana Fish, Wildlife and Parks provided their process for mapping wetland areas on the Crucial Areas Planning System (CAPS). Because the data used in their process were not available for all of the states included in the boundary of the potholes area of this ecoregion, this process was used, with slight modifications, as explained in the following list of steps.

1. Clip the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) layer to the ecoregion boundary.
2. Merge all NHD basin water bodies into single layer.
3. Remove Ice Mass and Reservoir categories.
4. Obtain the NWI dataset.
5. Clip the NWI dataset to the ecoregion boundaries.
6. Select all wetlands from NWI that include the word "impounded" in the description.
7. Intersect the NHD layer with the NWI layer.
8. Remove all wetlands in the NHD layer that intersect "impounded" NWI wetlands.
9. Obtain the GAP Landcover Dataset.
10. Combine all wetland land cover classes from the GAP Landcover into single raster layer.
11. Identify patches of wetlands from this layer and convert to polygons.
12. Overlay the NHD wetlands described above with the GAP Landcover wetlands to develop unique wetland boundaries for all overlapping polygons.

A combination of ecoregional knowledge, satellite imagery, other remotely sensed data, and map digitization provides a more accurate picture of what can be tiny but numerous occurrences of prairie potholes across the ecoregion landscape. Because the data sources mentioned above contain all types of water body data, we retained only those for emergent freshwater wetlands to narrow the focus closer to true prairie potholes, which occur as bodies of water in glacially-formed depressions that are primarily disconnected from other river and stream systems. This required removing other elements such as open water, ponds, ice mass, lakes, impounded waters, and reservoirs. Even with this effort, some wetlands connected to rivers and streams remained in the data layer and are likely not prairie potholes, but represent wetlands nonetheless.

The Montana Natural Heritage Program (NHP) is in the process of re-mapping wetlands for the state using the latest National Agricultural Imagery Program (NAIP) data and offered to provide Science Applications International Corporation (SAIC) with results. However, because the other pothole states did not have similar mapping to complete the ecoregion study area, these data could not be used for the mapping distribution process as they may have skewed or biased our results. Figure E-6-1 presents the distribution map for the prairie potholes CE.

4.0 CONCEPTUAL MODELS

Conceptual models were developed as part of the pre-assessment phase to understand the key factors that are important to prairie potholes. In addition, these models were developed to understand the relationships that all of the potential CAs could have on the CE regardless of the availability of data.

The current status and potential future threat analyses were based on an analysis using Key Ecological Attributes (KEAs) of the CE-specific ecological conceptual model. Selection of KEAs focused on those likely to result from the CAs, and most importantly, was based on the availability of data. The CAs initially considered for this CE analysis included development, climate change, and invasive species. However, after review of the data available for the CA analysis, only development and climate change could be represented in a geospatial format relative to the distribution of this CE. Although maps for climate change were developed, the scale of the models was not conducive to comparing the output; therefore, the potential risks related to climate change are explained in a qualitative manner. Further information on the data gaps for CAs are discussed in the respective CA analyses contained in Appendix C.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model (Figure E-6-2) was developed to identify and link the key processes to ecological attributes (EAs) that have the greatest potential to be affected, and in turn, to affect prairie potholes throughout the ecoregion (Table E-6-2). The key processes that drive the prairie pothole CE (e.g., inputs and outputs) are regulated by the seasons (green arrows and boxes on Figure E-6-2). Following Unnasch et al. (2009), three broad categories with which to assess CEs are size, condition, and context, and applicable EAs within these categories are identified on the model as blue diamonds. Size refers to attributes related to habitat or patch size and the proportion of the CE within its landscape, condition refers to the condition of the habitat for its values and ability to sustain itself, and context refers to the spatial relationship of the CE within the landscape in relation to other influences. At the landscape level, some of the EAs will be modeled using surrogates and applicable spatial data available to model the concept.

Table E-6-2. Key Ecological Attributes Retained or Excluded

Category	Key Ecological Attribute		Explanation
1. Size	a.	Pothole size	Retained to show where the larger potholes are located.
	b.	Proportion of land cover listed as wetland	Retained to show where potholes are congregated throughout the ecoregion.
2. Condition	a.	Proportion of developed land within 5 km^2 radius	This KEA was dropped because KEAs 3b through 3e completed the same analysis.
	b.	Potholes located on protected lands	Retained to show the relative protection of potholes from agriculture.
	c.	Perimeter to area ratio	This KEA was added to show identify the potholes with a large amount of edge versus just large size.
3. Context	a.	Density of potholes per land cover unit	This KEA was combined with 1b because both KEAs were attempting the same analysis.
	b.	Distance from urban/exurban housing density	This KEA was retained to show the distance of potholes relative to anthropogenic disturbance.
	c.	Distance from agricultural lands	This KEA was added at the recommendation of the RRT to show the proximity to existing agriculture.
	d.	Suitability for cropland based on soil type	This KEA was added at the recommendation of the RRT to show the risk for potholes to be converted to cropland based on soil types.
	e.	Distance from intense development	This KEA was added to show the proximity of potholes relative to intense development defined as oil and gas wells, mines and TIGER roads combined into one layer.

4.2 SYSTEM-LEVEL MODEL

The system-level conceptual model (Figure E-6-3) illustrates the interactions between the CAs and the prairie potholes. The position of prairie potholes as physical depressions in the relatively flat Northwestern Plains landscape dictates the types of system inputs that may result in effects. Water is supplied to the potholes by precipitation on the water surface, basin runoff, and seepage inflow of groundwater (Sloan 1972). Potholes experience the greatest effects from changes in adjacent land uses or hydrology (aboveground inputs or groundwater/water table changes), which may directly alter the function of these systems. Secondary or indirect effects to prairie potholes include sediment/nutrients/toxins entering the system that could change basin size, depth, water quality, or soil composition. Impairment to these types of functions may in turn adversely affect buffer vegetation composition and/or structure, which also affects wildlife habitat quality and recreational values of prairie potholes. The CAs identified for this CE may ultimately affect prairie pothole functions and values, ecological integrity, or the biodiversity that can be supported.

The system-level conceptual model (Figure E-6-3) illustrates the interactions between the identified primary CAs and the habitat functions and values of the prairie pothole CE. The two primary CAs identified as having the greatest influence on the prairie pothole CE and its future condition in the landscape are identified in red boxes: development (using a broad definition of all human-related land disturbances) and climate change, with its predicted effects to temperature, precipitation and drought. The KEAs likely affected by CAs are included in the system-level model under CAs (Figure E-6-3). In order to provide data gap information, the system-level model includes not only KEAs that are anticipated to be represented geospatially, but also additional ones that represent data gaps or that are at a scale that is not suitable for use in the larger-scale REA process. However, these KEAs may help resource managers develop additional methods for evaluating and assessing quality of local prairie pothole systems to further refine and compliment REA findings. For example, water quality is of primary importance in determining health and value of a prairie pothole, but there is no remote sensing or geospatial way to directly assess water quality. Some surrogate methods to obtain water quality effects were evaluated throughout the REA process. These included proximity analyses from agriculture or urban areas.

Interactions among CAs are indicated in the system model (Figure E-6-3) with interconnecting arrows. Research continues on the causes and accelerations of climate change effects being measured today and may pinpoint more human causes in the future. Potential sources of change effects on prairie potholes that may result from CAs are listed in the blue landscape effects box. Several of these are not measurable on the REA scale at this time, but may become important to evaluate in future investigations. For example, alterations in timing and intensity of seasonal temperatures and hydrologic inputs under future climate change scenarios affect phenological occurrences of plant blooming periods and bird migrations (Visser and Both 2005).

Basic functions and values important for prairie potholes are similar to those monitored for other wetland types. These functions and values include groundwater recharge, surface water permanence, toxins filtration, and water quality. These functions and values are included in the yellow box on Figure E-6-3. Two additional attributes for which many potholes may have been preserved is for their outstanding fish and wildlife habitat qualities, which translate to hunting and fishing opportunities for midwesterners. Monitoring these types of attributes measures the natural range of community variability fluctuating from low ecological integrity or community degradation to high integrity. These attributes can be expected to change in response to outside drivers, or CAs. Varying types and intensities of CAs can push the state of pothole systems in either direction, to states of higher CE value and ecological function or to states of lower value and function. Examples of potholes in degraded states are those in cropland-dominated watersheds (Kantrud and Newton 1996) and those of reduced overall size that are vulnerable to disappearing as a result of drought or sedimentation. For some of these attributes, accurate metrics are not practicable on the ecoregional scale.

Once the ecological process and system-level models were developed, indicators for the KEAs were identified, with a specific emphasis on the ability to measure the KEAs using existing geospatial data. The indicators will assist with answering the MQs that relate to what is happening to the CE across the ecoregion.

4.2.1 Development

The primary risk to potholes relating from development is through agricultural conversion. Draining and conversion of prairie pothole wetlands into agriculture account for up to 50 percent net loss of prairie pothole habitat since the time of European settlement. Today, more than ever, high grain crop prices and unlimited crop insurance subsidies threaten this CE more than any other CA. New analysis from the Environmental Working Group shows that increased crop production is leading to grassland and wetland loss. It has been documented that between 45,000 and 70,000 acres of grassland and wetland habitat has been plowed under in some counties in southeastern Montana in the last three years (Environmental Working Group 2012).

4.2.2 Climate Change

Prairie potholes are at risk in a variety of different ways from climate change. Climate change has the potential to directly affect potholes through decreases in precipitation and increases in temperature, which ultimately causes potholes to dry up. These changes indirectly affect potholes by allowing agricultural conversion of areas that might have been too wet for crops in the past. Locations of habitats are expected to change under many climate change scenarios. Some models have projected dramatic spatial shifts in specific grassland habitat conditions, which could prove problematic for potholes and associated species that utilize potholes. Precipitation has a pronounced effect.

The climate change CA analysis located in Appendix C-5 provides descriptions and maps of the areas of the Northwestern Plains potentially at risk from climate change.

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5.0 CHANGE AGENT ANALYSIS

Current status and future threat assessments for the prairie potholes were conducted for the Northwestern Plains ecoregion using both 30-meter (m) pixels and the HUC 12 as the analysis units. Based on the ecological process and system-level models, KEAs were identified for the CA analyses, with a specific emphasis on the ability to measure risks using existing geospatial data. The development CA is evaluated for current status. The CAs evaluated for future threats include development and climate change.

As Kantrud and Newton (1996) realized, there is no quantification for wetland health or quality, and no standards against which degree of degradation can be measured. Another characteristic of pothole wetlands is instability, which contributes to their value for wildlife. Unnasch et al. (2009) stated that ecosystems are far too complex to be fully represented by a static suite of metrics and attributes. Despite these challenges, we have attempted to identify indicators that will assist the Bureau of Land Management (BLM) with evaluating prairie potholes across the ecoregion using existing geospatial data. The indicators will assist with answering the MQs that relate to what is happening to prairie potholes across the ecoregion.

5.1 CURRENT STATUS OF THE PRAIRIE POTHOLES

Table E-6-2 identifies the original KEAs proposed in Task 3 and which of these were used in the final current status analysis. As a result of the rolling review team (RRT) meetings, some new KEAs were added that were not included in the original CE package; additionally, not all of the KEAs initially proposed were used, based on the rationale provided. Other KEAs were used but are not directly related to CAs.

Table E-6-3 identifies the KEAs, indicators, and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion (as illustrated on Figure E-6-3). Several indicators were used to create a series of intermediate layers that are primarily based on the development CA and the geospatial data that were available.

Table E-6-3. Prairie Potholes Key Ecological Attributes, Indicators, and Metrics for Current Status Assessment for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation
			Poor = 3	Fair = 2	Good = 1		
Size	Pothole Size	acres	<1	1-5	>5	Distribution layer	Faber-Langendoen et al. 2006
	Proportion of area classified as wetland	Percent of 5 km moving window	<10	10-30	>30	Distribution layer	Best professional judgment
Condition	Protected status	Percent of potholes on protected areas	<20	20-60	>60	Distribution layer & Protected Areas Database (PADS)	Best professional judgment
	Wildlife value	Perimeter to area ratio (in percent)	<26	26-58.5	>58.5	Distribution layer	Best professional judgment

Table E-6-3. Prairie Potholes Key Ecological Attributes, Indicators, and Metrics for Current Status Assessment for the Northwestern Plains Ecoregion (Continued)

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation
			Poor = 3	Fair = 2	Good = 1		
Landscape Context	Agriculture conversion risk	Distance from agricultural lands (m)	<200	200-500	>500	Distribution layer and National Land Cover Data (NLCD) croplands	Vance 2005
	Risk from runoff and disturbance	Distance from urban, exurban and housing density (m)	<1,000	1,000-2,000	>2,000	Distribution layer and Integrated Climate and Land-Use Scenarios (ICLUS) urban, exurban and housing density layers	Theobald 2005
	Suitability of cropland	Suitable or not suitable plus acres	Classes 1-4 and areas >40 acres	Classes 1-4 and areas <40 acres	Not classified as Type 1-4	Distribution layer and State Soil Geographic (STATSGO)	Best professional judgment
	Distance from intense development	Distance from oil and gas wells, mines, and roads (m)	<500	500-1,000	>1,000	Distribution layer oil and gas wells, mines layer and Topologically Integrated Geographic Encoding and Referencing (TIGER) roads	Vance 2009

5.1.1 Key Ecological Attribute Data Analysis for Current Status

For each of the KEAs listed in Table E-6-3 and used in the CA analysis, a discussion of the indicator, metric, metric rank and value, data source(s), and references is provided. Several indicators were used to assess the current threat status for this CE (Table E-6-3). This table was limited to size and landscape context based on spatially-available attributes and key factors affecting these potholes in the ecoregion.

In most cases, the metrics used to identify attribute quality were based on available publications, coupled with expert analysis and professional judgment in association with data-driven metrics. This process was carried out through the establishment of a prairie potholes RRT comprised of BLM and state-level experts. The RRT met two separate times to contribute information and to analyze input attributes and outputs that were derived from various forms of spatial analyses in GIS. This process enabled the RRT to determine the efficacy of attributes, indicators, and metrics, as well as to ascertain the accuracy of each step of the modeling process.

For each analysis, a series of intermediate data layers were created based on the KEA indicators that are scored according to a designated metric and then ranked (good, fair, or poor). If necessary, data from multiple source datasets were combined. These metrics were derived from the literature where possible; however, in some cases, best judgment was used following a review of the literature.

5.1.1.1 Pothole Size

Wetland size provides a measure of the relative value of the wetland to a variety of wildlife and the number of waterfowl and shorebirds that can use the wetland. In addition, one of the assumptions discussed during the RRT meetings was the assumption that the larger the pothole, the less vulnerable it is to climate change-induced drought and eventual conversion to agriculture. This KEA clustered contiguous pixels from the distribution layer labeled as wetland and categorized them into the metrics listed in the table above. The results of the pothole size assessment are shown on Figure E-6-4.

5.1.1.2 Congregation of Potholes

This KEA was designed to show where congregations of potholes occur throughout the prairie pothole portion of the Northwestern Plains. A 5 square kilometer (km^2) moving window analysis was completed for this KEA to identify areas where potholes are congregated. This analysis is different from the original distribution layer because it shows concentrations of potholes. The results of the pothole congregation assessment are shown on Figure E-6-5.

5.1.1.3 Potholes on Protected Lands

This KEA was carried forward from the original CE package and was initially designed to show the relative protection of potholes from disturbance and conversion. For this analysis, the Protected Areas Database (PADS) was used and pixels classified in PADS categories 1-3 were queried out. A cluster analysis was completed so that each contiguous group of pixels had its percentage of protected (1-3) versus not protected (not 1-3) calculated. This analysis not only looks at each pothole, but also calculates their percent protected versus not protected. Protected areas could be considered sustainable into the future given the limits on development most protected areas have. The results of the potholes on protected lands assessment are shown on Figure E-6-6.

5.1.1.4 Pothole Edge

This KEA was added at the suggestion of the RRT because some literature suggests that larger pothole size is not always better. Anteau (2012) examined the historic practice of draining smaller wetlands into large ones, which reduced natural water level fluctuations and, consequently, lowered densities of invertebrates that are essential forage species for water birds. Larger potholes equate to less water-vegetation edge when compared to smaller, irregular-shaped potholes. Water-vegetation edge is important because it provides valuable foraging and nesting habitat for many species. The metric that was designed was a perimeter to area calculation for every pothole in this area of the Northwestern Plains. This analysis took several hours to complete because of the amount of computation that was required. The natural breaks method was used to determine the metrics for this KEA. The results of the perimeter-to-area assessment are shown on Figure E-6-7.

5.1.1.5 Proximity to Agriculture

Agricultural conversion was identified as a primary CA for prairie potholes. One measure of the potential risk for agricultural conversion that was identified was proximity to existing agricultural lands. This KEA was developed using the assumption that potholes near existing agriculture have a higher risk for conversion versus those that are located farther away. For this analysis, the pothole distribution layer was used to determine the distance of pixels classified as wetlands from pixels labeled as agriculture.

Distance to croplands was discussed by Vance (2009) as a good surrogate for prairie pothole water quality and is a risk to wildlife values as well. The distribution, abundance, and reproductive success of ducks in the prairie pothole region is influenced by a suite of environmental conditions, but agriculture and water level fluctuations are the dominant factors (Vance 2005). The risk of agriculture can be direct, as is the case with wetland drainage, tillage, and conversion of adjacent grassland to cropland; or indirect, such as off-site erosion, fire control, road-building, and other land disturbances. Vance determined that a large percentage of agricultural lands at any time were fallow, which provides additional threats of soil loss through wind and water erosion that inevitably ends up in the lower-elevation potholes. The cumulative effects of these types of risks have had severe consequences for prairie pothole ecological integrity as well as on waterfowl.

Total cropland in the United States increased in the late 1940s, declined from 1949 to 1964, increased from 1964 to 1978, and decreased again from 1978 to 2007. Between 2002 and 2007, total cropland decreased by 34 million acres to its lowest level since the U.S. Department of Agriculture (USDA) began recording cropland statistics in 1945, even though harvested cropland (which accounts for most land planted to crops) increased by 5 million acres due to a recovery of failed cropland from severe droughts in

2002 (USDA 2011a). While cropland used for crops remained constant nationally between 1964 and 2007, cropland used for crops increased by 12 million acres in the Corn Belt and Northern Plains and decreased by 12 million acres in the remaining regions (USDA 2011a). The shift in agricultural land uses may also affect the ecological integrity of the prairie pothole region, as discussed above, especially with regard to the addition of fertilizers and herbicides, and sedimentation effects on water quality. The USDA implemented programs that may have assisted farmers in converting more grasslands used for grazing into crops. The benefits of crop insurance, disaster assistance, and marketing loans increased rangeland acreage converted to cropland by about 2.9 percent between 1998 and 2007 (USDA 2011b). Farmers can expand their eligibility to receive benefits from these programs by converting grassland to cropland. Authors estimate that between 1997 to 2007 about 1 percent of rangeland had been converted to crop production (roughly 770,000 acres), while only 100,000 acres were converted from cropland to rangeland; this trend is more prevalent in the Northern Plains (USDA 2011b). For those grasslands that consist of native vegetation, once converted, they are difficult to restore. Unfortunately, available data do not identify grasslands as "native" or "non-native" and all are lumped into the rangeland category, which can include manipulated forage (e.g., planted pastures, hay crops, and Conservation Reserve Program [CRP] lands). Wetlands (including potholes) are similar to native grassland in the sense that they are ecologically important and difficult to recreate once they have been destroyed. Environmental compliance programs, such as the Swampbuster provision of the 1985 Farm Act, include denying farm program payments on an entire farm for producers who drain wetlands on any part of their farm for crop production. The USDA is considering a similar program to protect native grasslands (USDA 2011b). For KEAs developed to identify pothole areas threatened with land conversion, we used the Vance 2005 metrics of mapping suitable farmland soils and looked at parcels over 40 acres adjacent to current croplands as being at high risk of conversion. The potholes proximity to agriculture analysis is shown on Figure E-6-8.

5.1.1.6 Distance from Development

It was recognized that measuring effects from anthropomorphic sources, such as various development types, is difficult. Even so, it is of utmost importance in understanding the current threats to pothole health and in predicting what may affect pothole sustainability within the landscape into the future. As mentioned earlier, water quality data on the ecoregional scale are not available for rapid assessment. Literature suggests that using distances from potential sources of pollutants and sedimentation that are known to affect prairie pothole water quality can be used as surrogates for water quality effects (Gernes and Helgrin 2002; Vance 2009; Kantrud and Newton 1996). These include anthropomorphic sources such as mining and energy development sites and major roads. When mapped using metrics from Gernes and Helgrin 2002 and Vance 2009, the areas with potholes of highest concern (closest to these CAs) occur primarily in the northern portion of the ecoregion. Recent land-use changes include agricultural conversions to residential uses, not so much for urban or even suburban development purposes but rather for low-density industrial/commercial and exurban residential housing located between the suburbs and rural areas but still within the commuting zone of larger towns (Clark et al. 2006). Estimated rural residential acreage outside urban areas increased by 29 percent from 1997 to 2002, and by 10 percent from 2002 to 2007, reflecting the downturn in the residential housing market (USDA 2011a). The effects of exurban development are grossly misunderstood and underestimated in size and influence. Theobald (2001; 2004) used the terms "urban fringe" and "urban-rural interface" (or better known as "sprawl") for suburban development, and he defines exurban as semi-rural regions beyond the suburbs characterized by housing densities of around 5 acres or more per unit, which often include second, vacation, and retirement homes. The low-density land uses can retain an open character, but management practices and level of land modifications can vary widely, as can the resulting effects to adjacent open lands or same-watershed natural systems such as the prairie potholes. Because exurban areas lie at the edge of natural areas, they have a profound influence on the quality of large acreages of public lands and protected areas (Theobald 2004; Ginn et al. 2008). There are varying metrics employed for density thresholds when urban becomes exurban, but Theobald (2001; 2004; 2005) assesses that more than one unit per 2 acres can be considered a relatively high building density because of the accompanying large percentage (up to 60 percent) of the parcel that is covered by impervious features such as houses, driveways, a garage, and other outbuildings. We used metrics based on Vance 2009 and Theobald 2005 for pothole distance from exurban and higher housing densities obtained from the USEPA Integrated Climate and Land Use Scenarios (ICLUS) housing density database.

Two separate KEAs were developed to identify the proximity of potholes relative to development. Both of these KEAs used different data sources and different metrics to determine good, fair, and poor rankings. The first analysis was completed through the use of a Euclidean distance of all urban, exurban, and housing density features. The output for this analysis shows the point from any part of the pothole to the development. The potholes distance to development analyses are shown on Figures E-6-9 and E-6-10.

5.1.1.7 Analysis Evaluated but Not Completed

It is widely recognized that groundwater recharge capability of lands adjacent to prairie potholes is a measure of land condition that sustains pothole hydrology. The amount of developed versus permeable land surrounding the pothole habitat affects the amount of recharge that can occur. In this manner, adjacent land uses were attempted to be used as the surrogate to measure and to compare recharge potential that affects groundwater inputs necessary to sustain prairie potholes across the ecoregion. Analysis of this indicator on the ecoregional scale proved difficult, as the highly impermeable elements (e.g., highways, driveways) were very small compared to the vast open lands surrounding the prairie potholes; for various analysis units chosen, the effects of small impermeable features tended to “wash out” and not appear on maps due to averaging over the unit by the program. After examining this analysis, the prairie potholes RRT decided that permeability may not be a driver of land condition at the ecoregional scale for prairie potholes.

With regard to precipitation input into potholes, we recognize that, because of the vast geographic area covered by the prairie pothole region, climatic variables such as annual precipitation are going to affect different portions of the region differently. This is especially true with future evaluations of climate change effects. Predicted small changes in annual precipitation amounts may not be as important in the eastern portion of the pothole region, roughly east of the North Dakota-Montana border, where annual precipitation averages 16 to 20 inches and where groundwater inputs are likely more available than in the western portion of the region where precipitation averages of as low as 10 inches annually are received by potholes for recharge. Precipitation amounts received become increasingly smaller, but more important, toward the west. This, in itself, presents challenges to applying a single metric for this attribute across the ecoregion. In addition, annual precipitation is a bit of a double-edged sword; higher inputs can increase a pothole’s resistance to changes such as drought and dilute sediment and toxin inputs, while in turn increasing the potential for runoff and other adverse pothole inputs. After evaluating the precipitation data for the ecoregion, it was determined that the data would not provide the level of detail necessary to evaluate the minor precipitation differences throughout this portion of the ecoregion. After discussion with the RRT, it was determined that this concept would not be evaluated in the REA analysis.

5.1.2 Current Status of Habitat

The individual KEA analyses provide the basis for the compilation of an overarching data layer that defines the current status of potholes in each HUC 12 across the potholes portion of this ecoregion. A method of aggregating scores was used to summarize overall current status with regard to potholes. Individual CAs attempt to identify areas of potential risk to potholes, but aggregated scores can provide important information relative to areas where potholes might be affected by multiple CAs.

In order to create a current status data layer, an overall score for each HUC unit was calculated. Based on each KEA rating of good, fair, or poor, an HUC quality rank score was subsequently assigned to the KEA. If the KEA rating was good, then the HUC quality rank score of 1 was assigned (Table E-6-3). No weighting factors were assigned because all of the KEAs were determined to be equal of equal significance.

Each HUC was then assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. A higher overall rating would result in a rating of poor for the HUC, indicating that potholes are at risk from the CAs based on the KEA metrics.

The results of the current status analysis for the ecoregion are presented on Figure E-6-12. Based on review of the current status assessment, nearly all of the watersheds within the pothole portion of this ecoregion returned fair score results, (Figures E-6-5 through E-6-11). Poor assessments included: Prairie Pothole Congregation Assessment (Figure E-6-6), Prairie Potholes on Protected Lands (Figure E-6-6), Prairie Potholes Perimeter to Area Assessment (Figure E-6-7), Prairie Potholes Distance to Intense Development Assessment (Figure E-6-10), and Prairie Potholes Potential Conversion to Agricultural Lands (Figure E-6-8). Good/fair assessments included: Prairie Potholes Proximity to Agriculture Assessment (Figure E-6-8) and Prairie Potholes Distance to Development Assessment (Figure E-6-9).

A large cluster of watersheds in north-central Montana returned good results, while the pothole regions in North and South Dakota returned a majority score of fair for the overall current status analysis. Poor results are limited, occurring heaviest throughout the southeastern border of South Dakota within the pothole region.

A summary of the current status ratings based on the CE distribution is provided in Table E-6-4. The CE distribution layer was used to calculate the total number of square miles of CE habitat and a percentage of the total number of square miles per HUC that were rated as good, fair, or poor. The results of the current status assessment indicate that approximately 50 percent of the 6th level HUC watersheds that intersect the prairie pothole distribution received an overall rating of good or fair.

Table E-6-4. Summary of Current Status Ratings for the Prairie Potholes

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	10,373	11.7
Fair	33,754	38.1
Poor	44,449	50.2

[a] These values include only the area of HUCs that intersect with the CE distribution layer.
[b] Values rounded to one decimal place.

5.2 FUTURE THREAT ANALYSIS

The system-level model (Figure E-6-3) was used to create a series of intermediate layers that are primarily based on the geospatial data available on the future projections for the development and climate change CAs. Future threats were evaluated for development for a short-term time horizon (5 to 10 years) and for climate change for a long-term time horizon (50-year; 2050 to 2069).

Because of the inherent inaccuracies of the temporal scale of the future data, it is only possible to infer information pertaining to a subjective future period (rather than a specific time period) for some of these attributes. However, because of the limits placed on these data outputs, it is fair to assume that this model predicts the overall future potential for these attributes within this ecoregion. It is an upper limit of potential growth and should therefore be carefully applied to future estimates of their effect on potholes.

5.2.1 Development Change Agent

Future spatial data for development were limited to potential energy development area, modeled urban growth, and potential agricultural development, as discussed in the development CA analysis presented in Appendix C-1.

5.2.1.1 Agricultural Growth

As mentioned previously, conversion of potholes to agriculture is probably the most predominant current and future CA to potholes. Grain prices will increase commensurate with world population levels, and the production of crops will need to increase as well.

Since no future agricultural models exist for use within this ecoregion, a model was created using surrogate data to derive potential future agricultural areas. This analysis was similar as to that which was completed for the current status under KEA 3d. Figure C-1-1 in Appendix C-1 shows the State Soil Geographic (STATSGO) soil classification types conducive to farming (types 1 through 4). Although this information can be portrayed spatially, there is no way to temporally show this future threat. The politics of government-subsidized agriculture programs is uncertain and dictates the temporal nature of this CA. Alternatively, this analysis considered the maximum potential for future agricultural areas within this ecoregion.

Figure E-6-11 shows the results of the analysis, indicating potential risk related to potential future agricultural land development. Most of the agricultural areas (current and future) are located throughout the potholes distribution layer. Thus, potholes are at risk from the effects of agricultural growth in the future.

5.2.1.2 Future Growth of Urban Areas

The risks to potholes from the effects of urban growth are similar to those of agricultural development. In the Northwestern Plains ecoregion, minor portions of the potholes area are currently in close proximity to urban/suburban populations. Urban growth, as noted by increasing population trends, is a risk to a variety of CEs, and potholes might be susceptible to localized habitat loss in near-term and long-term temporal periods.

The ICLUS model is a universally accepted model created by the USEPA for use in future climate change modeling that provides spatial data that can be used to determine the future extent of urban areas for various time periods. The model uses U.S. Census data to predict urban growth. The ICLUS future urban extent for the year 2060 was used in this analysis. This corresponds more closely to the data and scenarios used to perform the foraging habitat and wind turbine analyses than a near-term time period. The ICLUS urban area footprint for 2060 was used to calculate the proximity to potholes. Figure C-1-1, Future Urban Growth Potential, shows the results of the analysis.

Based on review of the map, it does not appear that urban growth needs to be considered as great of a threat to this CE as agriculture. A small area around Havre, Montana, is expected to become developed, but this does not appear to threaten potholes on a landscape scale.

5.2.1.3 Future Oil Development Potential

The future analysis characterized potential future oil development rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential risk of future oil production activities. Although these areas are based on oil density data, the application of these data to future potential well site activity is unknown. Therefore, a carefully considered approach should be taken when assessing the risk of potential oil production areas on potholes.

In the potholes portion of this ecoregion, there is risk to potholes in western North Dakota and northeastern Montana from oil production. However, based on review of this map, potholes in South Dakota do not appear to be at risk from oil production.

It is important to note that the Energy Policy and Conservation Act (EPCA) oil and gas data used in this assessment are based on the maximum potential for oil reserves within the Northwestern Plains. As a result, these data are likely overly represented in these figures, and care should be taken in assessing the effects of oil and gas production within the constraints of this analysis.

5.2.1.4 Future Natural Gas Development

The future analysis characterized potential gas development rather than actual gas well locations (Figure C-1-3). These larger gas production extents could be used to qualitatively assess the potential effect of future gas production activities. Although these areas are based on gas density data, the application of these data to future potential well site activity is unknown. Therefore, a carefully considered approach should be taken when assessing the risk of potential gas production areas on potholes.

Most of the potholes in this ecoregion will likely remain unaffected by future gas development. The majority of potential future gas development is limited to northeastern Wyoming. There is one area of the prairie potholes in north-central Montana that appear to be at high risk for future natural gas development. However, from an ecoregional scale it does not appear that potholes are at risk from future natural gas development.

5.2.1.5 Future Potential for Solar Development

This future potential analysis characterized the future potential for solar development based on the solar potential maps developed by the National Renewable Energy Laboratory (NREL). Areas at high risk from future solar development are outside the area of the prairie potholes. Therefore, it does not appear that the effects of future solar development will be a risk to potholes.

5.2.1.6 Future Wind Turbine Development

The USFWS wind turbine data contained attribute information for current and future wind turbine locations. However, the future turbine locations dataset was very limited in number as most turbines will presumably be erected in the very near future. Therefore, an alternative dataset was used to determine the potential areas for wind turbine development over a long-term period. The future wind turbine development areas were based on the availability of suitable wind speeds.

Data characterized by the NREL were used to create a potential future wind turbine area data layer. A full description of the methods and processes implemented to create this data layer and its corresponding scoring system can be found in Appendix C-1.

The potential threats to potholes relative to potential future wind energy development are presented on Figure C-1-7. Higher elevations within the Northwestern Plains ecoregion are more suitable for wind turbine development due to the higher wind speed levels within these areas. However, limited accessibility to these higher elevations could limit the range of wind turbine development to lower-elevation areas. While the potholes of north-central Montana are not near the highest suitable areas for wind turbine development, various areas of potholes in North and South Dakota are at risk from future potential wind energy development. In addition to the physical disturbance that wind turbines can have on potholes, bird mortality is also a concern with the development of new wind farms. Potholes and wetlands, where the majority of our nation’s waterfowl migrate through, should be considered when future wind farms are planned for development in this area. Although this assessment is primarily qualitative, the pothole areas located in the eastern portions of the ecoregion appear to be at risk from future potential wind energy development.

5.2.1.7 Overall Development Change Agent Future Threats

The future overall score was compiled by averaging the values associated with each of the two energy types: renewable and fossil fuels. Future potential agriculture and urban areas were characterized as binary functions only.

A fossil fuel energy output layer was created to address the MQs associated with future fossil fuels development. This layer was created by averaging the EPCA oil data layer with the EPCA gas data layer (Figure C-1-5).

Most of the potholes in the ecoregion will likely remain unaffected by fossil fuels development in the Northwestern Plains. The majority of potential fossil fuels development is limited to northeastern Wyoming.

A renewable energy output layer was created to address the MQs associated with future renewable energy development. This layer was created by averaging the NREL wind speed data layer with the NREL solar energy data layer (Figure C-1-8). This output layer provides equal weighting to potential wind and solar energy production areas, and could therefore mischaracterize the effects of each. Unlike oil and gas, wind and solar energy are not necessarily closely associated with one another spatially. Photovoltaic solar arrays threaten habitat due to their spatial requirements. Solar arrays are diverse in scope and size and it is therefore difficult to create a clear correlation between habitat loss and solar energy production.

Because of the intricacies involved in the assessment of renewable energy production with regard to potholes, a limited approach must be taken in this analysis. Although the majority of potholes in the Northwestern Plains are at low risk from future potential renewable energy development, other areas in the eastern portion of the ecoregion appear to be at a higher risk.

5.2.2 Climate Change Future Threats

5.2.2.1 Ecoregion Climate Change Analysis

From a climate change perspective, temperature and precipitation are the factors that would most affect potholes. Across the Northwestern Plains ecoregion annual precipitation is predicted to be highly variable around the 2060 timeframe. Most of the region is expected to experience a mild increase (25-75 millimeters [mm]) in annual precipitation or no annual change in precipitation. Increased annual precipitation is expected in the southeast corner of the ecoregion along the Missouri River (76 to 155 mm).

Climate change presents many different issues relating to potholes. However, it remains difficult to draw conclusions from the data presented in this REA. Climate change models are highly variable and often difficult to predict. In this case, the resolution of the spatial data is an important factor to consider.

Although the analysis completed for this REA does not indicate substantial changes could result from climate change, other recent research indicates otherwise. Johnson et al. (2005) developed a series of wetland simulation models for the prairie pothole region. The model runs that simulated increased temperature and decreased precipitation had the greatest modeled effect on wetland conditions. Under this scenario, the modeled wetland at 5 of the 6 locations became completely dominated by dry marsh conditions because of more frequent and longer periods of drought. The results of this research suggest that climate change could diminish the benefits of wetland conservation in the prairie potholes area of the Northwestern Plains. In addition, the combined impacts of increased temperatures, localized drought, and conversion of lands to agricultural uses could negatively affect potholes in the future.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the prairie potholes include those defined as part of the Aquatic/Riparian Biotic Resources category. The overall MQ was: Where are the important regionally significant aquatic/riparian biotic features, functions, and services across the ecoregional landscape? This MQ was considered in implementing the GIS analyses. Emphasis was placed on the spatial relationship of attributes mentioned in the MQs and the distribution output for the CE. Several examples of how the REA can be used to answer MQs (as noted in Appendix A) are provided below. These examples demonstrate the functionality of the REA and provide an opportunity to discuss data gaps that were identified during the REA.

6.1 WHERE ARE THE CURRENT LOCATIONS OF REGIONALLY SIGNIFICANT AQUATIC/RIPARIAN AND WETLAND HABITATS?

The prairie pothole distribution map (Figure E-6-1), along with the pothole size and congregation maps, provide the response to this MQ. Although the method developed to map the distribution of this CE seemed to be effective, small, isolated potholes are difficult to identify. All efforts were made to accurately illustrate the distribution of potholes within the Northwestern Plains ecoregion.

6.2 WHERE ARE CURRENT RIPARIAN OR AQUATIC AREAS CURRENTLY AT RISK OF FRAGMENTATION IMPOUNDMENT, DIVERSION, AND LOWERED WATER TABLES DUE TO DEVELOPMENT, MINERAL EXTRACTION, AND AGRICULTURAL AND RESIDENTIAL DEVELOPMENT?

The prairie pothole CA maps provide answers to this MQ. Agriculture remains the greatest threat to potholes, and the two agriculture proximity maps (Figures E-6-8 and E-6-11) provide answers to where the current and future conversion threats to potholes occur. As for the lowered water tables, the distance to development maps (Figures E-6-9 and E-6-10) attempt to provide an answer to this question.

6.3 WHERE WILL REGIONALLY SIGNIFICANT AQUATIC HABITATS POTENTIALLY BE AFFECTED BY CHANGE AGENTS (DURATION, MAGNITUDE AND TEMPERATURE FLOW; DURATION AND EXTENT OF SURFACE WATER PRESENCE, IF APPLICABLE)?

As mentioned in section 5.2.2, it is very difficult to draw conclusions from the climate change data presented in this REA. The climate change data are at a scale that makes it difficult to identify where potholes will be affected by temperature increases and precipitation decreases. Climate change models are highly variable and often difficult to predict. In this case, the resolution of the spatial data is an important factor to consider. Based on review of the maps presented in Appendix C-5, it does not appear that temperature or precipitation changes will negatively affect the distribution of potholes in the Northwestern Plains. However, as mentioned, the combined risk of increased temperatures, localized drought, and conversion of lands to agricultural uses could negatively affect potholes in the future.

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7.0 REFERENCES

Anteau, M.J. 2012. Do interactions of land use and climate affect productivity of waterbirds and prairie-pothole wetlands? Wetlands Vol. 32: No. 1, pp. 1-9.

Clark, J.K, D.K. Munroe, and E.G. Irwin. 2006. Exurban Settlement Pattern and the Exurban Condition: A Typology of US Metropolitan Areas. Paper prepared for the 53rd Annual North American Meetings of the Regional Science Association, Toronto, Ontario. November 16.

Cowardin, L.M., T. L. Shaffer, and P.M. Arnold. 1995. Evaluations of duck habitat and estimation of duck population sizes with a remote-sensing-based system. U.S. Department of the Interior National Biological Service, Washington, DC. Biological Science Report 2. May.

Environmental Working Group 2012. Faber, S., S. Rundquist, B. Lorenzen. Unlimited Subsidies, High Prices Threaten “Prairie Potholes”. Environmental Working Group. http://www.ewg.org/agmag/2012/04/subsidized-sodbusting-unlimited-subsidies-high-prices-threaten-%E2%80%9Cprairie-potholes%E2%80%9D/. April 24.

Faber-Langendoen, D., J. Rocchio, M. Schafale, C. Nordman, M. Pyne, J. Teague, T. Foti, and P. Comer. 2006. Ecological Integrity Assessment and Performance Measures for Wetland Mitigation. NatureServe, Arlington, Virginia.

Gernes, C.M. and J.C. Helgen, 2002. Indexes of Biological Integrity (IBI) for large depressional wetlands in Minnesota, final report to USEPA, Federal Assistance #CD-995525-01

Ginn, A.L., G.T. Green, N.P. Nibbelink, and H.K. Cordell. 2008. The spatial relationship between exurban development and designated wilderness lands in the contiguous United States. *In*: Proceedings of the 2008 Northeastern Recreation Research Symposium.

Johnson, C. W., B. Millett, T Gilmanov, R. Voldseth, G. Guntenspergen, and D. Naugle. 2005. Vulnerability of Northern Prairie Wetlands to Climate Change. BioScience 55(10):863-872.

