APPENDIX C

CHANGE AGENT DESCRIPTIONS AND ANALYSES

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APPENDIX C-1

DEVELOPMENT CHANGE AGENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

Successful completion of this REA will in part be based on a sound understanding of the landscape-scale change agents (CAs) and their potential impact on ecological values throughout this ecoregion. CAs are natural or anthropogenic disturbances that influence the current and future status of conservation elements (CEs). The initial CAs for this ecoregion were developed by the Rapid Ecoregional Assessment (REA) team in the early planning phase of this REA. Development is included as a CA for this REA because parts of the Northwestern Plains are experiencing an expansion of urban and exurban areas, an increase in infrastructure, oil and gas exploration, and wind farms, and the modifications of the landscape by agricultural and hydrological development. Human development activities often have a more significant effect on landscapes than natural disturbances because they alter the availability of energy, water, and nutrients to ecosystems; enhance the spread of exotic species; accelerate natural processes of ecosystem change; and adversely affect the structure and functioning of ecosystems. A variety of the management questions (MQs) applies to this CA, but can be summarized into one primary question: ***Where will core regionally significant values be affected through development*?**

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2.0 DESCRIPTION OF CHANGE AGENT

Development is the direct modification of the landscape through activities including urbanization, road development, and industrial development, which includes extraction of traditional energy and mineral resources and the establishment of renewable energy production areas. Areas to be evaluated include existing activities; applications; existing and planned corridors; and areas of high resource potential or expressed interest.

Broad categories of the development CA were initially identified. Specific subcategories were added or refined based on the results of the literature review of the potential impacts of CAs on CEs for this ecoregion as well as the evaluation of relevant and available data for the analysis. Development includes urban, exurban, and rural (industrial) development, energy development and exploration, agricultural development, surface water diversion, and groundwater extraction. Some human activities including livestock grazing and logging are agents of change in native ecological systems in this ecoregion, but are not included in the REA. Data collection related to livestock grazing on BLM managed lands has been a locally driven process focused on vegetation response. Livestock grazing data collected by the BLM is useful for analysis at the local scale but is not centralized. Due to differences in data collection techniques and only recent efforts towards data standardization, BLM data has uncertain potential to be useful at the ecoregional scale (http://pubs.usgs.gov/of/2011/1263/). Even with this effort, the available data does not cover all lands. In order to cross the entire ecoregion we need a data source that is collected in a standardized manner and considers grazing across all lands of the ecoregion, hence the reliance on remotely sensed data for much of the REA data. Unfortunately grazing impacts cannot be accurately assessed and separated from other disturbances with available remotely sensed data.

Ultimately, impacts from grazing should be reflected to some extent by condition measurements and trends in our CE current status assessments (through representations of conifer expansion, fire regimes, riparian habitat quality, etc.). The impact of disturbances in general will be reflected in vegetation communities, although direct ties (such as actual livestock utilization) cannot be made at the large ecoregional scale. Based on this information and consideration of grazing as a change agent, the AMT identified it as a data gap in the process (actual vs. authorized use, consistent data collection, etc.). So at this time, because of data limitations, grazing was not included as a specific CA in this landscape assessment. As part of the step-down process, focal areas can be evaluated with localized information and finer scale data supplementing the regional context to determine the potential impacts from grazing (from and outside the assessment) and management objectives can then be adjusted as necessary at the localized scale to meet local and regional objectives.

2.1 URBAN, EXURBAN, AND RURAL (INDUSTRIAL) DEVELOPMENT

Urban development including the rapid expansion of cities and large towns impacts bordering natural areas.. Urban growth requires public services public housing, schools, municipal water and sewer services and infrastructure in some form or another (roads, bridges, transmission lines) to accommodate additional annexations of developing areas. Exurban development includes the expansion of neighborhoods outside of urban areas to form commuter communities and the addition of new communities, often second and vacation homes, into open areas that are bordered by natural ecosystems. One example of exurban development is the recent increase in ranchette type expansion. These are large-scale permanent settlements of urban people in non-metropolitan areas on lots ranging from one to 40 acres or larger. Rural development generally refers to residential land use in relatively isolated and sparsely populated areas. Rural development has traditionally centered on land-intensive natural resources such as agriculture and forestry.

Areas of land covered by concrete, asphalt, buildings, or even severely compacted areas of soil are impervious to rain water. The addition of impervious cover decreases the amount of ground water recharge and increases the amount of storm water runoff. This can cause depletion of ground water resources and flooding of local streams and rivers. Aquatic resources are especially at risk, as growing human population and developments make increasing demands on water

Because of the potential for habitat fragmentation from not only development, but also new access roads and utility lines, particular attention was focused on planned, permitted, and leased development. This development category includes roadways and transmission facilities as well as those proposed or projected under reasonably foreseeable development scenarios for areas of intact habitat that are isolated from existing urban and industrial infrastructure.

2.2 ENERGY EXPLORATION AND DEVELOPMENT

Energy exploration and development, both fossil fuel and renewable, remain a large and important economic factor for this ecoregion and usually occur in roadless areas. For example, the Bakken Shale formation located in North Dakota and eastern Montana is the largest continuous oil play in the lower 48 states containing 3.65 billion barrels of oil and 1.85 trillion cubic feet of natural gas that can be recovered using current technologies (U.S. Department of Energy 2012). Interest in the Bakken Shale formation has caused a substantial amount of primary (well drilling, etc.) and secondary (roads, housing, etc.) development in this area. The BLM serves as the lead Federal agency in energy and minerals management for Federal lands and manages subsurface mineral rights for nearly every Federal agency. Energy exploration and development, both fossil fuel and renewable, remain a large and important economic factor for this ecoregion. The BLM plays a critical role in facilitating the development of energy resources such as oil and gas, coal, geothermal, hydropower, solar, wind and biomass.

Unlike many industries that operate from a fixed location located in urban areas, exploration and production (E&P) operations must go to where the oil and natural gas resources are located. In many cases, the resources are located in remote areas and in some cases the resources are in locations with high biodiversity. The development of oil and gas facilities require construction of access roads, well pad and compressor stations, oil and waste storage tanks, and installation of pipelines. Potential impacts to BLM resources from E&P operations may include soil, air, and water contamination, habitat fragmentation, deforestation and erosion. Direct impacts are characterized by the specific operations associated with E&P activities such as the drilling rig and the roads specifically constructed within an oilfield to service the wells, comprising land modifications and traffic that can degrade resources. The disposal of saline waters into existing surface or groundwater resources, which may accompany oil, gas, and coalbed methane (CBM) processing, is also an ecosystem stressor if not properly discharged. Particular attention is required for energy extraction developments due to the potential for landscape-scale indirect impacts such as habitat fragmentation, corridors for invasive species and human intervention, ignition sources for fire, groundwater extraction, erosion potential, dust generation, and impacts on various species, including removal of habitat, noise, and impairing access to habitat by blocking movement corridors. Impacts associated with hardrock mining arise from either tailings discharged into streams in the past that impact water quality, or from treated mine effluent currently being discharged into streams.

The potential impacts associated with renewable resource development are also considered in this REA. The Northwestern Plains ecoregion contains high quality wind resources for renewable energy development based on wind resource ratings developed by the National Renewable Energy Lab (NREL). Industry interest in developing renewable energy projects on federal lands is expected to increase as wind development on private land is completed and demand for land with good wind potential grows (BLM 2012). Wind energy generates electricity without many of the environmental impacts associated with other energy sources (e.g., air pollution, water pollution, mercury emissions, climate change). However, possible impacts of wind facilities on migratory birds and other wildlife, invasive species and habitat fragmentation continue to be an issue. Birds and bats are sometimes killed in collisions with turbines, meteorological towers, and power transmission lines at land-based wind facilities. Most of the migratory species migrate during the night at altitudes generally above rotor swept areas when weather conditions are favorable. Risk may be greatest during take-off and landing where wind facilities abut stopover sites. Songbirds are vulnerable to colliding with man-made structures such as buildings, communication towers, power lines, or wind turbines during poor weather conditions that force them to lower altitudes. Raptors are known to concentrate along ridge tops, upwind sides of slopes, and canyons to take advantage of wind currents that are favorable for hunting and traveling, as well as for migratory flights (National Wind Coordinating Collaborative 2010).

Solar energy can be used to generate electricity, heat water, and heat, cool and light buildings. This includes residential and commercial construction, and farming, ranching, recreation and other industries. The primary ecological and other land-use impacts of solar development relate to utility-scale photovoltaics (PV) and concentrating solar power (CSP) sites. A wide range of habitats, plant and animal species, and cultural and economic activities could be affected by widespread solar development. Solar energy provides environmental benefits compared with most other energy technologies and many other land uses. The adverse impacts of solar energy are mainly local. The impacts of solar development include direct impacts, such as soil disturbance, habitat fragmentation, and noise, and indirect impacts, such as changes in surface water quality because of soil erosion at the construction site. The specific impacts of utility-scale solar development will depend on project location, solar technology employed, size of the development, and proximity to existing roads and transmission lines. Solar projects have the potential to consume large amounts of water for cooling. Substantial diversion or use of local water resources has the potential to affect both aquatic and terrestrial species. Large areas covered by solar collectors also may affect plants and animals by interfering with natural sunlight, rainfall, and drainage. Solar equipment may provide perches for birds of prey that could affect bird and prey populations. Although solar energy requires water consumption (rinsing panels, mirrors, and reflectors to ensure maximum energy production) many solar configurations would use less water when compared with conventional energy production that uses evaporative cooling systems (i.e., cooling towers). Solar deployment may require use of land that was previously used for other applications (e.g., abandoned industrial, fallow agricultural, or former mining sites) or was previously undeveloped. The way in which solar technologies are deployed can change the nature of the impacts (USDOE 2012).

The National Renewable Energy Laboratory (NREL) currently shows no biomass power plants in this ecoregion but with the amount of crop based biomass in the eastern parts of the ecoregion there could be proposed developments seeking permitting. Geothermal energy provides a high-pressure steam that can be harnessed to generate electricity. The extraction of geothermal energy is accomplished without the large-scale movement of rock involved in mining operations (construction of mine shafts and tunnels, open pits, and waste heaps). Land areas required for geothermal developments would involve power plants and wells that vary with the local reservoir conditions and the desired power outputs and therefore may also contribute to habitat loss. An important issue previously associated with geothermal energy was the disposal of cooled water left after heat extraction or steam separation. Previously, such “waste” water was disposed of in surface ponds or rivers. Now, the common practice is to inject water through disposal wells back into the subsurface. This now not only minimizes the chance of contaminating surface waters, but it also provides replenishing water to help sustain a hydrothermal system (Duffield and Sass 2003).

2.3 AGRICULTURAL

The Northwestern Plains incorporates a wide variety of agricultural occupations contributing to the economy. Crops produced in the region include dryland grains, hay, and other grain and oil crops such as barley, safflower, and canola where irrigation water is available. The Northwestern Plains is North America’s largest grassland ecoregion and still contains large unplowed areas of grasslands. Tillage of previously untilled land for agricultural crops remains a threat to remaining native grasslands for complex reasons relating to various government programs and incentives, including crop subsidies and the Conservation Reserve Program (CRP), as well as present and future demand for biofuels.

Agricultural effects include habitat alteration (conversion to farmland for crops and grazing), exotic pest introductions and pollution from pesticides and fertilizers. Soil erosion also has a direct effect on habitat quality, making an area barren and unsuitable for plants that were native to that habitat. Potential effects of agriculture on surface and groundwater flows include changes in the groundwater table from extraction of water for irrigation and increase in nonpoint inputs of pollutants that impact riparian and stream channel habitat or altered flows. Declines in water quality, habitat, and biological assemblages have been noted as the extent of agricultural land increases within catchment areas (Allen 2004). 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).

2.4 HYDROLOGICAL – (DAMS, DIVERSIONS, WATER TABLE DRAWDOWN, INDUSTRIAL USES)

The creation of dams, surface water impoundments, and diversions and other hydrological uses such as the groundwater extraction is also considered an important CA for evaluation. Dams and surface water diversions have been documented to change hydrologic flows through a watershed, disrupt normal geomorphic processes downstream and are usually point sources of stocked non-native species. Surface water impoundments and diversions affect the timing and amounts of downstream flows, reducing connectivity and gene flow by affecting passage and survival of fish and other aquatic vertebrates. Impoundments curtail natural flood events that historically helped to regenerate cottonwood and willow riparian communities. In addition to physical habitat disturbance, groundwater extraction has the potential to impact groundwater tables and, in some cases, surface waters such as seeps, springs, or live stream segments. Introductions of game or forage fish in stock ponds anywhere in the watershed can infiltrate upstream or downstream areas to larger prairie rivers. These species then become permanent residents, competing with (e.g. green sunfish) or preying upon (e.g. northern pike) resident native fish species.

In addition to physical habitat disturbance, groundwater extraction has the potential to impact groundwater tables and, in some cases, surface waters such as seeps, springs, or live stream segments. Lowering groundwater tables can affect sensitive aquatic invertebrate and vertebrate species, as well as plant species and entire habitats dependent on surface water or elevated groundwater tables (e.g., most riparian and wetland species). The health of these aquatic and riparian communities is essential in the semi-arid regions for the survival of a great variety of resident and migratory wildlife species. Many listed and sensitive species in the ecoregion utilize riparian habitats for essential life stages such as breeding, and their decline can be tied to the general degradation of water-dependent habitats in the West. Effects on these habitats can also lead to soil destabilization and erosion.

2.4.1 Change Agent Effect Pathways

The potential effects of human development as a CA is depicted in system-level models for the fine-filter CEs and described in detail in the CE sections (Appendix E). In general, human developments CAs affect CEs by changing the total habitat area (habitat loss) and the suitability of available habitat (habitat degradation) for the CEs. As a result of impacts to habitat, effects at the population level (behavioral disturbance and direct mortality) may also result. Listed below are some of the ways in which the development CA and the potential effects relate to habitat loss and disturbance. This listing is not intended to be comprehensive but indicates some of the ways in which the CAs affects resources. In general, the effects of development can be grouped as follows:

- **Habitat Loss.** The effect pathways are relatively direct and result from land conversion from native ecosystems to human-dominated ecosystems. Conversion of native ecosystems to agriculture, urban, exurban, or industrial systems reduces the available habitat for CEs. In cases where CE species are able to occupy human-dominated ecological systems (such as pastures and croplands), habitat suitability is usually reduced relative to native ecosystems. Habitat loss includes the analysis of the extent (footprint) of the CA.
- **Habitat Degradation.** Degradation of habitats is related to proximity or adjacency to the offsite human development footprint and/or development-related activities. Indirect effects of human development and human activities on CEs include loss of habitat suitability due to changes in water availability and quality, changes in availability or access to shelter, prey or forage resources; barriers to movement, and reduced suitability of habitat patches, among others. Pathways for habitat degradation often involve changes in ecological processes and increased variability in natural disturbance regimes. For example, water withdrawal can lead to greater

variability in seasonal hydrograph and result in degradation or loss of wetlands, and loss of connectivity, spawning and rearing habitat for fish species. Indirect effects of human land use and activities can include increased spread of invasive species, predators, competitors, parasites, and disease organisms. Indirect effects are analyzed based on proximity or intensity of an adjacent human development activity and require analytical tools suited to measurement of intensity, interspersion, distance, or density.

