APPENDIX D

COARSE-FILTER CONSERVATION ELEMENT DESCRIPTIONS AND ANALYSES

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APPENDIX D-1

EVERGREEN FOREST WOODLAND COARSE-FILTER CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

Early in the Rapid Ecoregional Assessment (REA) process it was decided to evaluate major forest and woodland systems in the Northwestern Plains. However, due to the fact that the major insect threats are quite different for evergreen forests and deciduous forests, it was necessary to run the change agent (CA) analysis separately.

The evergreen forest woodlands vegetation system encompasses approximately three and a half percent of the Northwestern Plains ecoregion. Because some of the Gap Analysis Program (GAP) Level 3 systems comprise very small portions of the Northwestern Plains ecoregion, it was necessary to combine them so that they would be representative of major forest and woodland systems in the Northwestern Plains. The three categories of forest and woodland systems representing this coarse-filter conservation element (CE) include 1) deciduous, 2) evergreen and 3) riparian, with each of these categories containing representative GAP Level 3 systems as described below. The aggregation and crosswalk process for vegetation systems allows evaluation of a reduced number of coarse-filter CEs, while retaining the capability to evaluate nested geospatial data on every Level 3 mapping unit within or across divisions.

The evergreen forest woodland category is composed of the following GAP Level 3 systems: Northwestern Great Plains - Black Hills Ponderosa Pine Woodland and Savannah, Northern Rocky Mountain Ponderosa Pine Woodland and Savanna, Southern Rocky Mountain Ponderosa Pine Woodland, and Rocky Mountain Foothill Limber Pine – Juniper Woodland.

It is important to note that abrupt elevation gradients where prairies adjoin mountains both at the western margin of the Northwestern Plains ecoregion and in the mountain ranges that form “ecological islands” in the western part of the Northwestern Plains, there are significant differences in the Level 3 systems within the ecoregion boundaries depending on whether the HUC10 watershed buffer is included or not. This is because the watersheds within the buffer extend into the mountains toward the headwaters, causing some montane and subalpine ecosystems to be included within the buffered ecoregion boundaries. Although important ecotonal areas occur between the prairie and montane systems, these are represented in Level 3 Ecosystems that occur within the Northwestern Plains outside of the buffers as well as extending into the buffers and beyond. Examples are Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna, Rocky Mountain Foothill Limber Pine-Juniper Woodland, and Northern Rocky Mountain Foothill Conifer Wooded Steppe. These are included in the Evergreen Forest and Woodland category and retained in the coarse-filter analysis for the Northwestern Plains ecoregion.

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 those 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 was to identify suitable habitat for the CE within the ecoregion. Then, these areas were assessed relative to current and potential future CA threats. CAs considered in this analysis include climate change, wildfire, and insect outbreak and disease.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The evergreen forest woodlands coarse-filter CE for the Northwestern Plains is composed of five GAP Level 3 systems. These systems are listed and briefly explained below.

2.1 NORTHWESTERN GREAT PLAINS – BLACK HILLS PONDEROSA PINE WOODLAND AND SAVANNA

This system occurs primarily on gentle to steep slopes along escarpments, buttes, canyons, rock outcrops, or ravines and can grade into one of the Great Plains canyon systems or the surrounding prairie system. These woodlands can be physiognomically variable, ranging from very sparse patches of trees on drier sites, to nearly closed-canopy forest stands on north slopes or in draws where available soil moisture is higher (Montana Field Guide 2011a).

Woodlands dominated by Douglas-fir (*Pseudotsuga menziesii*) are found in the same ecological settings as ponderosa pine, and so are included in this system. In the breaks where it occurs, Douglas-fir has a very open canopy over graminoid undergrowth, predominantly composed of bluebunch wheatgrass (*Pseudoroegneria spicata*), with few to no shrubs present. In the absence of natural fire, periodic prescribed burns, selective thinning, and reduction of ladder and basal fuels to prevent crown fires can be used to maintain and restore this system to similar pre-settlement conditions (Montana Field Guide 2011a).

Threats to the system include surface fires, frequent on drier sites, and invasive cheatgrass (*Bromus tectorum*) induced by reduced associated grasses from grazing livestock (Montana Field Guide 2011a).

2.1 NORTHERN ROCKY MOUNTAIN PONDEROSA PINE WOODLAND AND SAVANNA

This system occurs on warm, dry, exposed sites in the foothills of the Rocky Mountains in west-central and central Montana, at the ecotone between grasslands or shrublands and more mesic coniferous forests. Elevations range from 1,066 to 1,676 meters (3,500-5,500 feet), with higher elevation examples mostly confined to central Montana. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. True savanna types are infrequent; the system is more characteristically an open forest with a grassy understory.

Ponderosa pine (*Pinus ponderosa*) is the dominant conifer. Douglas-fir (*Pseudotsuga menziesii*) and western larch (*Larix occidentalis*) may be present in the tree canopy in the more western areas, but are usually absent. In some areas, limber pine (*Pinus flexilis*) and horizontal juniper (*Juniperus horizontalis*) are frequently components. Although the understory of ponderosa pine forests is often shrubby or are mostly dominated by graminoids, although bitterbrush (*Purshia tridentata*), white snowberry (*Symphoricarpos albus*), and skunkrush (*Rhus trilobata*) occur in forests on benchlands and rocky slopes in the central portion of the state. Understory vegetation is more typically grasses and forbs that resprout following low to moderate intensity surface fires. Prolonged drought, beetle kill and exotic invasion are rapidly changing the dynamics of this system (Montana Field Guide 2012).