Kantrud, H.A. and W.E. Newton. 1996. A Test of Vegetation-related Indicators of Wetland Quality in the Prairie Pothole Region. Journal of Aquatic Ecosystem Health Management 5: 177-191. Available on internet at the Bozeman, MT Mountain Prairie Information Node at: http://bsi.montana.edu/files/bigsky/ATestOfVegetation.pdf (Version 17MAY06).

Montana Fish Wildlife and Parks. 2011. Crucial Areas & Connectivity Assessment. Wetland Areas. http://fwpiis.mt.gov/content/getitem.aspx?id=41532 accessed November 11, 2011

PPJV (Prairie Pothole Joint Venture). 2010. A conservation program coordinated by U.S. Fish and Wildlife Service, Denver, Colorado. Available on internet at http://www.ppjv.org/implement2.htm. Accessed 17 February 2011.

Sloan, C.E. 1972. Ground-Water Hydrology of Prairie Potholes in North Dakota. Hydrology of Prairie Potholes in North Dakota Geological Survey Professional Paper 585-C. Prepared as part of the program of the Department of the Interior for the development of the Missouri River basin.

Theobald, D.M. 2001. Land-use dynamics beyond the American urban fringe. American Geographical Society Geographical Review, Vol. 91, No. 3, pp. 544-564, July.

Theobald, D.M. 2004. Placing exurban land-use change in a human modification framework. Front Ecol Environ 2004; 2(3): 139–144.

Theobald, D.M. 2005. Landscape Patterns of Exurban Growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32.

USFWS (U.S. Fish and Wildlife Service). 2011. National Wildlife Refuge System, The Small Wetlands Program: A Half Century of Conserving Prairie Habitat. Available on internet at: http://www.fws.gov/Refuges/SmallWetlands/. Accessed 29 March.

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2009. The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System. Report to the National Park Service.

USDA (U.S. Department of Agriculture). 2011a. Major Uses of Land in the United States, 2007. Economic Research Service. Available online at: http://www.ers.usda.gov/Publications/EIB89/EIB89_ReportSummary.pdf.

USDA. 2011b. Grassland to Cropland Conversion in the Northern Plains, The Role of Crop Insurance, Commodity, and Disaster Programs. Economic Research Service. Available online at: http://www.ers.usda.gov/Publications/ERR120/ERR120.pdf.

Vance, L.K. 2005. Watershed Assessment of the Cottonwood and Whitewater Watersheds. Report to the Malta Field Office, Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana. December.

Vance, L.K. 2009. Assessing Wetland Condition with GIS: A Landscape Integrity Model for Montana. Prepared for: The Montana Department of Environmental Quality and The Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT. March.

Visser, M.E. and C. Both. 2005. Shifts in phenology due to global climate change: the need for a yardstick. Proceedings Biological Science December 22, 272(1581): 2561–2569. The Royal Society. Published online November 1 at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1559974/pdf/rspb20053356.pdf.

Zhang, B. 2007. A CART based sub-pixel method to map spatial and temporal patterns of prairie pothole lakes with climatic variability. School of Earth Science Ohio State University, Columbus, OH.

Zhang, B., F.W. Schwartz, and G.M. Liu. 2009. Systematics in the size structure of prairie pothole lakes through drought and deluge. Water Resources Research 2009 Vol. 45 No. 4 pp.

APPENDIX E-6

FIGURES

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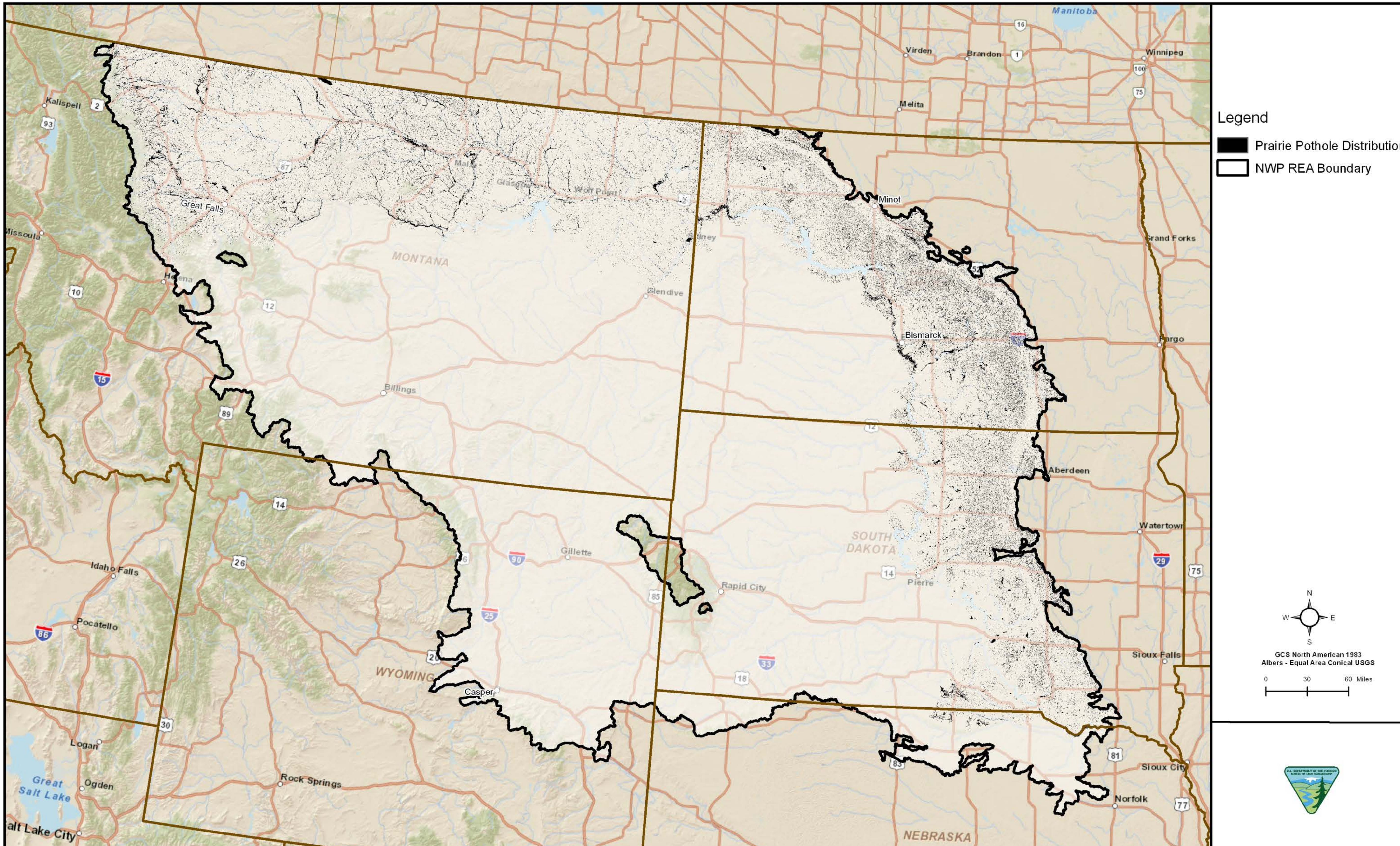


Figure E-6-1. Prairie Pothole Distribution Map for the Northwestern Plains Ecoregion

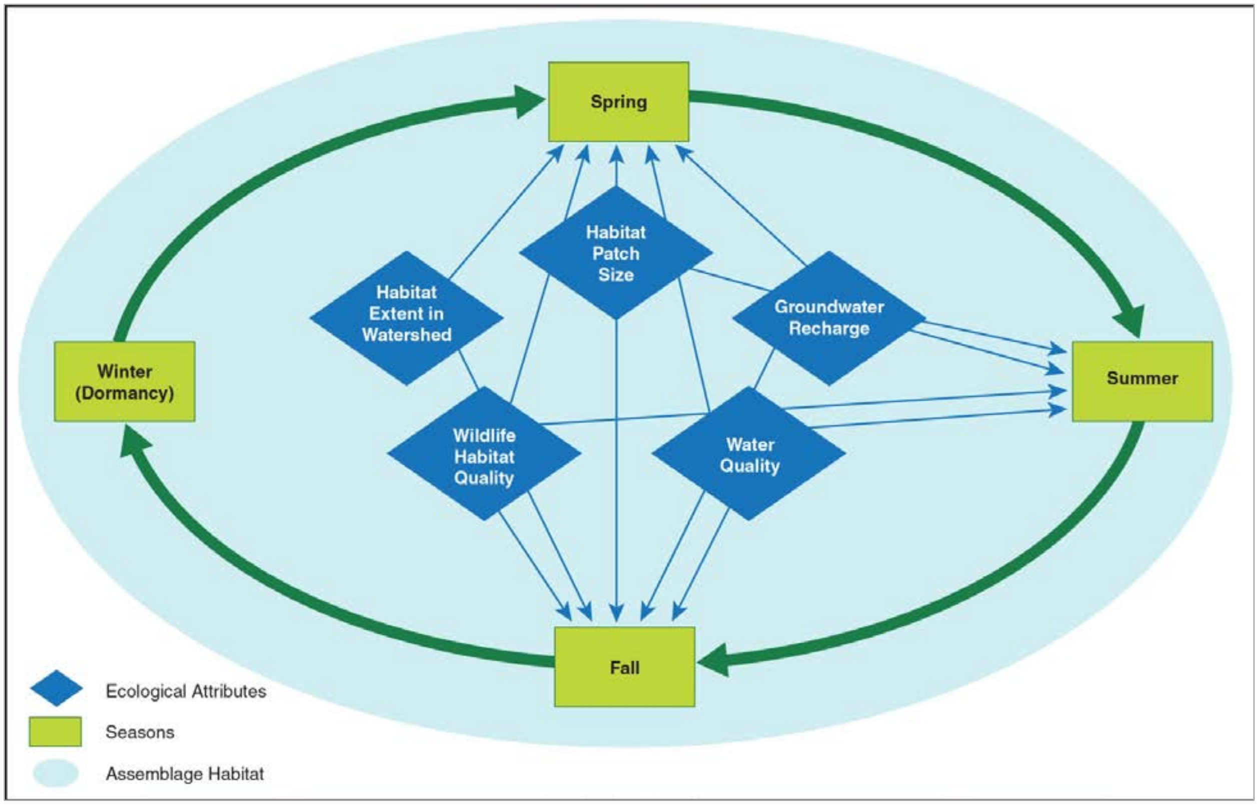


Figure E-6-2. Prairie Pothole Ecological Process Model

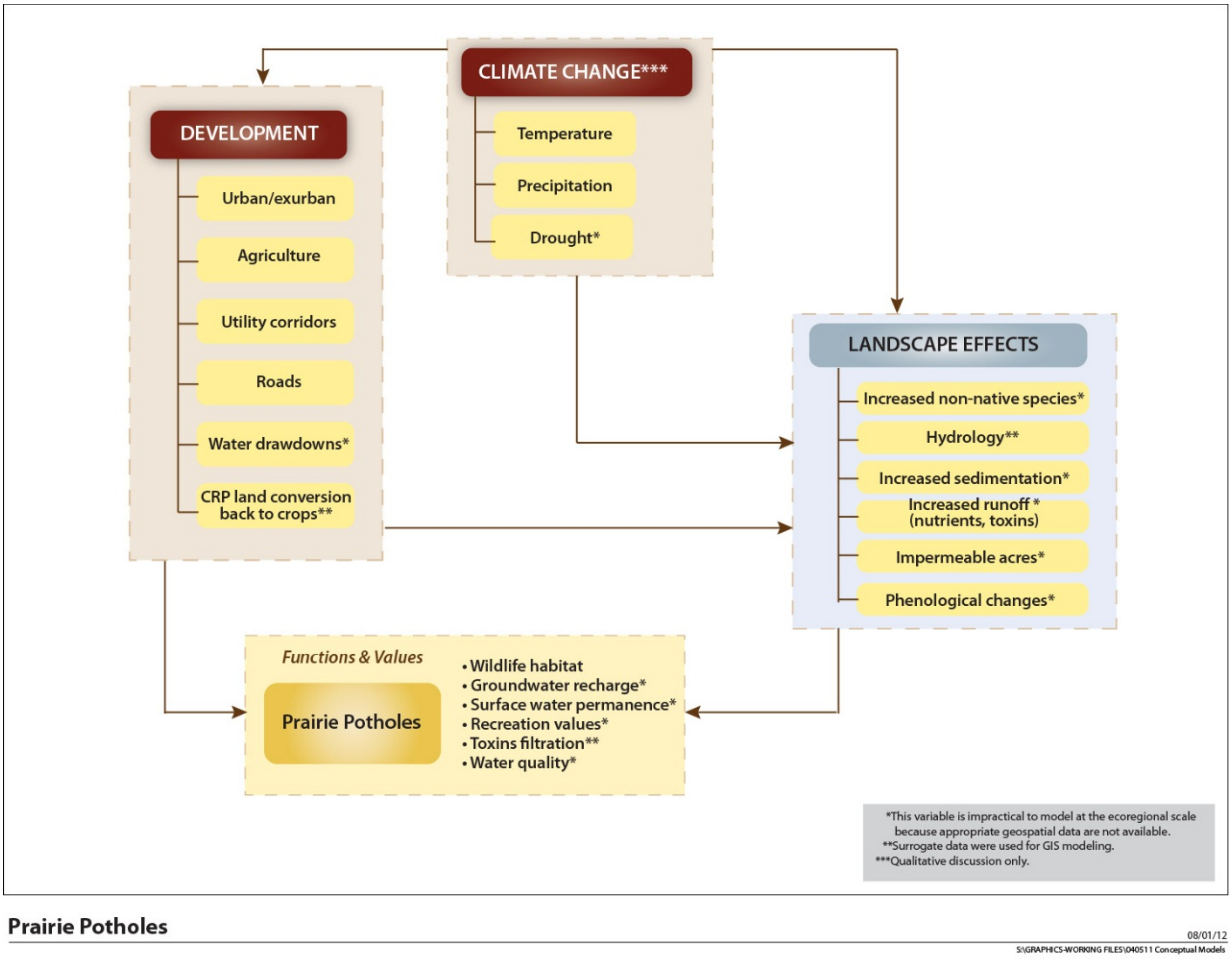


Figure E-6-3. Prairie Pothole System-Level Model

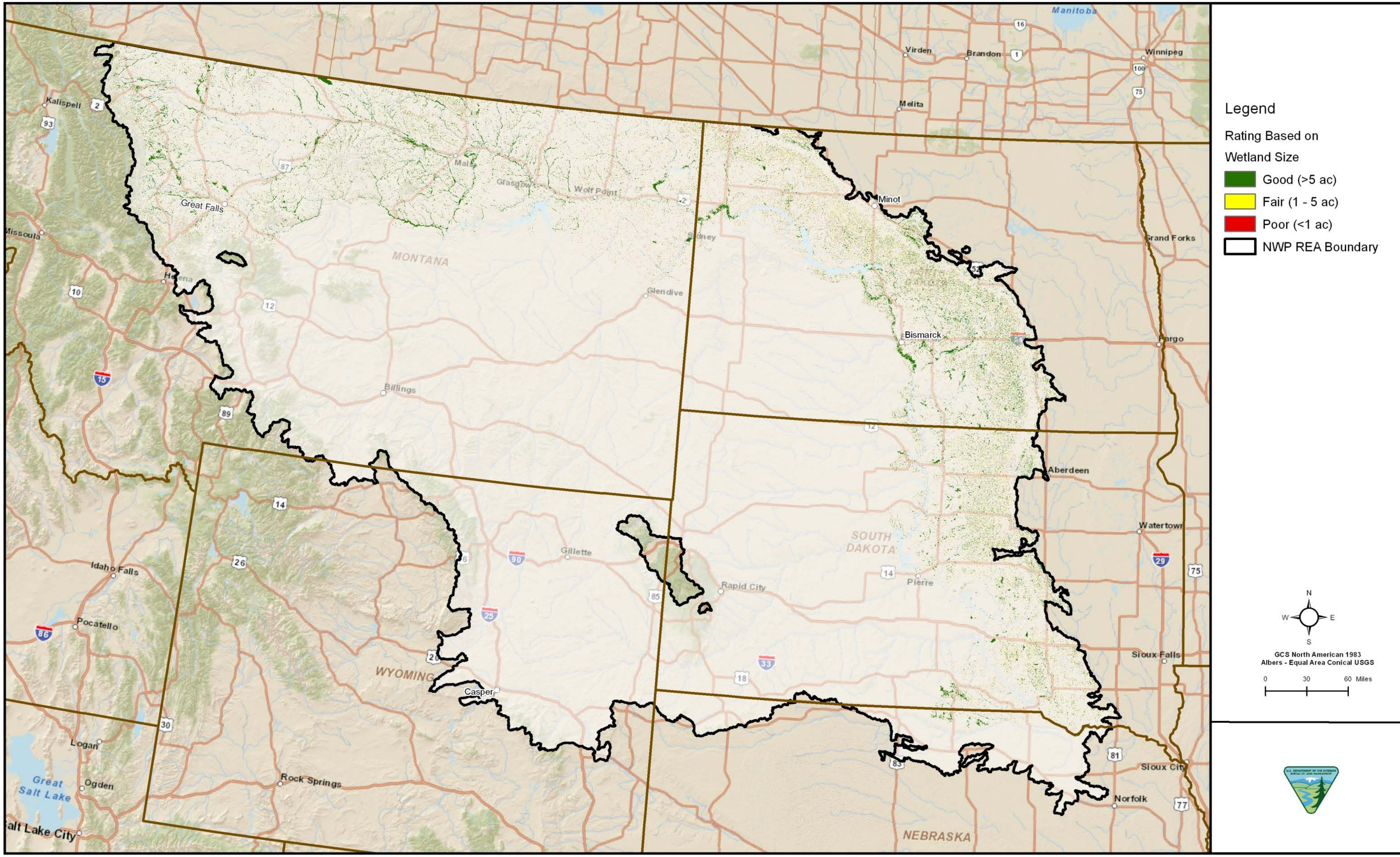


Figure E-6-4. Prairie Pothole Size Assessment

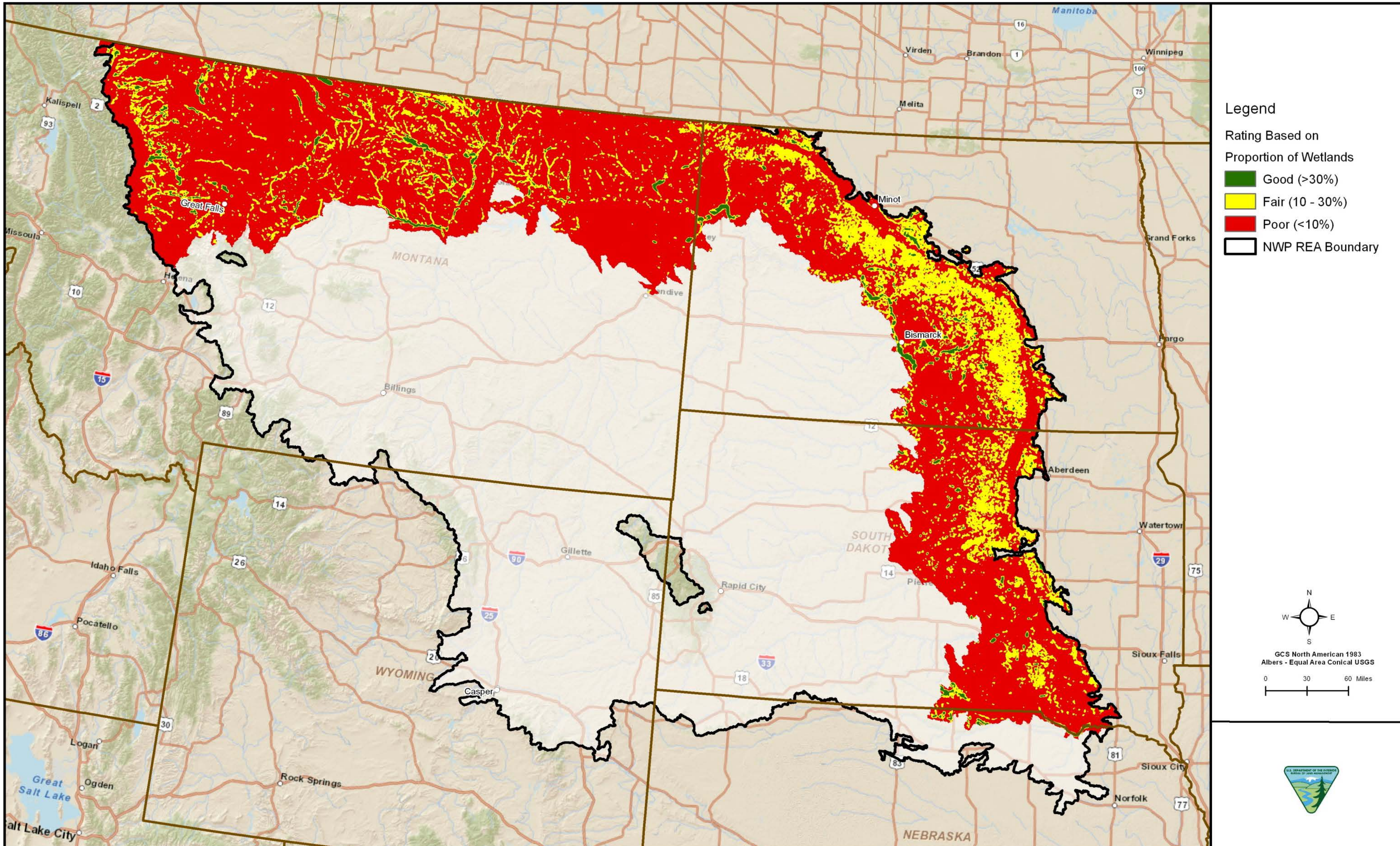
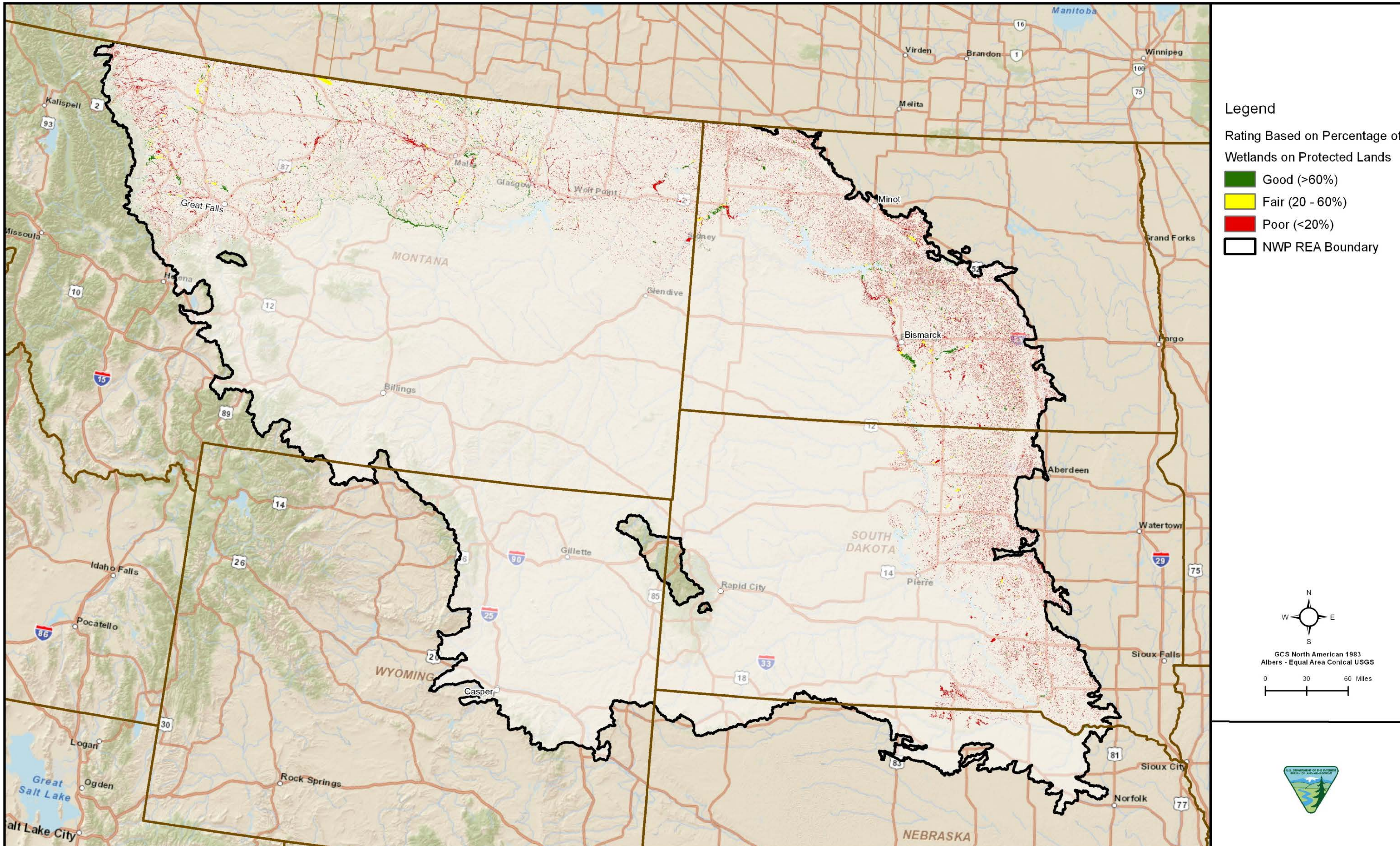


Figure E-6-5. Prairie Pothole Congregation Assessment



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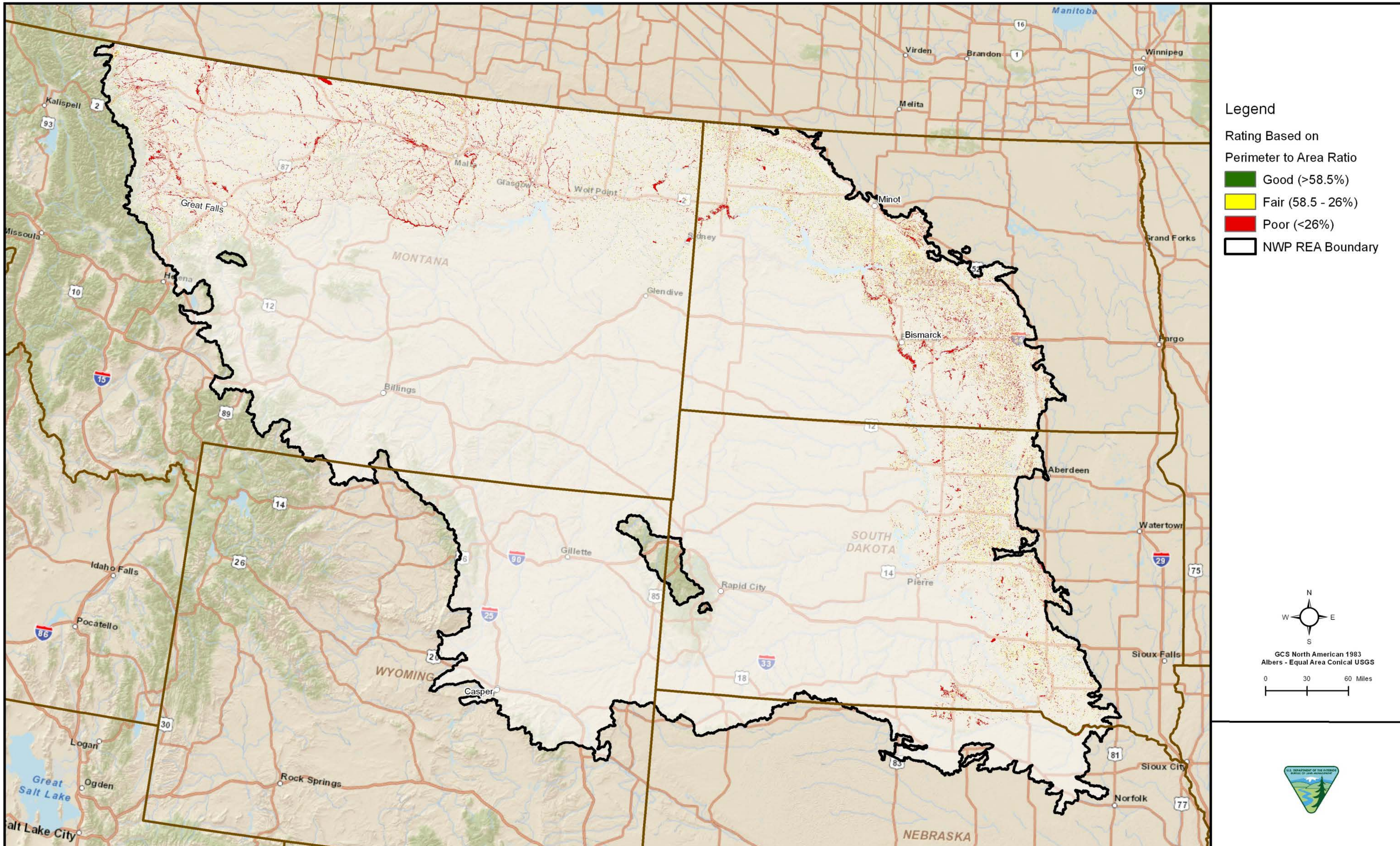

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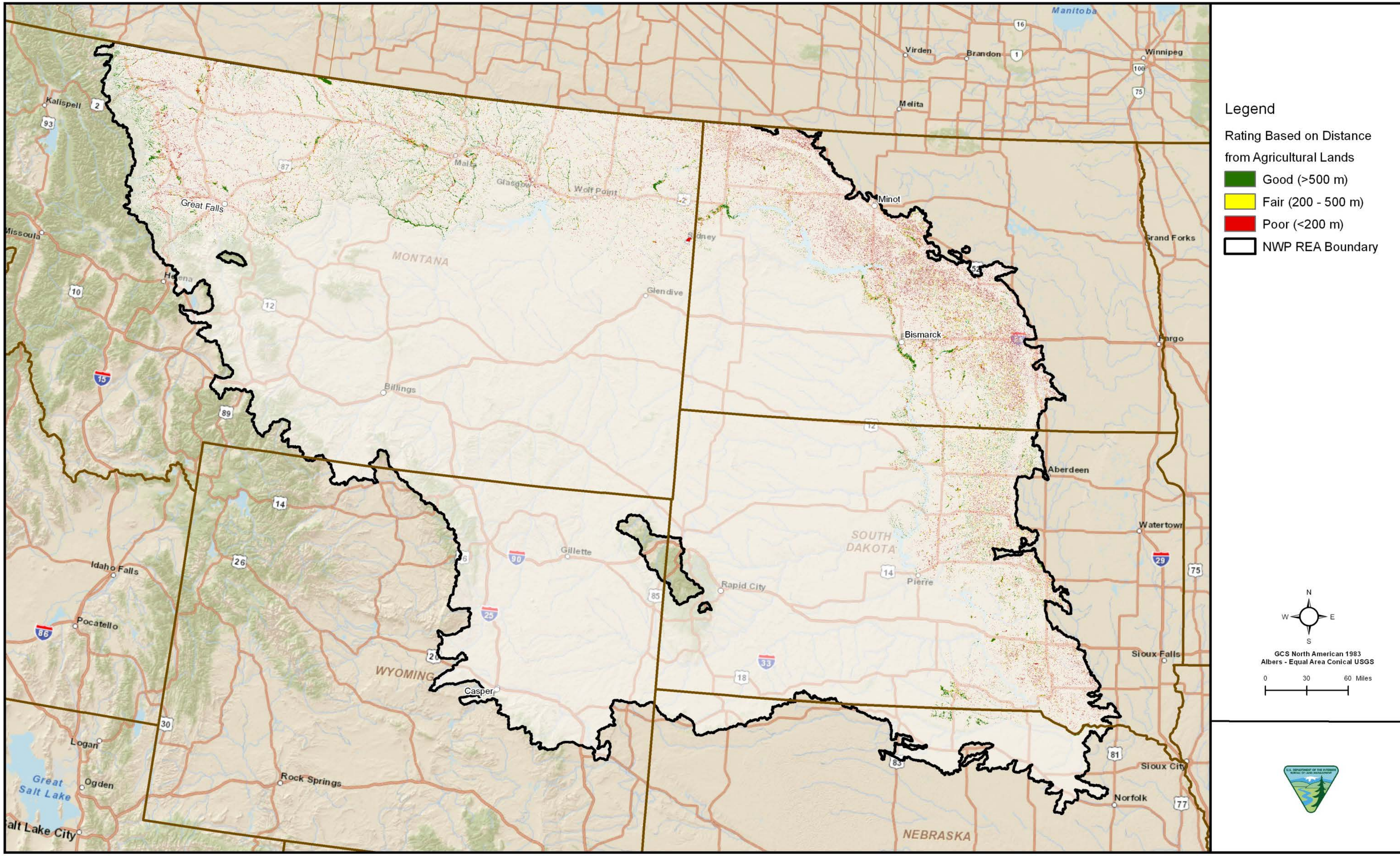

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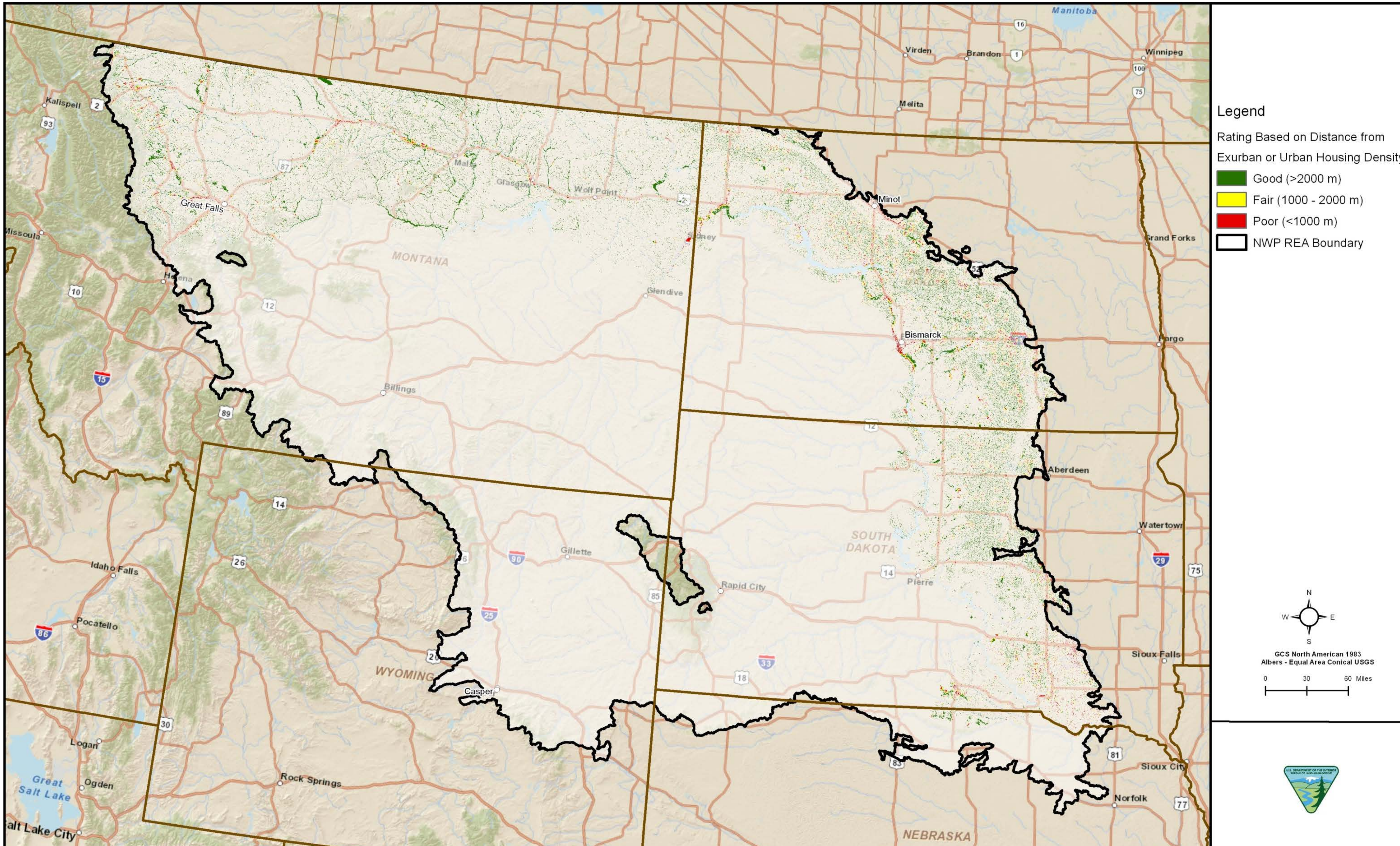

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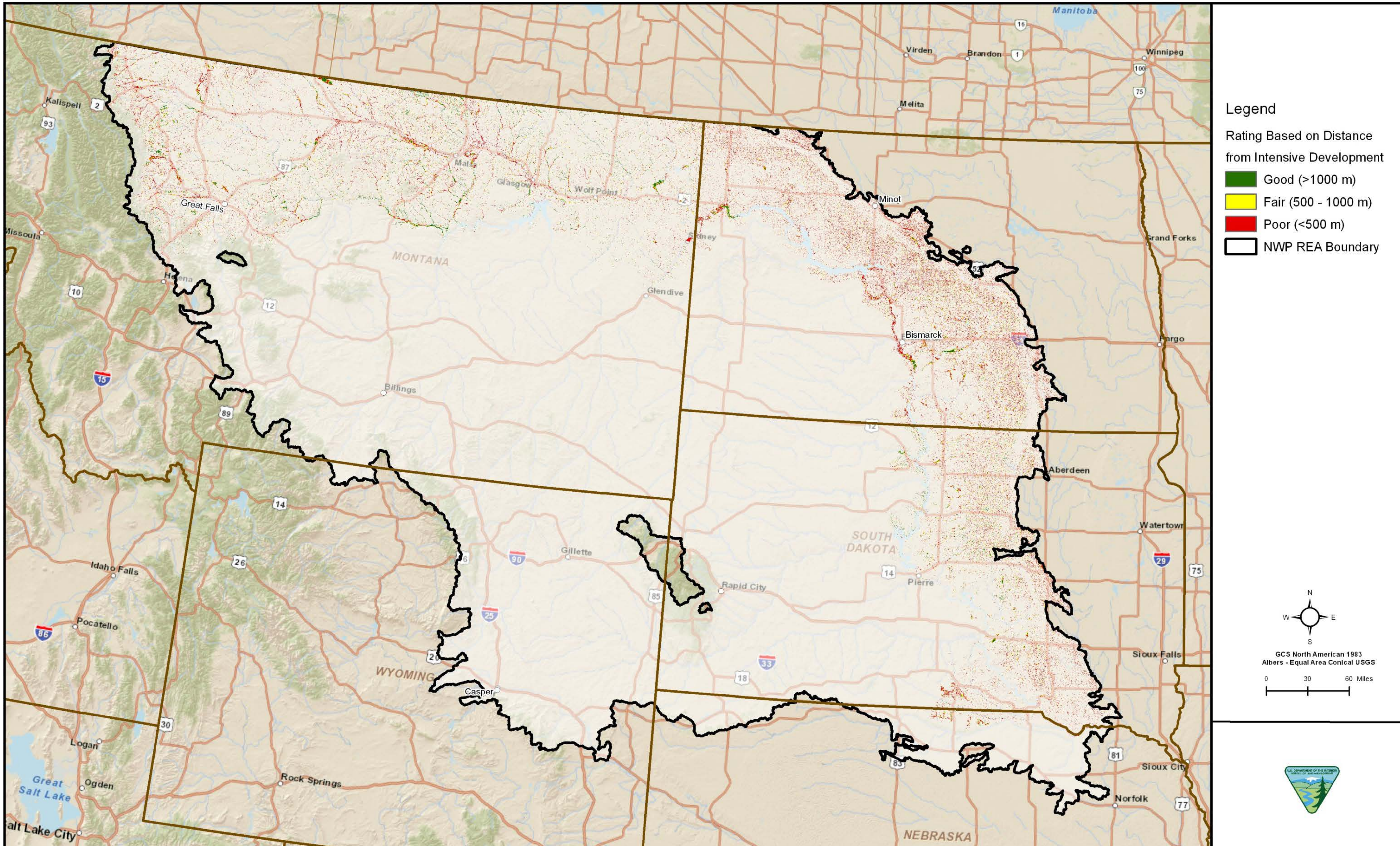