- **Population Effects (Behavioral Disturbance and Direct Mortality).** Effects pathways include disruption of wildlife movement due to behavioral avoidance, disruption of reproductive cycles, increased risk of predation, accidental mortality due to collisions with vehicles, transmission infrastructure, electrocution, poaching, and mortality resulting from adverse management actions. In stream barriers such as dams and impoundments, surface water diversions, alterations in channel configuration, and flow regimes affect the ability of fishes to migrate from spawning and rearing habitat, leading to population isolation, loss of genetic variability, and increased vulnerability to stochastic events. Effect pathways related to behavioral responses or risk of mortality of a CE, require analytical tools such as inverse distance weighting, which considers distance, intensity or severity.

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3.0 METHODS, MODELS, AND TOOLS

A GIS-based multi-criteria evaluation (MCE) model incorporated within the spatial analysis model in ArcGIS was utilized for this CA. MCE utilizes decision-making rules to combine the information from several criteria in the form of GIS layers. Multiple geographic layers are aggregated to produce a single index or map that shows the appropriateness of the land for a particular purpose or activity. The MCE approach was easily implemented with the ArcGIS platform using ModelBuilder. Each criterion was controlled using a weighted sum analysis in order to produce an overall development layer or map.

3.1 DATA IDENTIFICATION

CA data associated with development were the most readily available dataset. This information exists in a variety of formats and scales, covering many areas related to the analysis requirements. Identifying the best datasets and determining their level of quality was challenging due to the large number of datasets available. Generally, however, these datasets offered high quality data coverage for the entire ecoregion. These datasets were primarily used to model this CA against the CEs through the use of the KEA tables developed for each CE. Some CA data such as that related to wind and geothermal potential were not point specific and therefore and only qualitative information was used to assess the potential future conditions.

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4.0 ANALYSIS OF DEVELOPMENT ON ECOREGION CONDITIONS

A variety of indicators were used to assess condition and landscape context as a result of the development CA. These indicators were selected for analysis based on the specific CEs as further discussed in Appendix D or E.

4.1 CURRENT DEVELOPMENT CHANGE AGENTS

Table C-1-1 identifies the indicators, data sources, and metrics that were used to evaluate the potential impacts from development in terms of condition and landscape context. Each data source was used to create an intermediate layer based on the CE and then combined to form an overall current status score. In most cases, the metrics used to score the condition or context indicator were CE-specific and based on available publications, coupled with expert analysis and professional judgment in association with data-driven metrics. For the CEs, this process was carried out through the establishment of a rolling review team (RRT) for each CE 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 GIS spatial analyses. This process enabled the RRT to determine the efficacy of indicators, and metrics as well as to ascertain the accuracy of each step of the modeling process. In some cases, weights were attributed to each indicator to prioritize the criteria in order to ensure that key concerns are addressed in the REA.

Table C-1-1. Change Agent Datasets – Development (Urban/Exurban, Agriculture, Hydrological)

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Agriculture	Cropland Data Layer	USDA NASS	56m	Acquired	Yes
	Agriculture Census	USDA	Raster (1:20 million)	Acquired	Yes
	Livestock Grazing Areas	BLM	Polygon	Acquired	No[2]
	Fences	BLM, USFS, State	Polyline	Not Available	No[1]
	STATSGO Soils	NRCS	Polygon	Acquired	Yes
	SSURGO Soils	NRCS	Polygon	Acquired	No[2]
	Surficial Geology	USGS	Polygon	Acquired	No
	Surficial Materials Lithology	USGS	Raster (1km)	Acquired	No
	National Hydrography Dataset	USGS	Vector	Acquired	Yes
	Watershed Boundary Database	USGS	Polygon	Acquired	Yes
	Aquifers	USGS	Polygon	Acquired	No
Aquatic	National Inventory of Dams	USACE	Point	Acquired	Yes
	Fish Ladders	NHD	Point	Acquired	No
	Integrated Restoration and Protection Strategy (IRPS)	USFS	Polygon	Acquired	No
	Water Quality	NWIS	Point	Acquired	No
	Water Quantity	NWIS	Point	Acquired	No
	Pollution Source Points	EPA	Point	Acquired	Yes
	Impaired Rivers and Lakes (303d)	EPA	Point	Acquired	Yes
	Oil and Gas Leases	BLM	Polygon	Acquired	Yes
Industrial	Oil and Gas Wells	BLM	Point	Acquired	Yes
	Oil and Gas Pads	BLM	Polygon	Not Available	No[1]

Table C-1-1. Change Agent Datasets – Development (Urban/Exurban, Agriculture, Hydrological) (Continued)

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Energy/Transportation	Proposed Energy Developments and Corridors	BLM		Acquired	Yes
	Oil and Gas Developable Area and Strata Unit Area	Argonne National Laboratory	Polygon	Acquired	Yes
	Wind Resources	NREL	Polygon	Acquired	Yes
	Wind Turbines	BLM, DOE, State, USFWS	Point	Acquired	Yes
	Potential Geothermal	NREL/BLM	Polygon	Acquired	Yes
	Lands Targeted for Renewable Energy	BLM		Acquired	Yes
	Section 368 Energy Corridors	Argonne National Library	Vector	Acquired	Yes
	Cellular Towers	FCC	Point	Acquired	Yes
	Transmission Lines	SAGEMAP	Polyline	Acquired	Yes
	Linear Features	TIGER	Polyline	Acquired	Yes
	Census Data	US Census Bureau	Vector	Acquired	Yes
	ESRI Streetmap	ESRI	Polyline	Acquired	Yes
	ICLUS	EPA	Model	Acquired	Yes
	Military Expansion	DOD	Vector	Not Available	No[1]
	Roadless Areas		Vector	Acquired	Yes
Human	Existing and Proposed ACECs, RNAs, NWRs, Wilderness Areas, NCAs, etc.	BLM	Vector	Acquired	Yes
	Urban/ExUrban Areas	US Census Bureau	Polygon	Acquired	Yes
	Human Footprint in West	USGS	Raster (180m)	Acquired	Yes

1. Data gap
2. Scale is inappropriate

4.1.1 Development - Urban/Exurban

Spatial data related to the location of urban areas and future development plans will be important for the REA process. The Integrated Climate and Land Use System (ICLUS) project provides information and data related to population growth scenarios by county. These data were important for determining growth scenarios throughout this ecoregion. In addition, the Montana Crucial Areas Planning System (CAPS) contains data layers on projected housing densities from 1970 through 2020. These data were based on a spatially explicit regional growth model (SERGOM) developed by Dr. David Theobold of Colorado State University. Sources of similar data for the other states in this ecoregion were evaluated. There has been some initial release of statistics from the 2010 census. Depending on the census attributes being analyzed, census data from 2000, 2005 or 2010 was selected.

4.1.2 Development - Energy

A variety of data related to energy resources and transportation was provided by BLM (Table C-1-1). Renewable energy projects across the ecoregion include, biomass, wind, ethanol and geothermal. The National Renewable Energy Laboratory (NREL) currently shows no biomass power plants in this ecoregion, but there could be proposed developments seeking permitting. Wind energy is the most predominant form of renewable energy in the ecoregion along with geothermal energy, which is not used much in this ecoregion. Currently the NREL has information about wind and geothermal potential. These data, however, were not available across the ecoregion, and in some cases were greatly limited in quality and scale

BLM maintains extensive databases on potential oil and gas resources, leases, and the locations of current energy projects. BLM also has data on proposed energy corridors that likely overlap with other agency jurisdictions. Argonne National laboratory has mapped potential oil and gas and strata unit areas for which GIS has also been obtained. Oil and gas pads were sought in addition to point locations because of their spatial influence on some CEs. However, these data were unavailable. Potentially, it is possible to use a buffered well location as a surrogate for oil and gas pads.

Data for transmission lines and pipelines were important to the REA analysis process. Although some GIS data related to electric transmission lines has been provided and some data are available through Sagemap, data on lower voltage distribution lines was difficult to obtain. The National Pipeline Mapping System which is maintained by the Pipeline and Hazardous Materials Safety Administration (PHMSA) has data for all major gas and hazardous liquid transmission lines for this ecoregion. However, obtaining these data would require a formal request by the BLM.

4.1.3 Development - Agriculture

The crop land data layer for 2010 was used. SSURGO soils data are available in the study area. However, this layer is usually developed at a county or special project area level and at a much higher resolution than the STATSGO soils layer. Because of the scale of these data, gaps in coverage are also an issue. The SSURGO datasets for the large ecoregion are numerous, large, and there is no guarantee that adjacent counties would matched up. Fence layers were sought for the identification of areas creating hazards or impeding migration, however this layer is unavailable at the ecoregion level.

4.1.4 Development - Hydrological

The USACE maintained National Inventory of Dams (NID) dataset was obtained to locate impediments for fish. This dataset was obtained from the U.S. Army Corps of Engineers.

4.1.5 Development - Urban/Exurban

Spatial data related to the location of urban areas and future development plans is important for the REA process. The Integrated Climate and Land Use System (ICLUS) project provides information and data related to population growth scenarios by county. These data are important for determining growth scenarios throughout this ecoregion. In addition, the Montana Crucial Areas Planning System (CAPS) contains data layers on projected housing densities from 1970 through 2020. These data were based on a spatially explicit regional growth model (SERGOM) developed by Dr. David Theobold of Colorado State University. Sources of similar data for the other states in this ecoregion were evaluated. There has been some initial release of statistics from the 2010 census. Depending on the census attributes being analyzed, census data from 2000, 2005 or 2010 was selected.

4.1.5.1 Road Density

Areas of greater road densities indicate greater human activity, and therefore are an indicator of landscape context. The effect of roads on fine-filter CE include impacts to potential foraging habitat, cover, direct mortality associated with traffic collision and/or illegal shooting.

Road density models were created in ArcGIS based on the number of roads per square kilometer. TIGER data for all road types were used to create this layer which was then clipped to the Northwestern Plains ecoregion boundary. Although the TIGER data provides comprehensive transportation networks across the ecoregion, these data can fluctuate widely between state departments of transportation (DOT). For example, if one state DOT has greater funding than an adjacent state, their TIGER data could be more comprehensive than the state with less funding. In addition, the way each state DOT categorizes their roads by size or type could be different between states. This is important because if a KEA uses road density as an indicator, watersheds in the state with the better DOT funding could appear worse for that KEA than watersheds in the adjacent state with less funding.

Linear features such as roads, utility corridors, etc. were buffered so that all layers are polygons that can be used in GIS overlay analyses. The size of the buffer is relative to the significance of the disturbance by the linear feature. This type of proximity analysis yields an inverse distance weight that adds greater significance to features such as interstate highway and less significance to an unimproved road.

The roadway density (number of roadways per km^2) within the HUC was calculated and relative rank as good, fair, or poor based on the CE-specific scoring was determined. The road density analysis was reported relative to individual HUC units. The 12-digit HUC was used as the analysis unit and reporting unit for this metric.

4.1.5.2 Transmission Lines

Transmission lines play a similar role as roads to many of the fine-filter CEs. Larger transmission lines represent significantly disturbed areas in some locations. Clear-cut maintenance areas converts the structure of habitat by creating linear disturbances to natural habitat. Therefore, distance to transmission lines is considered in this assessment as an indicator associated poor landscape structure.

Transmission line data (EV Energy Map) was obtained for major utility lines within this ecoregion. These transmission lines are generally greater than 115kV and tie major power plants to the electrical grid. Minor distribution lines (e.g. neighborhood electrical lines, etc.), were not available for use in this analysis.

4.1.5.3 Wind Turbines

Wind turbines are an important factor affecting many species with one example being golden eagles (Hunt 1995 and 2002) and therefore can be used to define the condition of landscape structure. Wind turbines pose a direct threat to avian species, and development of wind farms pose additional threats to native plants and other non-avian species an additional potential threat to other species through the development of wind turbine areas. These areas are closely associated with other development features (i.e. roads, transmission lines, etc.) and were therefore considered in this analysis for all CEs.

The USFWS provided a compiled dataset for wind turbine locations and test towers throughout the United States.

4.1.5.4 Energy Resources

A variety of data related to energy resources and transportation was provided by BLM (Table C-1-1). Renewable energy projects across the ecoregion include, biomass, wind, ethanol and geothermal. The National Renewable Energy Laboratory (NREL) currently shows no biomass power plants in this ecoregion, but there could be proposed developments seeking permitting. Wind energy is the most predominant form of renewable energy in the ecoregion.

4.1.5.5 Dams and Surface Water Diversions

Dams and surface water diversions have been documented to change hydrologic flows through a watershed, disrupt normal geomorphic processes downstream and 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.

Data on dams and surface water diversions was obtained from the U.S. Army Corps of Engineers National Inventory of Dams (USACE 2010). The inventory consists of 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, who have basic information on the dams within their jurisdiction (USACE 2010).

For most of the analyses, a dam layer and a non-dam diversion layer was created which was overlain with the USGS National Hydrography Dataset 1:100,000 streams layer. This dataset represents all features coded as ‘rivers’ on the USGS 1:100,000-scale DLG Hydrography dataset. This current version was converted to ARC/INFO and edge-matched across map sheet boundaries.

The number of dams and non-dam diversions that intersected streams in the 5th code HUC watershed within the ecoregion were summed and then assigned a relative rank as good, fair, or poor based on a scoring system adopted from relevant literature or RRT input. The scoring system was specific to each CE and identified for each CE in Appendix E.

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5.0 FUTURE DEVELOPMENT THREATS

As part of the REA process, SAIC was tasked with the analysis of the risk of future CAs on various CEs. In order to perform this analysis, future change agents (i.e. wind, gas, oil, etc.) were subjected to analysis in areas where change agents overlapped CE distributions. For the most part this task was difficult because of a lack of detailed comprehensive data. However, in some cases suitable datasets could be used to determine analytical results with reasonable outputs. The methods used to assess the effect of future development are essentially qualitative, supported by available analytical data. The processes associated with this effort are outlined in this section.

5.1 AGRICULTURAL POTENTIAL

Current agricultural vegetation data were available for use in this analysis through the use of GAP land cover data. GAP was used in the current CA analysis for each CE and was applied to the future analysis for comparison to future potential areas for agricultural activity. There are currently no publicly available future agricultural models that could be used in this REA. In order to determine a future agricultural layer surrogate data were used to derive potential agricultural areas.

STATSGO soil data contains soil type information for the entire ecoregion. Soil types suitable to agricultural activities were used to derive future potential agricultural areas. These soil types were recommended for use in this analysis by the NRCS. The soil types selected as agricultural soil types were land capability classification types 1-4.

Unlike the renewable and fossil fuels CAs, agriculture and urban growth were addressed in this analysis as binary outputs. The potential agriculture data layer was created as potential agriculture versus non-potential agriculture. This method of analysis did not allow for a scored rating system. For clarification and in order to determine potential agricultural changes, the current agricultural layer from GAP land cover vegetation was also applied to the figure to provide some spatial information regarding the potential change in agriculture from the current time period to the future time period (Figure C-1-1).

Future potential agriculture is difficult to predict using any model. Modernized agricultural technology could significantly impact future agriculture. Demand on agriculture and specific crop types could affect the areas of production. Certain crops might not be suitable to the climate within the ecoregion, but demand on specific crops outside this growth zone could drive additional demand for agricultural areas. Additionally, this analysis did not consider terrain suitability, access, or other environmental conditions that could affect the spatial distribution of agriculture. However, this model applies a simplistic approach that can be used to infer from current data the areas that could potentially be used in long-term agricultural practices.