2.2 SOUTHERN ROCKY MOUNTAIN PONDEROSA PINE WOODLAND

This system intergrades with Rocky Mountain Ponderosa Pine Savanna. The two are distinguished by the high frequency, surface-fire regime, less steep or rocky environmental setting, and more open grassy understory structure of the savanna system. Like the northern system, these matrix-forming woodlands also occur at the lower treeline/ecotone between forest and woodlands or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. This system can occur on all slopes and aspects; however, it commonly occurs on moderately steep to very steep slopes or ridgetops. Vegetation is conifer dominant with a shrubby understory and grasses (Colorado Natural Heritage Program 2005).

Historically, ground fires and drought were influential in maintaining open-canopy conditions in these woodlands. With settlement and subsequent fire suppression, occurrences have become denser. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires (Reid et al. 1999).

2.3 ROCKY MOUNTAIN FOOTHILL LIMBER PINE – JUNIPER WOODLAND

These systems occur below continuous forests of Douglas-fir or ponderosa and lodgepole pine in the foothills, and can occur in large stands well within the zone of continuous forests in the northern Rocky Mountains. Climate is characterized by a relatively small amount of precipitation, with the wettest months during the growing season, very low humidity, and wide annual and diurnal temperature ranges (Montana Field Guide 2011b).

Vegetation is characterized by an open-tree canopy or patchy woodland. This system often occurs in complex ecotones on severe sites within other forest systems. It often intergrades with Rocky Mountain Dry-Mesic Montane Mixed Conifer, Rocky Mountain Lower Montane, Foothill and Valley Forest and woodlands, Mountain Mahogany Woodland and Shrubland, and Montane Sagebrush Steppe.

Major disturbances in this system include fire, soil erosion from over-used range, and biotic vectors. These woodlands often originate with and are likely maintained by fire (Montana Field Guide 2011b).

3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

3.1 DATA IDENTIFICATION

The major datasets identified to map the distribution of the evergreen forest woodland CE were the GAP and Regional Gap Analysis Program (ReGAP) landcover and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) datasets. These datasets had adequate coverage across the ecoregion and have been used in similar analyses. The evergreen forest woodland distribution datasets are further described in Table D-1-1.

Table D-1-1. Data Sources for the Evergreen Forest Woodland Coarse-Filter Conservation Element Distribution Mapping for the Northwestern Plains Ecoregion

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	GAP Land Cover Northwest ReGAP North Central GAP	U.S. Geological Survey (USGS)	Raster (30-meter [m])	Acquired	Yes
	LANDFIRE	LANDFIRE	Raster	Acquired	No
Soils Data	Soil Survey Geographic (SSURGO) State Soil Geographic (STATSGO2)	U.S. Department of Agriculture (USDA)	Raster or Polygon	Acquired	No

3.2 DISTRIBUTION MAPPING METHODS

To map distribution of evergreen forest woodlands in the Northwestern Plains ecoregion, Science Applications International Corporation (SAIC) used a mosaic of GAP data sources, including two of the National GAP landcover regions, the Northwest and North Central. The source data for the Northwest region was the Northwest ReGAP dataset that improved upon the original Northwest GAP. The North Central region contains states that have not been covered by a ReGAP project. For these areas the National GAP layer used data from the LANDFIRE project to create a seamless layer. The GAP was developed to help answer questions about species biodiversity and species habitat (USGS 2010). Its overall goal is to assist resource managers in decision making when there is a lack of information about the full range of species on the landscape. Once the data were downloaded, the two datasets were merged together to form a continuous layer of vegetation data across the four states. The continuous data layer was then clipped to the Northwestern Plains ecoregion, at which point the Level 3 systems were extracted for review by the Rolling Review Team (RRT) (Figure D-1-1).

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4.0 CONCEPTUAL MODEL

The current status and potential future threat analyses were based on the system-level conceptual models, selected environmental variables Key Ecological Attributes (KEAs) likely to be at risk from the CAs, and the availability of data.

4.1 SYSTEM-LEVEL CONCEPTUAL MODEL

The system-level conceptual model for the Northwestern Plains evergreen forest woodland system (Figure D-1-2) illustrates the major drivers across the top. The major drivers dictate where these vegetation systems occur throughout the ecoregion, while the CAs focus on what has potential to affect this CE over time. Below the CAs are the corresponding CA pathways that affect both the status and distribution of this CE across the Northwestern Plains ecoregion. Listed below the CA pathways are the three categories of size, context, and condition for development of the KEAs for this coarse filter CE. The KEAs were developed and refined through the rolling review process.

4.1.1 Wildfire

Presettlement fires were frequent in ponderosa and limber pine producing savanna-like landscapes. Present conditions and fire suppression have resulted in decreased stand diversity and increased fuel loads and stand densities. This has led to hotter crown fires occurring more frequently and over larger acreage when compared to historic fire patterns. Mortality due to bark beetles is also increasing fuel loads, creating conditions for severe, large-scale, catastrophic fires.