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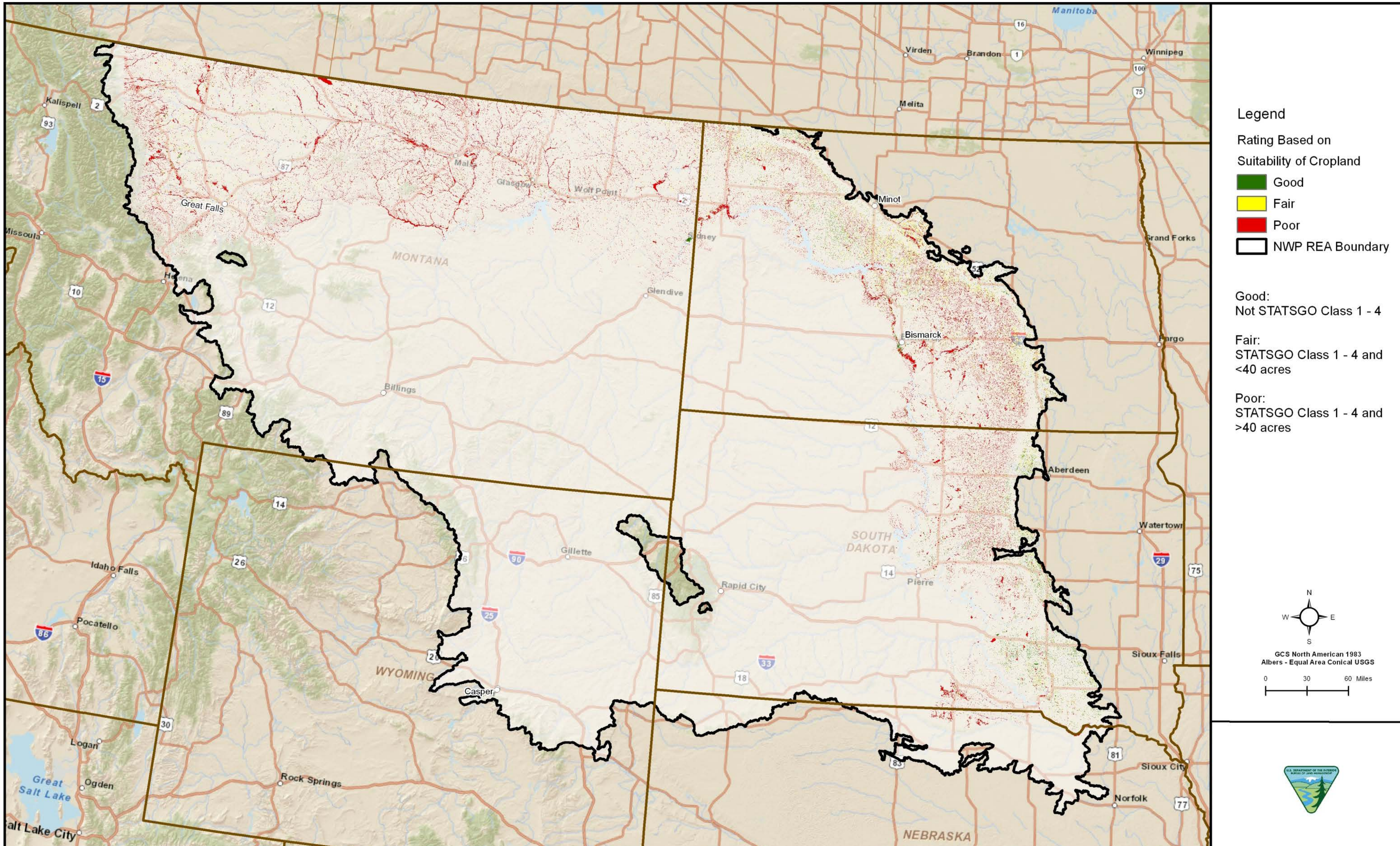

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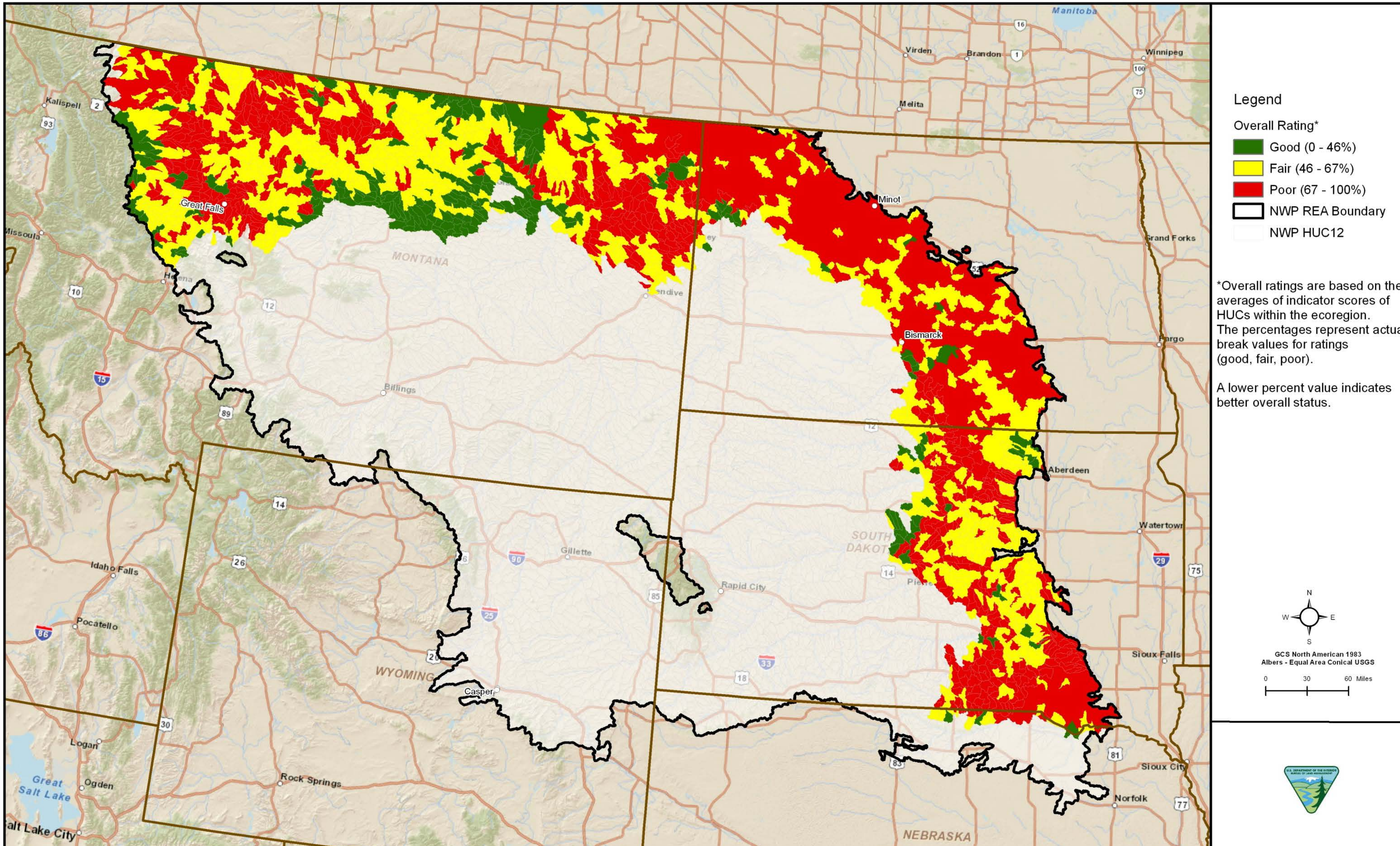

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APPENDIX E-7

PRAIRIE FISH ASSEMBLAGE CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The prairie fish assemblage is represented by two focal species: the pearl dace (*Margariscus margarita*) and the northern redbelly dace x finescale dace hybrid (*Phoxinus eos* x *P. neogaeus*). These two species are usually associated with a fairly small but distinctive assemblage of other native species that are also adapted to similar habitat requirements, including the northern redbelly dace (*Phoxinus eos*), blacknose dace (*Rhinichthyes atratulus*), brassy minnow (*Hybognathus hankinsoni*), blacknose shiner (*Notropis heterolepis)*, creek chub (*Semotilus atromaculatus*), and the plains topminnow (*Fundulus sciadicus*) (Stasiak 2006). This assemblage is found in small headwater streams, cool ponds, and small, spring-fed lakes (Stasiak and Cunningham 2006).

A variety of the management questions (MQs) apply to this assemblage. Many of the MQs can be summarized into two primary questions: 1) where are the important areas for this assemblage? and 2) what is happening to these areas? In order to answer the MQs, ecological conceptual models were developed for the conservation element (CE) based on species habitat requirements and perceived change agent (CA) threats. The Rapid Ecoregional Assessment (REA) analysis presented herein is based on the models, specific attributes defined as key parameters for evaluating CAs, and the availability of data.

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2.0 CONSERVATION ELEMENT DESCRIPTION

2.1 PEARL DACE

The pearl dace is not considered federally-endangered or threatened in the United States. However, this species is very uncommon in the Northwestern Plains ecoregion. It is listed as endangered or threatened at the state level in Wyoming (S1 - state endangered), North Dakota (SC1 – species of concern), Montana (S2 - species of concern), South Dakota (S2 – state threatened), and Nebraska (S3 – species of concern).

Pearl dace occur in small, confined habitats in places with permanent spring seeps, usually at the extreme headwaters of small streams, and are associated with well-vegetated stream banks, sinuous channels with undercut banks, and few (if any) large predatory fish species (Cunningham 2006). They spawn in clear water at depths of 1-2 feet over a gravel or sand bottom. The pearl dace does not migrate extensively; rather, they tend to be residents of a series of permanent pools. Unlike most minnows, males establish and defend territories during the spawning season. Pearl dace eat a variety of aquatic organisms (including insects, crustaceans, worms, and small fish) and grow to a maximum length of about 6 inches.

2.2 NORTHERN REDBELLY x FINESCALE DACE HYBRID

In many regions throughout their current range, the northern redbelly dace are syntopic with finescale dace. The northern redbelly dace x finescale dace hybrid was classified as a Montana species of special concern. The hybrid was placed on the species of concern list due to its rarity and unusual form of genetic reproduction. Montana appears to be the only state that designates special status for the hybrid fish. However, both the northern redbelly dace and the finescale dace have been listed by South Dakota (state threatened), while in Wyoming the finescale dace is listed as on S2 species of concern (imperiled). North Dakota and Nebraska have granted special status to the finescale (P. neogaeus) and northern redbelly dace (P. eos) (Tews 2001).

Both the northern redbelly dace and finescale dace have a very strong habitat preference for sluggish, spring-fed streams with cover in the form of undercut banks, heavy vegetation, and woody debris, with a preference for beaver ponds, bogs, and clear streams. Clear water is necessary for these sight-feeding fish to find their food and their mates. The water does not need to be deep, but it does need to provide a constant supply of cool, spring water with sufficient oxygen for the fish, even during the hot and dry summer conditions. These species may also be present in small lakes that can be characterized as spring-fed and clear, with heavy vegetation (at least along the shoreline). A critical component of their habitat is the exclusion of large predatory fishes (Stasiak 2006). The hybrid dace utilizes a unique reproductive strategy called gynogenesis. In gynogenesis, sperm from the male of a sexually reproducing related species is needed to stimulate egg development, even though the genetic material is not incorporated into the offspring.

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3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

In order to answer the MQs regarding the location and status of this assemblage across the Northwestern Plains ecoregion, a distribution layer was required for each of the two focal species. The geospatial modeling was based on the availability and quality of reference data layers for the states included in the ecoregion. For this REA, prairie fish species distribution models were completed by the Missouri Resource Assessment Partnership (MoRAP) using a predictive distribution model. MoRAP had previously completed fish modeling in the Northwestern Plains as part of the Missouri River Basin Aquatic Gap Analysis Program (GAP) Project (MoRAP 2012).

3.1 DATA IDENTIFICATION

A preliminary review of potential data was conducted as part of Task 2 of Phase 1 to define available data for use in this REA (Table E-7-1). Species data were obtainable as modeled habitat in most cases, but modeling data were not consistent among datasets, which resulted in data quality variation. As a result of the data evaluation, several data gaps were identified regarding information on this assemblage (as noted in Table E-7-1). Montana Fisheries Information System (MFish) contained some species distributions, but only contained data for Montana. Species occurrence data were difficult to obtain, as they are generally not available for download from agency websites. Data availability with regard to species, as opposed to spatial reference, was also a factor that affected dataset quality and availability. Large-scale stream data also affected the quality of spatial fisheries datasets.

Table E-7-1. Data Sources for Conservation Element Distribution Mapping

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Habitat and Range	MFish	Montana State Fish, Game & Parks	Point	Obtained	Yes
	Missouri River Basin Occurrence Data	MoRAP	Point	Obtained	Yes
Occurrence	State Natural Heritage	Natural Heritage Program (NHP) of MT, WY, ND, SD, NE	Point	Obtained	Yes
Areas with Potential for Restoration of Habitat or Habitat Connectivity	Management Plan Areas	U.S. Forest Service (USFS), National Park Service (NPS), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS)	Polygon	Not Available	No[1]

[1] Data gap

Fish occurrence data were obtained through the state Natural Heritage Programs (NHPs) and fish and game agencies, as well as through community collection records that MoRAP had assembled from historical collections as part of the Missouri River Basin Aquatic GAP Project (Annis et. al. 2010). Species occurrence data obtained from the NHPs and fish and game agencies were only species "presence" data and not community collection data; therefore, these data did not contain information about species absence, which is used in the type of modeling that MoRAP completed. The data were integrated into the community collection data described above, resulting in a database of presences and absences for the focal species. Although the northern redbelly x finescale dace hybrid was one of the original species in this assemblage, very little data for this hybrid species were available, with available data for Montana and Nebraska only. As a surrogate for additional data, the Assessment Management Team (AMT) agreed to integrate species collection data for the northern redbelly dace, finescale dace (*Phoxinus neogaeus*), and northern redbelly x finescale dace hybrid. These species utilize the same basic habitats as the hybrid species. The range for the hybrid dace model was defined using 8-digit hydrologic unit codes (HUCs) in which the hybrid has been collected, with the addition of HUCs for the finescale dace.

3.2 DISTRIBUTION MAPPING METHODS

Because minimal data were identified for the pearl dace and the northern redbelly x finescale dace hybrid, potential distribution layers were created using a predictive distribution model. A predictive distribution model integrates known distribution for a species with quantitative models of species-habitat associations to extrapolate species presence to unsampled areas, which allows estimates to be made about the amount of available habitat for each species (MoRAP 2012).

Fish species predictive distribution modeling was conducted in the Missouri River basin portion of the Northwestern Plains ecoregion. This area was selected to utilize existing datasets covering the Missouri River basin. Species distribution information was obtained from the MoRAP; Montana Fish, Wildlife, and Parks; and state NHPs. Modeling generally made use of presence community fish collection data. Some of the species data gathered during the analysis were species "presence" only information and not community collections; therefore, these data did not contain information about species absences. Additionally, the predictive distribution for the northern redbelly x finescale dace was modeled by combining species collections for the northern redbelly dace, finescale dace, and northern redbelly x finescale dace hybrid because occurrence data for the hybrid dace was not adequate.

Each species was modeled individually using the entire set of records within the species range. Results showed potential distributions based on abiotic variables independent of current condition. More specifically, for each fish, MoRAP ran a series of boosted regression tree (BRT) models in R adjusting the model parameters following Elith et al. 2008. For the series of models produced for each species, MoRAP selected the model with the highest cross-validated receiver operating characteristic (CV ROC) score as the final model. Using these methods, MoRAP was able to generate probability of occurrence models for the focal species.

The resulting community fish collection database was linked to streams attributed with the 54 predictor variables representing stream and watershed characteristics, independent of current condition. The list of attributes is provided as Attachment A. Riverine fishes are influenced by numerous landscape and in-channel factors and processes operating at multiple spatial and temporal scales. Six variables associated with the overall watershed and immediate drainage of a particular stream segment were included. Other predictor variables used in the model represented conditions within the watershed of a given stream segment that also have major influence on local habitat conditions of that segment and consequently have an influence on the distribution and abundance of riverine biota. These predictor variables generally pertain to climate, soils, geology, and landform. The source data for these variables are provided in the metadata that accompany this report.

Models were produced using a 1:100,000-scale modified version of the National Hydrography Dataset (NHD) stream layer with accompanying catchments and attribution developed as part of the Missouri River Basin Aquatic GAP Project (Annis et al. 2010). The distribution information is displayed by stream reach within the HUC 12 boundaries. The models were developed using boosted regression tree (BRT) analysis in R (MoRAP 2012). All models were fitted in R version 2.14.0, using generalized boosted models (gbm) package version 1.6-3.1 (Ridgeway 2007) and dismo package version 0.7-11 (Hijmans et al. 2011).

The results of the predictive distribution modeling are presented on Figures E-7-1 (for the pearl dace) and E-7-2 (for the surrogate northern redbelly x finescale dace hybrid model). The predicted fish distributions presented on these figures reflect the biological potential of a given stream segment and not necessarily the present-day assemblage of species. This means that the assemblage we predict to occur in a given segment of stream will in some instances (e.g., highly disturbed streams) be quite different from the present-day assemblage. However, in relatively undisturbed locations the predicted assemblage of fishes should reflect the present-day assemblage distribution (MoRAP 2012).

4.0 CONCEPTUAL MODELS

The current and potential future threat analyses were based on CE-specific ecological conceptual models, selected environmental variables (Key Ecological Attributes [KEAs]) likely to be impacted by CAs, and the availability of data. CAs considered relevant to this CE include development, climate change, wildlife, and invasive species.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model (Figure E-7-3) was developed to identify and link the key life cycle processes to specific ecological factors, or KEAs, that have the greatest potential to affect prairie fish habitat throughout the ecoregion. As noted in the species descriptions, this assemblage requires spring-fed streams with cover in the form of undercut banks, heavy vegetation and woody debris, and few (if any) large, predatory fish species.

The key processes are identified in the model as green boxes. Following Unnasch et al. (2009), three broad headings or categories of ecological attributes (EAs) (size, condition, and context) are identified in the model as blue diamonds. Size refers to attributes related to habitat or patch size, condition refers to the condition of the habitat, and context refers to the spatial structure of the habitat. At the landscape level, the EAs under the condition category will be the most challenging to spatially represent and will primarily depend on the data available.

4.2 SYSTEM-LEVEL CONCEPTUAL MODEL

The system-level conceptual model (Figure E-7-4) illustrates the interactions between the CAs and the primary habitat functions of this assemblage. The primary CAs for this REA are development, wildfire, climate change, and invasive species, which are identified across the top of the figure in red. The important factors (or “drivers”) affecting the abundance of prairie fish populations include those that impact habitat availability and habitat quality.

The CA threats to prairie fish species are habitat alteration resulting from development (intensive agriculture, overgrazing, road crossings, dams), climate change, wildfire, and the introduction of non-native fishes (Stasiak and Cunningham 2006; Montana Field Guide 2010a and b; Bramblett and Stagliano 2012).

4.2.1 Development

Bramblett et al. (2005) and Stagliano (2005) have determined that significant threats with the highest potential to disrupt natural processes and impair biodiversity in the prairie ecosystems of Montana include dams and diversions, roads in the watershed, and altered land cover (habitat conversion and degradation). The prairie fish species distributions have been affected by a variety of factors resulting from activities associated with human development, (such as the creation of dams and impoundments that act as migration barriers, elimination of riparian zones, and conversion of natural landscapes to agriculture which contributes to habitat loss). The primary historical causes of species/population declines include loss of available habitat resulting from increased stream temperatures, and increased turbidity resulting from soil erosion (resulting from development). Water development activities (reservoir construction, stream diversions, and channelization) that alter natural spring flow are a concern, as they often lead to habitat degradation and stream fragmentation. Surface and groundwater extraction for urban and exurban populations, agricultural irrigation, and industrial development adversely affect prairie fish populations. Logging, mining, urban/exurban development, road construction, and grazing have resulted in streambank erosion, sedimentation, adverse changes to channel configuration, and loss of riparian habitat that provides shading and a source of insect prey for aquatic habitats (Spahr et al. 1991; Eaglin and Hubert 1993).

4.2.2 Climate Change

Abiotic stressors such as drought, temperatures, and habitat availability are also important factors controlling reproductive success. Given their preference for cool temperatures, the species selected to represent the prairie assemblage may be vulnerable to the warming of water from global climate change (Dickson 2010). Added to human-induced stressors is the threat of climate change, which may exacerbate or accelerate many existing threats and create additional stressors.

4.2.3 Wildfire

The effects of fire on aquatic systems may be direct and immediate, or they may be indirect, occurring over an extended period (Gresswell 1999). Direct effects relate to short-term biological and physical changes that result directly from burning. Indirect effects of fire occur over a longer temporal scale as a result of fire-induced changes to the biota and physical environment. Fire can cause immediate changes in the water chemistry of forest streams and ponds, both as a by-product of heating and from smoke and ash inputs during the burning process (Spencer and Hauer 1991). Elevated water temperatures can reduce the solubility of dissolved oxygen and, along with adsorption of smoke and deposition of ash into surface waters, increase pH and nutrient levels in aquatic systems. During large fires, substantial quantities of particulates and volatile compounds are transported via the atmosphere and may produce large fluxes of nutrients in aquatic ecosystems (Spencer and Hauer 1991). Fire-caused changes in water chemistry may also kill fish directly or repel them from affected streams. During an initial firestorm, increased stream nutrient loadings would likely occur due to overland flow and subsurface transport following the fire and based on extent and proximity of wildfire to the stream. Nutrient concentrations may also periodically increase in fire-impacted sites, especially during spring run-off. Prior to European settlement, wildfires were part of the natural ecosystem and may well have increased nutrient loadings to surface waters. However, the possibility of increased wildfire activity following years of fire suppression could represent a chronic loading of smoke and ash (Spencer et al. 2003) The CA analysis for wildfire was not included for this CE because the direct effect indicators (post-wildfire water quality or fish occurrence) were determined to be data gaps.

4.2.4 Invasive Species

The introduction of non-native piscivorous sport fish species such as large sunfish (i.e., bass species), pike, or trout has been the primary cause for the reductions in the prairie fish assemblage focal species. Introduced species negatively affect native fishes through the combined pressures of predation, competition, potential for the addition of new parasites and disease, and altering the species' behavioral components (Cunningham 2006). Dams, improperly placed culverts, and irrigation diversions also provide suitable habitats for predatory species (Stagliano 2007). Over harvest of these species for bait resources has also contributed to their decline in the Northwestern Plains ecoregion. Analysis for the invasive species CA was not included for this CE because appropriate geospatial data were not available for predator fish of this assemblage.

4.3 CHANGE AGENTS PROPOSED FOR ANALYSIS

Although numerous attributes and indicators affecting this species were initially identified in the early phases of this REA, not all are included in this analysis. The specific indicators that could not be modeled are identified with an asterisk on Figure E-7-4. In some cases, however, surrogate data were available (as noted on Figure E-7-4) and were used for the analysis. Analysis for the wildfire and invasive species CAs were not included for this CE because the direct effect indicators were determined to be data gaps or because they were impractical to model at the ecoregional scale because appropriate geospatial data were not available.

The focus of the analysis for this CE will be on current status of the development CA and future threats associated with development and climate change CAs.

5.0 CHANGE AGENT ANALYSIS

A current status and future threat assessment for the prairie fish assemblage using the 12-digit HUCs as the analysis unit was conducted. Based on the ecological process and system level models, KEAs were identified for the current status and future threat analyses, with a specific emphasis on the ability to measure impacts using existing geospatial data. The CAs evaluated for current status include development. The CAs evaluated for future threats include development and climate change.

Since the scale of the analysis is at the HUC 12, a layer of 6^{th} level HUCs was extracted for the ecoregion. A geographic information system (GIS) process was iterated through the KEA indicators and determined the metric values associated with some watersheds. In other instances, sufficient published data indicated cut-off points for these values. These values were added as an attribute to the HUC 12 layer. Since the primary reporting units for final mapping outputs is at a minimum of the 6^{th} level HUC (HUC 12) for the CEs, the values from the final output maps need to be added as an attribute to the HUC 12 watersheds. The final layers were created by combining the HUC 12 watersheds (with ranked KEAs) with the final suitable habitat layer and the habitat layer from the current status CA layer.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

5.1.1 Key Ecological Attribute Selection

Several KEAs were identified for evaluation of the current status for the CE in the ecoregion. Table E-7-2 identifies the attributes that were initially evaluated for use as a condition attribute but were excluded due to the lack of data. Table E-7-3 identifies the remaining KEAs, indicators, and metrics that were used to evaluate development CA pathways affecting this CE across the ecoregion (as illustrated on Figure E-7-4).

Table E-7-2. Key Ecological Attributes Excluded

Category	Attribute	Rationale
Condition (Water Quality)	Percent of HUC 12 in National Wetlands Inventory (NWI) (all polygons)	Excluded because the necessary data to rank HUC was missing.
	Percent of HUC 12 in NWI (natural polygons)	Excluded because the necessary data to rank HUC was missing.

For each of the KEAs listed in Table E-7-3, a discussion of the indicator, metric, metric rank and value, data source(s), and references are provided. Several indicators for size, condition, and landscape context were used to assess the current status for the prairie fish assemblage.

A threat assessment of fish species in Montana by Stagliano (2007) informed the threshold metrics for habitat quality, water quality, and development for this CE. This study included both the pearl and hybrid dace, and many of the attributes proposed in Table E-7-3 were derived from Stagliano (2007). Stagliano (2007) defined metrics to measure current anthropomorphic disturbance to prairie fish habitat, including using proximity to various development types as a surrogate for the substances included in runoff that likely enter the waterways. Metrics used in the current status were equally weighted when evaluating the overall current status of the CE assemblage.

5.1.1.1 Dams and Surface Water Diversions

Dams and surface water diversions have been documented to change hydrologic flows through a watershed and disrupt normal geomorphic processes downstream, and they are usually point sources of stocked non-native species. Although counting the number of dams or diversions may not be completely representative of the impact of these features, it does provide a basis for comparing stream alteration between watersheds. The number of dams in an HUC could also be indicative of introduced species colonization points (Stagliano 2007).

Data on dams and surface water diversions in the Northwestern Plains ecoregion was obtained from the U.S. Army Corps of Engineers (USACE) National Inventory of Dams (NID) (USACE 2010). The inventory consists of data for approximately 45,000 dams, which were gathered from extensive record searches and some feature extraction from aerial imagery. In most cases, dams within the NID criteria are regulated (construction permit, inspection, and/or enforcement) by federal or state agencies, which have basic information on the dams within their jurisdiction (USACE 2010). Figure E-7-5 shows the location of dams within the ecoregion.

The number of dams and non-dam diversions that intersected streams in the 6th code HUC watershed within the ecoregion were summed and then assigned a relative rank of good, fair, or poor (as noted in Table E-7-3). The scoring system used for this indicator was adopted from Stagliano (2007). If there were 5 or less dams per HUC, then the HUC was ranked good and received a metric score of 1. If the number of dams was between 6 and 9 per HUC, then a rating of fair with a metric score of 2 was assigned. If the number of dams and non-dam diversions were 10 or greater, then a rating of poor with a metric score of 3 was assigned. Overall, fragmentation of habitat from dams is low for most of the ecoregion. There are areas in the south-central portion of South Dakota and into Nebraska that seem to correspond to the northern extent of the probability maps for these species.

Table E-7-3. Prairie Fish Assemblage Key Ecological Attributes, Indicators, and Metrics

Category	Key Ecological Attribute	Indicator / Unit of Measure	Metric Rank			Data Source	Rank Citation
			Poor = 3	Fair = 2	Good = 1		
Size	Habitat Size	Number of Dams in HUC	>=10	6 – 9	<=5	National Inventory of Dams (NID)	Stagliano 2007
Condition	Habitat Quality	Percent of HUC in GAP Status 1 or 2	< 25%	25–60%	> 60 %	Protected Areas Database (PAD) Version 1.2 April 2011	Stagliano 2007
		Percent in GAP Status 1,2, or 3	< 25%	25–60%	> 60 %	PAD Version 1.2 April 2011	Stagliano 2007
		Percent of HUC Riparian Corridor with Natural Land Cover	<25%	25-80 %	>80%	NLCD - 2006	USDA 2011
	Water Quality	Number of Oil/Gas wells	>20	10-20	0 – 9	BLM Oil and Gas Wells	Stagliano 2007
		Percent of streams that are 303(d)-listed	>10%	1-9%	0%	NHD Plus Streams USEPA 303(d) List	USDA 2011
		Number of Mines	>2	1 - 2	0	U.S. Geological Survey (USGS) Mineral Resources Data System	Data Quantiles
		Number of Toxic Release Inventory (TRI) Sites	>1	1	0	USEPA Envirofacts Data - TRI class	Data Quantiles
Context	Landscape Structure	Percent of Streams/ Shorelines of HUC that are within 40 m of road	>2.5%	1 - 2.5%	< 1%	NHD Plus Streams, Water Bodies, Area TIGER Roads 2010 - All Roads	Stagliano 2007
		Percent of HUC in Agricultural Use (Crop)	>60%	30 - 60%	<30%	NLCD - 2006	Similar to Allan 2004
		Percent of HUC Riparian Corridor in Agricultural Use (Crop)	>6%	3 - 6%	<3%	NLCD - 2006	Stagliano 2007
		Percent Impervious	>10%	6 - 10%	<6%	NLCD - 2006	Allan 2004 Table 1 from Appendix E; page 142 of Annis et al. 2010; Wang et al. 2008
		Percent of Riparian Corridor in Impervious	>10%	5 - 10 %	<5%	National Land Cover Dataset - 2006	Wang et al. 2008; Joubert and Loomis 2005
		Population in HUC 12 per Square Kilometer	>300	100-300	<100	Landscan 2000 Global Population Database	Wang et al. 2008

5.1.1.2 Percent of HUC 12 in GAP Status 1 or 2 and Percent of HUC 12 in GAP Status 1, 2, or 3

The indicator used to assess habitat condition is the proportion of the stream located within a public or privately protected land area; it is assumed that the higher the proportion of stream in protected areas, the higher the quality.

This analysis used data from the Protected Areas Database of the United States (PAD-US), which is a GIS database hosted by the GAP that illustrates and describes public land ownership, management, and conservation lands nationally, including voluntarily-provided, privately-protected areas. The lands included in PAD-US identify land that is managed through various measures for the preservation of biological diversity and other natural, recreational, and cultural uses. The PAD-US version 1.2 includes various protected areas such as National Park Service (NPS) boundaries, Department of Defense (DOD) boundaries in cooperation with DOD Partners in Flight, Marine Protected Areas, the BLM National Landscape Conservation System (NLCS) authoritative boundaries, and the NLCS National Trails and Wild and Scenic Rivers. The PAD-US provides a spatial dataset of public and private lands and waters secured by a conservation situation that includes an explicit level of security from future conversion and current incompatible uses (USGS 2012). All lands identified in the PAD-US are assigned GAP conservation status codes to indicate the level of protection provided to each parcel based management intent for long-term biodiversity conservation. GAP codes of 1 and 2 are lands managed for permanent biodiversity protection; 3 designates multiple-use lands that may support extractive uses; and 4 indicates no known mandate for permanent protection (USGS 2012). Figure E-7-6 shows the areas defined as GAP 1 and 2 lands. Figure E-7-7 shows the areas defined as GAP 1, 2, and 3 lands.

For the analysis of habitat quality, an estimate of the percentage of the HUC in GAP 1 or 2 protected areas was determined. Also, a second indicator was estimated for the percentage of the HUC in GAP 1, and 3. The scoring system used for these indicators was adopted from Stagliano (2007) and is presented in Table E-7-3. This KEA is important in the overall analysis because of the overall status of lands in this ecoregion. The majority of area seems to be designated GAP 3 (multiple-use lands that may support extractive uses) and 4 (no known mandate for permanent protection) (Figures C-7-6 and C-7-7). Lands that are not designated as 1 or 2 (permanent biodiversity protection) would result in A rating of poor, which is indicated over most of the ecoregion. The only exception is Lake Fort Peck in Montana and a few much smaller islands likely representing state or private natural areas.

5.1.1.3 Percent of Riparian Corridor with Natural Landcover

This KEA addresses habitat condition. The presence of native vegetation that is vigorous, healthy, and diverse in age, structure, cover, and composition is indicative of a watershed that is functioning properly throughout the stream corridor or along wetlands and water bodies (USDA 2011). Various studies have documented that intact riparian areas help to minimize the impact of agriculture and other disturbance to aquatic communities (Wenger 1999).

For this analysis, a riparian vegetation cover data layer was created using the most recent version (2006) of the National Land Cover Database (NLCD). The NLCD provides Landsat-based, 30-m resolution spatial reference and descriptive data for characteristics of the land surface such as thematic class (e.g., urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover. NLCD products are created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by the U.S. Geological Survey (USGS) (Homer et al. 2012).

For each 6^{th} level HUC, the data from the NLCD was used to estimate the percentage of stream miles containing riparian areas; a relative rank of good, fair, or poor (as noted in Table E-7-3) was then assigned (Figure E-7-8). The percentages used to rank this attribute were based on the USDA Riparian/Wetland Vegetation Condition Rating Rule Set (USDA 2011). Overall, the majority of watersheds within the species distribution of this assemblage returned a good or fair output for this KEA.

5.1.1.4 Number of Oil and Gas Wells

The number of oil and gas wells was used by Stagliano (2007) as an indicator of condition based on the assumption that presence and number of oil and gas wells in a particular location would impact water quality due to operational activities associated with well development, as well as potential spills. Potential impacts from exploration and production (E&P) operations may include soil, air, and water contamination; habitat fragmentation; deforestation; and erosion.

The BLM compiles a large amount of statistical information relating to oil and gas leasing on federal lands. Data for this indicator were prepared by BLM from a compilation of oil and gas well data from various state government agencies that oversee the administration of these data in their respective states. These data were used to create an oil and gas well data layer, which was then overlain on the HUC watershed layer (Figure E-7-9).

The number of oil and gas wells located within the HUC was calculated and then assigned a relative rank of good, fair, or poor (as noted in Table E-7-3). The scoring system used for this indicator was adopted from Stagliano (2007). If there were less than 10 oil and gas wells in the HUC, then the HUC was ranked as good and received a metric score of 1. If the number of oil and gas wells was between 10 and 20 per HUC, then a rating of fair with a metric score of 2 was assigned. If the number of oil and gas wells was greater than 20, then a rating of poor with a metric score of 3 was assigned. In the area of the ecoregion where oil and gas wells occur, the watersheds resulted in poor or fair scores.

5.1.1.5 303(d) Listing

This KEA represents the water quality of a stream based on its status as defined by Section 303(d) of the Clean Water Act (CWA). Waterbodies that are found on this list are considered impaired based on national water quality standards. Surface waters can be added to the 303(d) list for two reasons: 1) when water quality standards are not being met or, 2) designated uses are not being achieved. Although a 303(d) listing does not mean that the species associated with this assemblage would not be present, this listing is an indication of habitat condition.

Stream data were obtained from the USGS's National Hydrography Dataset (NHD), and water quality data were obtained from USEPA's Water Quality Standards Database (WQSDB). NHD-Plus is an integrated suite of application-ready geospatial data products, incorporating features of the NHD, the National Elevation Dataset (NED), and the National Watershed Boundary Dataset (WBD). NHD-Plus includes a stream network based on the medium resolution NHD (1:100,000 scale), elevation-derived catchments, feature naming, and value-added attributes that can produce cumulative drainage areas and land cover, temperature, and precipitation distributions.

USEPA's WQSDB contains information reported by the states to USEPA about the conditions in their surface waters and is comprised of information on the attainment of water quality standards. This WQSDB provides information regarding the waterbodies listed by the state as impaired under Section 303(d). As part of a state's water quality standards, designated uses (drinking water supply, recreational use, and fish protection) provide a regulatory goal for the waterbody and define the level of protection assigned to it (USEPA 2012).

For this analysis, the stream name and the spatial representation were extracted from NHD as a data layer, and the 303(d) list data were joined to the NHD layer to map the impeded streams (Figure E-7-10). The percentage of streams in the 5th code HUC watershed within the ecoregion that were included on the 303(d) list were calculated, and then a relative rank of good, fair, or poor (as noted in Table E-7-3) was assigned. No state-listed impaired or threatened water bodies (0 percent) were ranked as good and received a metric score of 1. If less than 10 percent of the stream miles or lake area were 303(d)-listed, then a rating of fair with a metric score of 2 was assigned. If more than 10 percent of the stream miles or lake areas are 303(d)-listed, then a rating of poor with a metric score of 3 was assigned. The percentages used to rank this attribute were based on the USDA Water Quality Condition Ranking Rule Set (USDA 2011). The results of the 303(d) KEA analysis predominantly returned fair to poor scores for this KEA.

5.1.1.6 Number of Mines

Surface water bodies and groundwater supply can be adversely affected by mining. Some of the impacts can include drainage of usable water from shallow aquifers, lowering of water levels in adjacent areas, poor-quality water flow to nearby streams, and increased runoff of poor-quality water and erosion from spoil piles.

Data on the locations of mines in the ecoregion were extracted from the USGS's Mineral Resources Data System (MRDS). The MRDS is a database that includes information on the metallic and non-metallic mineral resources in the United States and the world. Included are deposit name, location, commodity, deposit description, geologic characteristics, production, reserves, resources, and references (USGS 2005).

For this analysis, locations of the mines within the ecoregion were extracted from the MRDS as a data layer (Figure E-7-11). The total number of mines in each HUC watershed was summed, and a relative rank of good, fair, or poor (as noted in Table E-7-3) was then assigned. The percentages used to rank this attribute were based on quantiles of the dataset (MoRAP 2012). The prairie fish assemblage does not appear to be at a high risk from the number of mines in this ecoregion. Much of the distribution of these species occurs in watersheds that returned a good score for this KEA.

5.1.1.7 Number of Toxic Release Inventory Sites

Toxic chemicals are typically generated inland and are carried by air and/or fresh water to surface water bodies where they tend to accumulate in sediments. The impacts can be an immediate or acute affect on stream biota at high enough levels or they may be chronic, eliminating the more sensitive species and disrupting ecosystem balance over time. This ecoregion has also been impacted by historical mining activities which resulted in toxic releases that have impacted water, soil, and environment.

Data on the location of toxic releases was extracted from the USEPA's Envirofacts database. This database includes information from the USEPA's Toxic Release Inventory (TRI), which contains data on disposal or other releases of toxic chemicals from U.S. facilities. Data are submitted annually by U.S. facilities that meet TRI reporting criteria. Through the USEPA's Geospatial Data Download Service, the USEPA Geospatial Data File containing facility and site information from USEPA's TRI system can be downloaded. The file is internet accessible from the Envirofacts Website (www.epa.gov/enviro) and the data may be downloaded in Extensible Markup Language (XML), Environmental Systems Research Institute (ESRI) Shapefile, or ESRI relational feature class format.

For this analysis, locations of the TRI sites within the ecoregion were extracted from the Environfacts database as a data layer (Figure E-7-12). The total number of TRI sites in each HUC watershed was summed and a relative rank of good, fair, or poor (as noted in Table E-7-3) was then assigned. If no TRI sites were located in the HUC (0 percent), then the HUC was ranked as good and received a metric score of 1. If the number of mines was 1, then a rating of fair with a metric score of 2 was assigned. If the number of mines was 2 or greater, then a rating of poor with a metric score of 3 was assigned. The percentages used to rank this attribute were based on quantiles of the dataset (MoRAP 2012). The number of TRI sites in this ecoregion is fairly small and the watersheds where these species occur returned good results for this KEA.

5.1.1.8 Roadways

KEAs defined to assess landscape context evaluate the quality of the landscape immediately surrounding an ecological system in order to provide an assessment of the potential threats to the habitat of the prairie fish assemblage. Both improved and unimproved roads compact soil and vegetation, increasing surface runoff. Road rights-of-way are often inroads for exotic species colonization points, and unimproved roads contribute to wind and water-borne sedimentation. Streams in close proximity to roads are also more likely to be affected than those at a greater distance (Stagliano 2007).