5.2 FUTURE URBAN GROWTH POTENTIAL

Unlike several of the other models, a future urban growth potential was available for use in this analysis. The Integrated Climate and Land-Use Scenarios (ICLUS) model, created by the Intergovernmental Panel on Climate Change (IPCC), is able to predict potential urban area growth out to 2100. This model uses the current land use data and projections from census data to obtain information for potential urban expansion. The time period selected for use in this analysis was 2060, as this relates to the upper limit time period under examination in this REA. This time period is consistent with the other future CA in this analysis, as it is comparable with the potential upper limits of all other CAs.

The ICLUS urban growth potential model provided attribute information for extracting urban areas data for 2060 (Figure C-1-2). This model output was based on a binary (presence/absence) analysis since no additional data were available for use in the classification of attributes as good, fair or poor. The ICLUS model data layer was used to qualitatively determine the potential effect of urban growth on CEs.

The ICLUS model is accepted as a good model for predicting future urban growth. However, it is not without limitations. The data are derived from assumptions based on current demographic data. It is difficult to determine the level of accuracy for models that are based on data that could potentially deviate significantly from current data. ICLUS is unable to determine the effect of future roads in the model and is limited to urban boundaries and current road systems. Road areas are a significant part of urban growth models. However, this model is based on demographic trends and is therefore considered in this analysis as a reliable model for determining future urban growth.

5.3 FUTURE OIL AND GAS PRODUCTION

Oil and gas production data were available through the BLM EPCA III (Energy, Policy, and Conservation Act) natural resources report to the U.S. Congress. This dataset included information pertaining to oil and gas density estimates throughout the ecoregion. These data were modeled for several basins within the ecoregion boundary. Therefore the data required compilation and modification to provide a meaningful output for this analysis. Multiple datasets were merged together to create a useful ecoregion-wide model that combined the EPCA modeled data and the EPCA extrapolated model data.

1. <u>EPCA Modeled Data</u>

   The EPCA model data used in this analysis was comprised of outputs from the Montana Thrust Belt, Williston Basin, Powder River Basin, Wyoming Thrust Belt, and Southwestern Wyoming basin. These basins contained data for large portions of the ecoregion, but did not provide complete coverage. The EPCA Extrapolated Model was created by the BLM and USGS to interpolate potential oil and gas-rich areas beyond the original EPCA modeled area.

   The EPCA models were created using historical oil and gas well data. These data were used to interpolate potential production based on well locations and oil and gas density. Historical well data were based on vertical drilling methods. This is important because horizontal drilling, particularly in the Bakken formations of Montana and North Dakota. The attributes table for these data provided numerous output values available for analysis. Oil and gas density values were used as the analysis unit for these change agents.

   EPCA natural gas data were stored in the attributes table as total gas density and the EPCA oil data were stored as total oil density. The natural gas data were characterized in units as Bcf/acre for the entire ecoregion. EPCA oil data were characterized in units as MMbbl/acre.

2. <u>EPCA Extrapolated Model</u>

   The EPCA extrapolated model essentially was created to fill in the areas where the traditional EPCA model was unable to interpolate potential oil and gas reserves. These data contain information for areas that have not yet been drilled. The attributes of this model were extensive, and provided comparable values for oil and gas densities.

   EPCA Extrapolation Model gas data were stored in the attributes table as total gas density in extrapolation and the EPCA extrapolated oil data were stored as total liquid density in extrapolation. The natural gas data were characterized in units as Bcf/acre for the entire ecoregion. EPCA oil data were characterized in units as MMbbl/acre.

For this analysis oil and gas data were analyzed separately (Figures C-1-3 and C-1-4). Like many of the future CA attributes, little information regarding metric classification was available for use in rating the oil/gas locations as high risk, moderate risk, or low risk. If an area had high potential for development, it was considered a high risk to CE habitat. ArcGIS classification statistics (natural breaks) were employed to derive scores of 1-3 for these CAs. For this ecoregion the distribution of EPCA oil data ranged from 0 to 0.0004 MMbbl/acre. The distribution of EPCA natural gas data ranged from 0 to 0.0066 Bcf/acre.

The well location data and the EPCA models are the best information available for the CA analysis of oil and gas, however there are several weaknesses in using these data. Any type of comparison between current and future well locations is compounded in difficulty by advances in oil exploration technology.

Most of the historical well locations corresponded to vertical drilling locations. This is a result of the age of the wells. Modern techniques employ horizontal drilling techniques where fewer wells are required. Since the potential impact of this CA on a particular CE is related to above ground activities, it is difficult to compare historical wells to future wells. It is presumed that fewer wells will be required in the future to extract oil and gas.

This model fails to make a direct correlation between the EPCA model and future well locations. An ideal model would have predicted the future well locations, but because of reasons previously mentioned, that is impossible to predict. Therefore this model can only predict areas where oil and gas production is likely to occur in the future.

5.4 SOLAR ENERGY POTENTIAL

Solar energy potential data were available from the NREL for all future potential solar activity within the ecoregion. These data were derived from models of potential areas for photovoltaic cell locations. Specific modeling information was obtained from the NREL (http://www.nrel.gov/gis/solar.html/). This model predicts the potential for solar activity in units of watts per hour (W/h) on an average annual basis. For this analysis the data were reformatted in units of kW/h, a standard format for energy analysis.

Although some information is available regarding adequate value ranges for solar energy, it is difficult to determine these metrics within this ecoregion. The southwestern United States provides the most suitable areas for solar energy production, but the Northwestern Plains ecoregion does not fall within this region. For this analysis, the data were attributed scores that were associated only with the data value ranges that occurred within the ecoregion (Figure C-1-6). Because of this, natural breaks were used to derive the attribute metrics. The attribute metrics were developed as risk to CE habitat. Therefore areas with high development potential were assessed as high risk, areas with moderate potential were assessed as moderate risk and those areas labeled as low potential were considered low risk. In this ecoregion the distribution of NREL solar energy data ranged from 4.16 to 5.71 annual average kilowatts per hour (kW/h).

Similar to the wind model, the NREL solar model is limited in its ability to reliably predict disturbance to CEs through the construction of photovoltaic solar arrays. Through spatial representation and analysis, this model is able to display potential solar array construction areas based solely on the availability of solar activity potential. This model does not account for slopes, terrain, photovoltaic solar arrays size or spatial distribution. Direct comparisons between CEs and solar array locations are difficult to assess and should be further analyzed in the future as new data becomes available.

5.5 FUTURE WIND PROJECTIONS

Short term wind turbine data were available as part of the USFWS-provided wind tower location data. These data were presented in the form of point occurrence data for wind towers. Some of the wind turbine attributes associated with these data enabled the separation of current and future proposed wind turbines. However, the future data points did not provide a significant number of locations. These locations were already approved for construction and considered to be only near-term (1-3 years) future construction. Therefore, the point occurrence data were insufficient for use in the future analysis of wind turbine locations.

The National Renewable Energy Laboratory (NREL) maintains a wind model based on the annual average wind resource potential at 50m height (Figure C-1-7). This dataset provided good coverage across the ecoregion. The NREL data are important, because it does not relate to a specific temporal period, but rather provides all future potential for wind turbine development. Therefore it represents the maximum availability of areas for potential wind resource use. These data were characterized by numeric codes that indicated wind potential power classes (Table C-1-2).

Table C-1-2. NREL Wind Potential Power Classes

Power Class	Resource Potential	50m Wind Power Density (W/m^2)*
1	Poor	0 - 200
2	Marginal	200 - 300
3	Fair	300 - 400
4	Good	400 - 500
5	Excellent	500 - 600
6	Outstanding	600 - 800
7	Superb	>800

*Watts per meter^2 (W/m^2)

For the purposes of this REA all data were applied to the future potential wind development analysis. Future potential wind turbine potential locations are dependent upon numerous factors such as political factors, financial factors, necessity, property ownership, topography, accessibility and other various factors that would affect the suitability of constructing wind turbines throughout the ecoregion. These factors were beyond the scope of this analysis. Therefore a basic approach was undertaken to analyze areas where wind power suitability existed.

The output from this analysis was based on all power classes in Table C-1-2. The power classes were related to risk of potential development. If the power class was high and suitable for wind development, a high risk value was assessed. Power Classes were reclassified as high risk (1-2), moderate risk (3-4) or low risk (5-7). The outputs were classified cell by cell (30m). These data were applied to CEs as part of a qualitative analysis.

The NREL wind model is limited in its ability to reliably predict disturbance to CEs through the development of wind farms. Through spatial representation and analysis, this model is able to display future potential wind development areas based solely on the availability of wind. Direct comparisons between CEs and wind development locations are difficult to assess and should be further analyzed in the future as new data becomes available.

Table C-1-3. Wind Turbine Reclassification and Ranking for the Northwestern Plains Ecoregion

Wind Power Class	Assigned Rank	Metric per HUC (mean + S.D.)	Rating
1	1	1 - 1.93	Low
2			
3	2	1.94 - 2.33	Moderate
4			
5	3	2.34 - 3	High
6			
7			

5.6 RENEWABLE ENERGY AND FOSSIL FUEL POTENTIAL

The impact of renewable energy resources and fossil fuel resources on CEs relates to key management questions in this REA. In order to assess this potential impact, a renewable resources dataset and a fossil fuels dataset was created for spatial analysis. The renewable resource dataset was created by combining the output data layers for potential future wind energy development and potential future solar energy development (Figure C-1-8). The fossil fuel resource dataset was created by combining the output data layers for oil density potential and natural gas density potential (Figure C-1-5). This process was simplified through the use of a focal sum analysis, giving equal weight to each data layer. The combined data layer was subsequently classified as high risk, moderate risk, or low risk based on the combined, previously scored values for each renewable energy dataset. The classification of these values was determined using the mean and standard deviation of the combined dataset. This method of classification provided a realistic output with regard to data averaging.

This model was derived from available renewable energy data and prepared for use in this REA. The lack of suitable future renewable energy models contributed to the inability of this analysis to descriptively predict the potential effects of renewable energy on the CEs in this ecoregion. Renewable energy is currently undergoing a period of growth, and the need for a suitable model to try to predict its effects on vulnerable species is apparent. A wind turbine potential model or a solar array potential model could be created using available geospatial data, NREL wind and solar potential, and expert knowledge. Geospatial data such as slope, elevation, canopy cover, vegetation type, and development layers could be applied to the NREL models to derive potential renewable energy models that could benefit the CEs in this ecoregion.

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6.0 MANAGEMENT QUESTIONS

Although some of the original MQs were specific to the CAs, all of these are addressed in the specific CE packages contained in Appendices D and E. The individual KEA maps and the resulting overall current status output contained in these appendices answer all of the MQs specific to CAs.

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APPENDIX C-1

FIGURES

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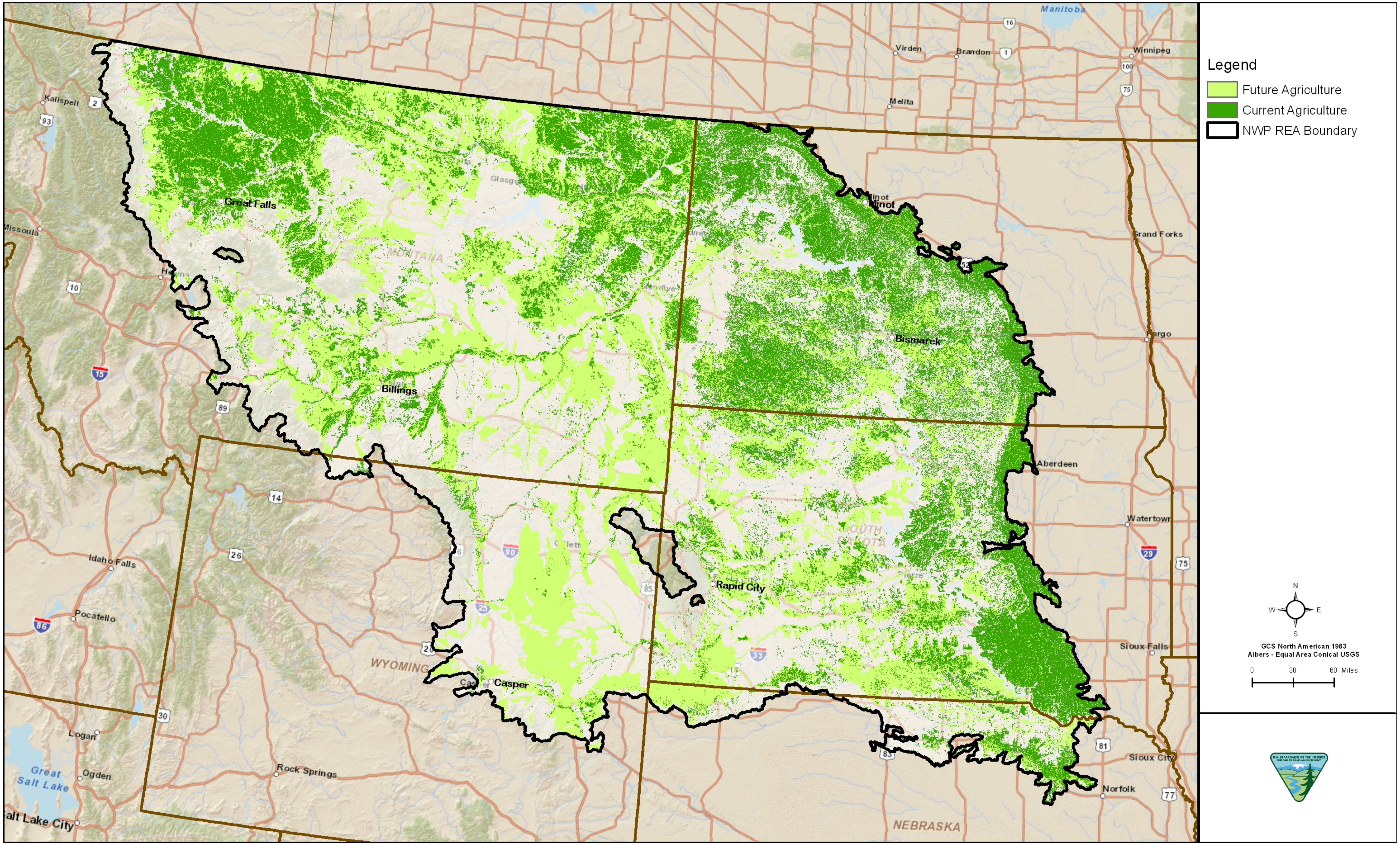

Figure C-1-1. Future Agricultural Potential for the Northwestern Plains Ecoregion