4.1.2 Insect Outbreaks and Disease

Native bark beetles such as the mountain pine beetle (MPB) are threats to ponderosa pine, and limber pine, with regular infestations occurring over centuries. However, more recently there have been significant outbreaks of MPB in the Black Hills every 11–20 years. Outbreaks occur when environmental conditions such as warmer temperatures promote large beetle populations and large numbers of susceptible host trees are available. MPB is a native species that has unique eruption outbreak characteristics and historically was largely confined to lower elevation lodgepole and ponderosa forests except during abnormal climatic events (Logan et al 2010, Raffa et al. 2008). MPB also attacks larger trees, generally those of reproductive age, and must attack in mass in order to overcome the tree's defenses, so developmental synchronization (fostered by thermal regimes) and adult communications that coordinate a mass attack are critical to its success (Raffa et al. 2008). MPB is endemic in lodgepole-ponderosa pine forests and periodically temperature-driven eruptive outbreaks occur in these forests.

Western spruce budworm (WSBW) is also a defoliator in the Northwestern Plains. Repeated defoliation events can decrease tree growth, cause mortality, or increase susceptibility of trees to other damage agents such as bark beetles.

4.1.3 Climate Change

Global climate change (GCC) effects and natural fire regimes are thought to have complex interactions with biotic mortality/damage agents. GCC is predicted to drive the upper tree line to higher elevations, although there may be local thermal refugia due to cold air drainage and aspect. Increased winter temperatures, longer growing seasons, and increased drought during the growing season may be playing major roles in MPB outbreaks. Fuel loads and fire return intervals and severity may also be affected by GCC. GCC appears to exacerbate the effects of wildland fire and MPB outbreaks. Changes in precipitation and temperature are predicted to lead to more frequent drought stress on lodgepole-ponderosa pine forests, which will lead to greater vulnerability to MPB; this will in turn alter fuel loads and the fire regime, and consequently, the age structure of woodlands and forests.

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5.0 CHANGE AGENT ANALYSIS

A CA analysis was conducted on the evergreen CE for the Northwestern Plains Ecoregion with the native 30-meter (m) raster data as the analysis unit. Based on the system-level model, 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. 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.

Since the scale of the reporting unit is at the Hydrologic Unit Code (HUC) 12, a layer of 6th 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. The intermediate CA layers were then combined together to form a single layer outlining the current status or future threat status for each HUC.

Although numerous preliminary KEAs and indicators that may affect the evergreen forest woodlands were initially identified in the early phases of the REA, not all were included in this analysis because either the attribute or indicator was not suitable for a landscape level analysis or because data are not available to support the analysis. The specific indicators that could not be modeled are identified with an asterisk in Figure D-1-2. Further information on the data gaps for these indicators are discussed in the respective CA analyses contained in Appendix C.

For the KEAs that were determined to be duplicative, some were pixel-based versus others being HUC-based, and others did not show any differentiation across the ecoregion. Table D-1-2 identifies the original KEAs and which of those were used in the final CA analysis.

Table D-1-2. Key Ecological Attribute Retained or Excluded

Category	Key Ecological Attribute		Explanation
1. Size	a.	Size of Patches	This analysis was completed but not used because the RRT determined this was more of a fine filter wildlife MQ.
2. Condition	a.	Vegetation Condition Class (VCC)	Retained to show the vegetation and fire regime departure in the ecoregion.
	b.	Invasive Species	Dropped due to insufficient data.
	c.	Insect Outbreak	Retained to show current outbreak of major insect threats in the ecoregion and future risk of outbreaks.
	d.	Future Protection	The analysis using the PADS database was excluded because it did not capture the complexity of the issue/risk factor
3. Structure	a.	Fragmentation	Retained to show the fragmentation throughout the ecoregion.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

Table D-1-3 identifies the KEAs, indicators, and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion. The evergreen forest woodland process analysis is designed to create a series of intermediate layers that are primarily based on the wildfire and insect and disease outbreak CAs. The analysis is based on the geospatial data that was available.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

For each of the KEAs listed in Table D-1-3, 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 the evergreen forests (Table D-1-3). This table was limited to size and landscape context based on spatially-available attributes and key factors affecting this CE.

Table D-1-3. Key Ecological Attribute Table for the Evergreen Forest Woodland Coarse-Filter Conservation Element for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation	Weight
			Poor = 3	Fair = 2	Good = 1			
Landscape Structure	Structure	VCC	VCC 3	VCC 2	VCC 1	LANDFIRE	RRT Guidance	0.25
Landscape Condition	Insect outbreak	MPB Infestation	>62%	18-62%	0-18%	Aerial Detection Survey (ADS)	RRT Guidance (Natural Breaks)	0.25
	Insect outbreak	"Other Beetle" Infestation	>46%	7-46%	0-7%	ADS	RRT Guidance (Natural Breaks)	0.25
	Insect outbreak	WSBW Infestation	>63%	17-63%	0-17%	ADS	RRT Guidance (Natural Breaks)	0.25

Analysis Unit = 30-m pixel
Reporting Unit = 6th level HUC

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 Forest and Woodlands RRT comprised of BLM foresters. 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. Weights were attributed to each metric in order to provide an overall score for all metrics combined, based on the reporting unit.

After much discussion, the evergreen forest woodlands RRT decided not to include patch size in the current status assessment. The decision was primarily made because there is no literature on optimum patch size for evergreen forest woodlands. All literature is focused on wildlife habitat requirements, which would be included in the fine-filter CE analysis.