Stream data were obtained from the NHD for each HUC area within the ecoregion and were overlain with the roadway data layer. Roadway data were extracted from selected geographic and cartographic information from the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER) database. For this REA, the criterion used was the All Roads County-based Shapefile (U.S. Census Bureau 2012).

The percent of streams/shorelines within the HUC located within 40-m of a roadway was calculated and each HUC was then assigned a relative rank of good, fair, or poor based on percentage (as noted in Table E-7-3). The scoring system used for this indicator was adopted from Stagliano (2007) based on the concept that if the percentage of stream miles within 40 m of a road are generally low, roads would not be a major source of disturbance in the study area (Figure E-7-13). Based on review of this figure, it is obvious that the prairie fish assemblage is at current risk from the roads KEA. All of the watersheds where these species occur returned poor results for this KEA.

5.1.1.9 Agriculture

Agricultural land use degrades streams by increasing nonpoint inputs of pollutants, impacting riparian and stream channel habitat, and altering flows. Negative impacts to aquatic life have been documented when approximately 30 to 60 percent of the land area is in agricultural use (Sheeder and Evans 2004). Where agriculture or other anthropogenic activity extends to the stream margin and natural riparian forest is removed, streams are usually warmer during summer and receive fewer energy inputs as leaf litter, and primary production usually increases (Quinn 2000).

For this analysis, two KEAs were evaluated: percent of agricultural land use within HUC as a whole and percent of riparian corridor within agricultural land use area. The land use data layers were created using the NLCD. Agricultural land use areas are defined by the NLCD as areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75 to 100 percent of the cover. Data extracted include land uses of cultivated crops and pasture/hay. The riparian corridor area data were extracted from the NLCD using the open water, woody wetlands, and emergent herbaceous wetlands criteria. Figure E-7-14 illustrates the landcover types used for this layer.

Data from the NLCD was used to estimate the percentage of agricultural land use within the HUC as well as the percentage of riparian corridor (stream miles) with adjacent agricultural land use. A relative rank of good, fair, or poor (as noted in Table E-7-3) was assigned based on the percentage calculated for each KEA. For the percentage of HUC in agricultural land use, if less than 30 percent of the HUC was for agricultural land use, then the HUC was ranked as good and received a metric score of 1. If the percentage was between 30 and 60 percent, then a rating of fair with a metric score of 2 was assigned (Figure E-7-15). If the percentage was greater than 60 percent, then a rating of poor with a metric score of 3 was assigned. The percentages used to rank this attribute were based on citations from Allan (2004).

Likewise, if the percentage of riparian corridor adjacent to agricultural land was less than 3 percent, between 3 and 6 percent, or greater than 6 percent, then ratings of good, fair, or poor were assigned, respectively. The metrics used to score the percent of riparian corridor in agricultural use were adopted from Stagliano (2007). Based on review of Figure E-7-15, it is evident that riparian areas (which provide habitat for this assemblage) are at risk from agriculture. Although the distribution areas of prairie fish in northern Nebraska and southern South Dakota do not appear to be at risk from this KEA, the watersheds in northern Montana where these species occur returned poor results for this analysis

5.1.1.10 Impervious Cover

Areas of land covered by concrete, asphalt, buildings, or even severely compacted areas of soil are impervious to rain water. Various studies from around the country show that stream ecosystems and water quality degrade as impervious surfaces increase. Significant impairment to streams often occurs when more than 10 percent of the land within a watershed is covered with impervious surfaces. When these levels exceed 25 percent, most watersheds experience severe ecosystem and water quality impairment (New Jersey Water Supply Authority 2002).

For this analysis, two KEAs were evaluated: percent of impervious cover within HUC as a whole and percent of impervious cover within the riparian corridor. The land use data layers were created using the NLCD. Data extracted from the NLCD included land use categories of developed and barren. The riparian corridor area data were extracted from the NLCD using the open water, woody wetlands, and emergent herbaceous wetlands criteria. Figure E-7-14 shows the landcover designations.

Data from the NLCD were used to estimate the percentage of impervious cover within the HUC as well as the percentage of impervious cover within the riparian corridor (stream miles). A relative rank of good, fair, or poor (as noted in Table E-7-3) was assigned based on the percentage calculated for each KEA. For the percentage of HUC in impervious cover, if less than 6 percent of the HUC was developed or barren, then the HUC was ranked as good and received a metric score of 1. If the percentage was between 6 and 10 percent, then a rating of fair with a metric score of 2 was assigned. If the percentage was greater than 10 percent, then a rating of poor with a metric score of 3 was assigned (Figure E-7-16). The percentages used to rank this attribute were based on Allan (2004); Wang et al. (2008); and Annis et al. (2010).

Likewise, if the percentage of impervious cover adjacent to the riparian corridor was less than 3 percent, between 3 and 6 percent, or greater than 6 percent, then ratings of good, fair, or poor were assigned, respectively. The metrics used to score the percentage of impervious cover adjacent to the riparian corridor were based on Wang et al. (2008) and Joubert and Loomis (2005). Because of the relatively rural nature of this ecoregion, the results of this analysis returned predominantly good results.

5.1.1.11 Population

Human population growth is an indicator of landscape context and is used as a surrogate indictor for the potential impacts associated with development and urbanization that impact stream quality.

Population data were extracted for the ecoregion using the Oak Ridge National Laboratory's LandScan 2010 Global Population Dataset. The LandScan global population distribution modeling process uses sub-national level census counts for each country and primary geospatial input or ancillary datasets, including land cover, roads, slope, urban areas, village locations, and high-resolution imagery analysis, all of which are key indicators of population distribution. Within each country, the population distribution model calculates a “likelihood” coefficient for each cell and applies the coefficients to the census counts, which are employed as control totals for appropriate areas. The total population for that area is then allocated to each cell proportionally to the calculated population coefficient. The resultant population count is an ambient or average day/night population count as people per cell (ORNL 2010).

Data from the LandScan were used to estimate the average population within the HUC. A relative rank of good, fair, or poor (as noted in Table E-7-3) was assigned based on the average population calculated by LandScan. An average population of < 100 people was ranked as good and received a metric score of 1. Populations between 100 and 300 people received a rating of fair with a metric score of 2. Average populations of greater than 300 were given a rating of poor with a metric score of 3. The values used to rank this attribute were based on Wang et al. (2008). Figure E-7-17 shows the population rank results within the ecoregion. Similar to the impervious surface KEA, because of the relatively rural nature of this ecoregion, the results of this analysis returned predominantly good results.

5.1.2 Current Status of Habitat

The individual KEA analyses provide the basis for the compilation of an overarching data layer that defines the current status of prairie fish habitat for each HUC across the Northwestern Plains ecoregion. In order to create a current status layer, an overall score for each HUC was calculated. Once the ranks for each individual KEA were assigned, a simple additive method was used to combine the ranks into an overall score for each HUC. The resulting additive scores from 13 individual KEAs ranged from 20 to 39, with larger numbers indicating lower threats or better ecological conditions. These cumulative scores were placed into categories of good, fair, or poor.

Although the good, fair, or poor ratings could be attributed any number of ways, roughly equal numbers of HUC polygons were placed into each category, thus the resulting ratings are relative to the study area and should be interpreted as a gradient from poor to good (MoRAP 2012). The overall ratings were developed as a relative measure of aquatic habitat status across a large geographic area. In addition, this assessment was intended to be repeated in a quick manner. As such, there are several limitations to the current status assessment. The first is that the resulting additive index and associated ranks are very much a factor of the data that were available consistently over the ecoregion. In addition, no consideration was given to the impacts of development residing upstream of a given HUC; therefore, the entire contributing area is not generally considered. It is also possible that one single indicator could substantially diminish the habitat status at any given location. Because the final rankings are based on additive scores, HUCs with a single pervasive condition will invariably score low, giving the false indication that the current status is good. Another weakness is that we were not able to assign specific weights to the individual CA indicators incorporated into the overall rating. With consideration of these limitations, this assessment can be used to provide a means to establish baseline conditions for this CE in the Northwestern Plains ecoregion and can be used to characterize habitats in the coming years.

Figure E-7-18 illustrates the current habitat status by HUC 12 watershed for this CE based on the KEA overall score. Although the distributions of prairie fish species in the southeastern portion of the ecoregion appear to be less at risk than those populations in northern Montana, the overall current status of watersheds where these species occur appear to be at some level of current risk from the CAs.

A summary of the current status ratings based on the CE distribution is provided in Table E-7-4. The CE distribution layer was used to calculate the total number of square miles of CE habitat and a percentage of the total number of square miles per HUC that were rated as good, fair, or poor. The results of the current status assessment indicate that nearly 71 percent of the 6th level HUC watersheds that intersect the prairie fish assemblage distribution received an overall rating of fair or poor.

Table E-7-4. Summary of Current Status Ratings for the Prairie Fish Assemblage

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	66,933	28.3
Fair	63,142	26.7
Poor	104,608	44.3

[a] These values include only the area of HUCs that intersect with the CE distribution layer.
[b] Values rounded to one decimal place.

5.2 FUTURE THREAT ANALYSIS

The system-level model (Figure E-7-4) was used to create a series of intermediate layers that are primarily based on the geospatial data that were available on the future projections for a short-term time horizon (5 to 10 years) for the development CA. Future threats were also qualitatively evaluated for climate change for long-term change (50-year; 2050 to 2069).

Because of the inherent inaccuracies of the temporal scale of the future data, it is only possible to infer information pertaining to a subjective future period (rather than a specific time period) for some of these attributes. However, because of the limits placed on these data outputs, it is fair to assume that this model predicts the overall future potential for these attributes within this ecoregion.

5.2.1 Development Change Agent

Future spatial data for development were limited to future potential energy development, modeled urban growth, and potential agricultural development, as discussed in the development CA analysis presented in Appendix C-1. Future threats associated with urban growth were not considered significant based on the analysis conducted (as discussed in Appendix C-1).

Based on a review of the distribution maps created for this assemblage (Figures E-7-1 and E-7-2) relative to the future development, it appears that the species of this assemblage are at risk from future agricultural development in Montana and South Dakota. The portions of the species distributions in western North Dakota and Montana appear to be at risk from future fossil fuel development, but do not appear to be at a high risk from future renewable energy development in these areas.

5.2.2 Climate Change

The climate change layer was created based on the results of the regional climate change models completed for the future time period of 2025 and 2060. Climate change was modeled based on a 15-km grid created for regional analysis. This analysis included a comparison of current climate patterns to future modeled climate patterns and resulted in the delta (change) output figures. These models document areas that may be negatively and positively affected by climate change.

Based on the analysis conducted for the ecoregion (as presented in Appendix C-5), predicted temperature increases may lead to increased instances of localized drought. This may have a dramatic effect on the prairie fish assemblage. Pools that serve as refuges for fish in small streams may be lost and stream reaches may become fragmented. Reduced flow from cool-water springs may result in increases in water temperature and lower dissolved-oxygen levels, which may directly impact populations within these streams.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the prairie fish assemblage include those defined as part of the Aquatic/Riparian Biotic Resources category. The overall MQ was: Where are the important regionally significant aquatic/riparian biotic features, functions, and services across the ecoregional landscape? This MQ was considered in implementing the GIS analyses. Emphasis was placed on the spatial relationship of attributes mentioned in the MQs and the prairie dish occurrence probability models for each focal species. Specific MQ examples for the REA were developed in Task 1 and are presented in Appendix A. Several of these MQs are discussed below to demonstrate the functionality of the REA and to provide an opportunity to discuss significant data gaps that were identified during the REA.

6.1 WHERE ARE THE CURRENT LOCATIONS OF REGIONALLY SIGNIFICANT AQUATIC/RIPARIAN HABITATS, INCLUDING RIVERS, STREAMS, LAKES, PONDS, WETLANDS, SPRINGS, AND RESERVOIRS?

For the prairie fish assemblage, the occurrence probability maps (Figures E-7-1 and E-7-2) can be used to identify general areas in which habitat conditions occur that most closely match the preferences of each focal species. The predicted fish distributions presented on these figures reflect the biological potential of a given stream segment and not necessarily the present-day assemblage of species. This means that the assemblage we predict to occur in a given segment of stream will in some instances (e.g., highly disturbed streams) be quite different from the present-day assemblage. However, in relatively undisturbed locations the predicted assemblage of fishes should reflect the present-day assemblage distribution (MoRAP 2012). These species were selected because of their requirement for small headwater streams; therefore, the probability of their occurrence could be used to indicate areas where significant aquatic habitat exists.

Because the species distribution maps were produced at 1:100,000 scale and are intended for applications at relatively broad spatial scales (homogeneous areas generally covering 1,000 to 1,000,000 ha and stream segments ranging from 10 to 1,000 km, which are made up of multiple local biotic communities), applications of these data to local site-level analyses (e.g., individual stream habitats) are likely to be compromised by finer-grained patterns of environmental heterogeneity not captured within the models (MoRAP 2012).

6.2 WHERE ARE CURRENT RIPARIAN OR AQUATIC AREAS CURRENTLY AT RISK OF FRAGMENTATION IMPOUNDMENT, DIVERSION, AND LOWERED WATER TABLES DUE TO DEVELOPMENT, MINERAL EXTRACTION, AND AGRICULTURAL AND RESIDENTIAL DEVELOPMENT?

For the prairie fish assemblage, the current status layer provided on Figure E-7-18 can be used to identify the general ecoregion areas with the HUCs illustrated in red, indicating habitat conditions that are currently at risk due to development activities.

6.3 WHAT IS THE CURRENT FLOW REGIME (HYDROGRAPH) OF REGIONALLY SIGNIFICANT STREAM OR RIVER HABITATS OR DURATION AND EXTENT OF SURFACE WATER IN REGIONALLY SIGNIFICANT POND AND LAKE HABITATS?

Information on flow regimes of particular streams or lakes can be accessed from USGS based on the desired stream reach or area where the probability of occurrence for the prairie fish is high (as indicated on Figures E-7-1 and E-7-2).

6.4 HOW HAVE DOMINANT SPECIES CHANGED OVER TIME?

This MQ cannot be answered based on the lack of a comprehensive dataset for fish within the ecoregion. Additionally, this REA focused on potential impacts associated with CAs on this assemblage on an ecoregional basis. This MQ is relevant to a stream-reach or lake-specific evaluation of the fish community without regard to potential CAs.

6.5 WHERE ARE EXOTIC SPECIES AN EXISTING AND POTENTIAL PROBLEM?

This MQ cannot be answered based on the lack of a comprehensive dataset for fish within the ecoregion. Instead, BLM may want to focus future studies or actions in those areas where the probability of occurrence for the prairie fish is high, as indicated on Figures E-7-1 and E-7-2.

6.6 WHERE ARE DEGRADED AQUATIC SYSTEMS (WATER QUALITY) AND WHAT ARE THE SOURCES OF THE DEGREDATION (SALINE DISCHARGES, PETROCHEMICAL DISCHARGES, LEACHING OF TOXIC MINERAL SALTS, EUTROPHICATION DUE TO CONCENTRATED NUTRIENT RUNOFF, OTHER)?

Several surrogate indicators were used to assess water quality conditions, including use of the 303(d)-listed streams (Figure E-7-10), the location and number of oil and gas wells (Figure E-7-9), locations of mines (Figure E-7-11), and the areas of land under agricultural use (Figure E-7-15). The overall current status layer provided on Figure E-7-18 can be used to identify areas with current landscape uses that may contribute to degraded aquatic systems.

6.7 WHAT/WHERE IS THE POTENTIAL FOR FUTURE CHANGE IN DOMINANT SPECIES COMPOSITION OF REGIONALLY SPECIFIC AQUATIC HABITATS?

This MQ cannot be answered based on the lack of a comprehensive dataset for fish within the ecoregion. Additionally, this REA focused on potential impacts associated with the assemblage as a whole, not on a community-level approach.

6.8 WHICH AREAS HAVE POTENTIAL FOR REGIONALLY SIGNIFICANT AQUATIC HABITAT RESTORATION (BASED ON AVAILABLE GEOSPATIAL DATA)?

Figure E-7-18, combined with the probability maps provided on Figures E-7-1 and E-7-2, can be used to identify areas where aquatic habitat restoration activities for the prairie fish assemblages may be important.

6.9 WHERE ARE AQUATIC HABITAT STRONGHOLDS FOR SENSITIVE SPECIES THAT ARE INTACT AND PROVIDE THE BEST OPPORTUNITY FOR PROTECTION, RESTORATION, AND ENHANCEMENT?

The answer to this question is very similar to the answer to MQ 6.8. The distribution maps (as shown on Figures E-7-1 and E-7-2) present the habitats where this CE occurs. Figure E-7-18 illustrates the areas of the CE distribution that are currently at risk from the CAs identified in the conceptual models.

7.0 REFERENCES

Allan, J. David. 2004. Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. Annual Review of Ecology, Evolution, and Systematics. 35: 257-284.

Annis, G. M., S. P. Sowa, D. D. Diamond, A. Garringer, P. Hanberry, and M. E. Morey. 2010. *A GAP Analysis for Riverine Ecosystems of the Missouri River Basin*. Final Report (Draft), submitted to the USGS National Gap Analysis Program. 1,351 pp.

Bramblett, R. G., T. R. Johnson, A. V. Zale, A. V., and D. Heggem. 2005. Development and Evaluation of a Fish Assemblage Index of Biotic Integrity for Northwestern Great Plains Transactions of the American Fisheries Society 134:624–640, 2005

Bramblett, R.G, and Stagliano, D. 2012. Northern Redbelly X Finescale Dace (Phoxinus eos x phoxinus neogaeus) Status Review. Montana Chapter of the American Fisheries Society Species of Concern Committee. Available at http://www.fisheriessociety.org/AFSmontana/SSCpages/NRedbelly_Finescale_Status_Review_2012.pdf. January 31.

Cunningham, G.R. 2006. Pearl Dace (Margariscus margarita): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/pearldace.pdf.

Dickson, Tom. 2010. *Tiny Fish Under Big Skies, Why Minnows Matter*. Montana Outdoors May-June. Available at http://fwp.mt.gov/mtoutdoors/HTML/articles/2010/minnows.htm

Eaglin, G.S. and W.A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. N. Am. J. Fish. Manage. 13:844-846

Elith, J., Leathwick, J.R., & Hastie, T. 2008. A working guide to boosted regression trees. *Journal of Animal Ecology*.

Gresswell, R.E., 1999. Fire and aquatic ecosystems in forested biomes of North America. Trans. Am. Fisheries Soc. 128, 193–221.

Hijmans, R. J., S. Phillips, J. Leathwick and J. Elith 2011. R dismo package version 0.7-11. Species distribution modeling.

Homer, C.H., Fry, J.A., and Barnes C.A., 2012, The National Land Cover Database, U.S. Geological Survey Fact Sheet 2012-3020, 4 p.

Joubert, Lorraine and George Loomis. 2005. Chepachet Village Pollution Risk Indicators (Report Appendix B). Chepachet Village Decentralized Wastewater Demonstration Project. University of Rhode Island. http://www.uri.edu/ce/wq/NEMO/Publications/PDFs/WW.AppB4.%20IndicatorsandRatingChep.pdf

Missouri Resource Assessment Partnership (MoRAP). 2012. *Aquatic Species Distribution Modeling and Threat Analysis in the Northwestern Plains Ecoregion*, *Methods Report.* School of Natural Resources, University of Missouri, Columbia, Missouri. January.

Montana Natural Heritage Program and Montana Fish, Wildlife and Parks 2010a. Pearl Dace — Margariscus margarita. Montana Field Guide. Montana Natural Herigate Program and Montana Fish, Wildlife and Parks. Retrieved on November 19, 2010, from http://FieldGuide.mt.gov/detail_AFCJB54010.aspx.

Montana Natural Heritage Program and Montana Fish, Wildlife and Parks 2010b. Northern Redbelly X Finescale Dace — Phoxinus eos x phoxinus neogaeus. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on June 25, 2012, from http://FieldGuide.mt.gov/detail_AFCJB31X10.aspx

Nebraska Game and Parks Commission. 2011. *Nebraska Endangered and Threatened Species.* http://outdoornebraska.ne.gov/wildlife/programs/nongame/Endangered_Threatened.asp. August. Accessed on June 25, 2012.

New Jersey Water Supply Authority. 2002. Raritan Basin; Portrait of a Watershed. Raritan Basin Watershed Management Project, New Jersey Water Supply Authority. August. Available at http://www.raritanbasin.org/Alliance/Documents/Summary_Report.pdf

North Dakota Game and Fish Department. 1994. Fishes of the Dakotas. North Dakota Game and Fish Department, Bismarck, ND. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/fish/dakfish/index.htm Accessed on June 25, 2012.

Oak Ridge National Laboratory (ORNL). 2010. *LandScan Documentation*. United States Department of Energy. Available at http://www.ornl.gov/sci/landscan/ Accessed on June 26, 2012.

Olden, J.D., and D.A. Jackson. 2002. A comparison of statistical approaches for modeling fish species distributions. Freshwater Biology 47:1976-1995.

Quinn, J.M. 2000. Effects of pastoral development. In *New Zealand Stream Invertebrates:Ecology and Implications for Management*, ed. K.J. Collier, M.J. Winterbourn, pp. 208–29. Christchurch, NZ: Caxton.

Ridgeway, Greg. 2007. Gbm package version 1.6-3.1. Generalized Boosted Regression Models.

Sheeder, S. A., and B. A. Evans. 2004. Estimating nutrient and sediment threshold criteria for biological impairment in Pennsylvania watersheds. Journal of the American Water Resources Association 40: 881-888.

Spahr, R., L. Armstrong, D. Atwood, and M. Rath. 1991. Threatened, Endangered, and Sensitive species of the Intermountain Region. USDA Forest Service, Intermountain Region, Ogden, UT.

Spencer, C.N., Hauer, F.R., 1991. *Phosphorus and nitrogen dynamics in streams during a wildfire*. Journal of the North American Benthological Society. Volume 10, 24–30.

Spencer, Craig N., Gabel, K.O., Hauer, F.R. 2003. Wildfire effects on stream food webs and nutrient dynamics in Glacier National Park, USA. Forest Ecology and Management 178 (2003) 141-153. Available at http://classes.uleth.ca/200803/geog3090a/Field%20Trip%20Spencer%20et%20al.%202003.pdf

Stagliano, David, M. 2005. *Aquatic Community Classification and Ecosystem Diversity in Montana's Missouri River Watershed.* Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana. 65 pp. plus appendices. http://www.mtnhp.org/reports.asp#Ecology

Stagliano, David, M. 2007. Freshwater Conservation Measures for the Northern Great Plains Steppe Ecoregion of Montana. Report to The Nature Conservancy, Ecoregional Measures Team and The Montana Field Office. Montana Natural Heritage Program, Helena, Montana 36 pp. plus appendices.

Stasiak, R.H. 1972. The morphology and life history of the finescale dace, Pfrille neogaea. In: Itasca State Park, Minnesota. Ph.D. Thesis, University of Minnesota, Minneapolis, MN.

Stasiak, R. and G.R. Cunningham (2006). Finescale Dace (Phoxinus neogaeus): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. March 7. Available: http://www.fs.fed.us/r2/projects/scp/assessments/finescaledace.pdf Accessed on June 25, 2012.

Stasiak, R. (2006). Northern Redbelly Dace (*Phoxinus eos*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. February 10. Available: http://www.fs.fed.us/r2/projects/scp/assessments/northernredbellydace.pdf Accessed on June 25, 2012.

Tews, Anne. 2001. Status of Northern Red Belly Dace x Finescale Dace Hybrid in Montana. Montana Fish, Wildlife, and Parks, Lewistown, MT. September. Available at http://www.fisheries society.org/AFSmontana/RedbellyHybrid.html Updated September 30, 2010

U.S. Army Corps of Engineers (USACE) 2010. National Inventory of Dams. Available at http://geo.usace.army.mil/pgis/f?p=397:1:0::NO:::/

U.S. Census Bureau. 2012. 2012 TIGER/Line Shapefiles. U.S. Census Bureau, Geography Division, Geographic Products Branch Created: August 16, 2012 Last Revised: August 28, 2012

U.S. Environmental Protection Agency (USEPA) 2012. Watershed Assessment, Tracking, and Environmental Results. Office of Water Programs. Updated May 30. Available at http://epamap32.epa.gov/radims/

U.S. Department of Agriculture (USDA) Forest Service. 2011. Watershed Condition Classification Technical Guide. Washington D.C.: U.S. Department of Agriculture, Forest Service, Watershed, Fish, Wildlife, Air, and Rare Plants Program.

U.S. Geological Survey (USGS) 2005, Mineral Resources Data System: U.S. Geological Survey, Reston, Virginia. http://tin.er.usgs.gov/mrds/

USGS 2006. National Land Cover Database 2006. Available at http://www.mrlc.gov/nlcd06_data.php

USGS 2012. PAD-US The National Inventory of Protected Areas. Available at http://gapanalysis.usgs.gov/padus/files/2012/10/usgs-gap-fact-sheet-padus-Sept2012.pdf. September.

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2009. The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System. Report to the National Park Service. January. http://www.natureserve.org/publications/NPS_EcologicalIntegrityFramework_January09.pdf

Wang, L., T. Brandon, P. Seelbach, A. Cooper, D. Allen, R. Clark Jr., M. Wiley. 2008. *Landscape Based Identification of Human Disturbance Gradients and Reference Conditions for Michigan Streams*. Environmental Monitoring and Assessment, 141. 1-17.

Wenger, S. 1999. A review of the scientific literature of riparian buffer width, extent and vegetation. Institute of Ecology, University of Georgia. Athens, GA 145pp.

Wyoming Natural Diversity Database. 2012. Fish Species of Concern. University of Wyoming http://www.uwyo.edu/wyndd/species-of-concern/vertebrate-animals/fishes.html. Accessed on June 25, 2012.

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APPENDIX E-7

FIGURES

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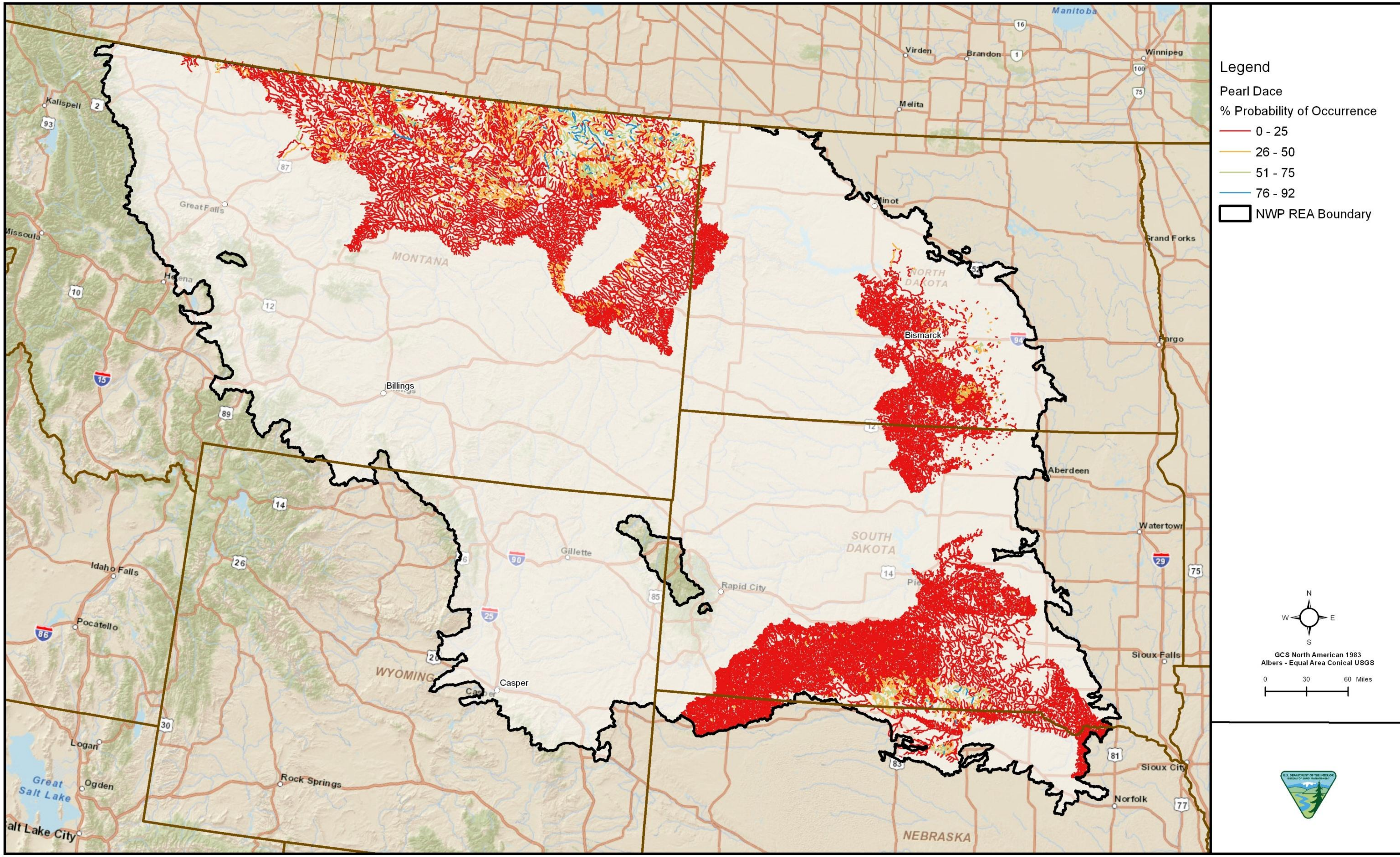

Figure E-7-1. Occurrence Probability Map for the Pearl Dace

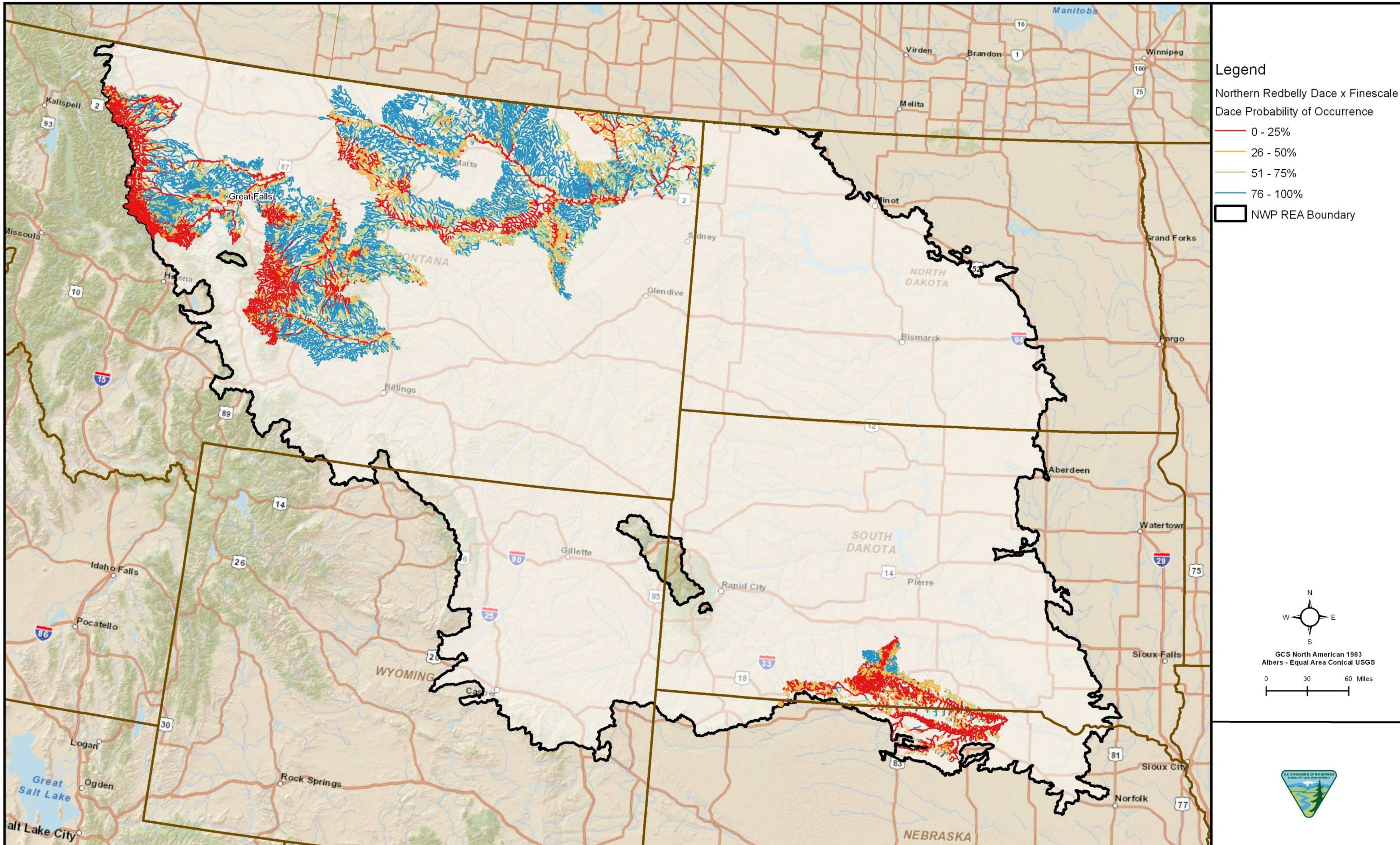

Figure E-7-2. Occurrence Probability Map for the Northern Redbelly x Finescale Dace hybrid