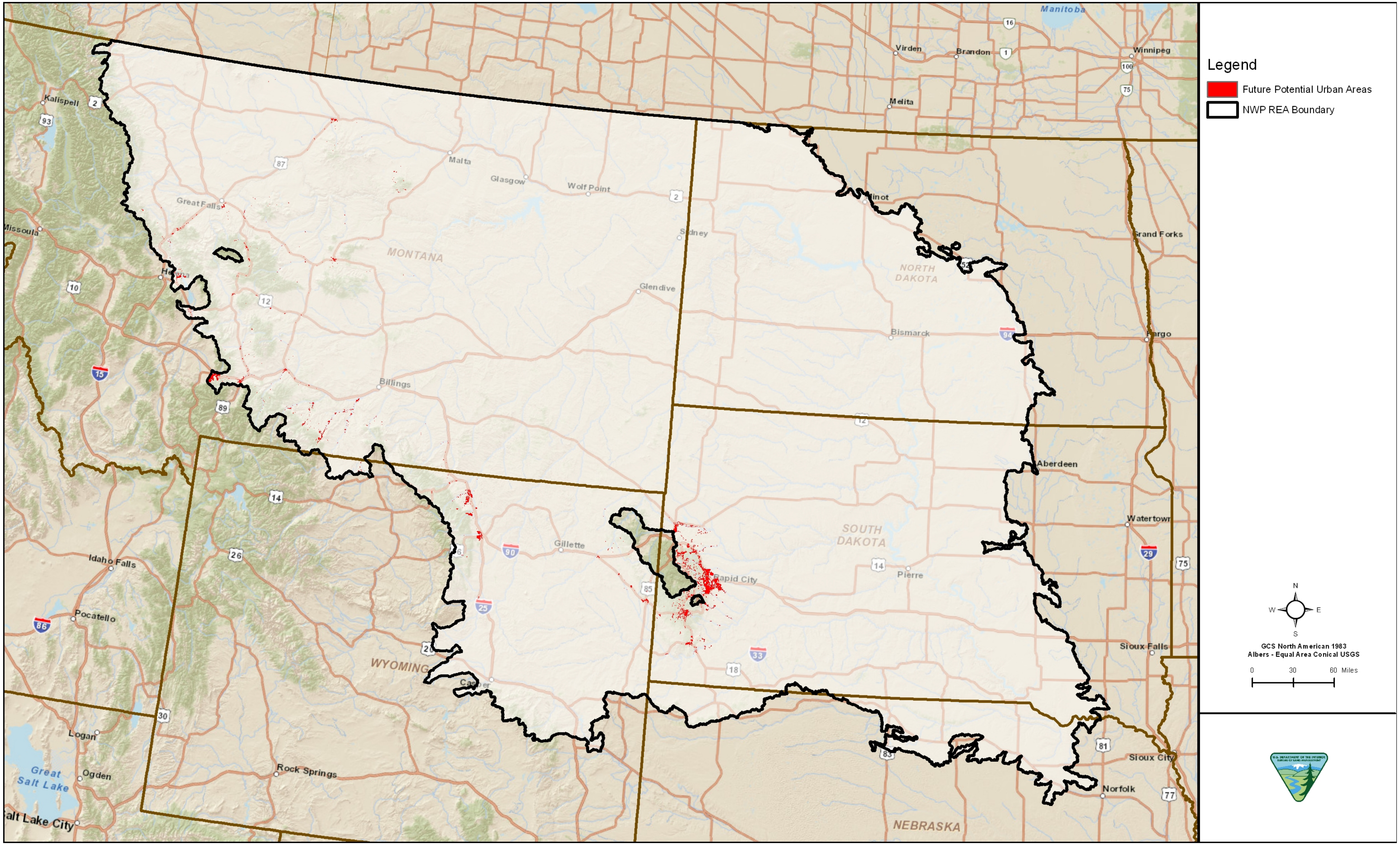

Figure C-1-2. Future Urban Potential for the Northwestern Plains Ecoregion

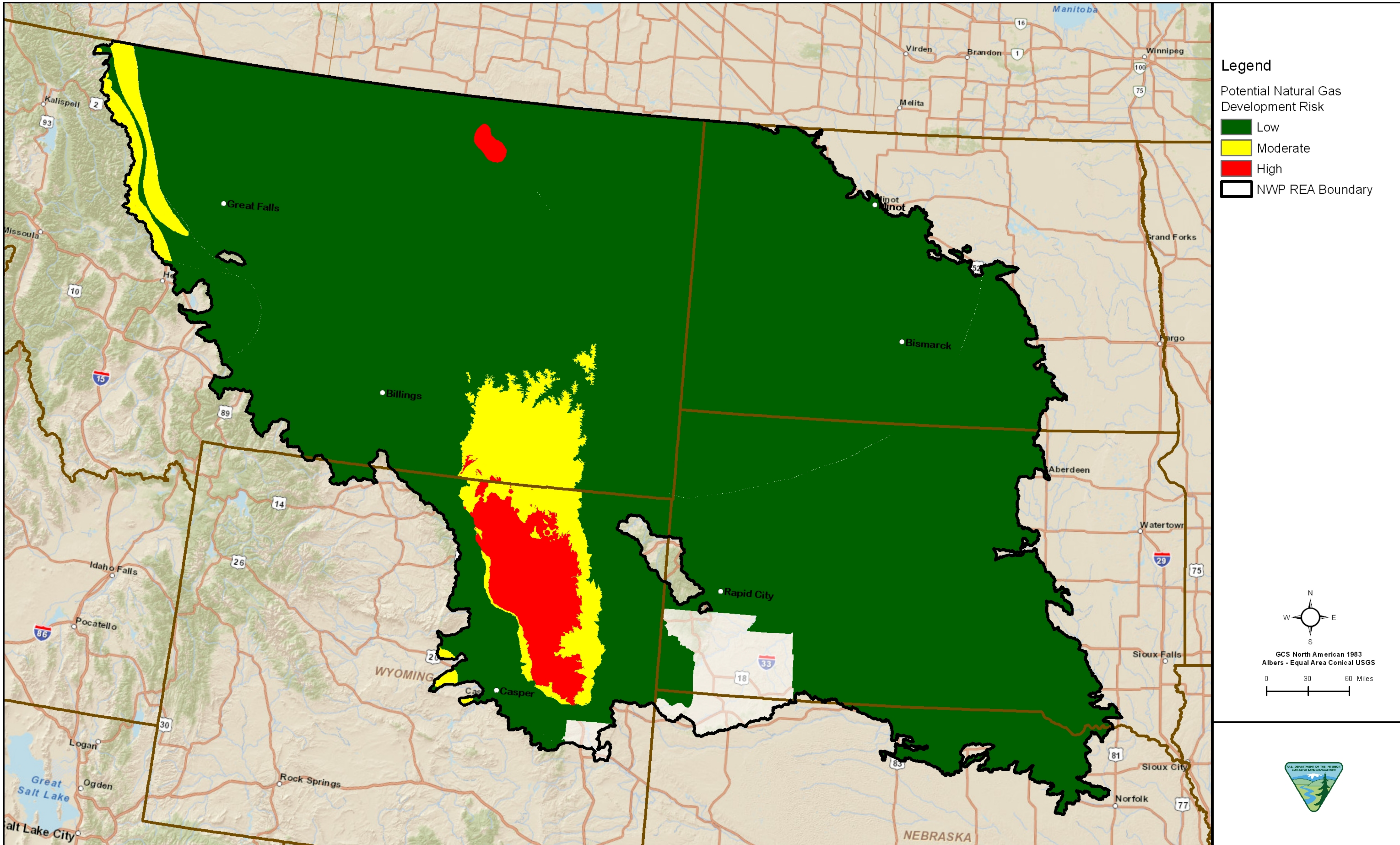

Figure C-1-3. Future Natural Gas Extraction Potential for the Northwestern Plains Ecoregion

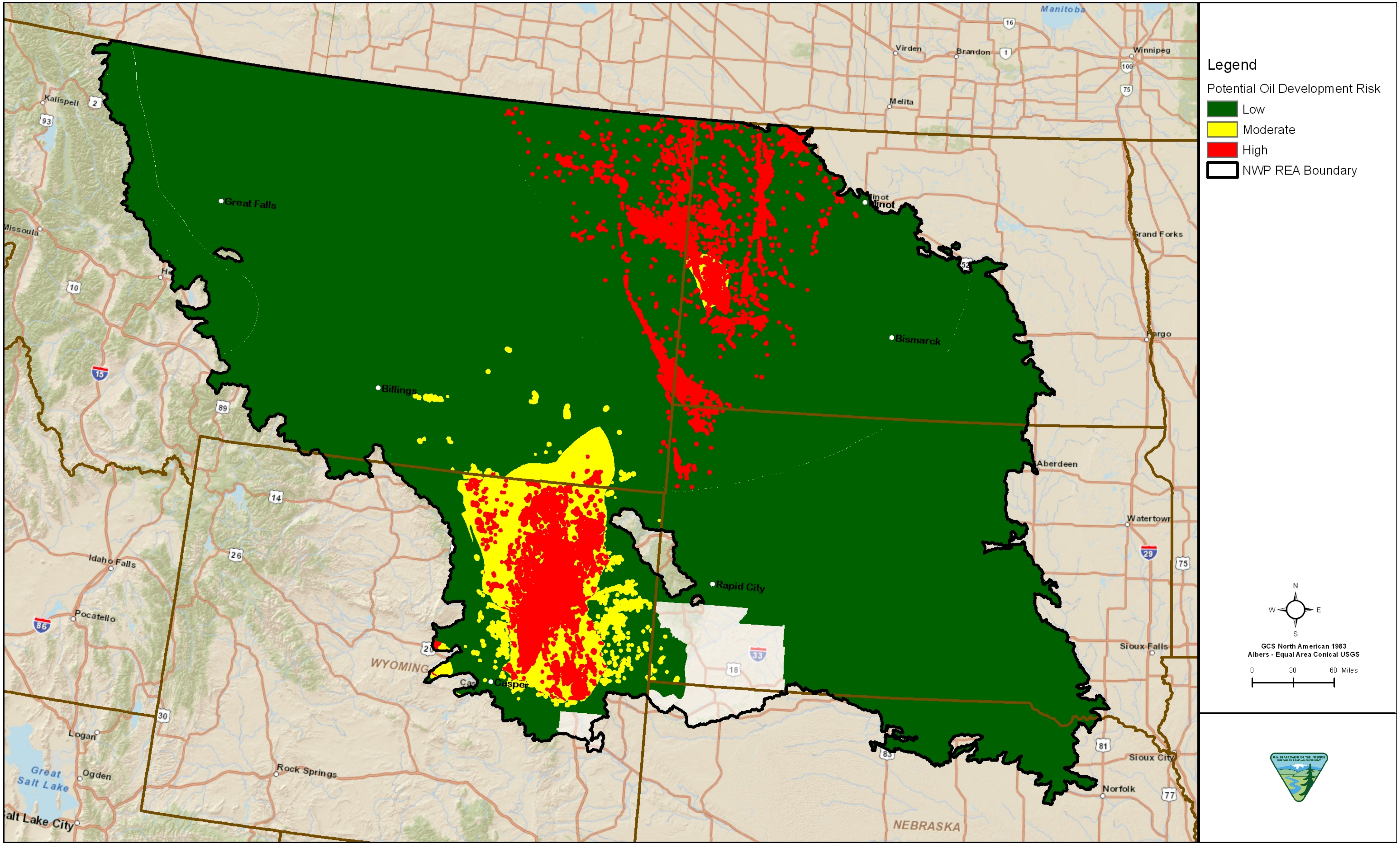

Figure C-1-4. Future Oil Extraction Potential for the Northwestern Plains Ecoregion

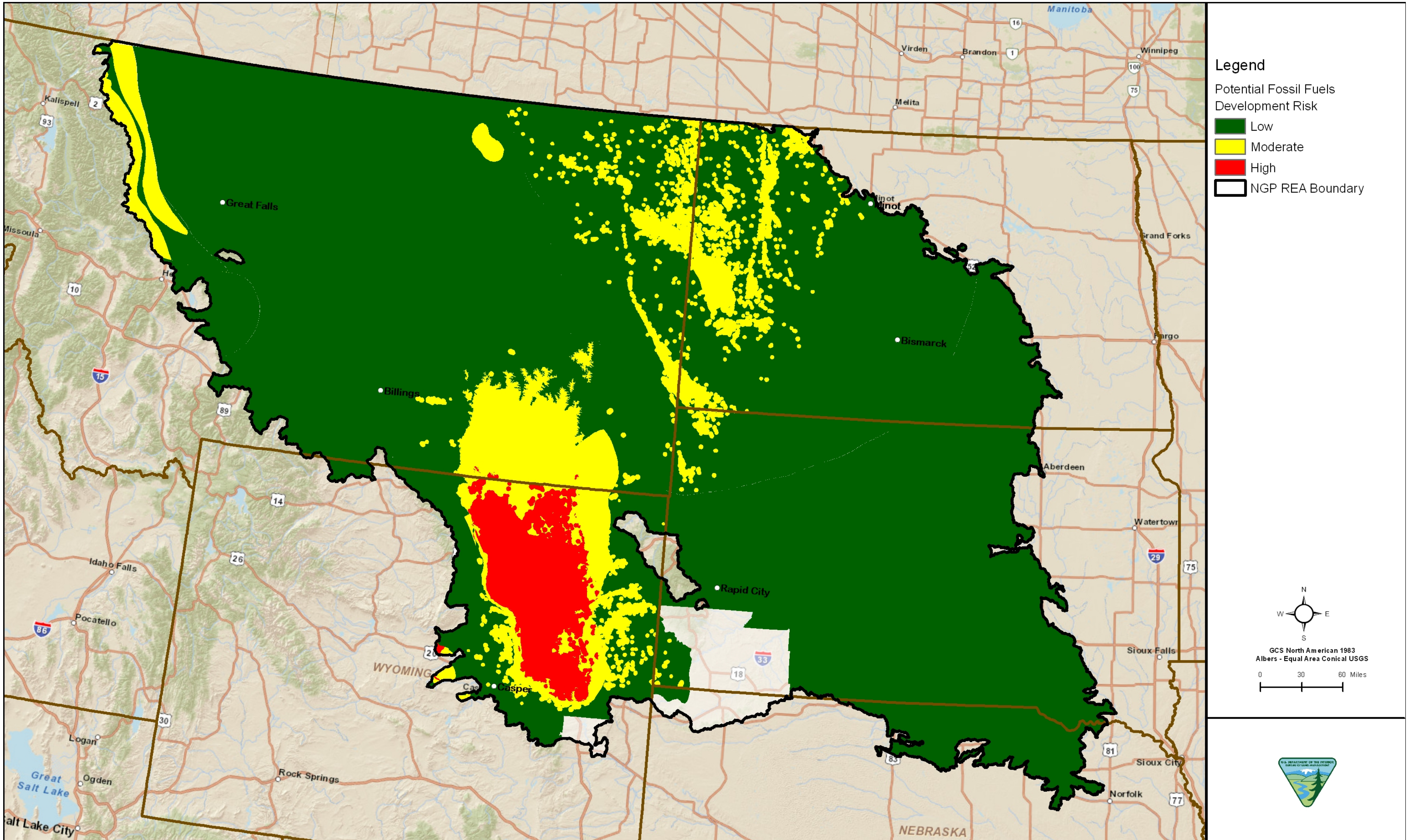

Figure C-1-5. Future Fossil Fuels Energy Potential for the Northwestern Plains Ecoregion