5.1.1.1 Vegetation Condition Class

For landscape structure, the LANDFIRE Vegetation Condition Class (VCC) data were used to show changes in vegetation and fuels from their historical condition. The VCC shows changes in vegetation and fire regimes. From these data, assumptions were made to classify evergreen forest woodland with higher potential of uncharacteristic wildland fires.

The VCC layer was extracted to the evergreen forest woodland layer. The data were already categorical, so VCC departure 1 was good, VCC departure 2 was fair, and VCC departure 3 was poor. All other values were given a zero. The evergreen forest woodland VCC layer is displayed in Figure D-1-3.

5.1.1.2 Insect Outbreak

The bark beetles and the WSBW CAs are the greatest threats to evergreen forest woodlands. The Assessment Management Team (AMT) noted that the MPB is the most serious problem in the ecoregion; therefore, the RRT suggested we analyze MPB separate from other beetles and WSBW. For the purposes of this analysis, "other beetles" that pose significant insect threats are the Douglas-fir beetle, Douglas-fir engraver beetle, pine engraver beetle, and spruce beetle. These beetles were combined together and analyzed as one threat for current status.

The U.S. Forest Service (USFS) Aerial Detection Survey (ADS) polygon data from 1994-2010 were used to map the insect presence in the evergreen forest woodlands. The vector layers were converted to raster so they could be overlayed on the evergreen forest woodlands 30-m raster data. Zonal statistics were then run to determine the amount of infestation on evergreen forest woodland patches. The higher the percent infestation calculated from the analysis, the worse the score. The three classes of good, fair, and poor were determined using natural breaks. Natural breaks classes are based on natural groupings inherent in the data. Class breaks are identified that best group similar values and that maximize the differences between classes.

Figures D-1-4 through D-1-6 show the insect infestation score maps. Red displays patches with higher infestation, while green shows lower infestation.

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 evergreen forest woodlands habitat for each HUC across the Northwestern Plains ecoregion. A method of aggregating scores was used to summarize overall threats with regard to evergreen forest woodland habitat quality. Individual indicators can identify areas of potential risk to evergreen forest woodlands, but aggregated scores can provide important information with relation to areas where evergreen forest woodlands might encounter multiple CAs.

In order to create a combined score for each HUC unit based on varying levels of importance for each KEA, it is necessary to aggregate the data through a weighting process. The weighted sum tool was used to combine each analysis input map to create an overall current status map (Figure D-1-7). Equal weights were used when summing the threats for the evergreen forest woodlands.

The resulting output gives each evergreen forest woodland 30-m pixel a score based on current status. Figure D-1-7 displays these results; red indicates areas of poor status, while green indicates areas rated at better current status based on the measured attributes.

The overall threat score for each 6th level HUC was assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. Statistics were run on the results from Figure D-1-7 to determine the average overall score. The overall result was then scored based on natural breaks. A higher overall threat score would result in a rating of “poor” for the HUC, indicating that there are existing threats to the evergreen forest woodlands based on the KEA metrics.

It should be noted that when displaying results at the 6th level HUC watershed, a few isolated 30-m pixels will determine the score for that watershed, thus potentially scoring a watershed as poor; however, this may be misrepresentative due to the lack of pixels classified as that vegetation type.

The results of the current status analysis based on the 6th level HUC for the ecoregion are presented in Figure D-1-8. The overall current status results indicate predominately good-to-fair scores across the range of evergreen forest woodlands within this ecoregion. Areas that appear most susceptible to current threats occur in the southern portion of the Black Hills and the areas surrounding the Bitterroot Mountain range. The overall status of evergreen forest woodlands is also characterized by distribution rather than by HUC (Figure D-1-7). This provides a detailed look at the threat scores on a cell-by-cell basis. The results of this detailed analysis indicate similar results to those of the HUC level analysis. The results of the VCC analysis (Figure D-1-3) suggest that these same areas have undergone a partial departure from natural forest ecosystems, as indicated by a fair score. Evergreen forests within the central portion of Montana appear more susceptible to this departure. Figure D-1-4 displays the effects of MPB on evergreen forests within the ecoregion. Other beetle infestations are limited to the Black Hills region (Figure D-1-5). Beetle infestations appear to be centralized around the same areas as the other threats. WSBW infestation appear to be limited to the Bitterroot Mountain range, with other small evergreen forest stands experiencing significant levels of infestation in southwestern Montana.

A summary of the current status ratings based on the CE distribution is provided in Table D-1-4. 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 50 percent of the 6th level HUC watersheds that intersect the evergreen forest distribution received an overall rating of good, 46 percent of the HUCs received an overall rating of fair, and only a small percentage (4.3 percent) received an overall rating of poor.

Table D-1-4. Summary of Current Status Ratings for the Evergreen Forest System

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	62,908	49.7
Fair	58,137	46.0
Poor	5,433	4.3

[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

Future threat analysis was conducted for development, insect outbreak and disease, and climate change. 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. Further details regarding the climate change analysis is contained in Appendix C-5.