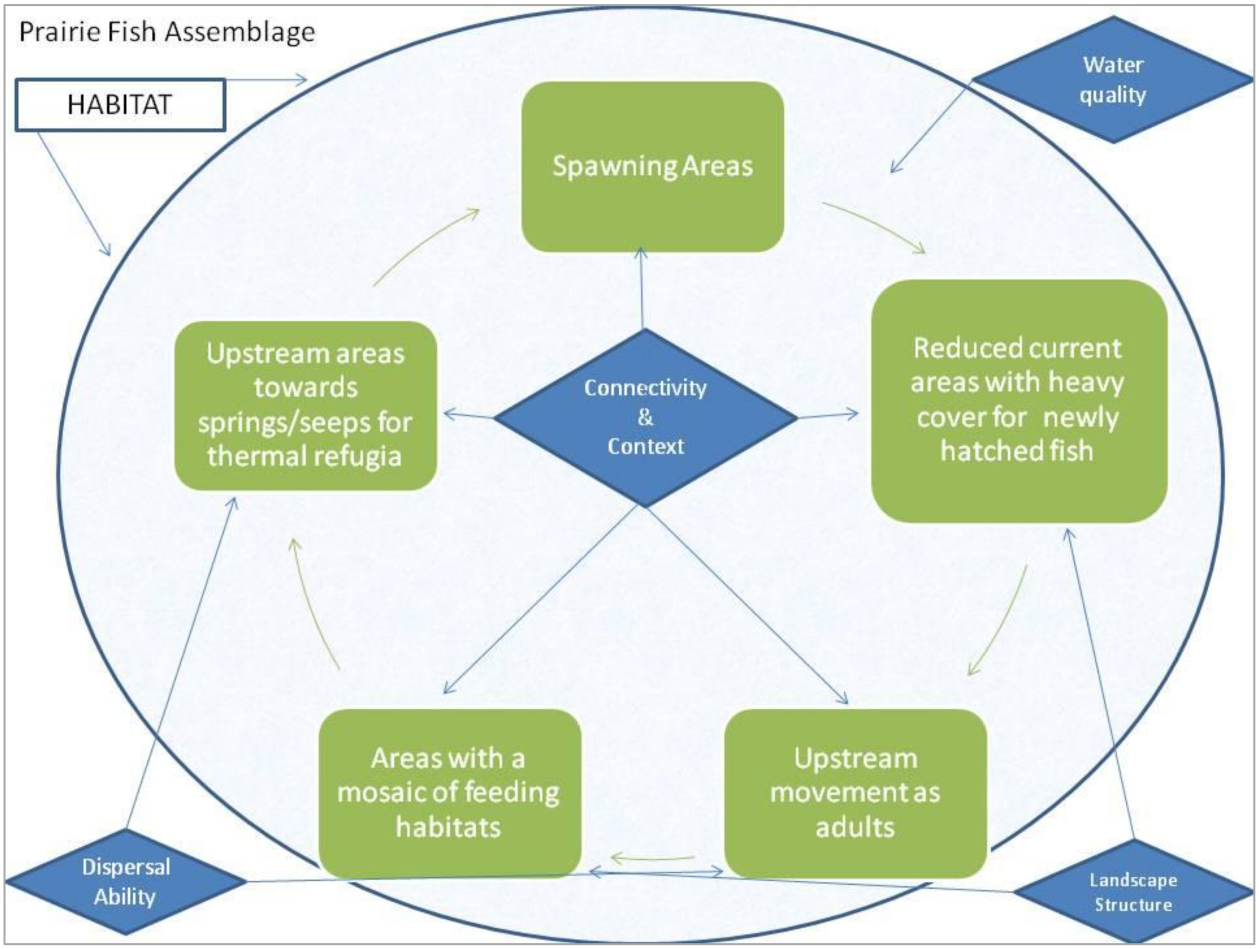

Figure E-7-3. Ecological Process Model for the Prairie Fish Assemblage

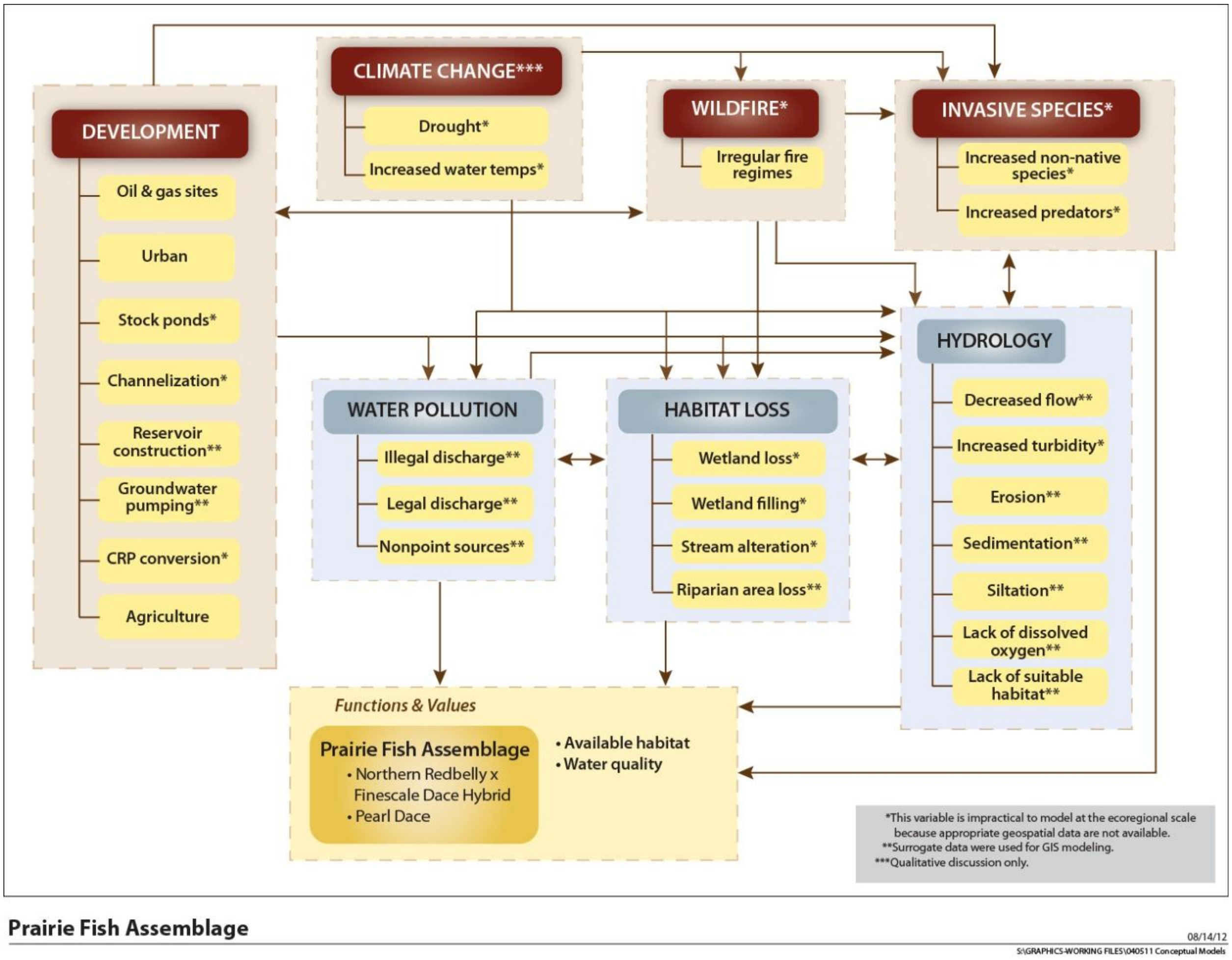

Figure E-7-4. System-Level Conceptual Model for the Prairie Fish Assemblage

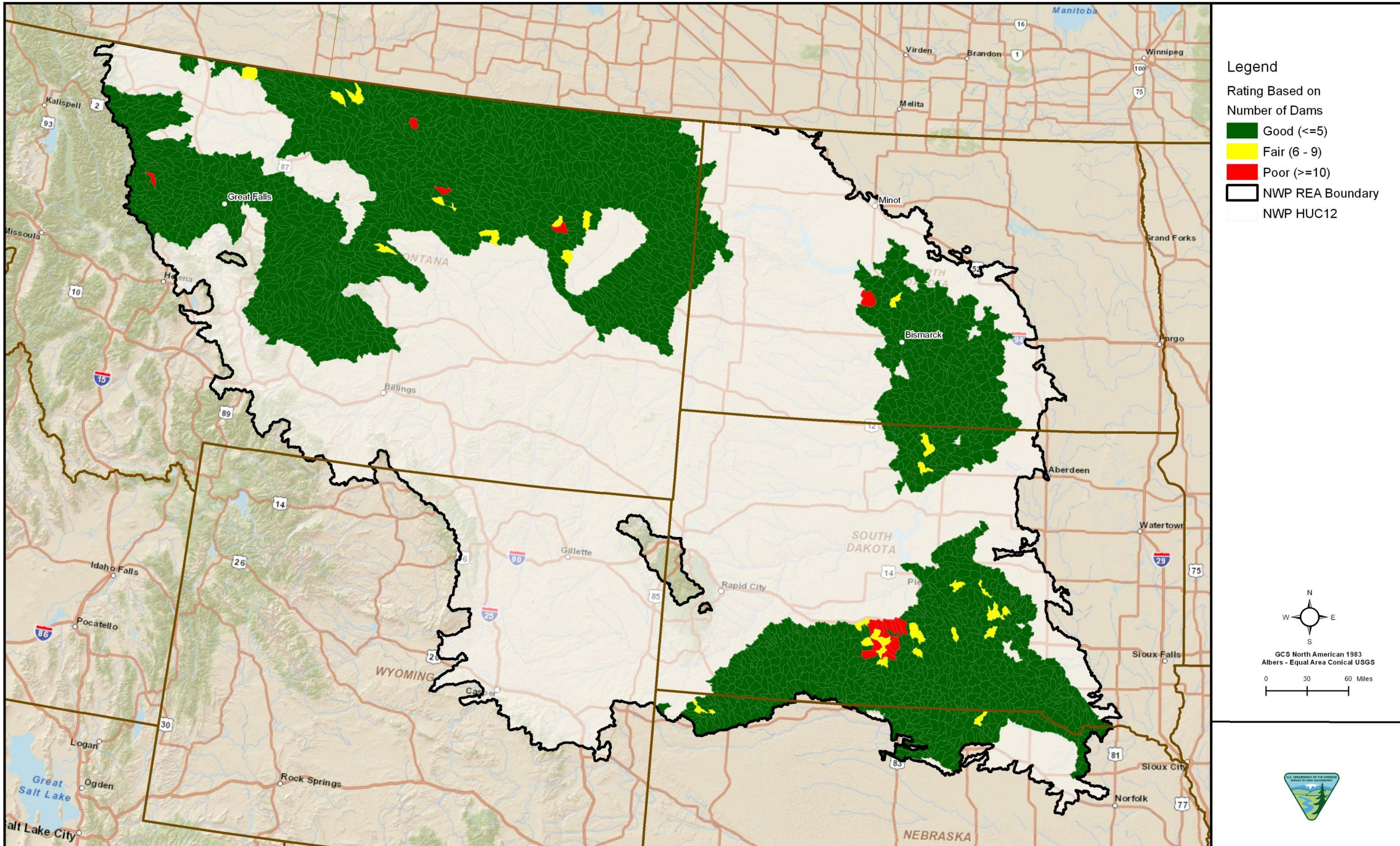

Figure E-7-5. Location of Dams

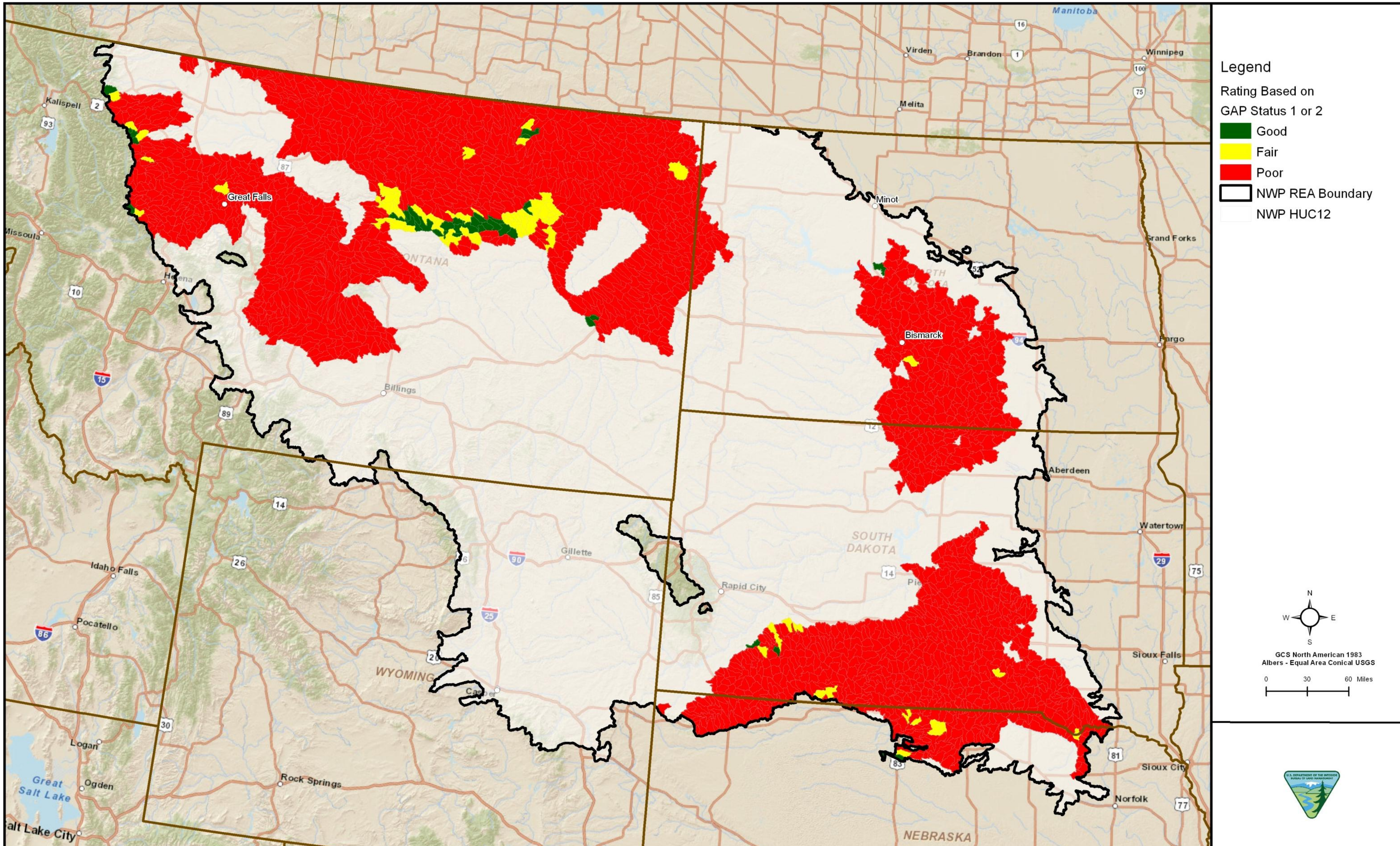

Figure E-7-6. Percentage of Hydrologic Unit Code in GAP 1 or 2 Lands

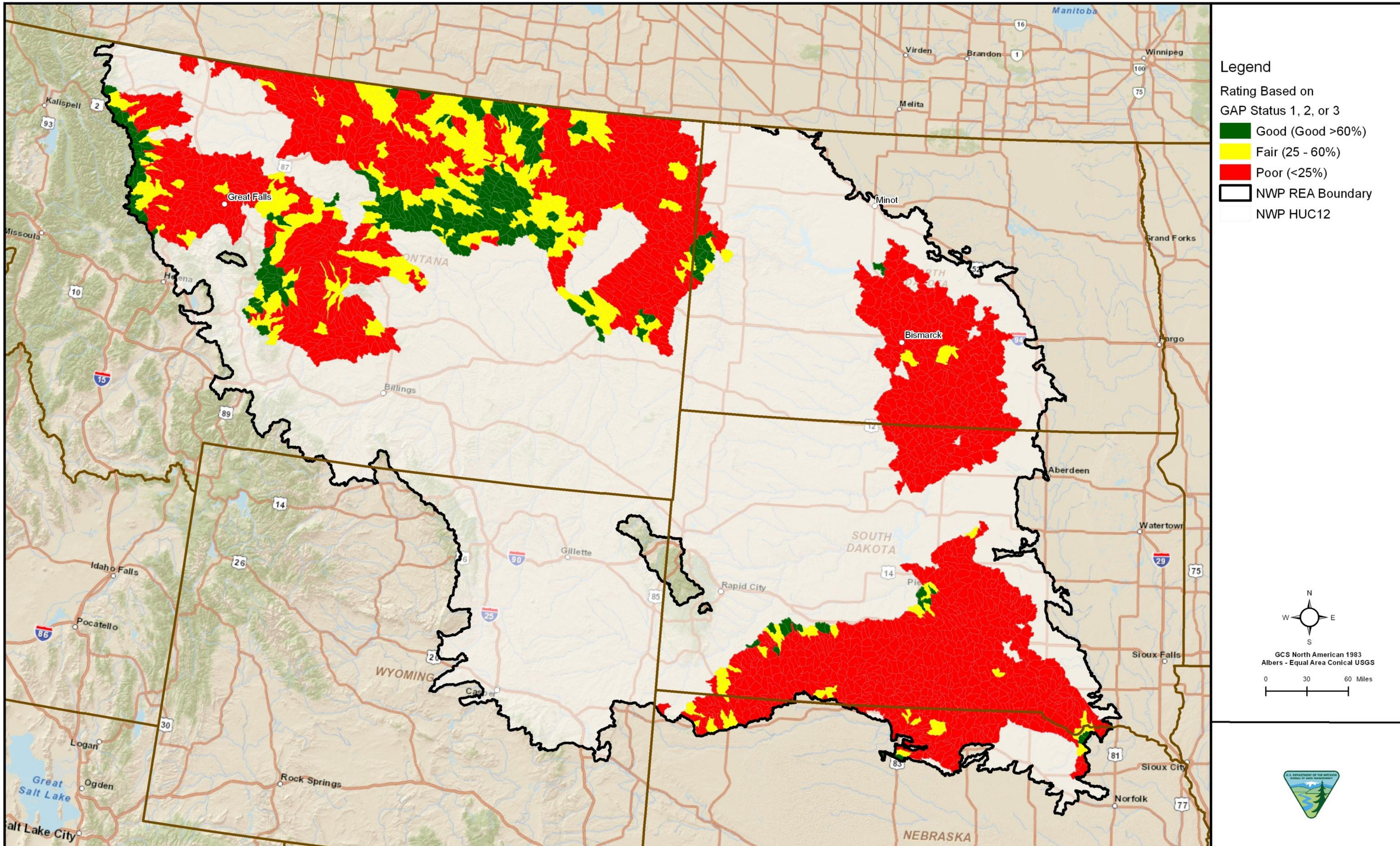

Figure E-7-7. Percentage of Hydrologic Unit Code in GAP 1, 2, or 3 Lands

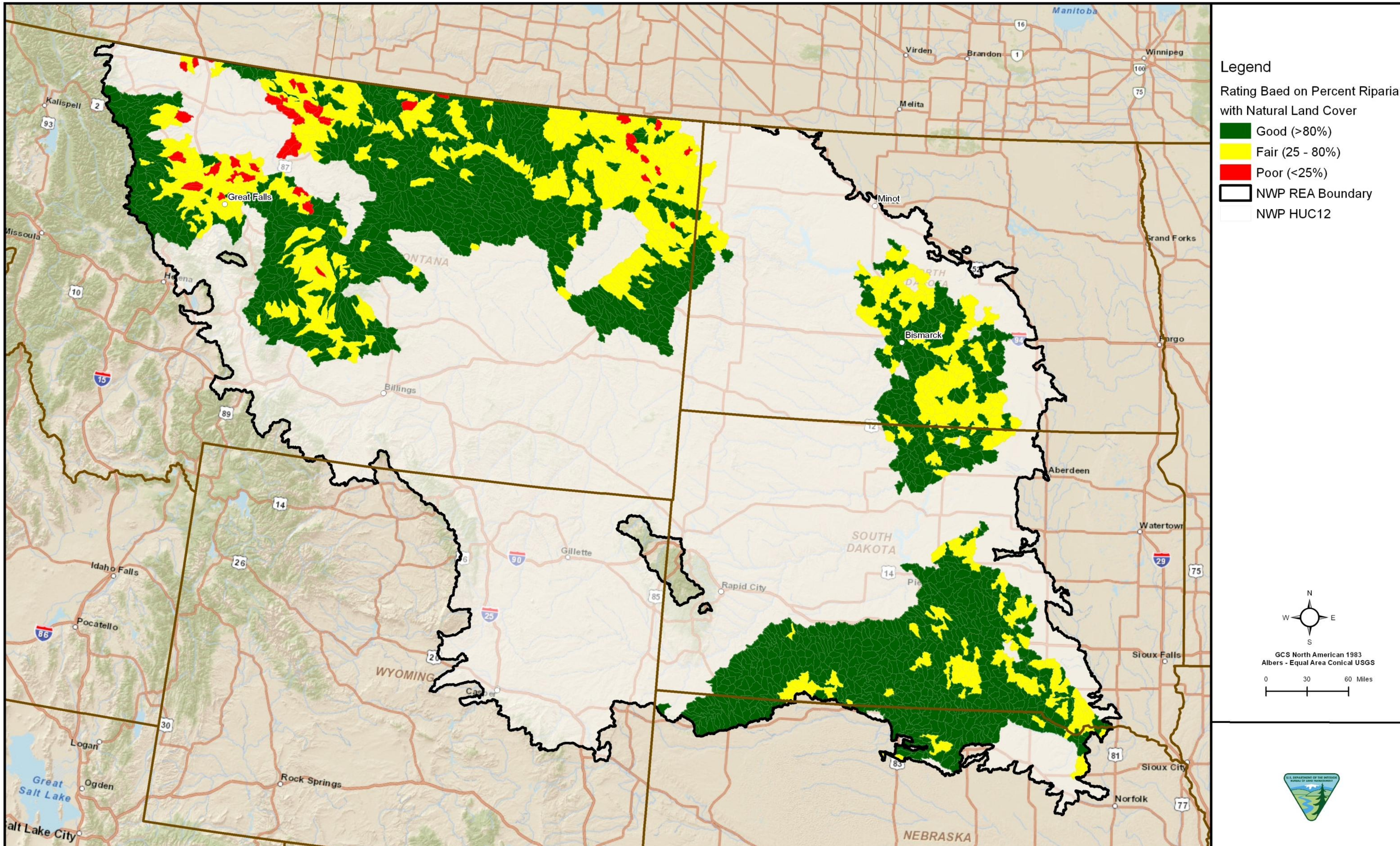

Figure E-7-8. Percent of Riparian Corridor with Natural Landcover

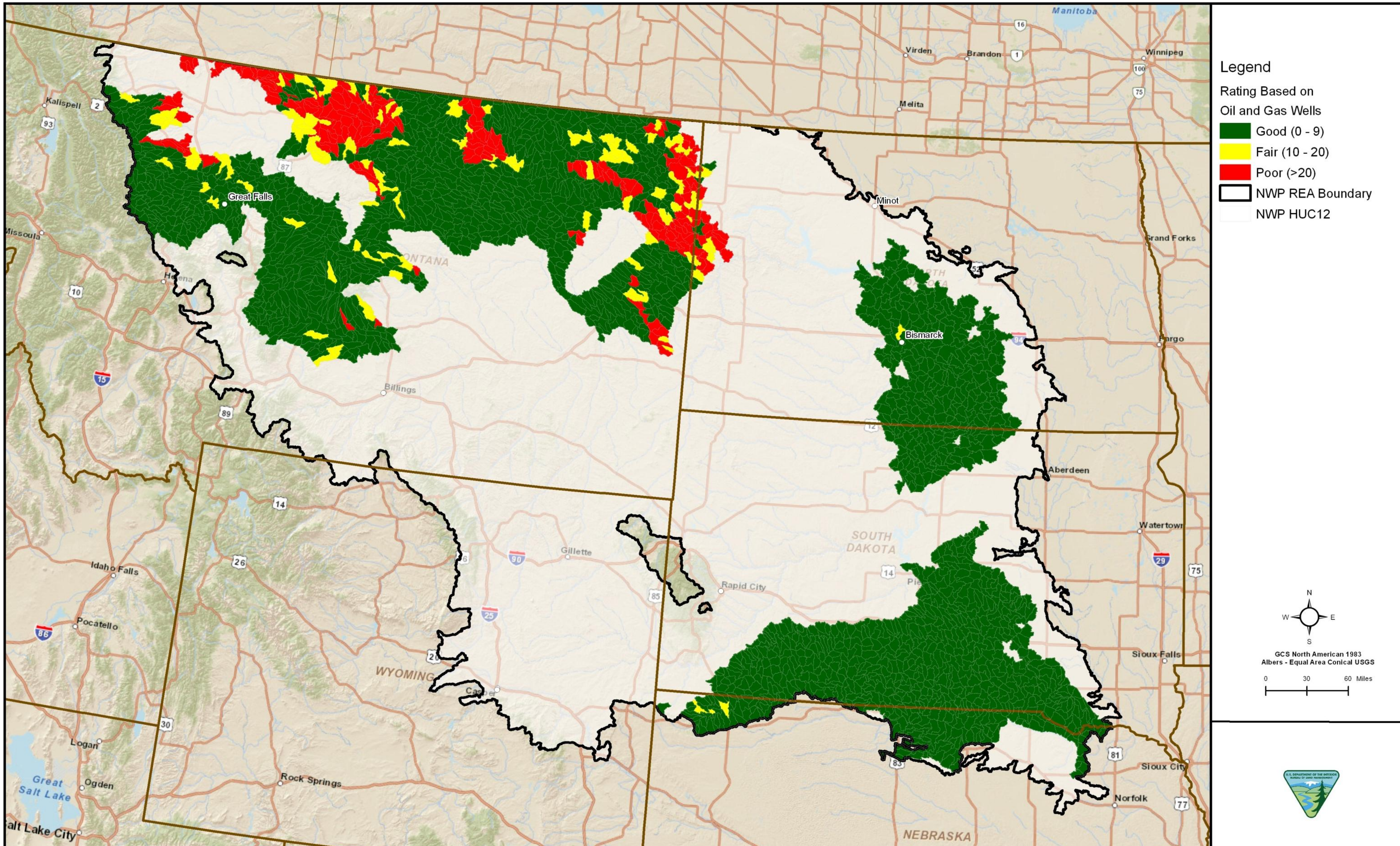

Figure E-7-9. Locations of Oil and Gas Wells

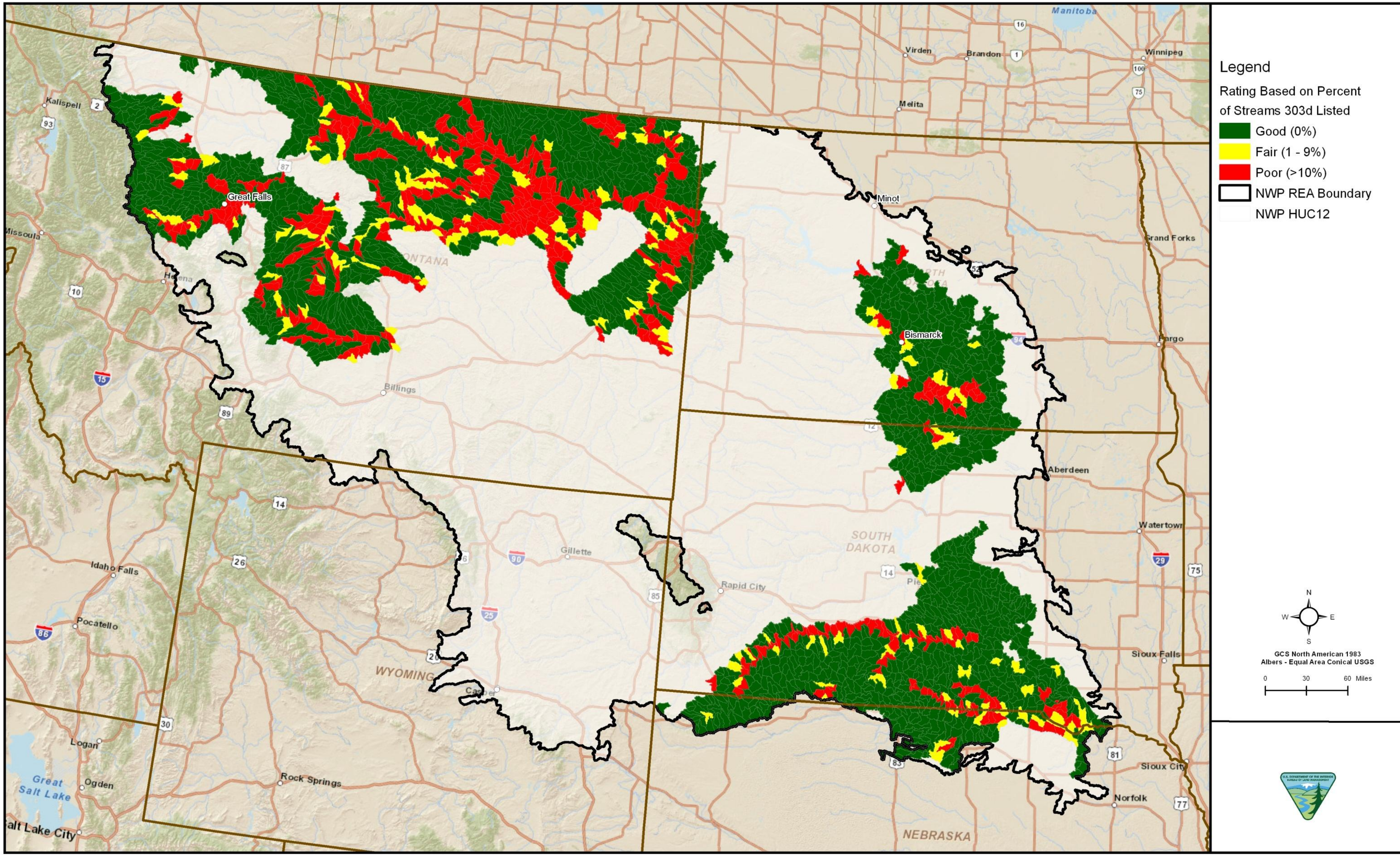

Figure E-7-10. Locations of 303(d)-Listed Streams

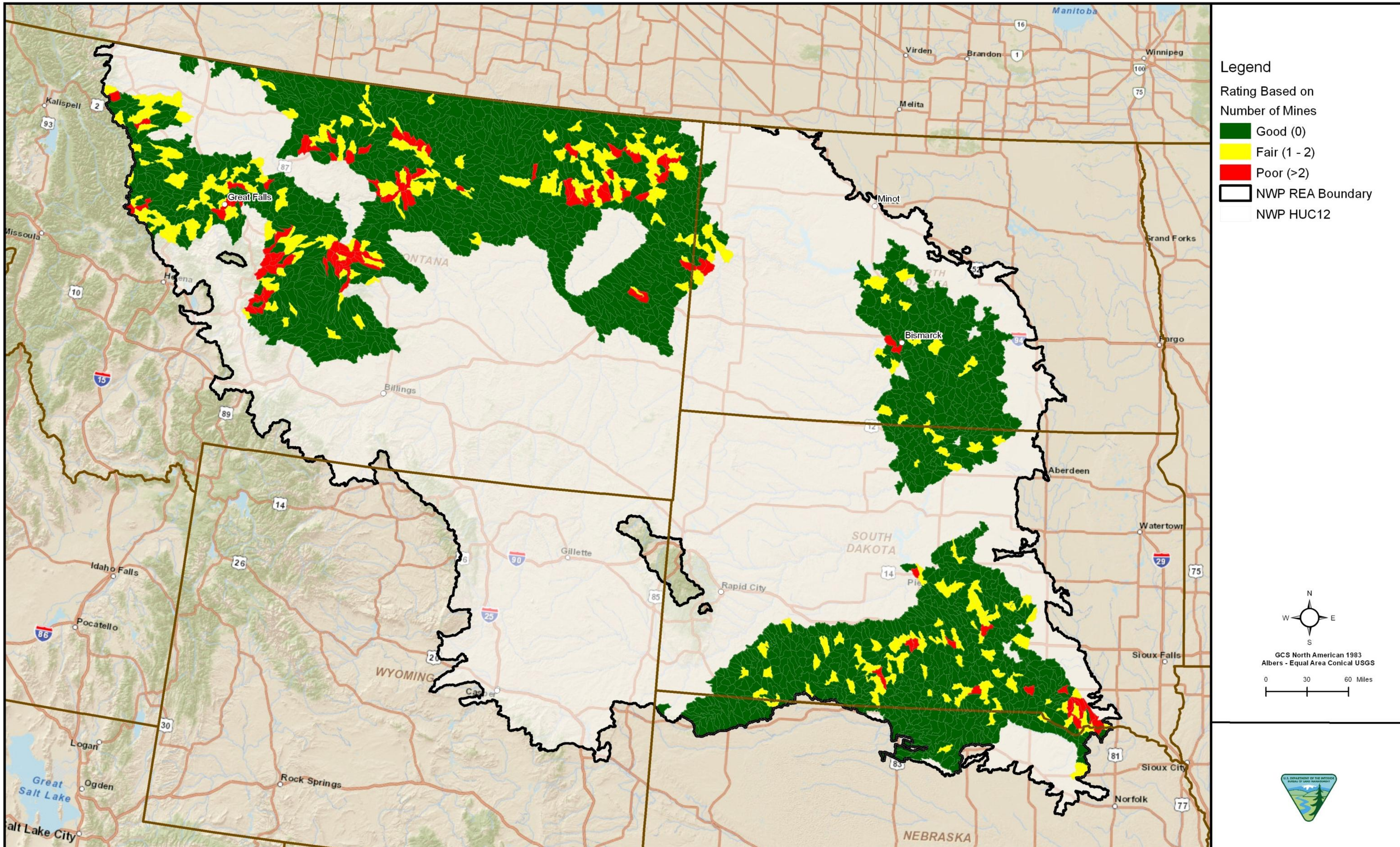

Figure E-7-11. Number of Mines

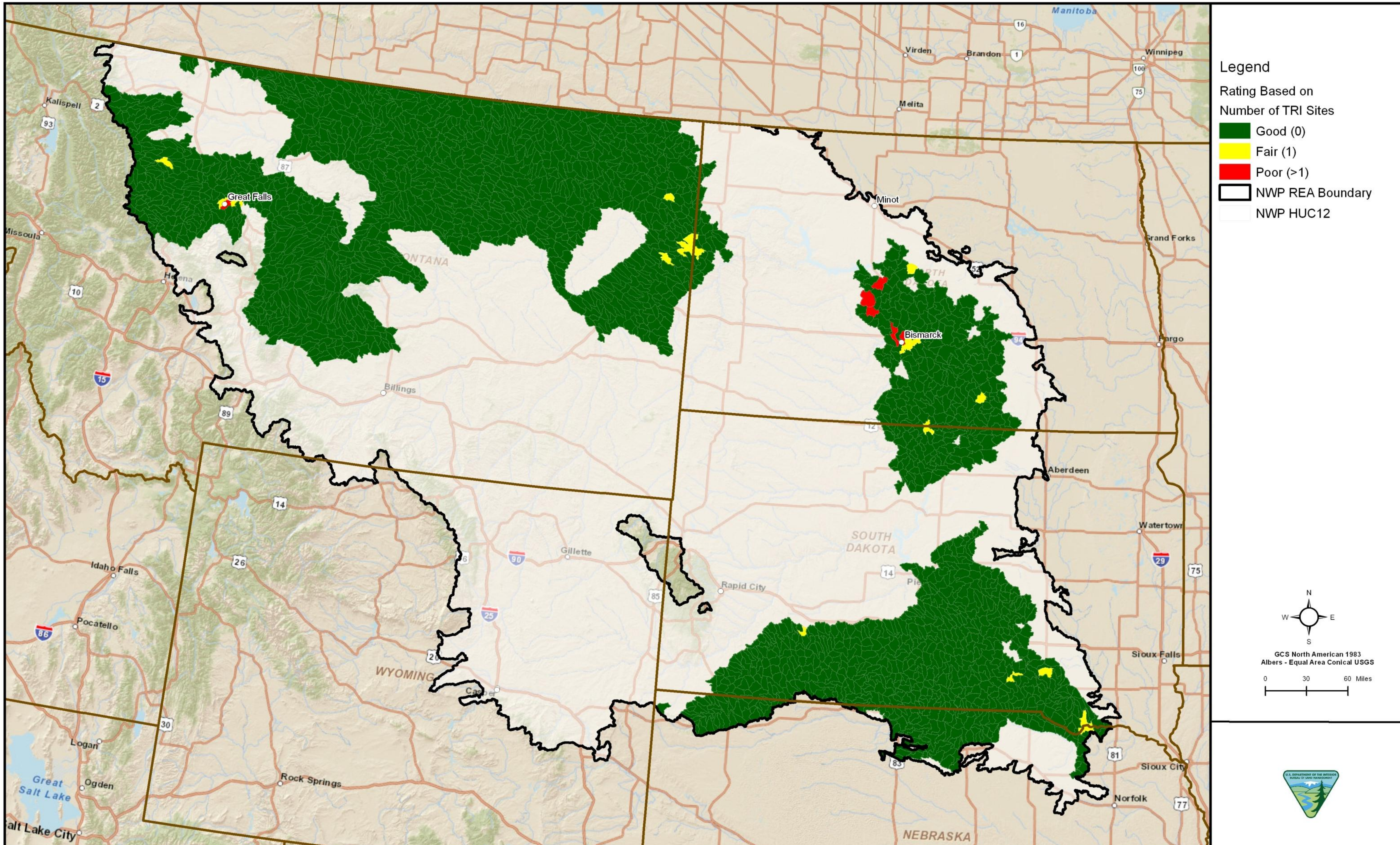

Figure E-7-12. Location of Toxic Release Inventory Sites

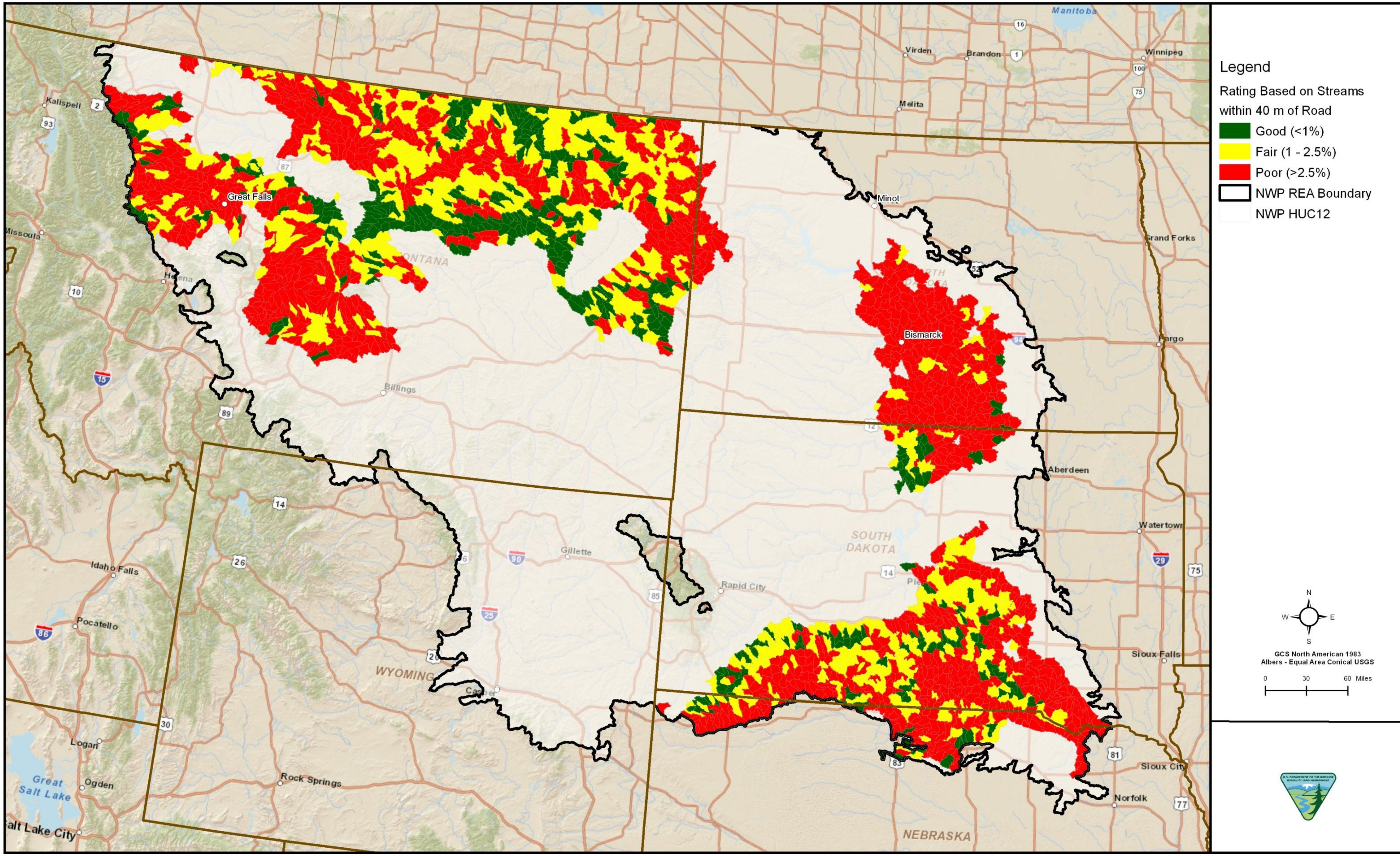

Figure E-7-13. Percentage of Streams within 40 m of a Road

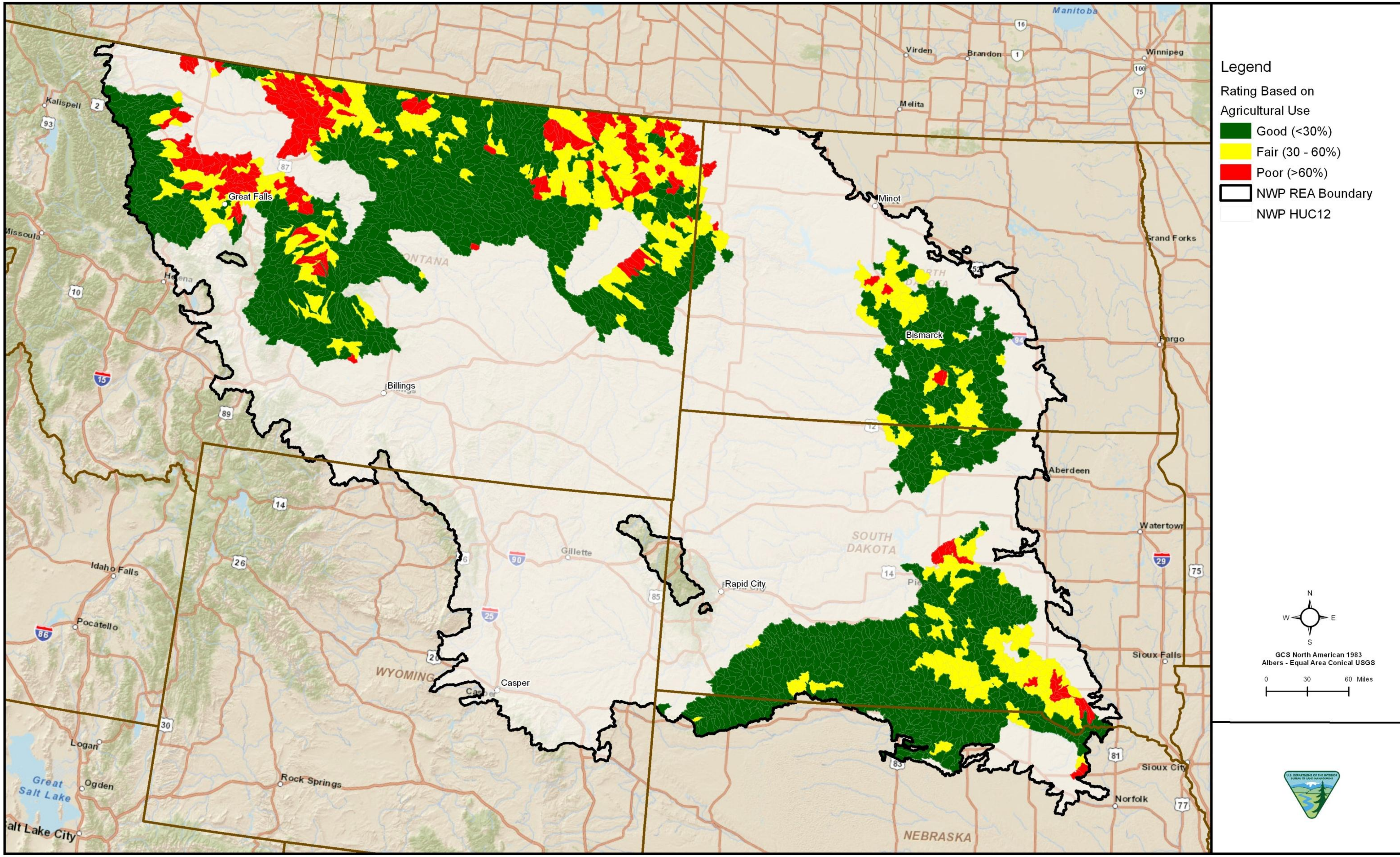

Figure E-7-14. Land Use Designations For Agricultural and Impervious Cover

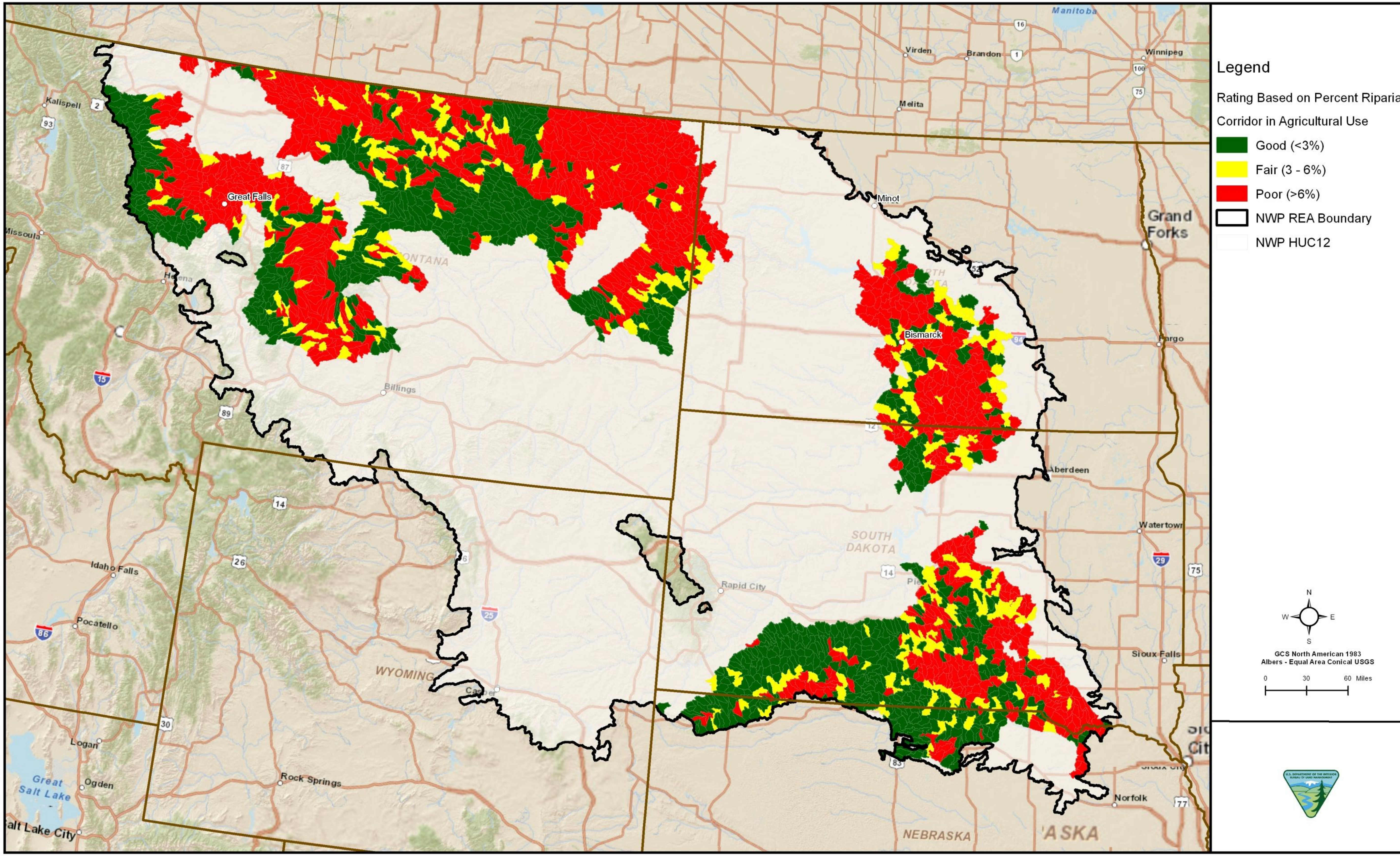

Figure E-7-15. Percentage of Riparian Corridor in Agricultural Use by Hydrologic Unit Code