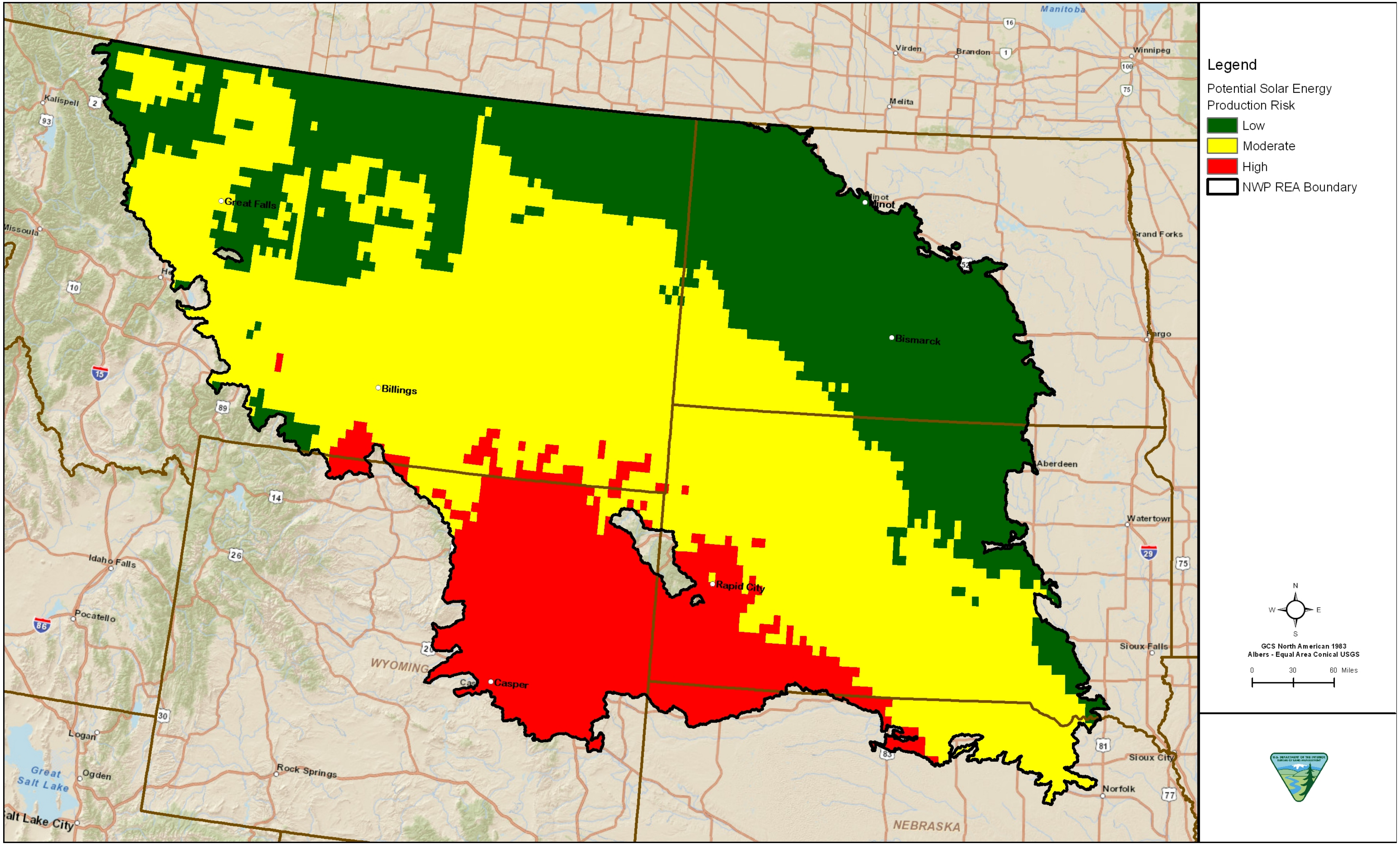

Figure C-1-6. Future Solar Potential Areas for the Northwestern Plains Ecoregion

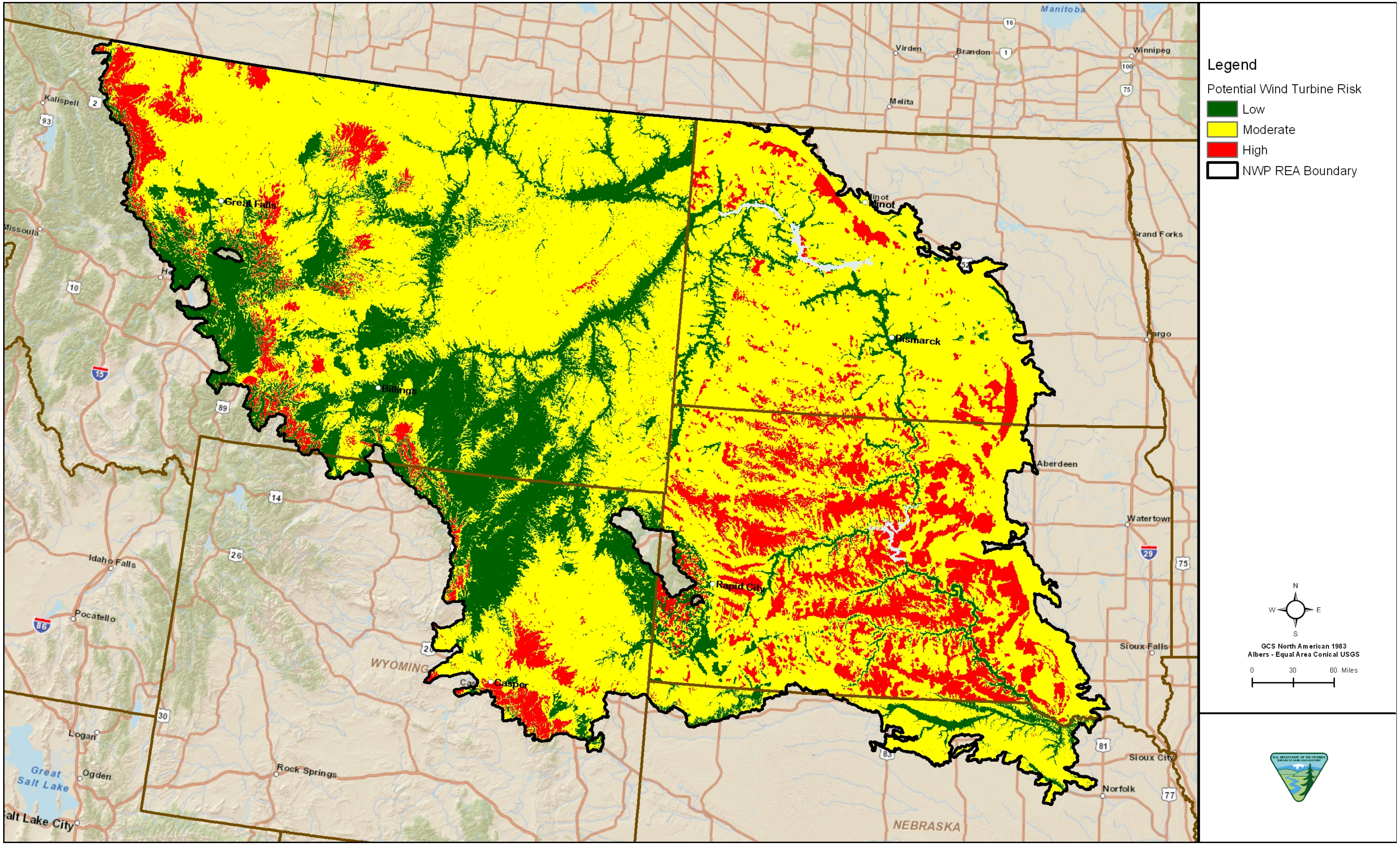

Figure C-1-7. Future Wind Turbine Potential for the Northwestern Plains Ecoregion

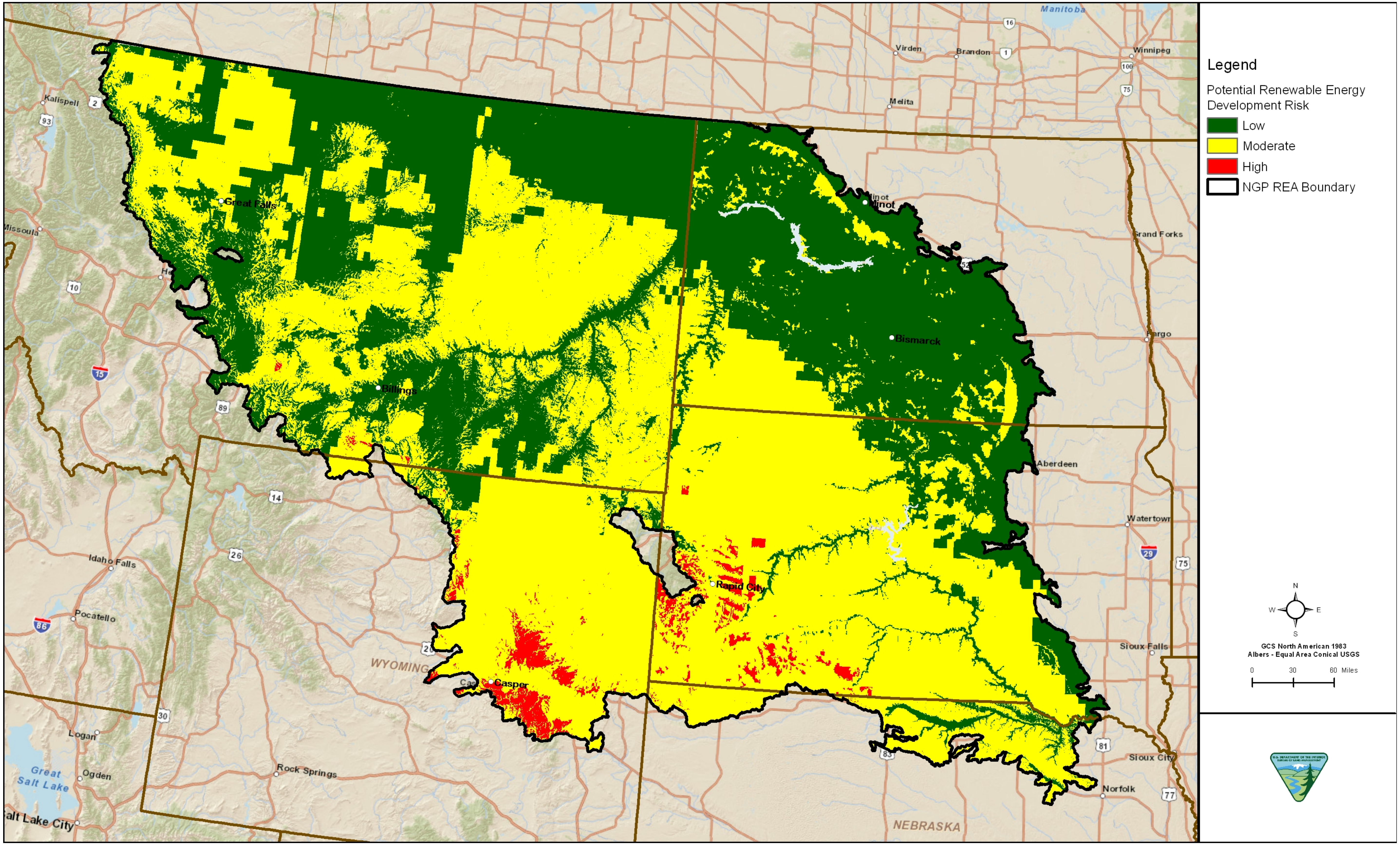

Figure C-1-8. Future Renewable Energy Potential for the Northwestern Plains Ecoregion

APPENDIX C-2

WILDFIRE CHANGE AGENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

Successful completion of this REA will in part be based on a sound understanding of the landscape-scale CAs and their potential impact on CEs throughout this ecoregion. CAs are natural or anthropogenic disturbances that influence the current and future status of CEs. The initial CAs for this ecoregion were developed by the Rapid Ecoregional Assessment (REA) team in the early planning phase of this REA. Wildfire is included in this REA in order to understand how predicted changes in wildland fire regimes may affect resources across the landscape. Additionally, this information can assist regional managers with determining how wildland fire regimes might affect resources at a regional scale. A variety of MQs apply to this CA which is summarized into one primary MQ: Where could core regionally significant values be negatively and positively affected from altered wildland fire regimes (frequency, severity, and seasonality change from historic to present to future)?

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2.0 CHANGE AGENT DESCRIPTION

The Northwestern Plains ecoregion is the northern portion of the Nation's largest grassland ecosystem. A common characteristic of grassland communities is their resilience to disturbances like fire, grazing, and drought. Under historic disturbance regimes, intense grazing by migratory bison (*Bison bison*) affected grass species composition and diversity. Fire provides positive feedbacks on plant growth through nutrient mobilization and alteration of physical conditions (solar exposure, soil temperature, mineral soil exposure) and is largely responsible for the tree less character of the region.

Descriptions of pre-settlement fire regimes in Great Plains grasslands are mostly estimates, because these grasslands generally lack trees to establish tree-scar fire histories. It is uncertain how fires set by Native Americans or lightening determined historical fire regimes in the Great Plains. Some scientists argue that the treeless nature of grasslands resulted from frequent, repeated aboriginal fires (Stewart 1951; 1953; Wedel 1957). In the Northern Great Plains, Native Americans set fires primarily in fall after frosts and plant dry-up. Historical accounts suggest that Native Americans set fires to attract and herd ungulates, improve spring grazing conditions and for social and cultural reasons.

Historically, the grassland and woodland communities of the Northwestern Plains probably had mean fire return intervals (FRIs) ranging from 3 to 20 years (Umbanhowar 1996). Estimates for historical fire-return intervals of interior ponderosa pine woodlands in eastern Montana, the Dakotas, and Nebraska range from 20 to 300 years for surface and stand-replacement fires, respectively (Brown and Sieg 1999). Frequent burning of native grasslands may be the most effective method to prevent invasion of undesirable species (e.g., Kentucky Bluegrass [*Poa pratensis*], Anderson et al. 1970, and smooth brome [*Bromus inermis*], Willson and Stubbendieck 1997). Sagebrush communities are generally thought of as being fire-tolerant; however, there is considerable debate among scientists on historic fire regimes in sagebrush communities. Especially xeric sagebrush environments, such as Wyoming big sagebrush (*A. tridentata ssp. wyomingensis*) communities may have historically had long fire intervals up to 450 years (Baker 2006).

The relationship between fire regimes, landscape mosaics, and stand structural diversity is fairly well studied. In general, short fire-free intervals and low-severity fire regimes are associated with relatively small fires, creating small-grained landscape mosaics of patchy or multi-cohort communities with substantial vertical and horizontal structural diversity (e.g., low-elevation ponderosa pine). In contrast, long fire-free intervals and high-severity fire regimes are associated with relatively large fires, which may create even-aged conditions over large patches. Based on coarse-scale definitions for historical fire regimes developed by Hardy et al. (2001) and Schmidt et al. (2002), five natural fire regimes are classified based on average number of years between fires (fire frequency) combined with the severity (amount of replacement) of the fire on the dominant overstory vegetation (Barrett et al. 2010).