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 Conservation Element-Specific Future Threats Analysis for Development and Insect Outbreak and Disease

5.2.1.1 Key Ecological Attribute Data Analysis for Future Threat Status

Table D-1-5 identifies the KEAs, indicators, and metrics that were used to evaluate the future threat CAs and pathways affecting this CE across the ecoregion, as illustrated in Figure D-1-1. The evergreen forest woodland analysis is designed to create a series of intermediate layers that are primarily based on geospatial data that was available on the future projections for the CAs impacting this CE (Table D-1-5). Future KEAs were determined primarily by the availability of data relevant to the future status of the evergreen forest woodland.

Table D-1-5. Evergreen Forest Woodlands Coarse-Filter Conservation Element Future Threat Attributes, Indicators, and Metrics for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation	Weight
			Poor = 3	Fair = 2	Good = 1			
Landscape Structure	Fragmentation	Distance Decay Proximity to anthropogenic layer	<0.31 miles	0.31-1.55 miles	>1.55 miles	TIGER, ICLUS	RRT Guidance	0.33
Landscape Condition	Insect Outbreak	Proximity to Insect Infestation	Insect Presence	0-2 miles	>2 miles	ADS	RRT Guidance based on Data	0.33

Analysis Unit = 30-m pixel
Reporting Unit = 6th level HUC

As with the current status analysis, the main CAs likely to impact the evergreen forest woodland are the MBP, WSBW, Douglas-fir beetle, Douglas-fir engraver beetle, pine engraver beetle, and spruce beetle. There are no future models available for future insect/disease. Therefore, existing data were used based on several assumptions. For example, it is assumed that the closer an evergreen forest woodland stand is to an existing outbreak, the more likely it will be infested in the future. These insects were combined together and analyzed as one threat. For the future threat analysis, all insects were combined into one layer. The future threat analysis also investigated risk of further fragmentation due to anthropogenic data.

5.2.1.2 Fragmentation Potential

Originally, SAIC created a forest fragmentation index using a neighborhood analysis on the evergreen forest woodland layer. The analysis looked at each pixel that is classified as evergreen forest woodland and its neighbors. A 10x10 neighborhood was used for this analysis. There is no literature specific to the moving window size for this type of analysis. Several other windows were looked at, but the 10x10 window seemed most appropriate. The index is based on the number of evergreen forest woodland pixels surrounding each other.

This was presented to the RRT, but it was decided to use a distance decay method to determine potential fragmentation based on the proximity to development. The Integrated Climate and Land-Use Scenarios (ICLUS) 2030 was used by extracting the urban, exurban, and industrial categories and then merging the Topologically Integrated Geographic Encoding and Referencing (TIGER) roads for the entire ecoregion. A Euclidean distance proximity analysis was run from this anthropogenic layer and then scored. To maintain consistency with other coarse-filter analyses, scoring was based on KEAs from other coarse-filters in the ecoregion. The resulting scoring classifications can be found in Table D-1-4. The fragmentation potential for the evergreen system is presented in Figure D-1-9.

5.2.1.3 Proximity to Insect Infestation

A Euclidean distance proximity analysis was run from the 1994-2010 USFS ADS polygon data. This analysis was completed based on the assumption the evergreen forest woodland stands closer to infestations are at higher risk in the future. The proximity analysis was extracted to the evergreen forest woodland and then scored based on Table D-1-4. The original scoring classification values were provided by the RRT. Those values were 0-5 miles = poor, 5-10 miles = fair, and >10 miles = good. However, with these values almost all evergreen patches were poor. SAIC then re-classified the data using 0-2 miles = poor, resulting in most patches still rated as poor. The data were also evaluated using a quantile classification, resulting in patches with an infestation rated poor. Areas within 2 miles of an infested patch were scored fair and patches greater than 2 miles were scored good. This analysis was presented and accepted by the RRT. The proximity to insect infestation for the evergreen system is presented in Figure D-1-10.

5.2.2 Future Threats Overall Score

The future overall score was compiled using the methods described in Section 5. The resulting output gives each evergreen forest woodland 30-m pixel a score based on future threat. Figure D-1-12 displays the overall combined score for future threats to evergreen forest woodlands and Figure D-1-13 displays the overall combined score by 12-digit HUC. Equal weights were used when summing the threats for evergreen forest woodland.

The overall future threat map indicates predominately fair-to-poor habitat conditions based on potential development and insect outbreak in middle portions of the Northwestern Great Plains for the evergreen forest woodlands. Areas in the north-central portion of the ecoregion west of Billings scored very poorly. Areas to the south of the Black Hills National Forest and areas in the northwest of the ecoregion also scored poorly. It should be noted that the majority of these areas fall in the 5th level HUC buffer and, in actuality, fall in the Middle Rockies ecoregion.

The results of fragmentation potential analysis (Figure D-1-9) indicate a fairly high potential of future fragmentation resulting from proximity to roads and urban areas. Southern areas of the Black Hills National forest appear to be at higher risk for fragmentation. Though much of these areas are in a national forest and are protected, it could be used to highlight areas of declining connectivity and a reduction in forest interior. The insect proximity analysis (Figure D-1-10) indicates that forests in the central and northwest portions of the ecoregion are at higher risk for insect infestation. Areas along the Black Hills National forest scored fair for future risk of infestation. Based on recent insect outbreaks the predicted increase in temperatures, it is likely that the continued trend of severe bark beetle outbreaks will occur.