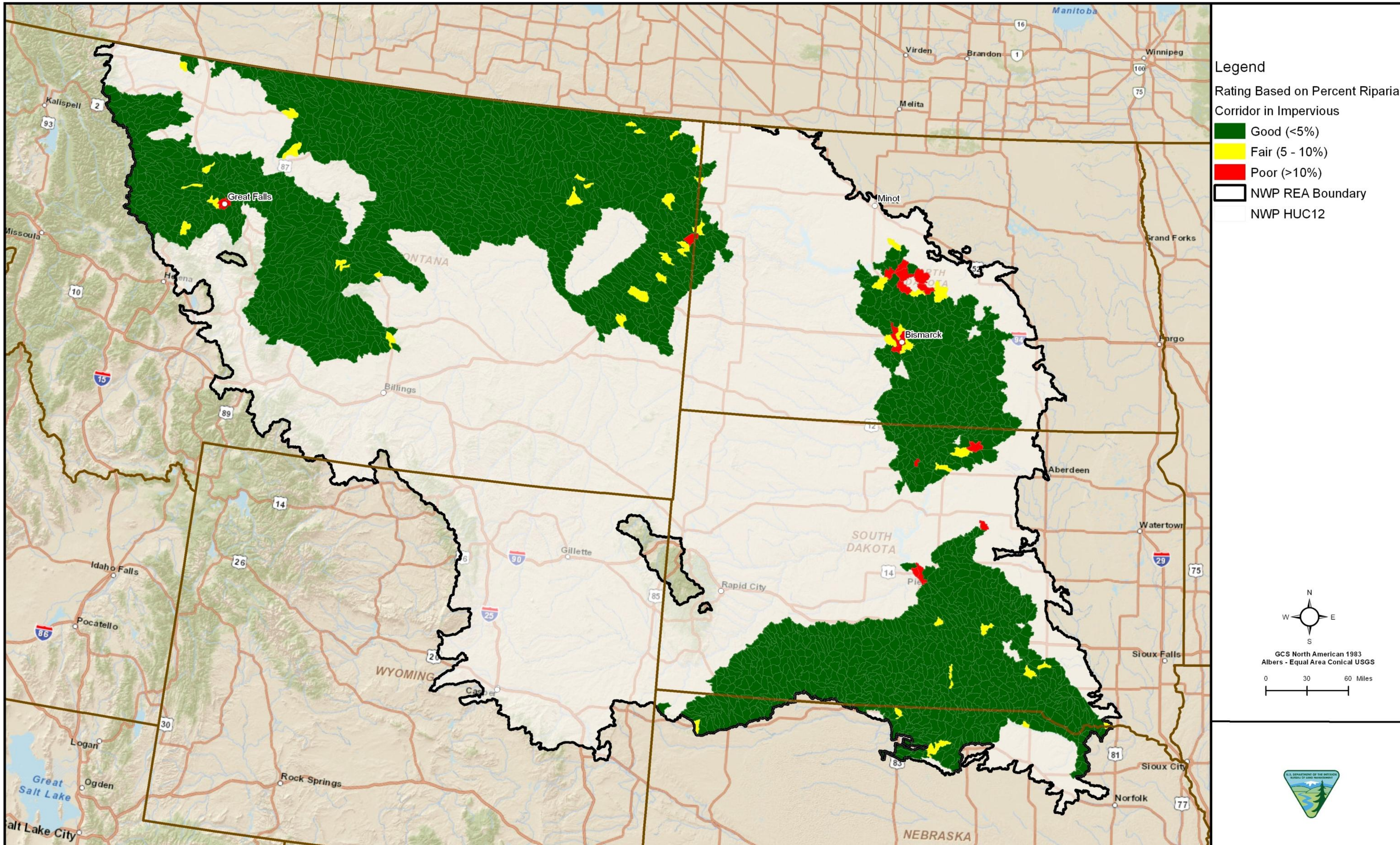

Figure E-7-16. Percentage of Riparian Corridor in Impervious Surface by Hydrologic Unit Code

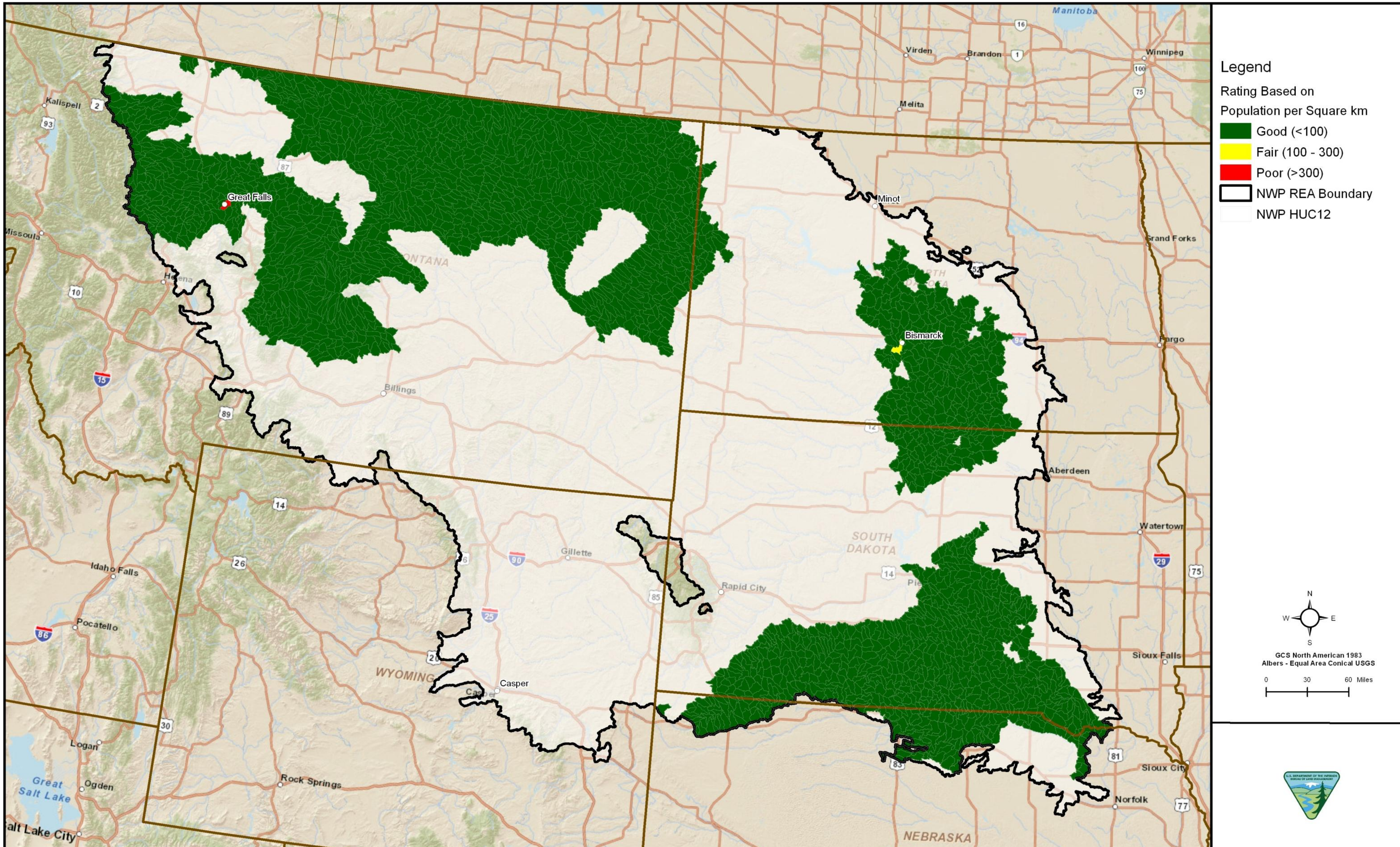

Figure E-7-17. Population Rank Results per Hydrologic Unit Code

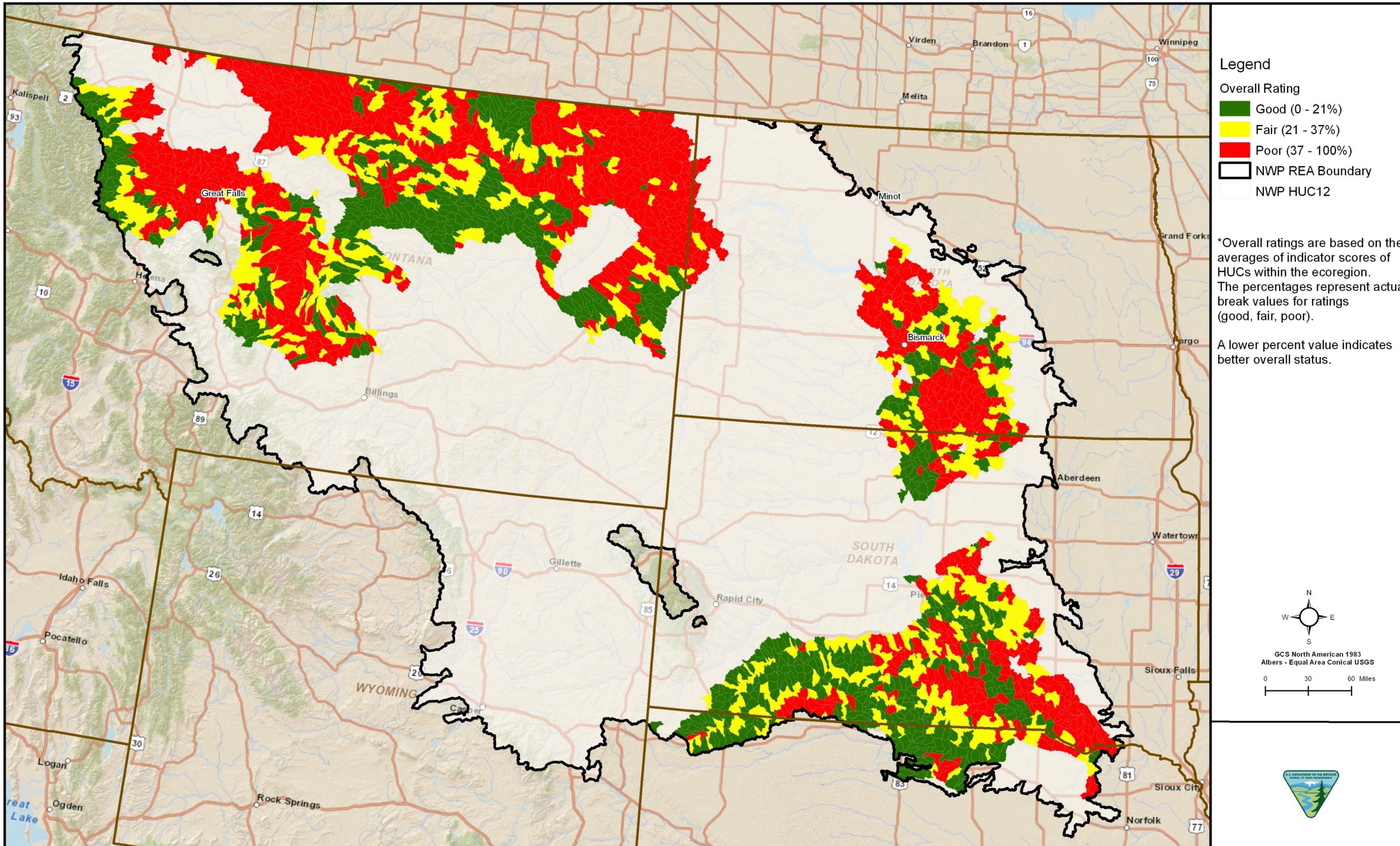

Figure E-7-18. Overall Current Habitat Status for Prairie Fish Assemblage

ATTACHMENT A

STREAM ATTRIBUTES USED IN THE BOOSTED REGRESSION TREE MODELING

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STREAM ATTRIBUTE PREDICTORS USED TO GENERATE BOOSTED REGRESSION TREE (BRT) MODELS

Local Variable	Description
size	Stream size (6 class)
Temp	Stream temperature (3 class)
sdiscr_2c	Binary variable differentiating stream segments that flow into the same size or larger streams
Flow	Variable that differentiates perennial and intermittent flow
gradseg_r	Range of stream segment gradients, 10 categories
surf_geo	Predominant surficial geology through which the stream segment flows
Watershed Variable	**Description**
ann_tot_r	Annual total rainfall, placed into 10 categories
temp_ave_r	Annual air temperature range, 10 categories
geo4_p	Percent of watershed in surficial geology class 4 (Pre-Wisconsinan drift)
geo5_p	Percent of watershed in surficial geology class 5 (Till, or ground moraine)
geo6_p	Percent of watershed in surficial geology class 6 (Ice-laid deposits, like tg but mostly sand and silt)
geo7_p	Percent of watershed in surficial geology class 7 (Thin ice-laid deposits, like 06 but thin and discontinuous. Extensive exposure underlying Cretaceous- and Tertiary-age formations)
geo8_p	Percent of watershed in surficial geology class 8 (Deposits of mountain glaciers)
geo10_p	Percent of watershed in surficial geology class 10 (Floodplain and alluvium gravel terraces)
geo11_p	Percent of watershed in surficial geology class 11 (Fan gravels)
geo13_p	Percent of watershed in surficial geology class 13 (Pliocene-age and older stream deposits on the Great Plains)
geo14_p	Percent of watershed in surficial geology class 14 (Lake deposits)
geo15_p	Percent of watershed in surficial geology class 15 (Sand sheets, mostly with dunes or sand mounds at surface)
geo17_p	Percent of watershed in surficial geology class 17 (Wisconsinan loess)
geo18_p	Percent of watershed in surficial geology class 18 (Deeply weathered loess)
geo19_p	Percent of watershed in surficial geology class 19 (Basalt)
geo24_p	Percent of watershed in surficial geology class 24 (Red clay, massive clay that is generally kaolinitic)
geo25_p	Percent of watershed in surficial geology class 25 (Cherty red clay; similar to 24, but with chert from the parent rock)
geo32_p	Percent of watershed in surficial geology class 32 (Sandy or silty residuum; probably includes loess. Depth generally less than 10 feet
geo34_p	Percent of watershed in surficial geology class 34 (Sandy ground; mostly on poorly consolidated sandstone)
geo35_p	Percent of watershed in surficial geology class 35 (Shaley or sandy ground; on mixed sandstone and shale formations; where shaley, contains considerable swelling clay)
geo40_p	Percent of watershed in surficial geology class 40 (Sandy and stony colluvium derived mostly from sandstone and shale)
geo41_p	Percent of watershed in surficial geology class 41 (Stony colluvium on limestone; considerable admixed silt)
geo42_p	Percent of watershed in surficial geology class 42 (Stony colluvium on metamorphic rocks; less silt and clay than class 41)

STREAM ATTRIBUTE PREDICTORS USED TO GENERATE BOOSTED REGRESSION TREE (BRT) MODELS (Continued)

Watershed Variable	Description
geo43_p	Percent of watershed in surficial geology class 43 (Colluvium on volcanic rocks)
geo44_p	Percent of watershed in surficial geology class 44 (Bouldery and sandy colluvium on granitic rocks)
text_vc_p	Percent of watershed in soil surface texture class vc (Very Coarse)
text_c_p	Percent of watershed in soil surface texture class c (Coarse)
text_mc_p	Percent of watershed in soil surface texture class mc (Moderately Coarse)
text_mf_p	Percent of watershed in soil surface texture class mf (Moderately Fine)
text_f_p	Percent of watershed in soil surface texture class f (Fine)
text_m_p	Percent of watershed in soil surface texture class m (Medium)
text_ud_p	Percent of watershed in soil surface texture class ud (Undefined)
hydro_a_p	Percent of watershed containing hydrologic soil group A (High infiltration rates)
hydro_b_p	Percent of watershed containing hydrologic soil group B (Moderate infiltration rates)
hydro_bc_p	Percent of watershed containing hydrologic soil group BC (equal amounts of Hydrologic soil group B and C)
hydro_bd_p	Percent of watershed containing hydrologic soil group BD (equal amounts of Hydrologic soil group B and D)
hydro_c_p	Percent of watershed containing hydrologic soil group C (Slow infiltration rates)
hydro_cd_p	Percent of watershed containing hydrologic soil group CD (equal amounts of Hydrologic soil group C and D)
hydro_d_p	Percent of watershed containing hydrologic soil group D (Very slow infiltration rates)
lform11_p	Percent of watershed containing landform class 11 (Flat Plains)
lform12_p	Percent of watershed containing landform class 12 (Smooth Plains)
lform13_p	Percent of watershed containing landform class 13 (Irregular Plains)
lform14_p	Percent of watershed containing landform class 14 (Plains with Low Hills)
lform22_p	Percent of watershed containing landform class 22 (Rugged Plains)
lform23_p	Percent of watershed containing landform class 23 (Breaks)
lform24_p	Percent of watershed containing landform class 24 (Low Hills)
lform25_p	Percent of watershed containing landform class 25 (Hills)
lform26_p	Percent of watershed containing landform class 26 (Low Mountains)

APPENDIX E-8

BIG RIVER FISH ASSEMBLAGE CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The big river fish assemblage is represented by three focal species: the pallid sturgeon (*Scaphirhynchus albus*), paddlefish (*Polyodon spathula*), and sauger (*Sander Canadensis*). Additional species were also initially selected as part of this conservation element (CE) assemblage: the sturgeon chub, and two sub-species of softshell turtles, smooth and spiny; however, species collection data and predictor variables were not adequate to produce models for these species. The species represented by this assemblage depend on large river systems (inclusive of major tributaries) in the West, whether occurring as residents or migrants, and have experienced significant declines in abundance, distribution, and the availability of suitable habitats since the turn of the twentieth century. Their distributions have been affected by a variety of factors including human development (e.g., the creation of dams, impoundments, migration barriers, elimination of riparian zones, and conversion of natural landscapes to agriculture).

A variety of the management questions (MQs) apply to this assemblage. Many of the MQs can be summarized into two primary questions: 1) where are the important areas for this assemblage? and 2) what is happening to these areas? The central focus of these two MQs is to document the current status of selected CEs at the ecoregional scale and to evaluate how this status may change over a future time period. The first step is to identify suitable habitat for the CE within the ecoregion. Then, these areas are assessed relative to current and potential future change agent (CA) threats.

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2.0 CONSERVATION ELEMENT DESCRIPTION

2.1 PALLID STURGEON

The pallid sturgeon (*Scaphirhynchus albus*) is native to the Missouri and Mississippi Rivers and is one of the rarest and largest freshwater fish in North America. The pallid sturgeon is a state endangered species in Nebraska, North Dakota, Montana, South Dakota, and Wyoming, and has been classified as endangered by the U.S. Fish and Wildlife Service (USFWS) since 1990.

The pallid sturgeon inhabits swift waters of large, turbid, free-flowing rivers. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and main channel waters form the large river ecosystem that provides macrohabitat requirements for pallid sturgeon and other native big river fish, such as paddlefish and other sturgeon. The pallid sturgeon prefers sandy substrates and requires a spring pulse flow for initiating migrations to up-river spawning areas (Gardner 2001). Once pallid sturgeon spawn, the resulting larvae have a strong tendency to drift great distances downstream over a long period of time. Studies have found that yearling pallid sturgeon used relatively deep channel areas (average = 2.0 meters [m]) near the channel thalweg, which is similar to where adults reside. Because of unique biological characteristics, including obligatory lengthy migrations and larval drift distances, a high habitat specificity, and late sexual maturity, the pallid sturgeon is a species vulnerable to extirpation (Gardner 2001).

Its historic range included the middle and lower Mississippi River, the Missouri River, and lower reaches of the Kansas, Platte, and Yellowstone rivers (Dryer and Sandvol 1993). Currently, the pallid sturgeon has a widespread distribution occurring in low numbers in the Missouri River from Montana to its confluence with the Mississippi River. In Montana, pallids have been found in the Missouri River between the mouth of the Marias River and Fort Peck Reservoir; between Fort Peck Dam and the North Dakota border; and in the 70 miles of the Yellowstone River below the mouth of the Powder River (Gardner 2001).

2.2 PADDLEFISH

Paddlefish (*Polyodon spathula)* inhabitat slow or quiet waters of large rivers or impoundments. They frequent many types of riverine habitats but often seek out deeper, low-current areas such as side channels, backwaters, oxbow and other river-lakes, and tailwaters below dams. Paddlefish spawn in rivers during high-water periods in late spring or early summer (May to June). Paddlefish can grow well in reservoirs (even faster than in rivers), but they need free-flowing, naturally-fluctuating river levels (which provide good spawning habitat); high water; the right temperature; and a good substrate of clean cobble, gravel, and sand. Paddlefish are highly mobile and have been observed to move more than 2,000 miles in a river system (USGS 2011).

Paddlefish are found throughout the Missouri and Mississippi river basins, which drain most of the central United States. Twenty-two states have paddlefish; Montana is the most westerly of these states. In Montana, paddlefish are found in the Yellowstone River as far upriver as Forsyth, as well as in the Missouri River above and below Fort Peck Dam (Scarnecchia and Schmitz 2012). In recent years paddlefish populations throughout the historic range have been declining, likely due to habitat modification and construction of dams that distrupt natural spawning cycles. Stocking programs for paddlefish have been implemented in several states. Paddlefish are identified as a species of concern in Montana and North Dakota.

2.3 SAUGER

The sauger (*Sander canadensis*) inhabits both large rivers and reservoirs, but is mainly a river fish. In the spring, sauger broadcast their spawn over gravelly or rocky areas in shallow water. Sauger spawn from mid-April to May at water temperatures of 50 degrees Fahrenheit (°F), with peaks in early May. Spawning is often accompanied by migration upstream and/or into tributary streams in the spring (Montana Field Guide 2012a). Sauger are heavily dependent throughout their life history on unimpeded access to the wide diversity of physical habitats that are present in big river systems. Sauger are highly selective for spawning sites and commonly travel long distances to aggregate in a relatively few discrete areas to spawn. During a 10-12 day period following emergence, it is thought that larval sauger drift long distances downstream, up to 300 kilometers (km), prior to gaining the ability to maneuver horizontally and begin feeding. Juveniles rear in side channels, backwaters, oxbows, and other off-channel habitats during spring and summer before shifting to main channel habitats in autumn. Adult sauger also use off-channel and channel-margin habitats during the spring and early summer periods of high flow and turbidity, and then move to deeper, main channel habitats in late summer and autumn as decreasing flows and turbidities cause suitable off-channel habitats to become unavailable (Jaegar 2004). The sauger is identified as species of concern in Montana.

2.4 STURGEON CHUB

The sturgeon chub (*Macrhybopsis gelida*) is indigenous to the Missouri-Mississippi river basins from Montana to Louisiana. The biology of the species is not well known beyond the fact that sturgeon chub are highly adapted to life in turbid waters. Chubs need riffles and runs in turbid shallow waters or deeper running waters and are most closely associated with sites having moderate currents and depths and sand or rock substrates. As for the other big river fish, the major threats to the sturgeon chub include habitat alteration by dam and irrigation development and operations (Montana Field Guide 2012b).

2.5 SICKLEFIN CHUB

The sicklefin chub (*Macrhybopsis meeki)* is one of the rarest fishes in Montana and throughout the ecoregion. Its general habitat and distribution is much like that of the sturgeon chub. The sicklefin chub is found in large, turbid rivers where they live in a strong current over a bottom of sand or fine gravel in the plains region of this ecoregion. This species is very similar in appearance to the sturgeon chub except that its pectoral fins are strikingly long (Montana Field Guide 2012c).

2.6 SOFTSHELL TURTLES

The two turtle species chosen as part of the big river fish CE assemblage are the smooth softshell turtle (*Apalone mutica*) and the spiny softshell turtle (*Apalone spinifera*). Softshell turtles are almost entirely aquatic and are powerful, fast swimmers. They spend nights and overwinter buried in mud or sand at the river bottom. The smooth softshell is found in the Mississippi and other large rivers of the ecoregion. The species can be found in colonies in portions of rivers, large streams, and, rarely, large lakes with sandy or muddy bottoms. These lakes are usually close to a large river. Sandbars are important for basking and as egg laying sites, but these turtles spend most of their time in water. Eggs are vulnerable to carnivores and drowning if sandbars remain submerged; neonate softshells are eaten by a variety of carnivorous vertebrates including large fish. Softshell turtles are carnivorous and will hunt down or use ambush tactics to secure prey, which includes but is not limited to: insects, crayfish, tadpoles, frogs, fishes, and other small vertebrates. The spiny softshell is more abundant than the smooth softshell. Within their geographic distribution spiny softshell turtles can be found in streams, rivers, oxbows, lakes, lagoons, water-filled ditches, and coastal areas. Threats to softshell turtles include water pollution, over-harvest, and shoreline development.

3.0 CONSERVATION ELEMENT DISTRIBUTION MODELING

In order to answer the MQs regarding the location and status of this assemblage across the Northwestern Plains ecoregion, a distribution layer was required for each of the focal species. The geospatial modeling was based on the availability and quality of reference data layers for the states included in the ecoregion. For this Rapid Ecoregional Assesssment (REA), the species distribution models were completed by the Missouri Resource Assessment Partnership (MoRAP) using a predictive distribution model. MoRAP had previously completed fish modeling in the Northwestern Plains as part of the Missouri River Basin Aquatic Gap Analysis Program (GAP) Project (MoRAP 2012).

3.1 DATA IDENTIFICATION

A preliminary review of potential data was conducted as part of Task 2 of Phase 1 to define available data for use in this REA (Table E-8-1). Important data for these assemblage species include occurrences, habitat and range, and spawning and rearing areas. Distribution of the pallid sturgeon and paddlefish covers four of the five states in this ecoregion (Montana, Nebraska, North Dakota, and South Dakota), while the sauger occurs in all five states of the ecoregion. The NatureServe habitat model was the only dataset that was identified for each of the three focal species (Table E-8-1). The USFWS and state fish and game agencies were identified as the primary sources for locating additional information on these species. As a result of the data evaluation, several data gaps were identified regarding information on this assemblage (as noted in Table E-8-1). Species occurrence data were difficult to obtain, as they are generally not available for download from agency websites. Data availability with regard to species, as opposed to spatial reference, was also a factor that affected dataset quality and availability. Although sport fishing is popular, fisheries data were difficult to locate. Large-scale stream data also affected the quality of spatial fisheries datasets.

Table E-8-1. Data Sources for Conservation Element Distribution Mapping

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Habitat and Range	NatureServe Habitat Models	NatureServe	Polygon	Acquired	No[2]
	Habitat and Range	MT, ND, NE, SD, WY Fish and Game; MoRAP	Polygon	Acquired	Yes
Occurrence	State Natural Heritage	Natural Heritage Programs (NHP) of MT, ND, NE, SD, WY	Point	No[1]	No[1]
Spawning and Rearing Areas	Unknown	MT, ND, NE, SD Fish and Game; MoRAP	Polygon	No[1]	No[1]
Important Angling Areas (Pallid Sturgeon and Sauger)	Unknown	MT, ND, NE, SD, WY Fish and Game	Polygon	No[1]	No[1]
Areas with Potential for Restoration of Habitat or Habitat Connectivity	Fish Restoration Priority Watersheds	MT, ND, NE, SD. WY Fish and Game	Polygon	Not Available	No[1]
Dams and Fish Ladders	National Inventory of Dams (NID)	United States Army Corps of Engineers (USACE)/ Bureau of Land Management (BLM)	Point	Obtained	Yes

[1]Data gap
[2]More representative data were selected for use

Fish occurrence data were obtained through the state Natural Heritage Programs (NHPs) and fish and game agencies, as well as through community collection records that MoRAP had assembled from historical collections as part of the Missouri River Basin Aquatic GAP Project (Annis et. al. 2010b). Species occurrence data obtained from the NHPs and fish and game agencies were only species presence data and not community collection data; therefore, these data did not contain information about species absence, which is also used in the type of modeling that MoRAP completed. Each species was modeled individually using the entire set of records within the species range.

For each fish, MoRAP ran a series of boosted regression tree (BRT) models in R, adjusting the model parameters following the guidance of Elith et al. 2008. For the series of models produced for each species, MoRAP selected the model with the highest cross-validated receiver operating characteristic (CV ROC) score as the final model. Using these methods, MoRAP was able to generate a probability of occurrence model for the sauger only (Figure E-8-1). The paddlefish and pallid sturgeon did not have enough collection data to produce a BRT model; therefore, only presence models were developed for these species (Figures E-8-2 and E-8-3). For these two species, models were based on species range, habitat affinity, collection data, and professional judgment. As such, the resulting models designate only expected presence or absence. Additionally, MoRAP attempted to model the spiny softshell turtle and the smooth softshell turtle; however, species collection data were not adequate to produce distribution models for these species (MoRAP 2012).

Because of the pallid sturgeon, paddlefish, and softshell turtle species data gaps, the rolling review team (RRT) for the big river fish assemblage determined that, with only the sauger probability of occurrence model, the MQs for this assemblage could not be answered; therefore, the RRT recommended dropping this assemblage from the analysis. The Assessment Management Team (AMT) agreed with this recommendation, and the big river fish assemblage was dropped from further analysis.

4.0 CONCEPTUAL MODELS

The CE-specific conceptual models were developed in order to answer the MQs regarding current status and potential future threats. Because species collection data were not adequate to produce distribution models, further analysis as part of this REA was not conducted. These conceptual models are provided to document the efforts that were initially conducted as part of Task 2.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model (Figure E-8-4) was developed to identify and link the key life cycle processes to specific ecological factors, or Key Ecological Attributes (KEAs), that have the greatest potential to affect big river fish habitat throughout the ecoregion, As noted in the species descriptions, this assemblage requires large, free-flowing rivers as well as other macrohabitats of the large river ecosystem for spawning and juvenile recruitment.

The key processes are identified in the model as green boxes. Following Unnasch et al. (2009), three broad headings or categories of ecological attributes (EAs) (size, condition, and landscape context) are identified in the model as blue diamonds. Size refers to attributes related to habitat or patch size, condition refers to the condition of the habitat, and context refers to the spatial structure of the habitat. At the landscape level, the EAs under the condition category will be the most challenging to spatially represent and will primarily depend on the data available.

4.2 SYSTEM-LEVEL CONCEPTUAL MODEL

The system-level conceptual model (Figure E-8-5) illustrates the interactions between the CAs and the primary habitat functions of this assemblage. The primary CA identified for this REA was development, as well as potential impacts resulting from climate change. These CAs are identified across the top of Figure E-8-5 in red. The important factors (or "drivers") affecting the abundance of the big river fish populations include those that impact habitat quality.

4.2.1 Development

Development is the primary threat to big river fish. Modification of habitat by human activities has blocked fish movement, destroyed or altered spawning areas, reduced food sources or ability to obtain food, altered water temperatures, reduced turbidity, and changed the hydrograph of the river system (Dryer and Sandvol 1993). River and stream fragmentation related to impoundments, diversion dams, and stream dewatering are consequences of increasing demand for water resources throughout the west and have effectively created a mosaic of large river fragments throughout the Great Plains. In addition, the impacts of dam construction include inundation of riverine habitats, creating lake conditions, changes to the downstream structure of river instream habitats, reduced water turbidities and nutrient concentrations, and/or altering temperature and flow regimes that have destroyed suitable habitat for these species in downstream waters. Alteration to flow regime is a common factor related to the decline of stream-dwelling fish populations, and a growing body of literature suggests flow regime is a major component required for maintaining integrity within the big river fish communities (Perkin et al. 2010). Water diversions, barriers, and impoundments also impair species' abilities to access spawning tributaries and recolonize upstream, and preclude downstream dispersion of drifting eggs and pre-larvae development. Other impacts from human development have included sediments, nutrients, and pollutants entering the water systems, over-harvest, and hybridization for some species.

4.2.2 Climate Change

Predicted changes resulting from climate change may also alter the riverine ecosystems. Changes in temperatures and precipitation are likely to affect the amount and timing of snowmelt in this region, which would also affect hydrological input to seasonal river flows. Changes in river flows would have an adverse effect on conditions required in suitable habitat and spawning areas used by the big river fish assemblage focal species. Perkin et al. (2010) reported that future climate change scenarios project that stream fragments in the southern Great Plains may lose up to 12 percent of their discharge before 2060, while stream fragments in the northern Great Plains may gain up to 5 percent.

5.0 MANAGEMENT QUESTIONS

The relevant MQs for the big river fish assemblage include those defined as part of the Aquatic/Riparian Biotic Resources category. The overall MQ was: Where are the important regionally significant aquatic/riparian biotic features, functions, and services across the ecoregional landscape?

Important data for this assemblage, including species occurrences, habitat and ranges, and spawning and rearing areas, is needed to answer the MQs. The results of this REA effort found that there is a significant lack of data for a majority of the species defined for this assemblage (paddlefish, pallid sturgeon, spiny and smooth softshell turtles, and the two species of chubs). As a result, appropriate distribution models for the assemblage could not be developed and the current status and threat analysis for the big river fish assemblage could not be conducted.

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6.0 REFERENCES

Annis, G. M., S. P. Sowa, D. D. Diamond, A. Garringer, P. Hanberry, and M. E. Morey. 2010. *A GAP Analysis for Riverine Ecosystems of the Missouri River Basin*. Final Report (Draft), submitted to the USGS National Gap Analysis Program. 1,351 pp.

Dryer, M.P. and A.J. Sandvol. 1993. Recovery plan for the pallid sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service. Bismarck, ND. 55 pp. http://fwp.mt.gov/fwpDoc.html?id=31198.

Elith, J., Leathwick, J.R., & Hastie, T. (2008). A working guide to boosted regression trees. *Journal of Animal Ecology*.

Gardner, William M. 2001. Montana's Fish Species of Concern, Pallid Sturgeon. Montana Fish, Wildlife, and Parks. Lewistown, MT. January. Accessed on July 24, 2012 from http://www.fisheriessociety.org/AFSmontana/SSCpages/Pallid%20status.htm.

Joregensen, D.G. 2005. Some Concepts Relative to Pallid Sturgeon (Scaphirhynchus albus) Spawningand Plans To Facilitate Successful Spawning. Prepared for the Missouri Levee and Drainage Districts Association, Missouri River Technical Committee of the Siouxland Chamber of Commerce. Available on internet at: http://missouririvertechnicalteam.com/pdf_reports/SpringRisefor Corps.pdf . January.

Missouri Resource Assessment Partnership (MoRAP). 2012. *Big River Fish Assemblage Threat Analysis in the Middle Rockies Ecoregion, Methods Report.* School of Natural Resources, University of Missouri, Columbia, Missouri. May.

Montana Field Guide 2012a. Sauger — Sander canadensis. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on July 25, 2012, from http://FieldGuide.mt.gov/detail_AFCQC05010.aspx.

Montana Field Guide 2012b. Sturgeon Chub — Macrhybopsis meeki. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on July 25, 2012, from http://FieldGuide.mt.gov/detail_AFCJB53030.aspx.

Montana Field Guide 2012c. Sicklefin Chub — Macrhybopsis meeki. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on July 25, 2012, from http://FieldGuide.mt.gov/detail_AFCJB53030.aspx.

Nebraska Game and Parks Commission 2011. *Nebraska Endangered And Threatened Species.* August. Accessed on July 24, 2012 from http://outdoornebraska.ne.gov/wildlife/programs/ nongame/pdf/E_T_Species_List.pdf.

Perkin, J.S., K.B. Gido, E. Johnson, and V.M. Tabor. 2010. Consequences of Stream Fragmentation and Climate Change for Rare Great Plains Fishes. Final Report. Available on internet at: http://www.greatplainslcc.org/PDFs/2010reports/Gido_GPLCC_final_report.pdf. September 30.

Olden, J.D., and D.A. Jackson. 2002. A comparison of statistical approaches for modeling fish species distributions. Freshwater Biology 47:1976-1995.

Scarnecchia, Dennis L, and Brad Schmitz (2012). Montana's Fish Species of Concern, Paddlefish. Montana Chapter of the American Fisheries Society. January. Accessed on July 24, 2012 from http://www.fisheriessociety.org/AFSmontana/SSCpages/Paddlefish.htm.

Jaeger, Matthew. 2004. Montana's Fish Species of Concern, Sauger. Montana Cooperative Fisheries Research Unit. Montana Chapter of the American Fisheries Society. January. Accessed on July 25, 2012. http://www.fisheriessociety.org/AFSmontana/SSCpages/Sauger%20Status.htm.

South Dakota Game Fish and Parks. 2010. Threatened, Endangered, And Candidate Species Of South Dakota. Updated March 16. Accessed on July 24, 2012 from http://gfp.sd.gov/wildlife/threatened-endangered/threatened-species.aspx#Fishes.

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2009. *The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System***.** Report to the National Park Service. Version 1.0. January.

U.S. Fish and Wildlife Service 2001. *Pallid Sturgeon Scaphirhynchus albus Fact Sheet*. La Crosse Fishery Resources Office.

Onalaska, Wisconsin. Revised May 2. Accessed on July 24, 2012 from http://platteriverprogram.org/News/Documents/USFWS%20Pallid%20Sturgeon%20Fact%20Sheet.pdf.

U.S. Fish and Wildlife Service. 2012. *Federally Listed, Proposed and Candidate Species.* Wyoming Ecological Services Field Office, Cheyenne, Wyoming. Updated on February 2. Accessed on July 24, 2012 from http://www.fws.gov/wyominges/Pages/Species/Species_Endangered.html.

USGS 2011. Paddlefish Study Project. U.S. Geological Society, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. Updated March 7. Accessed on July 25, 2012 from http://www.umesc.usgs.gov/aquatic/fish/paddlefish/faq.html.