Human-influenced changes in forest and grassland management have affected and altered fire regimes including fire frequency, severity, and seasonality. For the Northwestern Plains, the primary influence has been the conversion of native grasslands and shrub steppes to agriculture, which no longer permits any fire regime. Although historical records of fire in the Great Plains are limited, fire suppression has affected the composition of native grass and shrublands substantially (Daubenmire 1968; Gartner and White 1986; Gartner et al. 1986). Removal of fire has caused cascading effects (Keane et al. 2002) that have affected stand level attributes (structure, species composition, nutrient cycles, decomposition rates, evapotranspiration, soil temperatures, productivity and water-holding capacity, litter and duff layers, herbaceous forage for ungulates and wildlife cover), and landscape level ecosystem attributes (proportion of early seral stages), landscape homogeneity, patch diversity, patch size, contagion, insect and disease outbreaks, higher carbon emissions, and increases in drought.

Wildland fire, particularly changes, frequency, magnitude, and extent and their effects are evaluated for the identified resource values (CEs). The identification of the areas with the greatest threat from changes in the natural fire cycle is of concern.

The REA attempts to display fire risk potential across the ecoregion to identify areas that may be severely impacted by fire and that may benefit from fire.

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3.0 METHODS, MODELS, AND TOOLS

A GIS-based multi-criteria evaluation (MCE) model incorporated with spatial analyst tools was built within ArcGIS for this analysis. The MCE approach utilizes decision-making rules to combine the information from several criteria in the form of GIS layers. Multiple geographic layers are aggregated to produce a single index or map that shows the appropriateness of the land for a particular purpose or activity. Each criterion was controlled using a weighted sum analysis in order to produce an overall development layer or map.

3.1 DATA IDENTIFICATION

Data sources for this CA include the USFS fire history and fire potential data, LANDFIRE, monitoring trends in burn severity (MTBS) data and GeoMac fire occurrence data. In addition, the BLM has historic fire perimeter data that was used in modeling this CA across the ecoregion. Vector datasets were clipped and merged to the ecoregion boundary to create one layer. Raster datasets were extracted and mosaiced together to create one 30-meter (m) raster grid. Outputs included vector data showing fire perimeters and past fire occurrences. Raster datasets and a 30-m raster grid showing vegetation condition class (VCC), mean fire frequency intervals and fuel models.

Table **C-2-1. Change Agent Datasets – Wildfire**

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Fire History/Fire Occurrence	Fire History 1985-2009	USFS	Polygon/Point	Acquired	No
	MTBS	MTBS	Polygon/Point	Acquired	Yes
	GeoMac	Multi-Agency	Polygon	Acquired	No
Forest Fuels	LANDFIRE	LANDFIRE	Raster 30-m	Acquired	Yes

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4.0 ANALYSIS OF WILDFIRE ON ECOREGION CONDITIONS

The wildfire CA analysis attempted to assess vegetation condition departure, topography and fuel loads to determine potential fire risk across the ecoregion. Based on existing information data were assigned values of low, moderate and high risk to potential fire. The analysis attempted to answer the MQs related to: where are the areas that have changed as a result of wildfire in the past and where are the areas that have the potential to change from wildfire in the future?

4.1 CURRENT WILDFIRE INDICATORS

Table C-2-2 identifies the indicators, data sources, and metrics that were used to evaluate the potential for fire in terms of condition and landscape context. Each data source were used to create an intermediate layer based on the CE and then combined to form an overall fire potential risk map. The intermediate data layers were created based on the KEA indicators and were assigned classes of risk (low, moderate or high).

For each of the KEAs listed in Table C-2-2, a discussion of the indicator, metric, metric rank and value, and data source(s), is provided.

Table C-2-2. Indicators, and Metrics for Future Wildfire Threat for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation
			High = 3	Moderate = 2	Low = 1		
Landscape Context	Landscape Structure	VCC	VCC 3	VCC 2	VCC 1	LANDFIRE	LANDFIRE
		Elevation	>1,680-2,690 m	<1,680 m	>2,690 m	National Elevation Data set	Haak et al. 2010
		Slope	>40%	>25-40%	<25%	National Elevation Data set	Oregon's Communities at Risk Assessment 2006
		Aspect	S, SW, SE	W, E	N, NW, NE	National Elevation Data set	Oregon's Communities at Risk Assessment 2006
		Fuel Model	FBFM8-13	NA	FBFM1-7	LANDFIRE	Haak et al. 2010

4.1.1 Vegetation Condition

A Fire Regime Condition Class (FRCC) (Barrett et al. 2010) characterizes the degree of departure from the historical fire regime, mostly due to human intervention in natural fire regimes. This departure results in changes to one (or more) of the following ecological components: (a) vegetation characteristics (species composition, structural stages, stand age, canopy closure, and mosaic pattern) and (b) fuel composition, (c) fire frequency, severity, and pattern and (d) other associated disturbances (e.g. insect and disease mortality, grazing, and drought). Low departure is considered to be within the natural (historical) range of variability, while moderate and high departures are outside of that range. Characteristic vegetation and fuel conditions are considered to be those that occurred within the natural (historical) fire regime. Uncharacteristic conditions include invasive weeds, insects, diseases, selectively harvested forest composition and structure, or repeated annual grazing (Barrett et al. 2010).

LANDFIRE provides coarse-scale reference condition for vegetation communities from its VCC data. VCC data, formerly known as FRCC provides a categorized measure of the difference between current vegetation and structure and estimated vegetation structure and composition from the time just prior to European settlement. VCC data were used to show an estimate of change in vegetation and fuels from their historical condition.

In addition, the mean FRI and Severity data layers from LANDFIRE were mapped for the Northwestern Plains ecoregion. The mean FRI quantifies the average period between fires under the historical fire regimes. The fire severity layers quantify the data based on low-severity, mixed severity and stand placement fires relative to the low and severe replacement fires within a fire perimeter for a given vegetation type. Low severity is defined as less than 25 percent average top-kill, mixed severity is defined as between 25 and 75 percent average top-kill, and replacement severity is defined as greater than 75 percent average top-kill.

The VCC data are categorical. VCC departure 1 was low, VCC departure 2 was moderate, and VCC departure 3 was high. This layer was used in the overall fire risk potential analysis. The VCC layer is displayed on Figure C-2-1.

In addition, Figure C-2-9 displays the mean FRI data which attempts to represent the historic fire frequency across the Northwestern Plains. Fire experts in the ecoregion could potentially use data to determine how fire frequencies have departed from historic conditions to current conditions.

4.1.2 Topography

Topography influences wildfire behavior largely by affecting fuel moisture (solar exposure) and air/oxygen movement. On slopes, warm air rises along the slope causing a draft which will cause wildfires to usually burn up-slope. The steeper the slope, the more rapidly the fire will burn up-slope (and more intensely). Steepness of the slope also results in more preheating of fuel in front of the fire and faster fuel ignition. Elevation affects the type of vegetation and the length of the season.

4.1.1.1 Elevation

For the elevation indicator, the 30-m National Elevation Data (NED) was used clipped to the ecoregion boundary then reclassified and assigned a risk value.

Haak et al. (2010) cite work by Westerling et al. (2006) defining areas in the Rocky Mountain between 1,680 and 2,690 m as a fire risk zone. Areas within this elevation zone have recently been prone to earlier snowmelt and more wildfires thus given a high risk value. Elevations above 2,690 m were given a low risk value because of the lack of vegetation at this altitude. Elevations below 1,680 m were given a moderate risk value. This intermediate layer (Figure C-2-2) was then used in the overall potential fire risk analysis.

4.1.1.2 Slope

This metric was determined by calculating the slope of each 30-m pixel from the NED using the slope function in ArcGIS 3-D analyst. For each cell, the slope tool calculated the maximum rate of change in value from the reference cell to neighboring cells using the elevation data. The output is a slope raster displaying the amount of slope in degrees (Figure C-2-3).

The slope layer was then reclassified and assigned risk values as described in Table C-2-2. This intermediate layer was then applied to the potential fire risk analysis.

4.1.1.3 Aspect

Aspect was determined by identifying the down slope direction with the maximum rate of change in value from the reference cell from to its neighbors. The value of each cell in the output raster was determined by the direction the reference cell faces as described in Table C-2-2. The aspect layer was then reclassified and assigned risk values (Figure C-2-4).

4.1.2 Fuel Models

Fuels are combustible materials comprised of both living and dead vegetation. Fuel types vary in their flammability and in the height of flames they promote. Wildland fuels can also be described using vertical separation as ground, surface, ladder and aerial fuels. The LANDFIRE fuel loads data describe the composition and characteristics of both surface and canopy fuels.

The 13 Anderson Fire Behavior Fuel Model (Anderson 1982) data from the LANDFIRE 2008 refresh (http://www.landfire.gov/NationalProductDescriptions1.php) was used to assign fuel risk. The 13 Anderson Fire Behavior Fuel Model (FBFM13) layer represents distinct distributions of fuel loading found among surface fuel components (live and dead), size classes, and fuel types. The fuel models are described by the most common fire-carrying fuel type (grass, brush, timber litter, or slash).

The fuel model layer was clipped the ecoregion, reclassified and scored. Nonfuel types (urban, snow/ice, agriculture, water, or barren) were assigned a zero for no risk. Grasslands and mesic shrublands were considered low risk and assigned a score of 1 (fire behavior fuel model types 1-7). All other fuel types, typically closed canopy conifer and hardwood forests (fire behavior fuel model types 8-13) were considered high risk and assigned a score of 3 (Figure C-2-5).

4.1.3 Potential Fire Risk Output

In order to create a combined potential risk layer, it was necessary to aggregate the data through an overlay analysis. The weighted sum tool was used to combine each analysis input map to create an overall Fire Risk Potential Map (Figure C-2-6). This was done by using the weighted overlay tool to combine the VCC, elevation, slope, aspect and fuel models into one overlay layer. Equal weights were used when summing the fire indicators.

The resulting output scored each pixel based on the indicators and metrics. Figure C-2-6 displays these results, where red indicates areas of higher potential risk and green indicates areas currently at lower risk based on the measured attributes. For this analysis the low, moderate and high were assigned using equal intervals classification based on the output results.

In addition, Figure C-2-7 displays the fire perimeters from 2000-2007. These fire perimeters were then overlaid on the fire risk potential map (Figure C-2-8). Depending on the vegetation type this could be used to help determine the frequency of another fire occurring in that area. Based on the fire perimeters, assumptions could also be made that those areas may burn less severe.

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5.0 MANAGEMENT QUESTIONS

Although some of the original MQs were specific to the CAs, all of these are addressed in the specific CE packages contained in Appendices D and E. The individual KEA maps and the resulting overall current status output contained in these appendices answer all of the MQs specific to CAs.

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APPENDIX C-2

FIGURES

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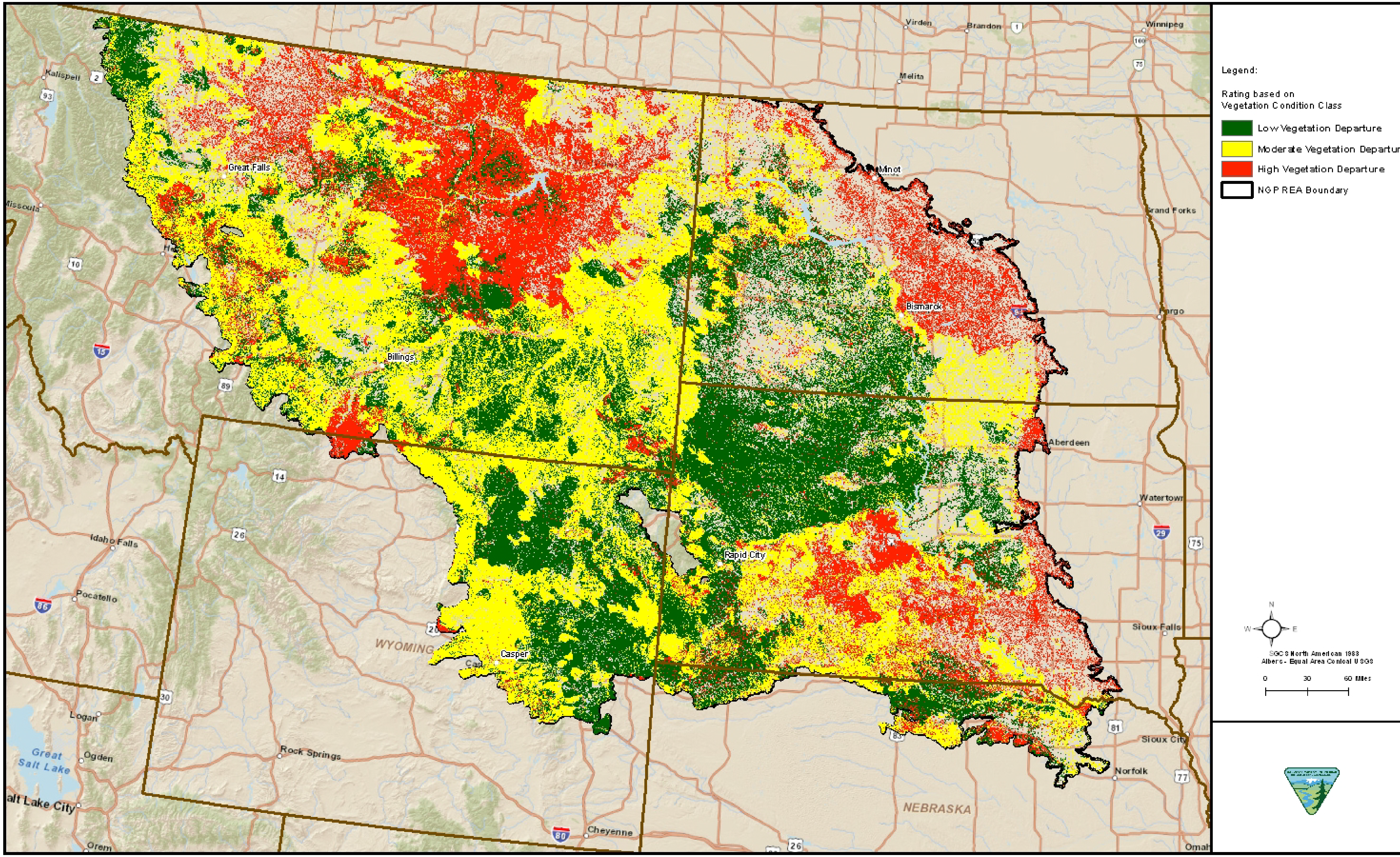

Figure C-2-1. Vegetation Condition Class (VCC)