5.2.3 Development Change Agent

The ecoregion-wide future threat analysis was conducted (as presented in Appendix C-1) in addition to the KEA-specific analysis for development for this specific CE. For this broad assessment, development was limited to potential energy development and climate change, as this coarse filter appears to be at low risk from the threats of modeled urban growth (based on the modeled growth for the ecoregion [Figure C-1-8]) and potential agricultural development in forested areas.

5.2.3.1 Oil Production Potential

The future analysis characterized potential oil production areas rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential effect 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 effect of potential oil production areas on evergreen forest woodlands.

Most of the evergreen forest woodlands in this ecoregion are at low risk from potential oil production. The majority of potential oil production is limited to lower elevation areas in northeastern Wyoming. However, evergreen forests could be at high risk in these areas for potential 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.

5.2.3.2 Natural Gas Production Potential

The future analysis characterized potential gas production areas 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 effect of potential gas production areas on evergreen forest woodlands.

Most of the evergreen forest woodlands in this ecoregion are at low risk from potential gas production. The majority of potential gas production is limited to lower elevation areas in northeastern Wyoming. There is an area in north central Montana that has a moderate potential for natural gas development, but, from an ecoregional scale, it appears that evergreen forest woodlands are at a low risk from future natural gas development.

5.2.3.3 Future Potential for Solar Development

As with wind energy, developers are less likely to site solar farms in forested areas versus more open areas. In addition, the elevations where this CE occurs are not conducive to 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). Although these maps are very crude, the highest potential for solar development is shown to occur primarily outside of the evergreen forest woodland distribution area. However, these are relatively minor disturbances and it does

not appear that evergreen forest woodlands are at a high risk from future solar development, with the exception of some areas in the southwestern portion of this ecoregion.

5.2.3.4 Wind Turbine Potential

Wind energy development does not appear to be a probable threat to forests because developers would more likely site wind farms on open lands where clearing would not be required. However, the wind turbine potential map is presented in Figure C-1-7. Higher elevations within this ecoregion would be more susceptible to the threat of wind turbine development do to the higher wind speed levels within these areas. However, limited accessibility to these areas could limit the range of wind turbine development to lower-elevation mountainous regions.

Due to location, evergreen forest appear to be at a low risk from potential wind turbine development.

5.2.3.5 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). Based on the EPCA gas data layer, most of the evergreen forest woodlands in the ecoregion are at low risk by fossil fuels 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 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 the species by their effect on habitat availability. 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 evergreen forest woodlands, a limited approach must be taken in this analysis. The majority of the evergreen forest woodlands in this ecoregion are considered to be at a low risk from potential renewable energy production.

5.2.4 Climate Change Future Threats

It remains difficult to draw conclusions from the climate change 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.

Increasing temperatures due to climate change allow more time for the MBP to complete its life cycle, which allows populations to grow more quickly than in the past (Bentz et al. 2007). The climate change figures contained in Appendix C-5 show an increase in the temperatures predicted to 2060. Increases in the mean annual temperature in the Northwestern Plains ecoregion are predicted to range from 1.9-2.4 degrees Celsius (^{o}C). Based on the current trends of increased outbreaks associated with increased temperatures, it is assumed that there will be a higher population of MPB in the evergreen forest woodlands, likely increasing mortality.

In addition, the climate change figures contained in Appendix C show the model for predicted precipitation change to 2060. In general, the model shows large (76-125 millimeters [mm]) annual increases in precipitation in the southeast corner of the ecoregion with decreases of up to 51 mm in the southwest corner of the ecoregion. These changes, coupled with the predicted increase in temperatures and altered fire regimes, could result in more frequent and severe fires.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the evergreen forest woodland systems would include those defined as part of the Terrestrial Biotic Resources category. The overall MQ was: Where are the important regionally significant terrestrial 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 evergreen forest woodland distribution model. 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 this REA.

6.1 HOW ARE EVERGREEN FOREST WOODLAND SYSTEMS DISTRIBUTED OVER THE LANDSCAPE?

Figure D-1-1 maps the ReGAP evergreen forest woodland systems across the ecoregion.

6.2 WHERE WILL CURRENT CONSERVATION ELEMENT VEGETATION TYPES BE AT GREATEST RISK FROM CHANGE AGENTS?

The full range of figures and analyses for evergreen forest woodland systems can be used to answer this complex MQ. The models created throughout this process were created to directly address the effects of CAs on evergreen forest woodland systems. All of the CAs were addressed spatially and described in detail in this section. The CAs were also spatially attributed to the distribution of the evergreen forest woodland. Figure D-1-11 represents the sum of Figures D-1-9 and D-1-10 by the 30 m analysis unit, while Figure D-1-12 represents the sum of all the threats at the 12-digit HUC reporting unit.

6.3 WHAT AREAS HAVE POTENTIAL FOR RESTORING CONSERVATION ELEMENT SPECIES HABITAT OR HABITAT CONNECTIVITY FOR CONSERVATION ELEMENT SPECIES, CURRENTLY AND IN THE FUTURE?

The fragmentation potential (Figure D-1-9) represents the potential for further fragmented evergreen forest woodland systems. It can also be used to show areas where future restoration may be the most beneficial. The fragmentation potential shows areas where restoration could potentially connect larger stands together.

6.4 WHERE WILL CONSERVATION ELEMENTS BE AT RISK FROM ALTERED FIRE REGIMES? WHERE ARE AREAS WITH POTENTIAL TO SHOW FUTURE INCREASES OR DECREASES IN WILDFIRE FREQUENCY OR INTENSITY?