APPENDIX E-8

FIGURES

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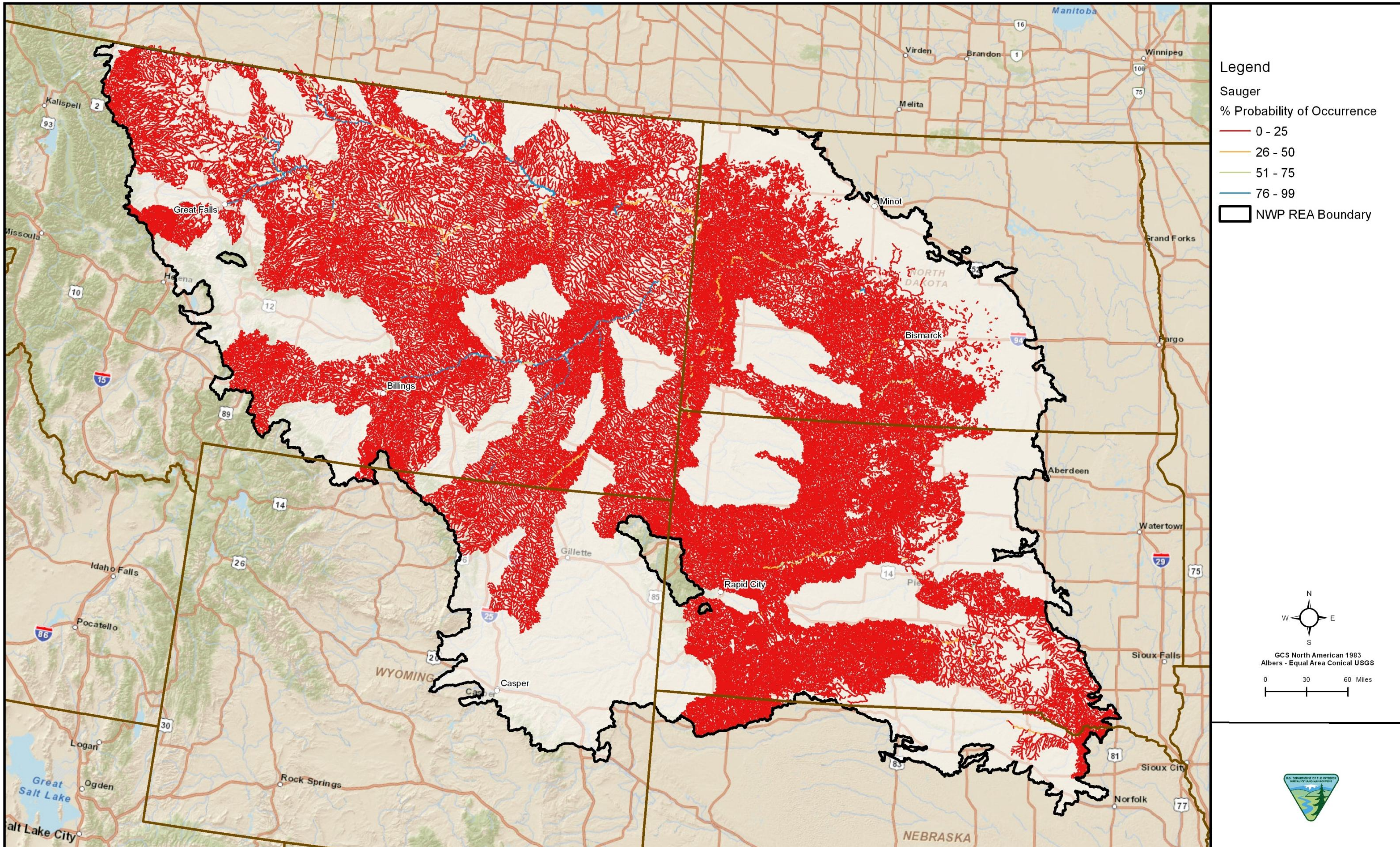

Figure E-8-1. Probability of Occurrence Model for the Sauger

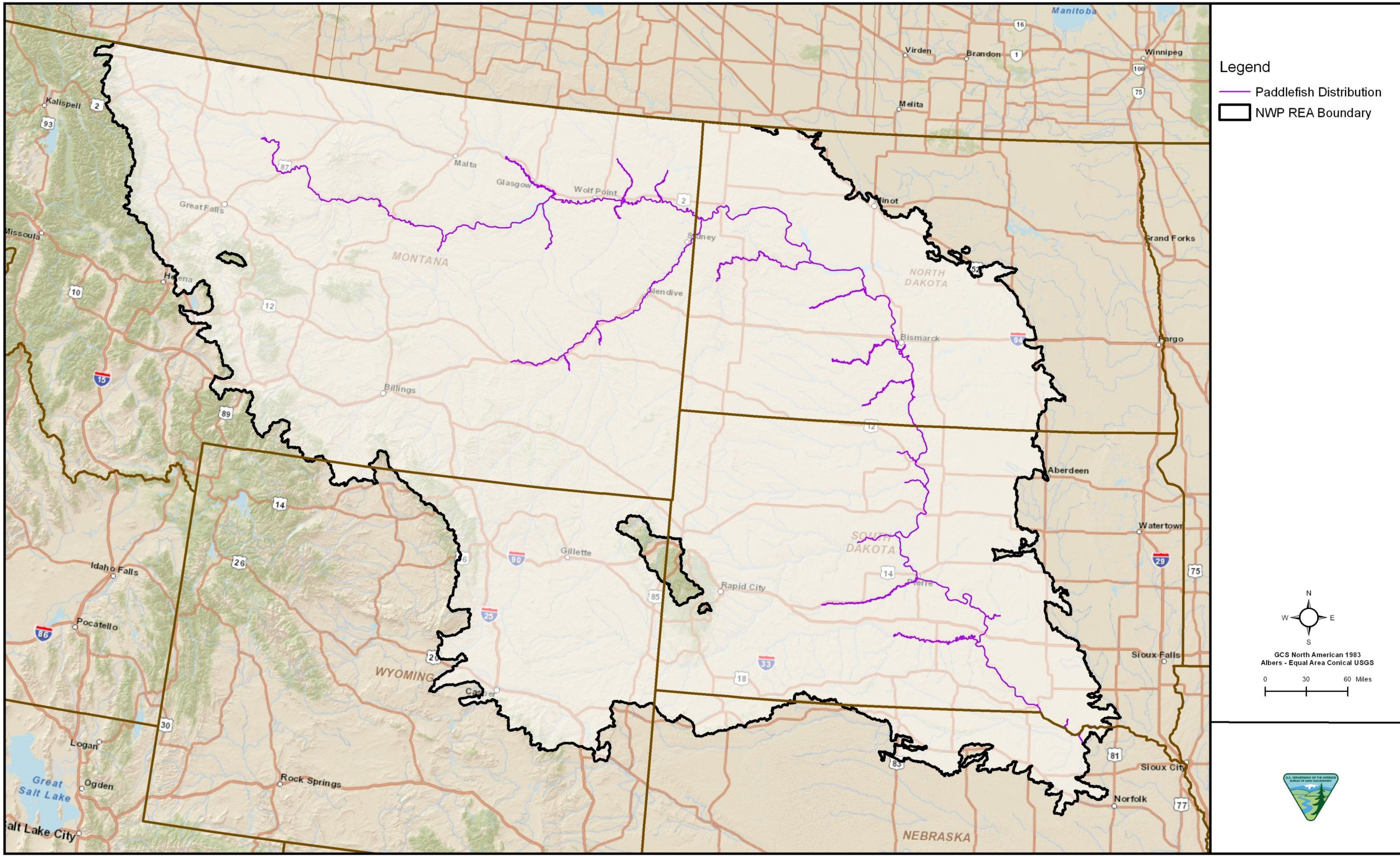

Figure E-8-2. Presence Model for the Paddlefish

Figure E-8-3. Presence Model for the Pallid Sturgeon

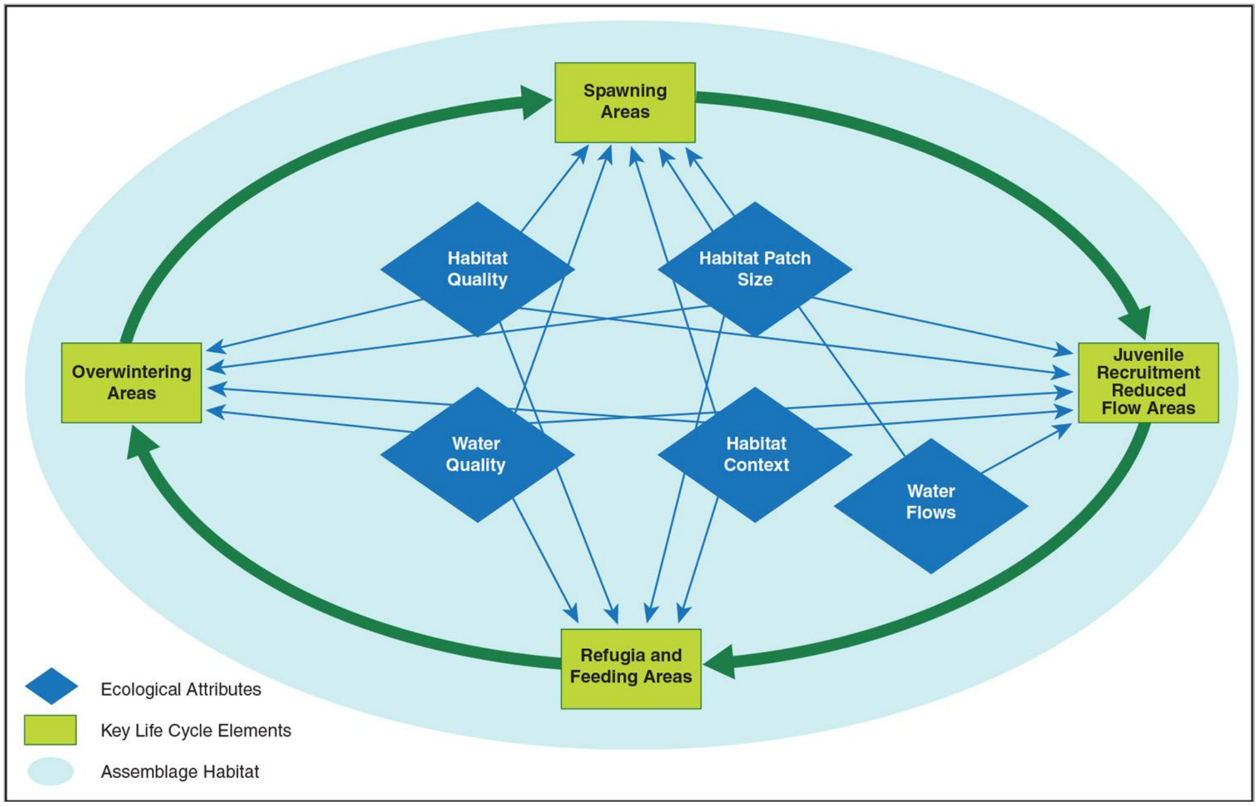

Figure E-8-4. Ecological Process Model for the Big River Fish Assemblage

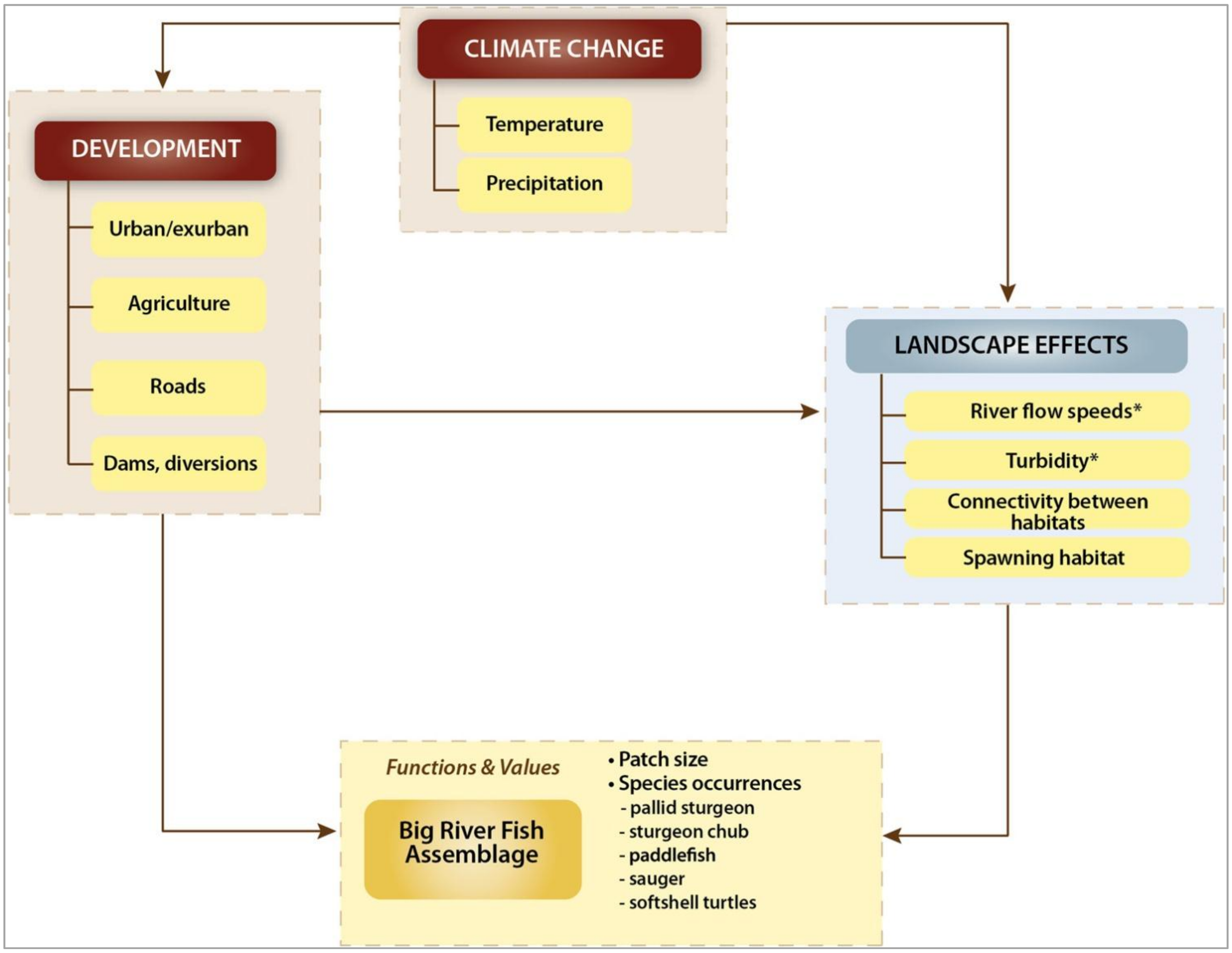

Figure E-8-5. System-Level Conceptual Model for the Big River Fish Assemblage

APPENDIX E-9

PLAINS SHARP-TAILED GROUSE CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The plains sharp-tailed grouse (PSTG) (*Tympanuchus phasianellus jamesii*) is one of six subspecies of sharp-tailed grouses found in North America (Aldrich 1963). Because of the similarities, the plains and Columbia sharp-tailed grouse are often confused. The PSTG is the only sharp-tailed grouse that exists within the boundaries of the Northwestern Plains ecoregion. The PSTG inhabits a broad range of plant communities dominated by grasses and shrubs and require expansive and often complex habitat, thus making the species excellent indicators of ecosystem function at landscape scale. The highest densities of breeding PSTG occur in western North Dakota (USGS 2005). In Montana, Nebraska, North Dakota, South Dakota, Wyoming, Alberta, British Columbia, Manitoba, and Saskatchewan, the PSTG is considered a game bird. PSTG have been extirpated from Kansas, Oklahoma, and New Mexico and are endangered in Colorado (Miller and Graul 1980). The PSTG is the most abundant and widespread prairie grouse species. Although widely distributed, PSTG numbers vary and are dependent upon the amount of grassland habitat and existing management, as well as short-term climatic conditions (Vodehnal and Haufler 2007).

Management questions (MQs) pertaining to this ecoregion were identified in Task 1 and can be summarized into two primary questions: 1) where are the important areas for this species? and 2) what is happening to these areas? The central focus of these two MQs is to document the current status of selected conservation elements (CEs) at the ecoregional scale and to evaluate how this status may change over a future time period. The first step is to identify suitable habitat for the CE within the ecoregion. Then, these areas are assessed relative to current and potential future change agent (CA) threats.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The PSTG makes its home in the northern Great Plains in southern Alberta and Saskatchewan, eastern Montana, North and South Dakota, Nebraska, and northeastern Wyoming. PSTG are characteristic inhabitants of tracts of mixed-grass prairie that contain scattered patches of small trees and shrubs or are located near the margins of woodlands.

Usually this species is restricted to mixed-grass prairies that are relatively undisturbed by excessive grazing or other intensive land-use practices. Most nests of this species are situated in ungraded or lightly grazed native prairie, often within or at the margins of thickets of shrubs or small trees. Occasionally, this species also utilizes alfalfa, sweet clover, and other domestic hayfields (USGS 2006). PSTG feed mainly on the ground during spring, summer, and fall, occasionally foraging in the treetops. When snow is deep during winter, they may forage in shrubs and trees. During severe winters PSTG may confine most of their foraging activity to hardwood draws, riparian forest, or brushlands. The habitats that provide cover for grouse must also provide food, especially during the winter, when food sources may be limited. PSTG consume a variety of forbs, grasses, flowers, fruits, seeds, buds, and insects. The plant components of their diet are variable and strongly influenced by geographical and seasonal availability. Insects form the major part of chicks' diets (NRCS 2007).

Breeding PSTG ordinarily congregate on communal dancing grounds each spring from mid-March to late May (Miller 1955). These birds display in open areas, known as leks, with other males; anywhere from a single male to upward of 20 will occupy one lek (averaging 8-12). Female PSTG usually do not travel far from leks to nest if suitable cover is available. The mean distance from known leks to 78 nests in western North Dakota was 0.8 miles (1.3 kilometers [km]), with a maximum distance of 2 miles (3.2 km). The mean distance between nests and leks in Saskatchewan was about 0.5 miles (0.9 km); all nests were within 1 mile (1.6 km) of leks (Prose 1987). PSTG prefer lek sites with short, sparse vegetation such as grasses, weeds, forbs, and some shrubs. Sparse and open vegetation on leks enables aggressive displays by males and minimizes predation. Sparse shrubs providing escape cover from predators are often found adjacent to leks. Leks are sometimes associated with recently burned or grazed sites. Changes in land use on a lek resulting in taller, denser vegetation have been shown to cause eventual abandonment of the lek (NRCS 2007).

Though they are not considered migratory, PSTG may move short distances (less than 21 miles) to winter in woody habitats when snow covers foraging areas. This movement usually occurs between late November and early January, though the timing is strongly influenced by snowfall. PSTG often burrow beneath deep, powdery snow to roost after feeding. Snow burrowing helps them conserve heat and avoid detection by predators. PSTG travel an average of 1 to 5 miles from breeding areas to winter habitats; however, they have been observed moving farther, particularly during harsh winters (NRCS 2007).

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3.0 CONSERVATION ELEMENT DISTRIBUTION MODELING

To answer the MQs regarding the location of this species across the ecoregion, a variety of existing data layers representing important habitat for the species were evaluated. The goal of this evaluation was to obtain data to determine the current distribution and status of this species throughout the ecoregion. The PSTG is found in all of the states in the ecoregion (Montana, Nebraska, North Dakota, South Dakota, and Wyoming).

A preliminary review of potential data was conducted as part of Task 2 of Phase 1 to define available data for use in this rapid ecoregional assessment (REA) (Table E-9-1). Important data for this species would include occurrences, habitat and range, leks, nesting, brood-rearing, and winter habitat.

Table E-9-1. Data Sources for Conservation Element Distribution Mapping

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	GAP Habitat Models	USGS	Raster (30-meters [m])	Acquired	No[2]
	State Derived Models	MT, WY, ND, SD, NE Fish and Game	Raster	Not available	No[2]
	Western Governors' Association (WGA) Decision Support System (DSS) Models	WGA Pilot Crucial Habitat	Raster	Future Dataset	No
Occurrences	State Natural Heritage Databases	Natural Heritage Programs of MT, WY, ND, SD, NE	Point	Acquired	No[2]
	Breeding Bird Survey	USGS	Polygon	Acquired	No[2]

[1] Data gap
[2] More representative data were selected for use

Although North and South Dakota are working on a distribution model for this subspecies, the Gap Analysis Program (GAP) habitat model was the only dataset that was identified for the species. The state of Wyoming provided sharp-tailed grouse data for this project, but these data included information for both the PSTG and Columbian sharp-tailed grouse; the PSTG data could thus not be differentiated from the Columbian sharp-tailed data. The GAP dataset differentiates between western sharp-tailed grouse and eastern sharp-tailed grouse, but it is not known if the eastern dataset refers to the plains subspecies or not. Furthermore, this GAP model does not include any distribution information for Nebraska, North Dakota, or South Dakota. In addition, the U.S. Geological Survey (USGS) GAP species viewer does not differentiate range distribution maps of the various subspecies. As a result of the data evaluation, several data gaps were identified regarding information on this species (as noted in Table E-9-1). Species occurrence data were difficult to obtain, as they are generally not available for download from agency websites. Data availability with regard to species, as opposed to spatial reference, was also a factor that affected dataset quality and availability.

Because of the lack of appropriate data for modeling, the Assessment Management Team (AMT) determined that current distribution and status of this species throughout the ecoregion could not be mapped or modeled and therefore recommended dropping this CE from further analysis as part of the REA.

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4.0 CONCEPTUAL MODELS

The CE-specific conceptual models were developed in order to answer the MQs regarding current status and potential future threats. Since species collection data were not adequate to produce distribution models, further analysis as part of this REA was not conducted. These conceptual models are provided to document the efforts that were initially conducted as part of Task 2.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model (Figure E-9-1) was developed to identify and link the key life cycle processes to ecological factors, or Key Ecological Attributes (KEAs), that have the greatest potential to affect PSTG habitat throughout the ecoregion. As noted in the species description, the PSTG is restricted to mixed-grass prairies that are relatively undisturbed by excessive grazing or other intensive land-use practices.

The key processes are identified in the model as green boxes. Following Unnasch et al. (2009), three broad headings or categories of ecological attributes (EAs) (size, condition, and context) are identified in the model as blue diamonds. Size refers to attributes related to habitat or patch size, condition refers to the condition of the habitat, and context refers to the spatial structure of the habitat. At the landscape level, the EAs under the condition category were the most challenging to spatially represent and will primarily depend on the data available.

4.2 SYSTEM-LEVEL MODEL

The system-level conceptual model (Figure E-9-2) illustrates the interactions between the CAs and the primary habitat functions of this species. The CAs for this CE are development, climate change, invasive species, wildfire, and disease, which are identified across the top of the figure in red. The habitat availability and suitability of the vegetation communities are the primary factors affecting PSTG populations. Although PSTGs have been noted to disperse more than 20 miles from their natal lek, most of the PSTG life cycle is concentrated in an area of approximately 1 mile (1.6 km) around a lek. All effects of CAs must therefore be considered primarily to the extent that they impact lek areas.

4.2.1 Development

Development, infrastructure (roads, pipelines, transmission lines), and oil and gas exploration in proximity to PSTG habitat and leks can cause impacts, but few detailed studies regarding such impacts have been conducted. Habitat fragmentation has been one of the driving factors of PSTG decline across its entire range for all subspecies throughout North America (Silvy and Hagen 2004). Habitat fragmentation occurs when large expanses of mixed grasslands are increasingly interspersed with non-native habitats (croplands) and in which fire suppression, tree plantings, and an increase of invasive woody species have occurred. PSTG are less affected by secondary roads than by primary roads. Williamson (2009) found little aversion of PSTG to roads associated with oil field development. However, linear infrastructure (primarily roads and power transmission lines) have been cited as a negative impact on PSTG (Hanowski et al. 2000). Disturbances to lekking grouse may also cause temporary abandonment of the lek site. Disturbances may include predators (Hartzler 1974; Ellis 1984) or human activities (Giesen and Connelly 1993) in the lek area. It has been suggested that PSTG are negatively affected by reduced habitat patch sizes, patch shapes, and juxtaposition of suitable habitat in the landscape, and not just the percentage of habitat available (Miller 1963). The U.S. Fish and Wildlife Service (USFWS) recommends against constructing wind turbines within 5 miles (8 km) of known leks in known prairie grouse habitat (Manville 2004). Conversion of mixed grasslands to dryland farming or cropland has been widely recognized as a dominant factor in alteration of PSTG habitat, and has been cited as the primary factor responsible for the species decline (Buss and Dziedzic 1955; Bart 2000). On the landscape scale, reducing the land cover of shrub patches below 5 percent has been suggested as a strong predictor of PSTG disappearance from leks (Prose 1987).

4.2.2 Climate Change

Climate effects are expressed primarily as the frequency and duration of drought. Although drought will not be included in the REA analysis due to lack of geospatial data, the frequency of severe drought was found to predict PSTG persistence (Prose 1987). This is consistent with the strong reliance of broods on insects and forbs, which are diminished during drought. In addition, climate change may impose altered fire regimes onto PSTG habitats, which could provide opportunities for invasive species to take over preferred habitat.

4.2.3 Invasive Species

Residual standing vegetation height is a key factor in determining quality nesting habitat, because nesting begins prior to vegetation growth. PSTG habitat was severely affected by the grazing practices of early settlers, especially unmonitored and excessive cattle grazing (Kirsch et al. 1973; Giesen and Connelly 1993; Kirby and Grosz 1995; Reece et al. 2001; Sidle 2005). Since bison are now absent from most of the ecoregion, cattle can be an important tool to manage habitat structure for PSTG (Evens 1968; Kirby and Grosz 1995; Sidle 2005). Revegetation efforts on former croplands have often involved non-native, highly-competitive vegetation such as smooth brome (*Bromus inermis*) and crested wheatgrass (*Agropyron cristatum*). In some instances, crested wheatgrass and smooth brome have forced out native vegetation, creating monoculture habitats not favored by PSTG. Also, PSTG appear to be particularly sensitive to even small increases of deciduous upland and coniferous tree cover (1-2 percent) within a 3-km distance to the lek.

A data gap exists with regard to invasive species due to the lack of large-scale comprehensive geospatial datasets covering the ecoregion and the inability to identify suitable surrogates.

4.2.4 Wildfire

Fire is considered one of the key factors affecting PSTG habitat. In fact, Native American tribes often referred to the PSTG as “fire bird” due to its close association with recently burned habitats and treeless grassland habitats. Similar to greater sage-grouse, PSTG evolved with fire as the primary disturbance process; they are attracted to recently burned areas during the brood-rearing period, when forbs are abundant. The impacts of fire on PSTG depend on vegetation type, timing, frequency, intensity, and size of burn. Fire can be a threat to PSTG populations when it reduces shrub cover below 5 percent of the landscape (Pose 1987). Fire is known to be an important factor in creating and maintaining PSTG habitat. In sagebrush and willow habitats, prescribed fire may be useful for opening dense stands of sagebrush and creating an interspersion of grass and shrub cover. Snowberry, chokecherry, willow, aspen, and Gambel oak, favorites of PSTG, all sprout profusely after fire. Fire suppression can lead to conifers invading bunchgrass prairie habitats in some areas to the detriment of PSTG populations. In these situations, prescribed burning is effective in maintaining suitable habitats. Prescribed burning on mixed prairie has become a controversial management technique (Gartner and White 1986). Repeated burning every few years or burning in early summer will deplete a stand of perennial grasses and allow annual grasses, primarily cheat grass, to increase. Once a mixed grassland shrub community is depleted of perennial plant cover, colonizing weeds (such as Russian thistle [*Salsola iberica*], and mustard [*Sisymbrium* and *Descurainia* spp]) are replaced by cheat grass within 5 years (Wright and Bailey 1982). Wildfires that occur in early summer have a tendency to kill perennial shrubs that are important to PSTG. Elimination of perennial shrubs leads to cheat grass invasion, especially after drought.

4.2.5 Disease

Naugle et al. (2004) reported the first West Nile virus (WNV) case in greater sage-grouse in northeast Wyoming, resulting in a 25 percent decline in survival of four populations (Naugle et al. 2004). Walker (2007) identified WNV as the primary cause of adult and chick sage-grouse mortality, which resulted in declining lek attandance. A highly efficient vector of WNV in North America is the mosquito (*Culex tarsalis*), (Hayes et al. 2005; Turell et al. 2005), which is thought to increase due to water development and well ponds associated with oil and gas exploration.

5.0 MANAGEMENT QUESTIONS

The relevant MQs for the PSTG include those defined as part of the Landscape Species/Species Richness category. The overall MQ was: Where are the key habitat types (seasonal, refuges, corridors/connectivity, migration routes, concentrations of regionally significant species, etc.) for landscape species, keystone species, regionally significant species, and regionally significant suites of species?

In order to answer the MQs, important data for this species include occurrences, ranges, and breeding areas. The results of this REA effort found that there is a significant lack of data for the PSTG. As a result, appropriate distribution models could not be developed and current status and threat analysis for the PSTG could not be conducted. In the future, resources should be directed toward the collection of data for this particular subspecies.

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6.0 REFERENCES

Aldrich, J. W. 1963. Geographic orientation of American Tetraonidae. Journal of Wildlife Management 27:529–545.

Bart, J. 2000. Status assessment and conservation plan for Columbian sharp-tailed grouse. Snake River Field Station. Forest and Rangeland Science Center, USGS. Boise, Idaho.

Brown, R.L 1966. Response of sharp-tail breeding populations to annual changes in residual grassland cover. Proc. Annu. Conf. West. Assoc. State Game and Fish Comm. 46:219-222.

Brown, R.L., 1961. Effects of land-use practices on sharptail grouse. Montana Dep. Fish and Game Job Completion Rep. P-R Proj. W-91-R-3, Job II-F. 12 pp.

Buss, I. O., and E. S. Dziedzic. 1955. Relation of cultivation to the disappearance of the Columbian sharp-tailed grouse from southeastern Washington. Condor 57:185-187.

Ellis, K.L. 1984. Behavior of lekking sage-grouse in response to a perched Golden Eagle. Western Birds 15: 37-38.

Evans, K.E. 1968. Characteristics and habitat requirements of the greater prairie chicken and sharp tailed grouse—A review of the literature. USDA For. Serv. Conserv. Rep. 12. 32 pp.

Gartner, F. R. and E. M. White. 1986. Fire in the northern Great Plains and its use in management. Pages 13-21 in Prescribed fire and smoke management symposium proceedings. Soc. Range Manage., Denver, Colorado.

Giesen, K. M., and J. W. Connelly. 1993. Guidelines for management of Columbian sharp-tailed grouse habitats. Wildlife Society Bulletin 21(3):325-333.

Hamerstrom, F.N. 1963. Sharptail brood habitat in Wisconsin's northern pine barrens. J. Wildl. Manage. 27:793-802.

Hamerstrom, F.N., Jr., and F. Hamerstrom. 1951. Mobility of the sharp-tailed grouse in relation to its ecology and distribution. Am. Midl. Nat. 46(1): 174-226.

Hamerstrom, F.N., Jr., and F. Hamerstrom. 1973. The prairie chicken in Wisconsin - highlights of a 22-year study of counts, behavior, movements, turnover and habitat. Wis. Dep. Nat. Resour. Tech. Bull. 64. 52 pp.

Hanowski, JAM, D.P. Christian, and G.J. Niemi. 2000. Landscape requirements of prairie sharp-tailed grouse Tympanuchus phasianellus campestris in Minnesota, USA. Wildlife Biology 6: 257–263.

Hartzler, J.E. 1974. Predation and the daily timing of Sage Grouse leks. Auk 91:532-536.

Hayes, E.B., Komar, N., Nasci, R.S., Montgomery, S.P., O'Leary, D.R., Campbell, G.L., 2005. *Epidemiology and transmission dynamics of West Nile virus disease*. Emerging Infectious Diseases 11, 1167–1173.

Kirby, D. and K. L. Grosz. 1995. Cattle grazing and sharp-tailed grouse nesting success. Rangelands 17(4): 124-126.

Kirsch, L. M., A. T. Klett, and H. W. Miller. 1973. Land use and prairie grouse population relationships in North Dakota. Journal of Wildlife Management 37(4):449-453.

Manville, A. M., II. 2004. Prairie grouse leks and wind turbines: U.S. Fish and Wildlife Service justification for a 5-mile buffer from leks; additional grassland songbird recommendations. Division of Migratory Bird Management, USFWS, Arlington, VA, peer-reviewed briefing paper. 17 pp.

Miller, H.A. 1963: Use of fire in wildlife management. - In: Proceedings, 2nd Annual Tall Timbers fire ecology conference. Tallahassee, Florida, USA, pp. 19-30.

Miller, G. C., and W. D. Graul. 1980. Status of sharp-tailed grouse in North America. Pages 18-24 in P. A. Vohs and F. L. Knopf, editors. Proceedings Prairie Grouse Symposium. Oklahoma State University, Stillwater, Oklahoma, USA.

Moyles, D.L.J. 1981. Seasonal and daily use of plant communities by sharptailed grouse (Pedioecetes phasianellus) in the parklands of Alberta. Can. Field-Nat. 95(3):287-291.

National Resources Conservation Service (NRCS) 2007. Sharp-tailed Grouse (*Tympanuchus phasianellus*) Fish and Wildlife Habitat Management Leaflet Number 40, February. U.S. Department of Agriculture, Washington, DC. Available at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_022164.pdf.

Naugle, D. E., C. L. Aldridge, B. L. Walker, T. E. Cornish, B. J. Moynahan, M. J. Holloran, K. Brown, G. D. Johnson, E. T. Schmidtmann, R. T. Mayer, C. Y. Dato, M. R. Matchett, T. J. Christiansen, W. E. Cook, T. Creekmore, R. D. Falise, E. T. Rinkes, and M. S. Boyce. 2004. *West Nile virus: pending crisis for greater sage-grouse*. Ecology Letters 7:704-713.

Prose , B.L., B. S. Cade, and D. Hein. 2002. Selection of nesting habitat by sharp-tailed grouse in the Nebraska Sandhills. Prairie Naturalist 34;85-105.

Prose, B. L. 1987. Habitat suitability index models: plains sharp-tailed grouse. Biol. Rep. 82(10.142). Fort Collins, CO: U. S. Department of Interior, Fish and Wildlife Service. 31 p.

Reece, P.E., J.D. Volesky, and W.H. Schacht. 2001. Cover for Wildlife after Summer Grazing on Sandhills Rangeland. Journal of Range Management. Vol. 54, No. 2 pp. 126–131.

Sidle, J. G. 2005. In my opinion: grousing and grazing on national grasslands. Wildlife Society Bulletin 33:1139–1144.

Silvy, N. J., and C. A. Hagen. 2004. Management of imperiled grouse species and their habitat. Wildlife Society Bulletin 32:2–5.

Turell, M.J., Dohm, D.J., Sardelis, M.R., O'Guinn, M.L., Andreadis, T.G., Blow, J.A., 2005. *An update on the potential of North American mosquitoes (Diptera: Culicidae) to transmit West Nile virus*. Journal of Medical Entomology 42, 57–62.

Swenson, J.E. 1981. The hardwood draws of southeastern Montana: their importance to wildlife and vulnerability to man's activities. Pages 37-61.

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2009. *The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System***.** Report to the National Park Service. Version 1.0. January.

USGS 2006. *Breeding Birds of North Dakota Sharp-tailed grouse*. Update August 3, 2006. Available from http://www.npwrc.usgs.gov/resource/birds/bbofnd/species/3080.htm.

Vodehnal, W. L., and J. B. Haufler, Compliers. 2007. A grassland conservation plan for prairie grouse. North American Grouse Partnership. Fruita, CO. Available at http://www.nwtf.org/NAWTMP/downloads/Literature/Grassland_Conservation_Plan_Prairie_Grouse_1.pdf.

Walker, B.L., D.E. Naugle, and K.E. Doherty. 2007. Greater sage-grouse population response to energy development and habitat loss. Journal of Wildlife Management 71(8):2644-2654.

White, R.S., and P.O. Currie. 1983a. Prescribed burning in the northern Great Plains: yield and cover responses of three forage species in the mixed grass prairie. J Range Manage 36:179-183.

Williamson, R.M., 2009. Impacts of Oil and Gas Development on Sharp-tailed Grouse on the Little Missouri National Grasslands, North Dakota. South Dakota State University.

Wright, H. A., and A. W. Bailey. 1982. Fire ecology, United States and southern Canada. John Wiley and Sons, New York, NY.