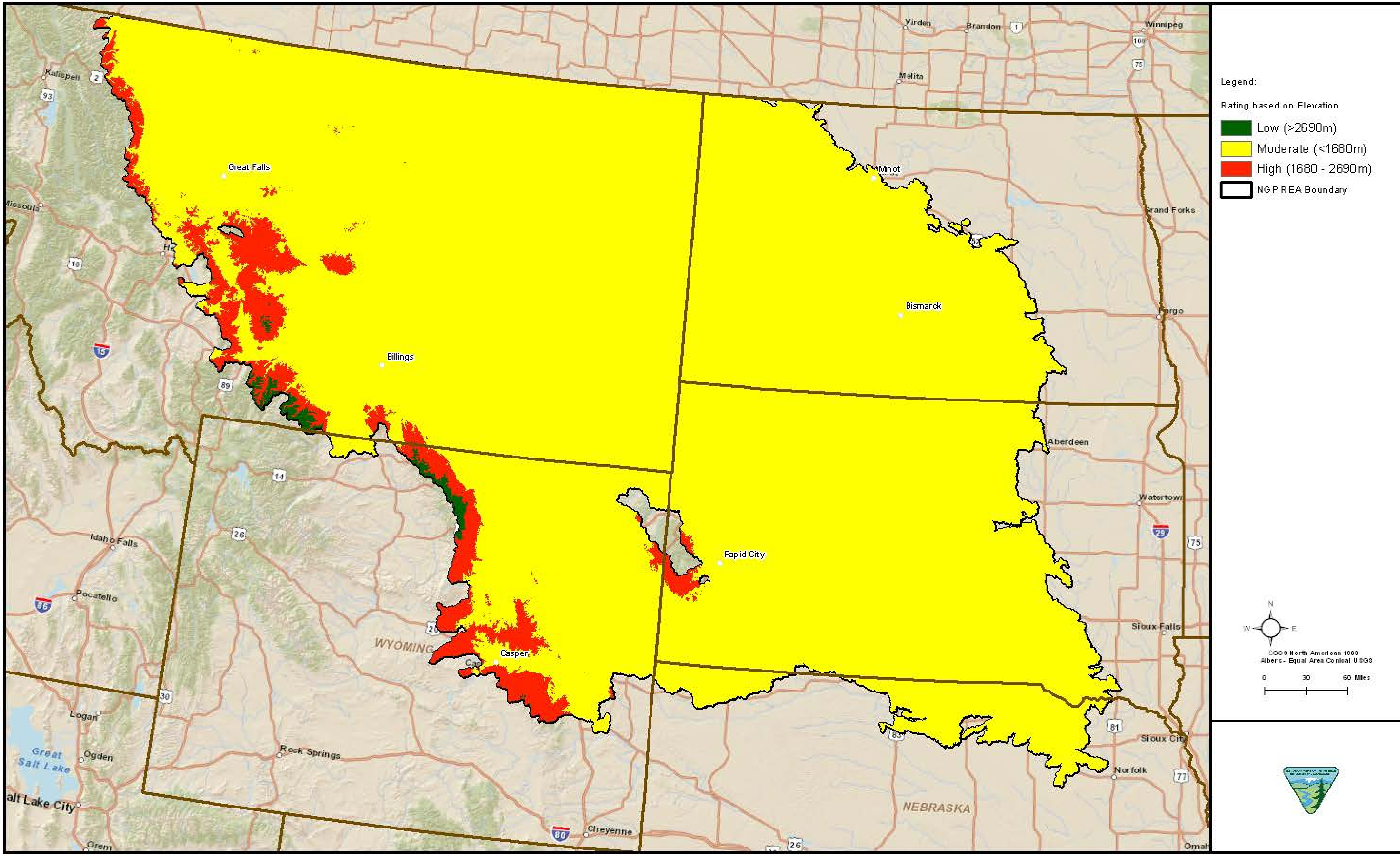

Figure C-2-2. Elevation

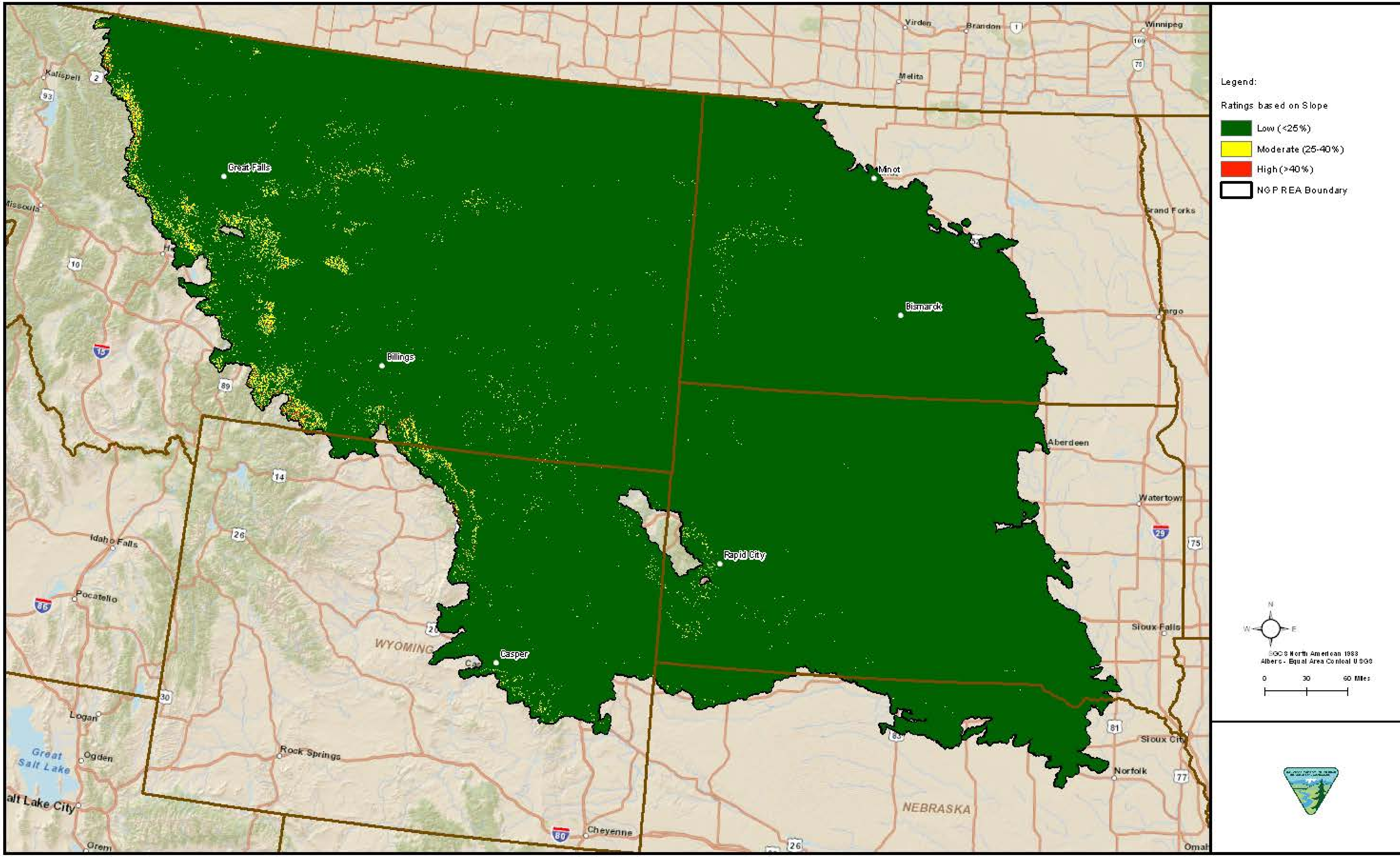

Figure C-2-3. Slope

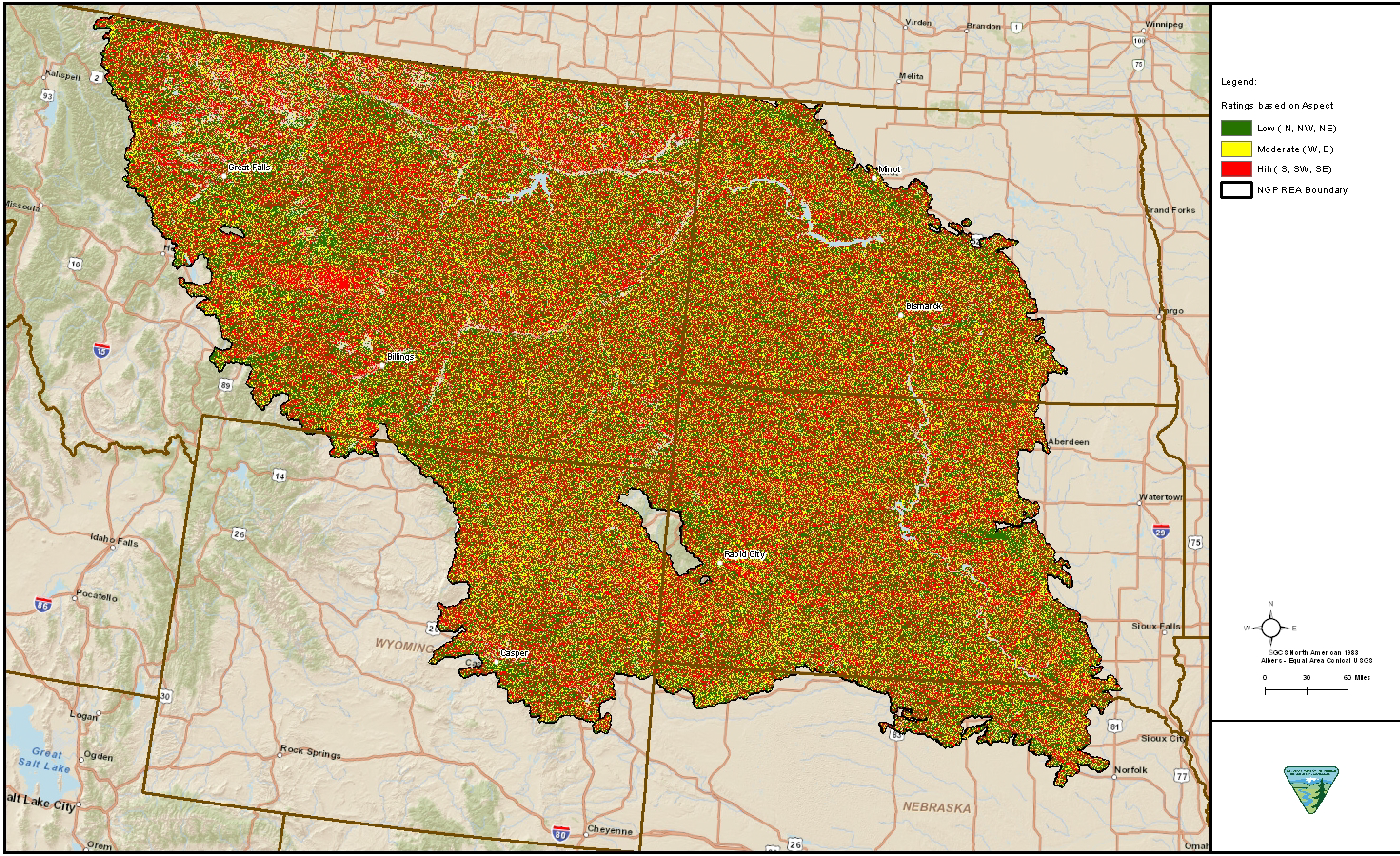

Figure C-2-4. Aspect

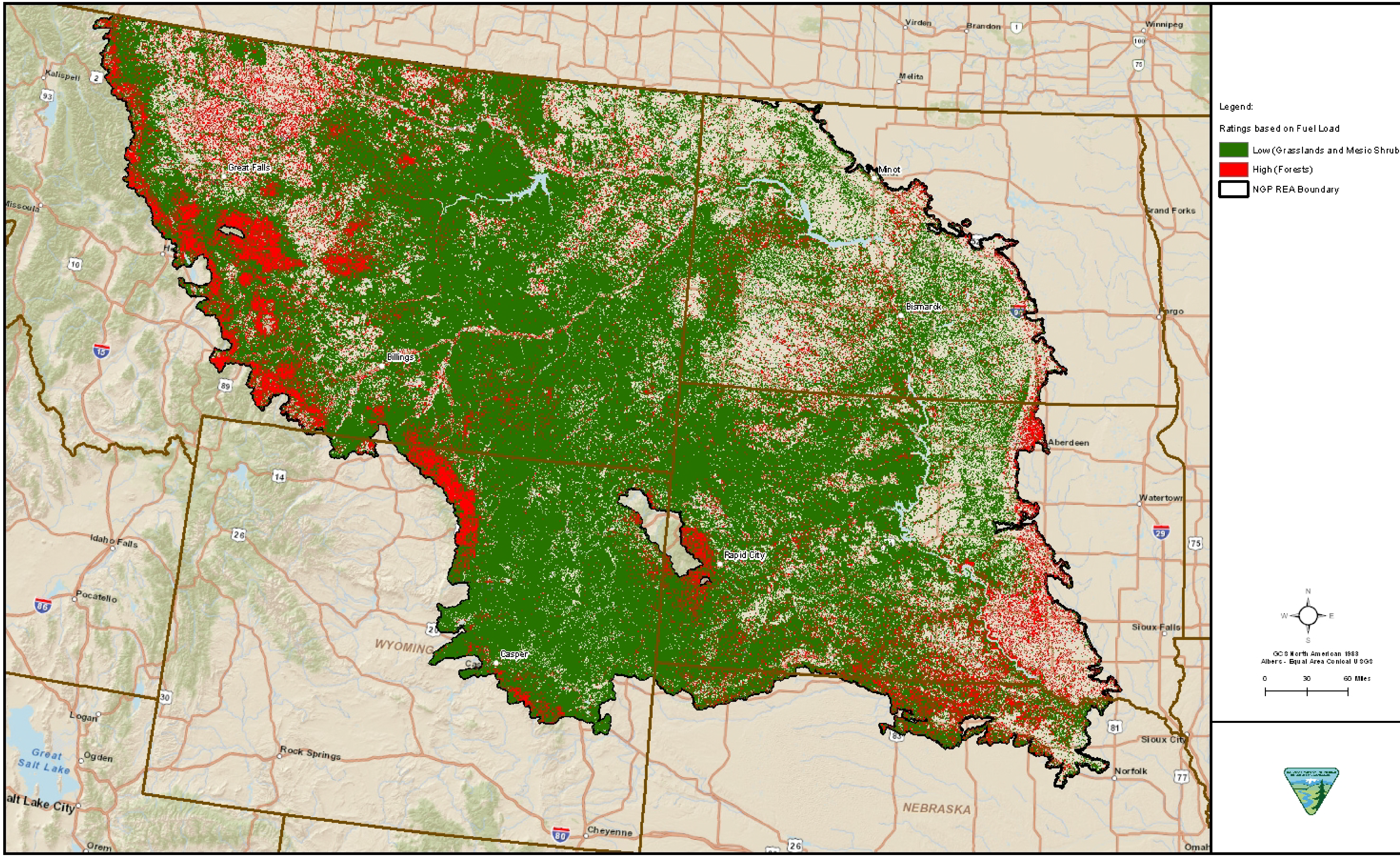

Figure C-2-5. Fuel Loading

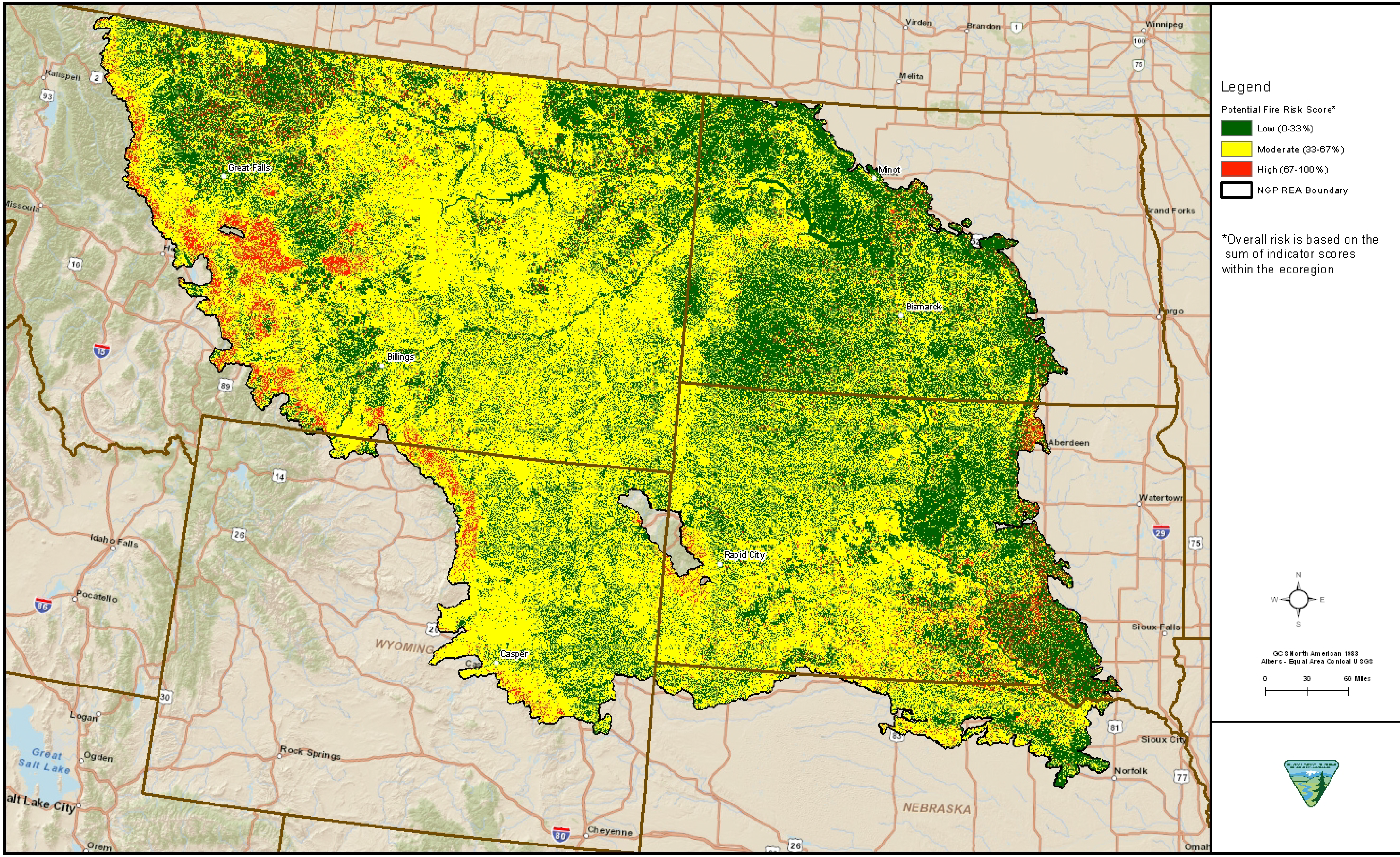

Figure C-2-6. Potential Fire Risks

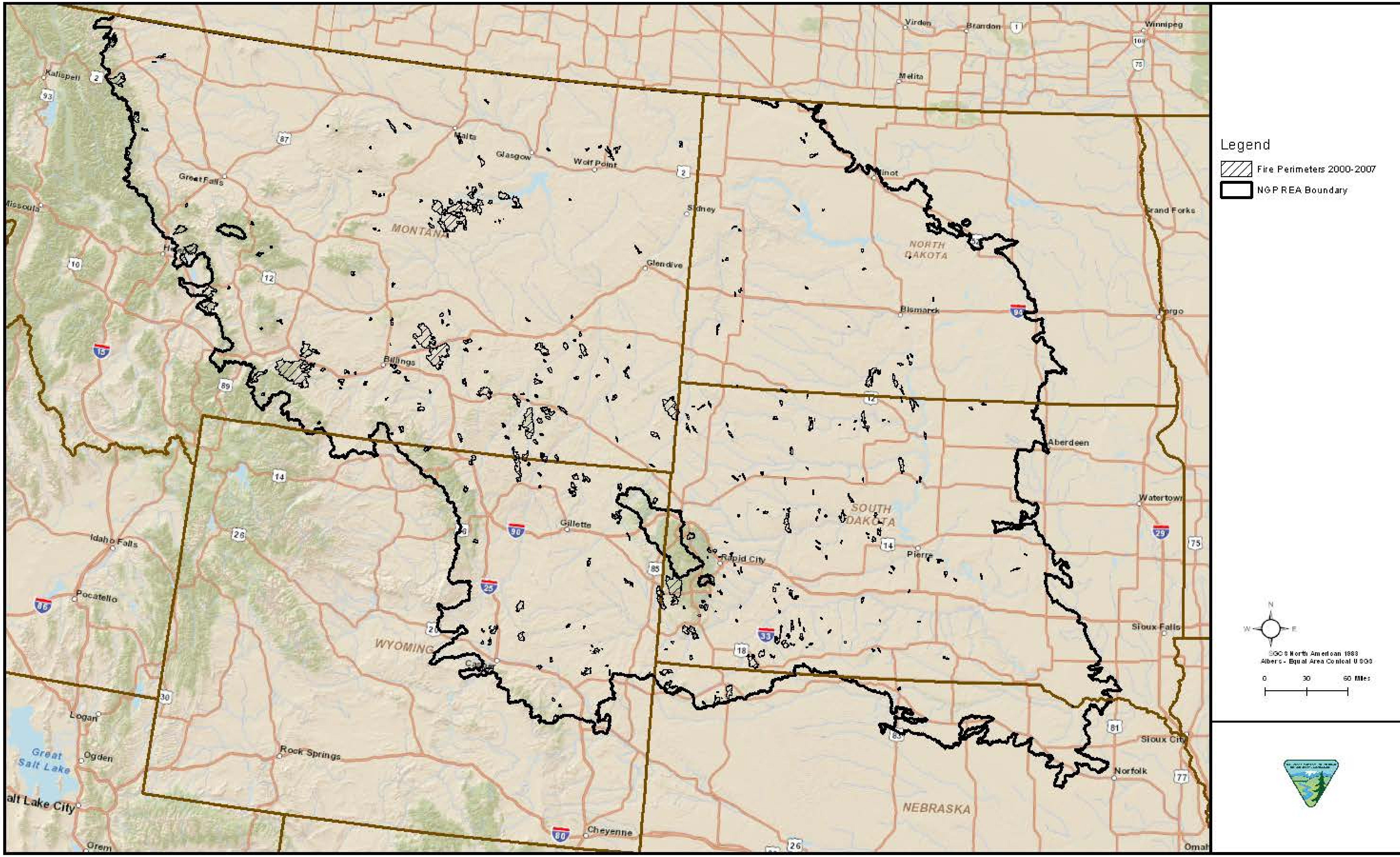

Figure C-2-7. Fire Perimeters

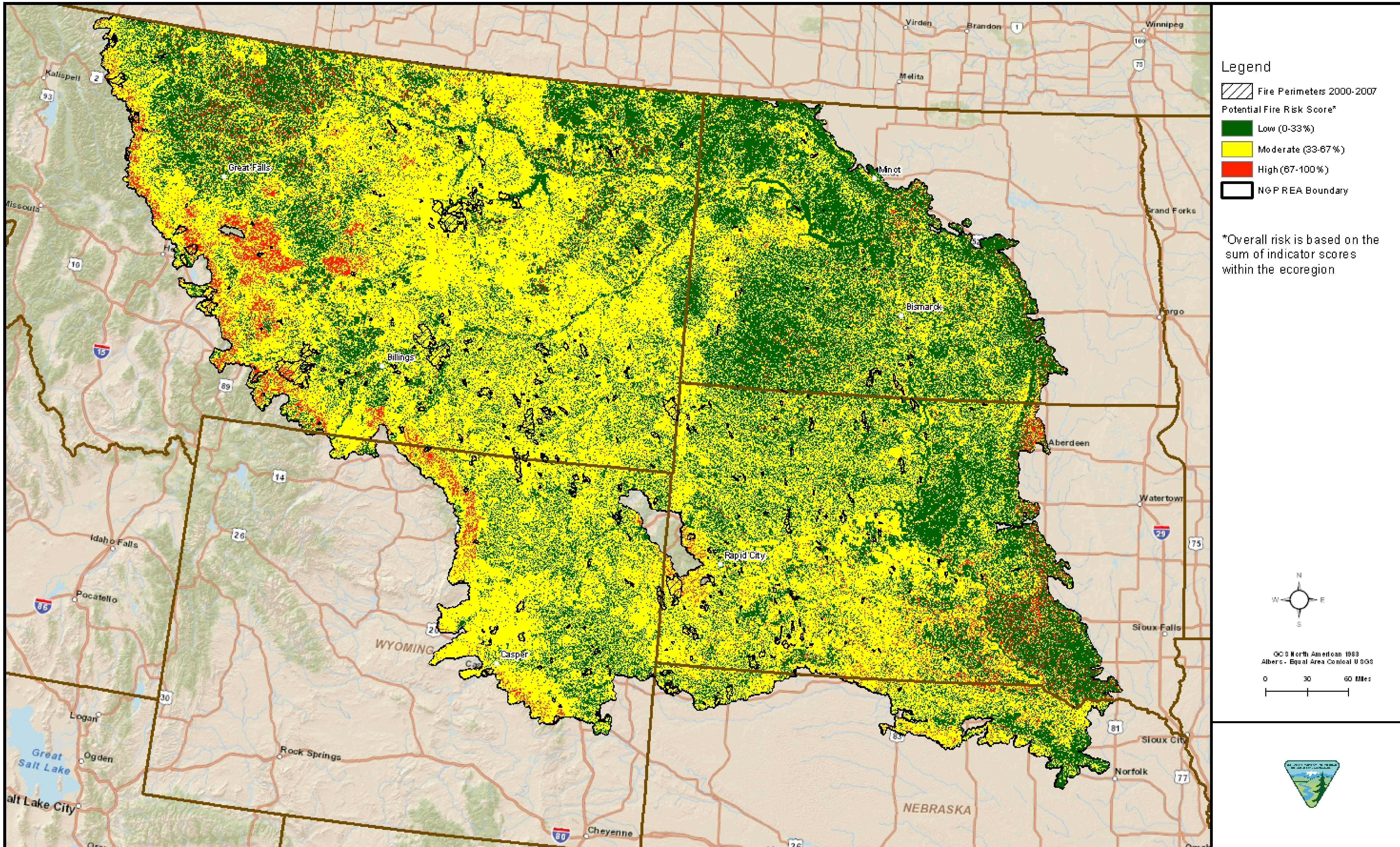

Figure C-2-8. Potential Fire Risk and Fire Perimeters

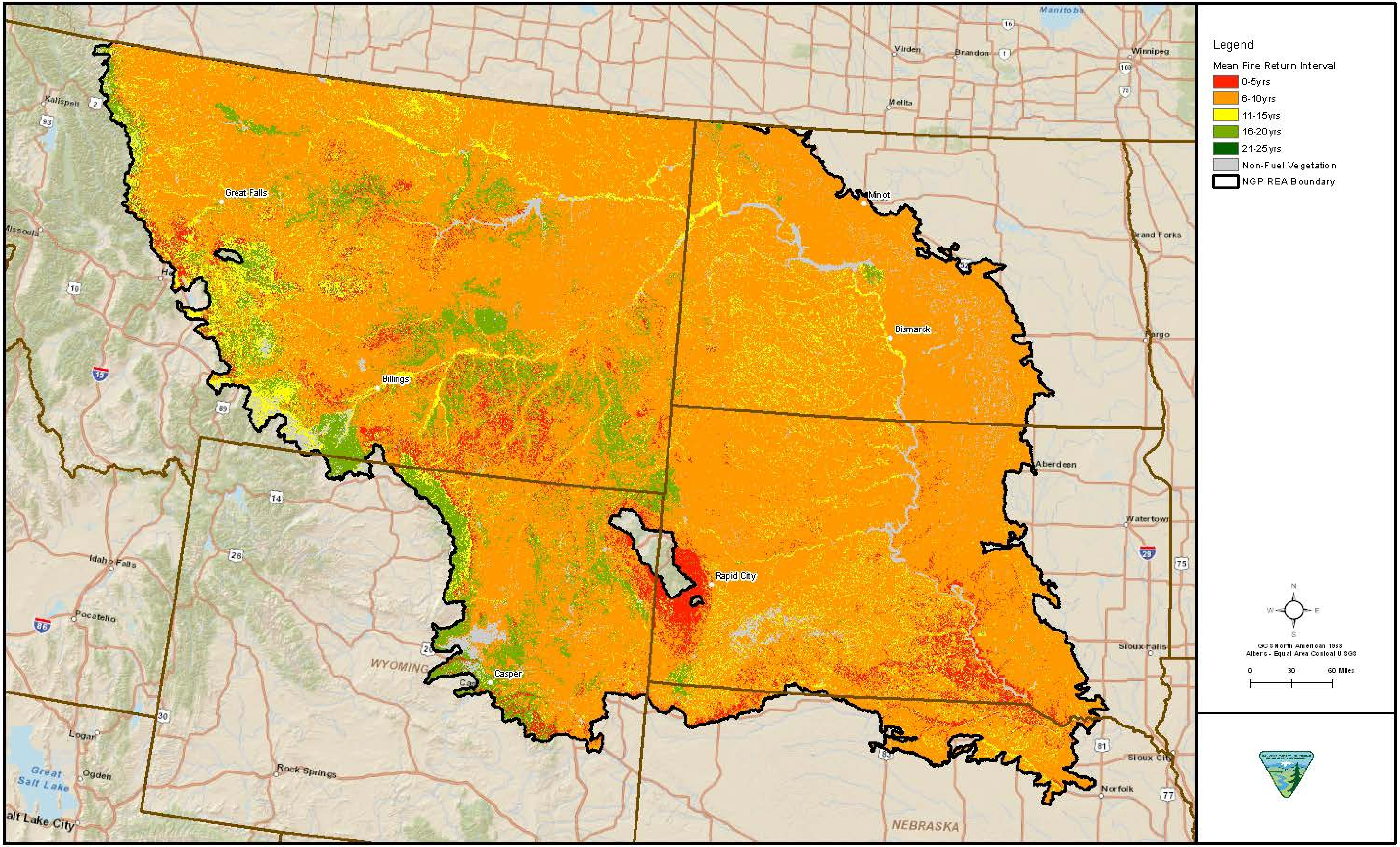

Figure C-2-9. Mean Fire Return Interval

U.S. Department of the Interior
Bureau of Land Management

Data Request Method

Rapid Ecoregional Assessments (REAs)—National Operations Center, CO

Individual REA data layers and some other products are still available but are no longer being published.

If you would like to obtain more information, including data and model zip files* (containing Esri ModelBuilder files for ArcGIS 10.x and relevant Python scripts), please email **BLM_OC_REA_Data_Portal_Feedback_Team@blm.gov**.
*Note that a few models require software that BLM does not provide such as R, Maxent, and TauDEM.

Models associated with individual REAs may require data links to be updated to function properly. REA reports, technical appendices, and model overviews (for some REAs) contain detailed information to determine what products are available and what datasets are necessary to run a certain model.

Please include the report name and any specific data information that you can provide with your request.

Other BLM data can be found on the Geospatial Business Platform Hub (https://gbp-blm-egis.hub.arcgis.com).