Figure D-1-3 represents the VCC for the evergreen forest woodland. This figure represents changes in vegetation and fuels from their historical condition. For the Northwestern Plains, a group of subject matter experts (SMEs) went through an exercise to illustrate fire regime (frequency and severity) departure. The historic biophysical setting (BpS) was attributed with a current fire severity and frequency, then compared with the reference (historic) fire frequency and severity for each type. From these data, we were able to develop a fire frequency departure map, a fire severity departure map, and then a composite map (which took the highest of either departure). This modified composite layer was used as the best indicator for potential threats to evergreen forest and woodlands from an uncharacteristic fire.

6.5 WHICH INSECTS AND DISEASES MIGHT POSE A SIGNIFICANT FUTURE PROBLEM?

The bark beetle and WSBW are the greatest threats to the future of evergreen forest woodland systems. Figure D-1-10 displays evergreen forest woodlands in close proximity to current infestations. The

assumption is that the evergreen forest woodland stands in close proximity to infestations are at risk in the future. Red displays patches with higher MPB infestation, while green shows lower infestation.

6.6 WHERE WILL STATE AND FEDERAL HIGH-VALUED RESOURCE AREAS BE EFFECTED BY CHANGES IN INTENSITY AND RANGE OF INSECTS AND DISEASE?

The MBP and the WPBR are the greatest threats to the future of the evergreen forest woodland systems. Figure D-1-10 displays evergreen forest woodlands in close proximity to current MPB and WPBR infestations. It is assumed that evergreen forest woodlands in close proximity to MBP and WPBR infestations are at risk in the future. Red displays patches with higher MPB infestation, while green shows lower infestation.

6.7 HOW AND WHERE ARE FREQUENCY AND SEVERITY OF OUTBREAKS EXPECTED TO CHANGE IN RESPONSE TO CLIMATE CHANGE AND OTHER CHANGE AGENTS SUCH AS CHANGE IN FIRE FREQUENCY?

Based on the predicted increase in temperatures shown on the climate change models discussed in Appendix C-5, it is likely that the continued trend of severe bark beetle outbreaks will occur. The climate change models predict a temperature increase across the entire ecoregion; however, it predicts a somewhat gradual gradient of higher temperatures from north to south. In addition, warming seasonal temperatures could increase the likelihood of more severe fires due to current fire regime departures.

6.8 WHERE ARE THE STANDS OF MAJOR TREE SPECIES THAT HAVE NOT BEEN IMPACTED BY INSECTS OR DISEASES?

Figures D-1-4 through D-1-6 display current infestation of the major insect threats to the evergreen forest woodland systems. Areas in green are stands that have been less impacted by insect infestation.

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APPENDIX D-1

FIGURES

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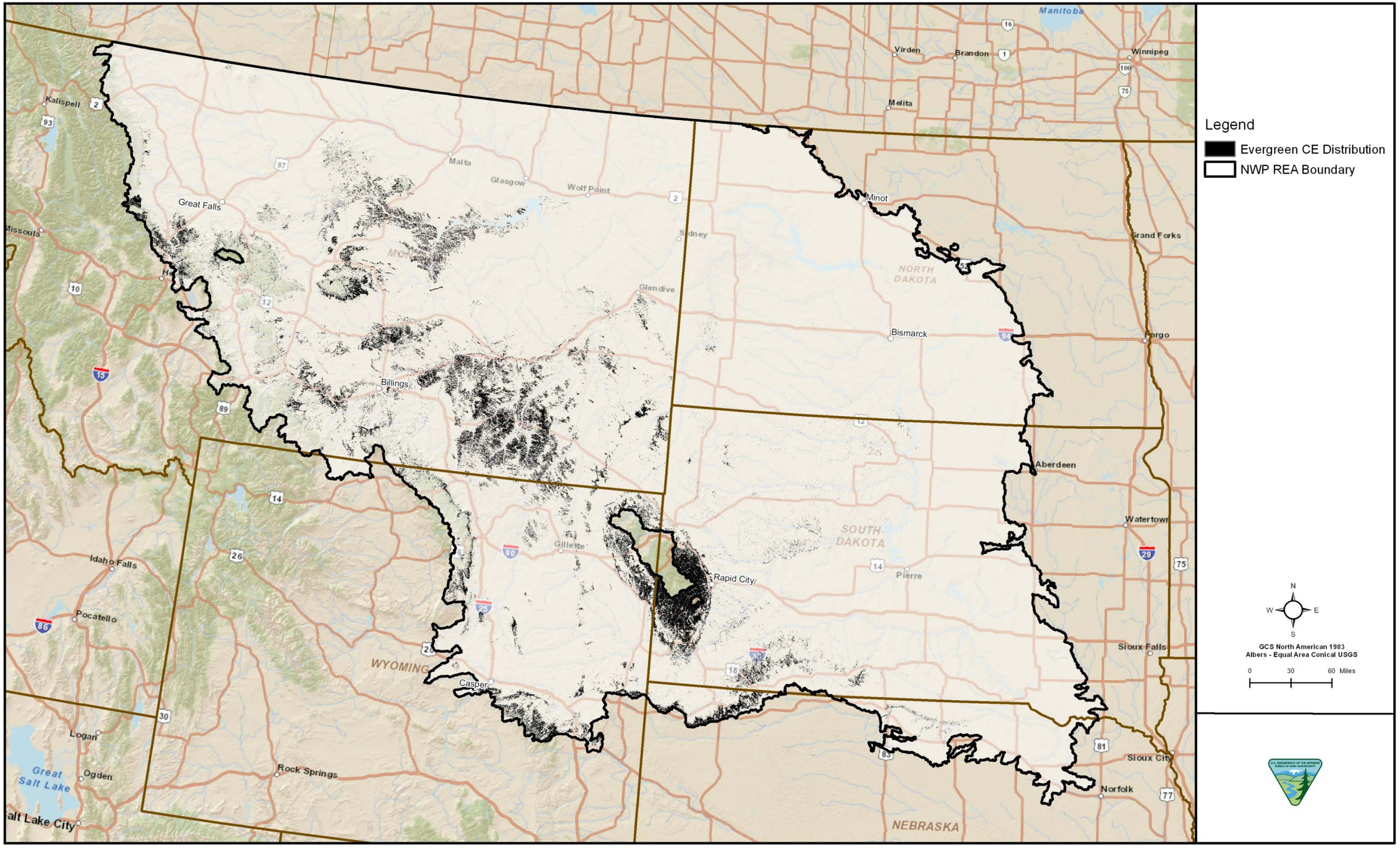