APPENDIX E-9

FIGURES

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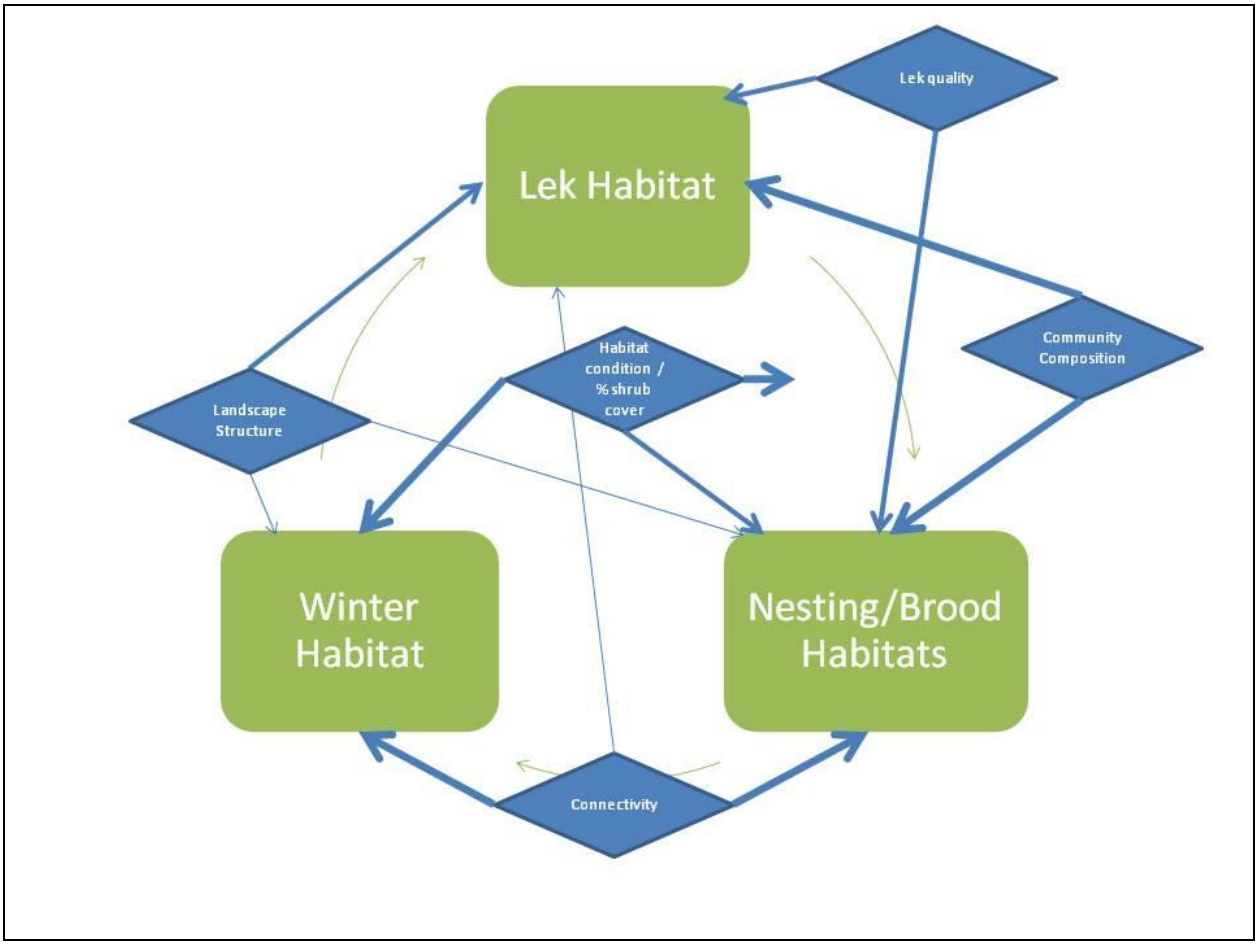

Figure E-9-1. Plains Sharp-tailed Grouse Ecological Process Model

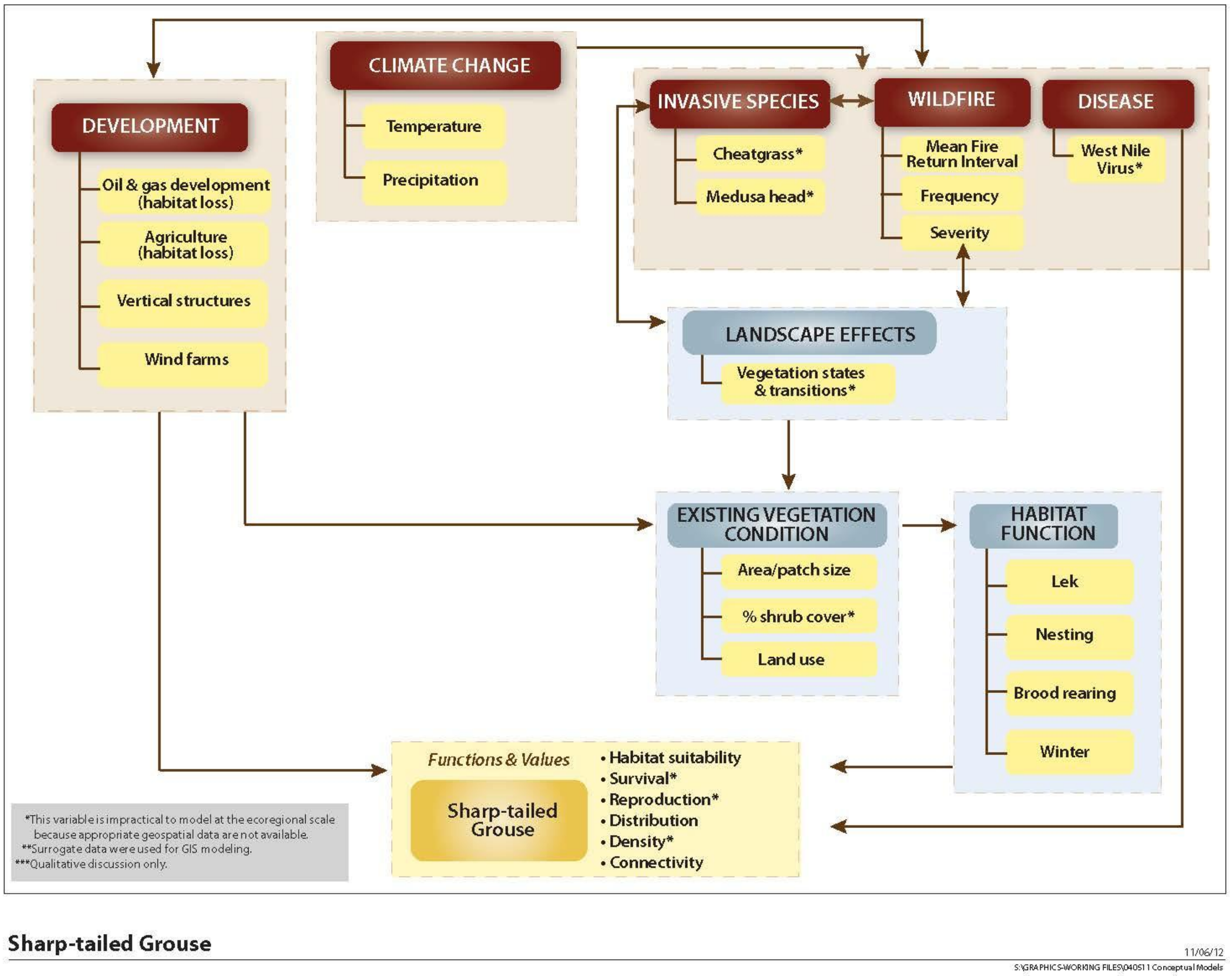

Figure E-9-2. Plains Sharp-tailed Grouse System-Level Conceptual Model

APPENDIX E-10

PRONGHORN CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The pronghorn (*Antilocapra americana*) is considered a regionally significant species within the Northwestern Plains ecoregion and occupies much of the mixed grassland ecosystem. The North American pronghorn population is estimated to be 1.1 million animals. The core pronghorn area consists of Colorado, Montana, South Dakota, and Wyoming. Over 80 percent of the continent's pronghorn can be found in these four states, with population estimates becoming smaller with movement to the edges of continental pronghorn range (Morton et al. 2008). Of the states included in the Northwestern Plains ecoregion, Wyoming supports approximately 51 percent of the North American population; Montana and South Dakota have populations of approximately 20 percent and 7 percent, respectively; and North Dakota and Nebraska support much smaller populations, with 1.4 percent and 0.05 percent of the North American population (Morton et al. 2008).

Management questions (MQ) pertaining to the pronghorn in the ecoregion can be summarized as: 1) where are important habitat areas for the species? and 2) how will the condition and suitability of these areas change in the future? The central focus of these two MQs is to document the current status of pronghorn migration corridors on an ecoregional scale and to evaluate how this status may change over a future time period. The first step is to identify suitable habitat for the conservation element (CE) within the ecoregion. Then, these areas are assessed relative to current status and potential future change agent (CA) threats.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The pronghorn is commonly associated with grassland and sagebrush communities of western North America; habitats with short vegetation and relatively flat terrain help the pronghorn evade predators. The pronghorn generally prefers areas with vegetation averaging about 15 inches or less in height and avoids taller vegetation areas. The vast majority of pronghorn populations depend on the large, woody sagebrush species as a preferred food source (Wyoming Interagency Vegetation Committee 2002). Studies also indicate that areas with an intermixing of ridges and drainages provide a greater diversity of vegetation, which may provide foraging benefits to the antelope (Wyoming Game and Fish Department 2002). In northern climates, deep snows frequently preclude the use of less nutritious dried forb and grass forage in winter, and it is here the available, highly nutritious sagebrush species permit the continued survival of the pronghorn and provide for its maximum productivity (Sundstrom et al. 1973).

In Wyoming, home ranges tend to be relatively small (1 - 2 square miles) in the summer, if water and food are adequate, and as large as 4 - 6 square miles in winter (although fall and spring migrations have been reported to exceed 250 miles). Snow depth strongly influences the pronghorn's choice of winter range. At snow depths exceeding 7 inches, antelope seek areas with topographic diversity (e.g., windswept ridges, south-facing slopes) where snow depths are reduced (Wyoming Game and Fish Department 2002).

Pronghorn are well-known for their seasonal migrations, especially between summer and winter ranges and during inclement weather. Seton (1927) was first to suggest that pronghorn from Jackson Hole annually migrated 150 miles to the Red Desert in southern Wyoming, which has since been confirmed by modern radio tracking technology (Riddle 1990; Sawyer et al. 2005). Pronghorn migration distances are the longest known for terrestrial animal species in the 48 contiguous states (Feeney et al. 2004). Typically, migration habitat for pronghorn consists of suitable winter habitat characterized by relatively flat, open, native sagebrush and grassland habitats free of encroaching trees, fragmenting infrastructure (e.g., roads, fences, and oil and gas development), and anthropogenic disturbances.

The pronghorn mates during a September breeding season and gives birth in late May or early June. The vegetative structure of sagebrush often provides crucially needed cover for fawns in the spring and early summer (O'Gara and Yoakum 1992).

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3.0 CONSERVATION ELEMENT DISTRIBUTION MODELING

To answer the MQs regarding the location and status of this CE across the ecoregion, a variety of existing data layers representing important habitat for the focal species were evaluated for use. The goal was to obtain data to determine the current distribution and status of each species throughout the ecoregion for critical periods (e.g., winter range, migration corridors).

Table E-4-1 lists the types of data and data sources for the pronghorn that were proposed for use in the Rapid Ecoregional Assessment (REA) as part of the pre-assessment data identification effort in Task 2. Distribution of this species covers all five states in this ecoregion (Montana, Nebraska, North Dakota, South Dakota, and Wyoming). The most important datasets required for pronghorn are migration corridors. Migration corridors are areas of habitat connecting wildlife populations or seasonal ranges (Rosenberg et al. 1997).

Table E-4-1. Data Sources for the Pronghorn Conservation Element Distribution Mapping

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Modeled Suitable Habitat	Gap Analysis Program (GAP) Habitat Models	U.S. Geological Survey (USGS)	Raster (30-meter [m])	Acquired	No[2]
	NatureServe Habitat Model	NatureServe	Polygon	Acquired	No[2]
	State Derived Models	MT, WY, ND, SD, NE State Fish and Game Agencies	Raster	Require Data	Yes
	Western Governors' Association (WGA) Decision Support System (DSS) Models	WGA Pilot Crucial Habitat	Raster	Future Dataset	No[1]
Crucial and Severe Winter Ranges	Crucial and Winter Range	MT, WY, ND, SD, NE State Fish and Game Agencies		Require Data	No[1]
Parturition Areas	Parturition Areas	MT, WY, ND, SD, NE State Fish and Game Agencies		Require Data	No[1]
Travel Corridors	Travel Corridors	MT, WY, ND, SD State Fish and Game		Require Data	No[1]
Migration Corridors	Migration Corridors	WGA; MT, WY, ND, SD State Fish and Game		Require Data	No[1]

1 Data gap
2 More representative data were selected for use

Because the species is considered to be common, occurrences are not recorded by natural heritage programs. A variety of studies are currently in progress to evaluate pronghorn migration routes relative to the potential impact of oil and gas exploration and production. One such study, which includes the National Park Service (NPS), Wyoming Game and Fish, and the Wildlife Conservation Society, is currently in year two and follows up on a study completed in 2004. Although there were localized datasets and some multi-state migration corridor datasets (as noted in Table E-4-1), no comprehensive, ecoregion-wide data could be acquired that were uniform enough for the entire ecoregion.

Due to the lack of adequate geospatial data to define the distribution of the pronghorn, the Assessment Management Team (AMT) determined that current distribution and status of this species throughout the ecoregion could not be mapped or modeled and therefore recommended dropping this CE from further analysis as part of the REA.

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4.0 CONCEPTUAL MODELS

The CE-specific conceptual models were developed in order to answer the MQs regarding current status and potential future threats. Because species collection data were not adequate to produce distribution models, further analysis as part of this REA was not conducted. These conceptual models are provided to document the efforts that were initially conducted as part of Task 2.

4.1 ECOLOGICAL PROCESS MODEL

The ecological process model for the pronghorn (Figure E-10-1) was developed to identify and link the key life cycle processes to specific ecological factors, or Key Ecological Attributes (KEAs), that have the greatest potential to affect pronghorn migration routes throughout the ecoregion.

The key processes are identified in the model as green boxes. Following Unnasch et al. (2009), three broad headings or categories of ecological attributes (EAs) (size, condition, and context) are identified in the model as blue diamonds. Size refers to attributes related to habitat or patch size, condition refers to the condition of the habitat, and context refers to the spatial structure of the habitat. At the landscape level, the EAs under the condition category will be the most challenging to spatially represent and will primarily depend on the data available.

4.2 SYSTEM-LEVEL MODEL

The system-level conceptual model (Figure E-10-2) illustrates the interactions between the CAs and the primary habitat functions of this species. The primary CAs for this CE are development, climate change, invasive species, wildfire, and insect outbreak and disease, which are identified across the top of the figure in red. The important factors (or "drivers") affecting the abundance and distribution of pronghorn populations include those that impact survival, reproduction, distribution, density, and metapopulation structure.

Pronghorn migratory behavior is characterized by high individual plasticity, ranging from entirely sedentary to completely migratory, with some individuals exhibiting partial or intermittent migratory behavior (White et al. 2007). Generally, changes in climatic and vegetative conditions trigger the onset and length of seasonal movements. The greater the winter severity, the farther individuals and herds travel to areas with less snow to avoid mortality that is often associated with snow depths exceeding 16 inches (40 centimeters [cm]) (Creek 1967; Guenzel 1986; Raper et al. 1989; Sawyer and Lindzey 2000; Yoakum 1978; Yoakum et al. 1996).

Slope is an important indicator of pronghorn migration habitat. Studies suggest that pronghorn avoid slopes of greater than 20 percent and apparently prefer areas where the slopes are less than 10 percent (Yoakum 2004, Longshore and Lowry 2008).

4.2.1 Development

The specific types of development that may impact the important migration corridors for the pronghorn include roads, oil & gas exploration and development, mining, urban/exurban expansion, recreation, and renewable energy development. Pronghorn evolved in open landscapes without vertical barriers.

Roads are widely recognized by the scientific community as having a range of direct, indirect, and cumulative effects on wildlife and their habitats (Gucinski et al. 2001; Gaines et al. 2003; Wisdom et al. 2004a; Wisdom et al. 2004b; New Mexico Department of Game and Fish 2005). Roads impact the pronghorn's use of winter range, as well as seasonal movements. In southwestern Wyoming and Arizona, unfenced roads appeared not to be a barrier to pronghorn movement, but the combination of heavy traffic volume and fences along roads can be considerable barriers to movement and can fragment habitat (Buechner 1950; Ockenfels et al. 2007; Sheldon 2005; Van Riper et al. 2001). Divided highways, interstates, and other high-volume roadways (i.e., > 2,000 Average Annual Daily Traffic) are usually fenced, restricting pronghorn movements to designated crossing structures. Yoakum (2004b) speculated that pronghorn behavior may prevent the use of under and overpasses of high-volume highways. Fences often severely impede pronghorn movements (Spillet et al. 1967; Oakley and Riddle 1974; Mitchell 1980; Barrett 1982; Pyrah 1987; Hailey 1979). There is strong evidence that, if prevented from seasonal migration by obstacles, pronghorn may experience massive die-offs (Ryder et al. 1984).

Physiological stresses occur when energy expenditures by an animal are increased due to alarm and/or avoidance movements. These are generally attributed to interactions with humans and/or activities associated with human presence (traffic, noise, pets, etc.). Added consequences from human presence include, but are not limited to, mortality and injury due to vehicle collisions, illegal hunting, and harassment from a variety of increasing recreational activities (WAFWA 2010).

The recent expansion of energy development in the west has the potential to have serious impacts to pronghorn and their migration corridors (Hebblewhite 2008). Berger et al. (2006) showed that some pronghorn continued to use areas that were heavily developed, whereas other animals showed strong avoidance to such areas. Migrating pronghorn avoid more densely developed areas (Berger et al. 2006) in the Upper Green River Basin in southwestern Wyoming. Energy development resulted in avoidance of heavily developed areas by pronghorn and the total abandonment of the Jonah Field, which had previously been important winter transition range. The study documented reduced use and abandonment of habitat parcels that were less than approximately 600 acres (242 hectacres [ha]) in size. Avoidance distances reported for pronghorn range from 0.25 miles (0.4 kilometers [km]) to 0.6 miles (0.96 km) from sources of disturbance (Autenrieth 1983; Easterly et al. 1991). Pronghorn did not change their 24-hour activity pattern to forage in the habitat near well pads, even at night when human disturbance was reduced. Areas within 100 m of gas wells were also consistently avoided. Sawyer et al. (2002) suggested that energy development could sever migration corridors for pronghorn and could influence the winter distribution of pronghorn on winter ranges. Primary effects of oil development and well-site access roads may come with associated fences and the resulting hindrance of pronghorn movements (Riddle and Oakley 1973). Those impacts, both direct and indirect, will likely be compounded during times of drought or when deep snow accumulations limit the available winter range (Beckman et al. 2006). Sawyer et al. (2005) tracked pronghorn moving along a 150 km corridor and identified a number of bottlenecks along this migration route. Corridor widths of 0.5 miles (<0.8 km) have been identified as a major management concern (Sawyer et al. 2005).

4.2.2 Climate Change

The primary impacts of climatic conditions on pronghorn and their habitat are through the effects of the moisture and temperature regime on forage resources (i.e., productivity, species composition, and nutrient content are affected by drought, late frosts, etc.), and snow depth on winter ranges and migration corridors. A close relationship was observed between pronghorn distribution and water locations in Wyoming's Red Desert; 95 percent of pronghorn were within 4 miles (6.4 km) of a water source (Sundstrom 1968). Numerous studies have reported positive associations between fawn/doe ratios and both the previous growing season precipitation and current season precipitation, which emphasizes the importance of female pre-winter condition on fawn survival (Byers and Hogg 1995; Fairbanks 1993; Gregg et al 2001). Smyser et al. (2006), working in Wyoming, noted a negative relationship associated with winter precipitation and fawn/doe ratios. Berger et al. (2007) suggested that snow depth above 15 inches (38 cm) limited pronghorn use of winter range in southwestern Wyoming. Beckman et al. 2006 suggest that both snow depth and fragment size explain threshold levels for use by pronghorn within or adjacent to gas fields.

4.2.3 Invasive Species

Habitat fragmentation creates landscapes made of altered habitats or developed areas fundamentally different from those shaped by natural disturbances that species have adapted to over evolutionary time (Noss and Cooperrider 1994). These changes very likely manifest themselves as changes in vegetative composition, often to weedy and invasive species. This, in turn, changes the type and quality of the food base as well as the structure of the habitat. Increased 'edge effect' between developed and undeveloped areas often results in reduced forage quality and security cover, potentially increasing susceptibility to predation (WAFWA 2010).

In addition, some invasive species (especially *Bromus* spp.) can alter fire regimes and thus affect entire landscapes and their communities. The increase of severe droughts associated with global warming will exacerbate cheat grass growth and the spread of other harmful invasive species, thereby converting sagebrush steppe into exotic annual grassland with less forage value. Furthermore, cheat grass and other invasive plants increase the frequency and intensity of wildfires, thereby leaving sagebrush habitat with little chance of recovering (National Wildlife Foundation 2012).

4.2.4 Wildfire

Wildfire is considered one of the key factors affecting pronghorn migration and winter habitat. Historic mean fire return intervals (MFRIs) in native sagebrush systems are influenced by site productivity and geographic location, but also coincide with the range of big sagebrush cover types. Moderate fire return intervals (FRIs) and low-intensity fires are necessary to maintain the mixed composition of sagebrush communities that provide the composition of forage and open migration habitat pronghorn require. Therefore, the greatest threat to pronghorn migration habitat is fire suppression that causes "decadent" sagebrush conditions with excessive shrub heights, tree encroachment, and loss of the open character of the landscape. Pronghorn generally avoid trees and woodland habitats within 100 m (Ockenfels et al. 1994; Yoakum 2004a).

4.2.5 Insect Outbreak and Disease

Pronghorns are relatively disease and parasite-free (Schemnitz 1994). However, pronghorn commonly come in contact with other free-ranging ungulates, as well as domestic livestock, and therefore could be exposed to diseases that affect these species (Dubay et al. 2006). Of particular concern is hemorrhagic disease caused by bluetongue viruses and epizootic hemorrhagic disease viruses. Hemorrhagic disease has been implicated in deaths of pronghorn in Wyoming (Thorne et al. 1988). Hemorrhagic disease epizootics occur in late summer and early fall and coincide with the pronghorn breeding season; infections could cause behavioral or physiologic changes or reproductive pathology that decreases breeding success and fawn recruitment (Dubay et al. 2006).

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5.0 MANAGEMENT QUESTIONS

The relevant MQs for the pronghorn include those defined as part of the Landscape Species/Species Richness category. The overall MQ was: ***Where are the key habitat types (seasonal, refuges, corridors/connectivity, migration routes, concentrations of regionally significant species, etc.) for landscape species, keystone species, regionally significant species, and regionally significant suites of species***?

Important data for this species, including occurrences, habitat and ranges, and migration corridors, is needed to answer the MQs. The results of this REA effort found that there is a significant lack of data for the pronghorn. As a result, appropriate distribution models could not be developed and current status and future threat analysis for this species could not be conducted. In the future, resources should be directed toward the collection of data for this particular CE.

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6.0 REFERENCES

Autenrieth, R. E. 1983. Guidelines for the management of pronghorn antelope. Texas Parks and Wildlife Department, Austin, TX. 51 pp.

Barrett, M. W. 1982. Distribution, behavior, and mortality of pronghorns during a severe winter in Alberta. Journal Wildlife Management 46:991–1002.

Berger, J., K.M. Berger, and J.P. Beckmann. 2006. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 1 Summary. Wildlife Conservation Society, Bronx, NY. Available at: http://www.wcs.org/media/file/Shell%20Year%201%20Progress%20REVISED%20III.pdf.

Beckmann, J. P., J. Berger and K, Murray Berger. 2006 Petroleum Development and Pronghorn: Where Are the Break Points? 22nd Biennial pronghorn workshop, P 178. Idaho Falls, Idaho

Buechner, H. K. 1950. Life history, ecology, and range use of the pronghorn antelope in Trans-Pecos Texas. American Midland Naturalist. 43(2): 257-354.

Byers, J. A. and J. T. Hogg. 1995. Environmental effects on prenatal growth rate in pronghorn and bighorn: further evidence for energy constraint on sex-biased maternal expenditure. Behavioral Ecology 6:451–457

Creek, D. E. 1967. A summary of pronghorn antelope investigations. Wyoming Game and Fish department, Cheyenne, Wyoming, USA.

Creel, S., J. Fox, A. Hardy, J. Sands, B. Garrot and R. Peterson. 2002. Snowmobile activity and glucocorticoid stress responses in wolves and elk. Conservation Biology 16(3):809-814.

Dubay, S.A., T. H. Noon, J. C. deVos, Jr. and R. A. Ockenfels 2006. *Serologic Survey for Pathogens Potentially Affecting Pronghorn (Antilocapra americana) Fawn Recruitment in Arizona, USA.* Journal of Wildlife Diseases, 42(4), 2006, pp. 844–848. Available at http://www.jwildlifedis.org content /42/4/844.full.pdf+html

Easterly, T.A.A.W., T.L. 1991.Responses of Pronghorn and Mule Deer to Petroleum Development on Crucial Winter Range in the Rattlesnake Hills. Wyoming Game and Fish Department, Cheyenne, Wyoming,

Fairbanks, W. S. 1993. Birthdate, birthweight, and survival in pronghorn fawns. *J. Mamm.* 74: 129-35.

Fairbanks, W. S. 1994. Dominance, age, and aggression among female pronghorn, Antilocapra americana (Family: Antilocapridae). Ethology 97:278-293.

Feeney, D., et al. 2004. Big Game Migration Corridors in Wyoming. University of Wyoming, Laramie Wyoming Cooperative Extension Service, Bulletin (B-1155).

Gaines, W., P. Singleton, and R. Ross. 2003. *Assessing the Cumulative Effects of Linear Recreation Routes on Wildlife Habitats on the Okanogan and Wenatchee National Forests*. General Technical Report PNW-GTR-586. U.S. Department of Agriculture, U.S. Forest Service, Pacific Northwest Research Station, Portland, OR.

Gregg, M. A., M. Bray, K. M. Kilbride, and M. R. Dunbar. 2001. Birth synchrony and survival of pronghorn fawns. Journal Wildlife Management 65:19-24.

Gucinski, H., J.J. Furniss, R.R. Ziemer, and M.H. Brookes. 2001. *Forest Roads: A Synthesis of Scientific Information*. General Technical Report PNW-GTR-509. U.S. Department of Agriculture, U.S. Forest Service, Pacific Northwest Research Station, Portland, OR.

Guenzel, R. J. 1986. Pronghorn ecology in southcentral Wyoming. Thesis, University of Wyoming, Laramie, Wyoming.

Hailey, T. L. 1979. A handbook for pronghorn antelope management in Texas. Texas Parks and Wildlife Department, Austin, Texas, USA.

Hebblewhite, M. 2008. A literature review of the effects of energy development on ungulates: Implications for central and eastern Montana. Report prepared for Montana Fish, Wildlife and Parks, Miles City, MT.

Longshore, K. and C. Lowrey. 2008. Habitat analysis and food habits of pronghorn antelope in the Carrizo Plain National Monument, California. U.S. Geological Survey, Western Ecological Research Center, Henderson, Nevada, USA.

Mitchell, G. J. 1980. The pronghorn antelope in Alberta. University of Regina, Saskatchewan, Canada. 165 pp.

Morton, Kim, P.F. Jones, J. Taggert. 2008. Province and State Status Report on Pronghorn Antelope 2008. Proceedings of the 23rd Biennial Pronghorn Workshop 2008. May 13 – 16, 208. Canmore, Alberta. Available at http://homepages.ucalgary.ca/~berrendo/Draft2008Proceedings.pdf

National Wildlife Foundation 2012. Global Warming and Sagebrush Steppe Habitat. Accessed on August 6, 2012 from http://www.nwf.org/Global-Warming/Effects-on-Wildlife-and-Habitat/Sagebrush-Steppe.aspx

New Mexico Department of Game and Fish. 2005. *Habitat Fragmentation and the Effects of Roads on Wildlife and Habitats*. Available at http://www.wildlife.state.nm.us/conservation/ habitat_handbook/ documents/2004EffectsofRoadsonWildlifeandHabitats.pdf.

Noss, Reed F.; Cooperrider, Allen Y. 1994. Saving nature's legacy: protecting and restoring biodiversity. Washington, DC: Island Press. 416 p.

Oakley, C. and P. Riddle, 1974. The impact of a severe winter and fences on antelope mortality in south-central Wyoming. Proceedings Pronghorn Antelope Workshop 6:155-173

Ockenfels, R.A., A. Alexander, C.L. Dorothy Ticer, and W.K. Carrel. 1994. Home Range Movement Patterns and Habitat Selection of Pronghorn in Central Arizona. Technical Report 13. Arizona Game and Fish Department, Phoenix, AZ.

Ockenfels, R. A., J. C. deVos, J. J. Hervert 2007. Transportation corridors in Arizona and Mexico and pronghorn: Case studies. Road Ecology Center eScholarship Repository, John Muir Institute of the Environment, University California, Davis, California, accessed online at http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1417 &context=jmie/roadeco, July 2009.

O'Gara, B.W. and J.D. Yoakum, eds. 1992. Pronghorn Management Guides. Fifteenth Biennial Pronghorn Antelope Workshop. Rock Springs, Wyoming. 101 p.

Pyrah, D.B. 1987. American pronghorn antelope in the Yellow Water Triangle, Montana. Montana Department Fish, Wildlife and Parks, Helena, Montana, USA.

Raper, E., T. Christiansen and B. Petch. 1989. Sublette antelope study: Final report. Pages 124-169 in Annual big game herd unit report. Wyoming Game and Fish Dept., Cheyenne, Wyoming

Riddle, P. 1990. Wyoming antelope status report -1990. Proceedings Pronghorn Antelope Workshop 14:24.

Riddle, P. and C. Oakley. 1973. The impact of severe winters and fences on antelope mortality in south-central Wyoming. Proceedings Western Association State Fish and Game Commissioners 53:174-188

Rowland, M., M. Wisdom, B. Johnson, and M. Penninger. 2004. Effects of roads on elk: Implications for management of forested ecosystems. Pgs. 42-52 in Wisdom, M.J, technical editor, The Starkey Project: a Synthesis of Long-Term Studies of Elk and Mule Deer. 2004. Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, Kansas, USA.

Rosenberg, D.K., B.R. Noon, and E.C. Meslow. 1997. Biological corridors: form, function, and efficacy. BioScience 47:677-687.

Ryder, T. 1., L. L. Irwin and D. S. Moody. 1984. Wyoming's Red Rim pronghorn controversy: History and current status. Proc. Pronghorn Antelope Workshop. 11: 195-206.

Sawyer, H. and F. Lindzey. 2000. The Jackson Hole pronghorn study. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming. 57 pp.

Sawyer, H., F. Lindzey, D. McWhirter and K. Andrews. 2002. Potential effects of oil and gas development on mule deer and pronghorn populations in western Wyoming. Transactions North American Wildlife and Natural Resource Conference 67:350-365.

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin 33:1266-1273.

Schemnitz, Sanford D. 1994. Pronghorn Antelope. From *Prevention and Control of Wildlife Damage* Edited by S.E. Hygnstrom, R.M. Timm, and G.E. Larson. University of Nebraska Cooperative Extension. Available at http://icwdm.org/handbook/mammals/mam_d71.pdf.

Seton, E. T. 1927. Lives of game animals. Vol.III. Doubleday, Page, & Co. New York, New York.

Seton, E. T. 1929. The common prongbuck prong-horn, antelope or prong-horned antelope of America, Cabrit or Cabrie, pied goat of the plains. Pages 413-467 in Lives of game animals. Volume 3 - Part 2 hoofed animals. Doubleday, Doran and Company, Garden City, New York, USA.

Sheldon, D. P. 2005. Movement and distribution patterns of pronghorn in relation to roads and fences in southwestern Wyoming. Thesis. University of Wyoming, Laramie, Wyoming, USA.

Smyser. T, E.O. Garton, P. Zager. 2004. The Influence of Habitat Variables on Pronghorn Recruitment. Idaho Department of Fish and Game, Boise, Idaho. October.

Smyser, T. J., A. F. Reeve, and E. O. Garton. 2006. Evaluation of pronghorn population productivity relative to broad-scale habitat variables in Wyoming (1978-2003). Proceedings Pronghorn Antelope Workshop 22

Spillett, J. J., J. B. Low, and D. Sill. 1967. Livestock fences-how they influence pronghorn antelope movements. Bulletin 470, Agriculture Experiment Station. Utah State University, Logan, Utah, USA.

Sundstrom, C. 1968. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. Proceedings Pronghorn Antelope Workshop 3:39-47.

Sundstrom, C., W.G. Hepworth, and K.L. Diem. 1973. Abundance, Distribution and Food Habits of the Pronghorn - A Partial Characterization of the Optimum Pronghorn Habitat. Wyoming Game and Fish Commission. Cheyenne, Wyoming. Bulletin No. 12. 61 p.

Thorne E.T., E. S. Williams, T. R. Spraker, W. Helms, And T. Segerstrom. 1988. *Bluetongue in freeranging pronghorn antelope (Antilocapra americana) in Wyoming: 1976 and 1984*. Journal of Wildlife Diseases 24: 113–119. http://www.jwildlifedis.org/content/42/4/844.full#ref-24

Unnasch, R.S., D. P. Braun, P. J. Comer, G. E. Eckert. 2009. *The Ecological Integrity Assessment Framework: A Framework for Assessing the Ecological Integrity of Biological and Ecological Resources of the National Park System***.** Report to the National Park Service. Version 1.0. January.

Van Riper III, C., J. Hart and J. Bright. 2001. Effect of fenced transportation corridors on pronghorn antelope movements in Petrified Forest National Park, Arizona. Pages 71-74 in D. Harmon, editor. Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands, George Wright Society, Hancock, Michigan, USA.

WAFWA 2010. Conservation Actions to Benefit Mule Deer Affected by Energy Development. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies.

White, P. J., T. L. Davis, K. K. Barnowe-Meyer, R. L. Crabtree, and R. A. Garrott. 2007. Partial migration and philopatry of Yellowstone pronghorn. Biological Conservation 135:502-510.

Wisdom, M.J., N.J. Cimon, B.K. Johnson, E.O. Garton, and J.W. Thomas. 2004a. Spatial partitioning by mule deer and elk in relation to traffic. *Transactions of the North American Wildlife and Natural Resources Conference* 69:509-530.

Wisdom, M.J., A.A. Ager, H.K. Preisler, N.Cimon, and B.K. Johnson. 2004b. Effects of offroad recreation on mule deer and elk. *Transactions of the North American Wildlife and Natural Resources Conference* 69:531-550.

Wyoming Game and Fish Department 2002. Pronghorn Antelope. Habitat Extension Bulletin No. 28. Reprinted April 2002.

Wyoming Interagency Vegetation Committee. 2002. Wyoming Guidelines for Managing Sagebrush Communities with Emphasis on Fire Management. Wyoming Game and Fish Department and Wyoming BLM. Cheyenne, WY. 53 pp.

Yoakum, J. D. 1978. Managing rangelands for the American pronghorn antelope. Proceedings Pronghorn Antelope Workshop 8:321-336

Yoakum, J. D., B.W. O'Gara, and V. W. Howard. 1996. Pronghorn on western rangelands. Pages 211-226 in: Krausman, P. R. Rangeland wildlife. Society Range Management, Denver, Colorado, USA

Yoakum, J.D. 2004a. Habitat characteristic and requirements. Pages 75-105 in B.W. O'Gara and J.D. Yoakum, Pronghorn: Ecology and Management. Colorado University Press, Boulder, Colorado, USA.

Yoakum, J. D. 2004b. Habitat Conservation. Pages 571-630 in O'Gara B.W. and J.D. Yoakum. Pronghorn: Ecology and Management. Colorado University Press, Boulder, Colorado, USA.

APPENDIX E-10

FIGURES

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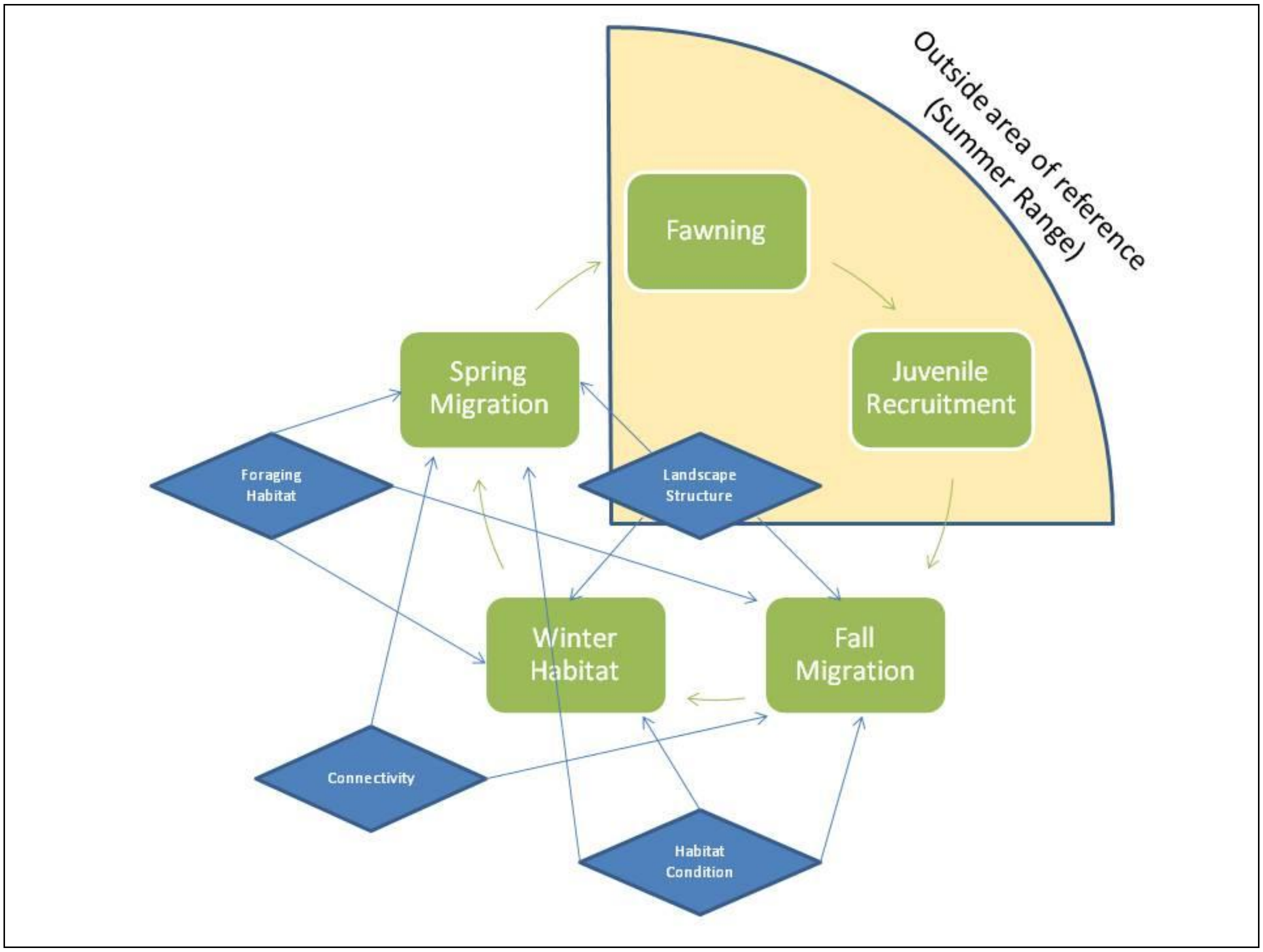

Figure E-10-1. Pronghorn Ecological Process Model

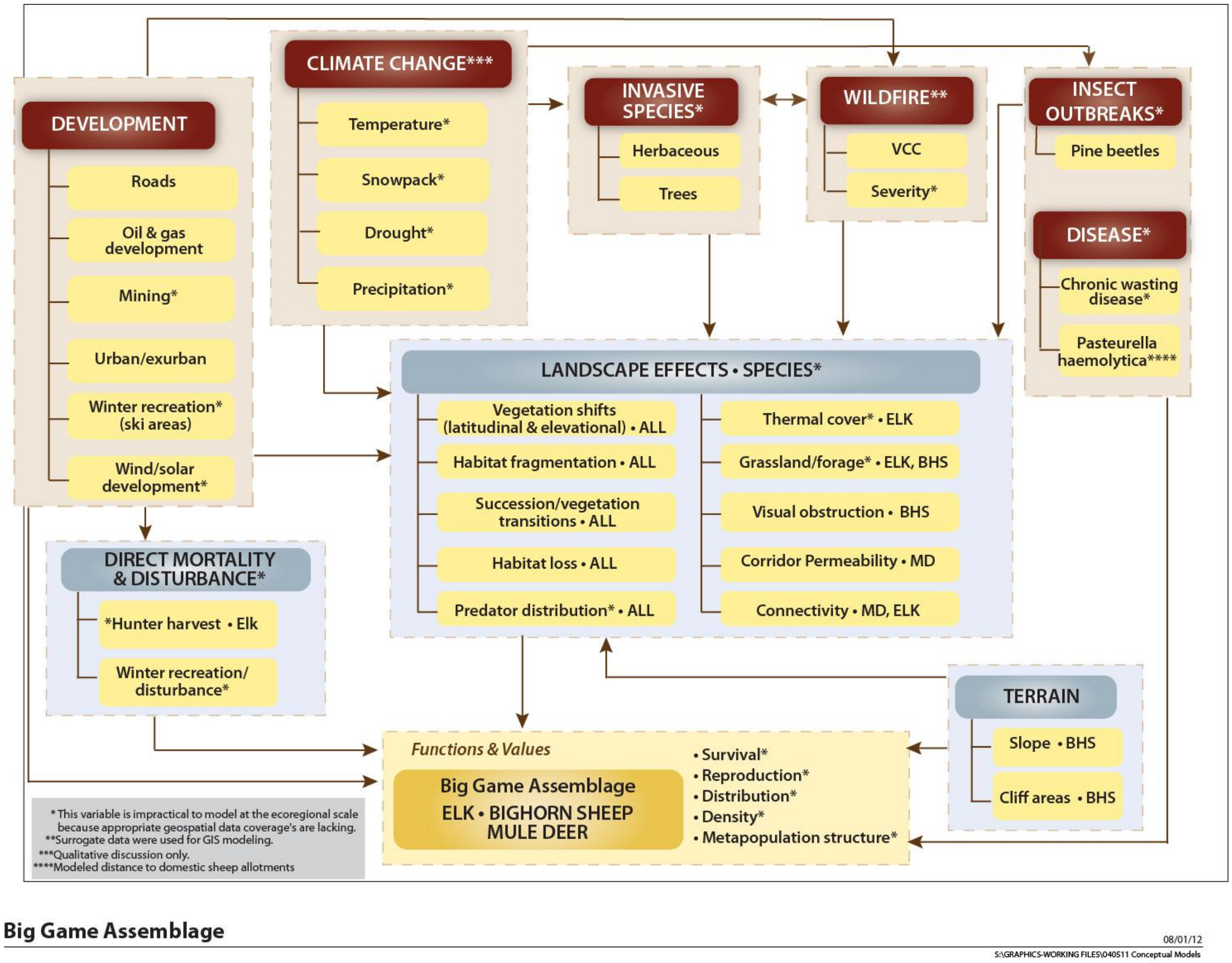

Figure E-10-2. Pronghorn Component of a Big Game Assemblage System-Level Model