Figure D-1-1. Northwestern Plains Evergreen Distribution

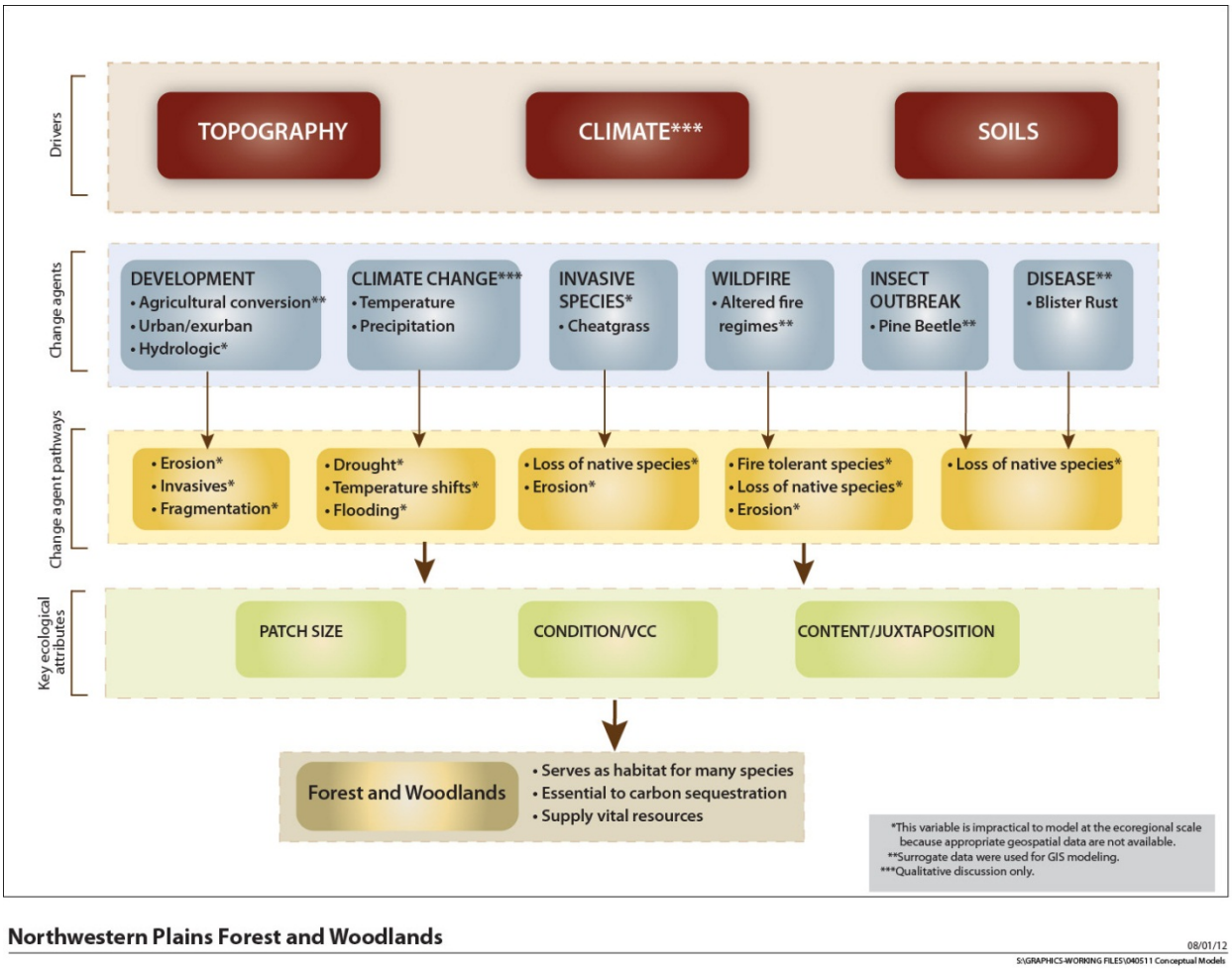

Figure D-1-2. Northwestern Plains Evergreen System-Level Model

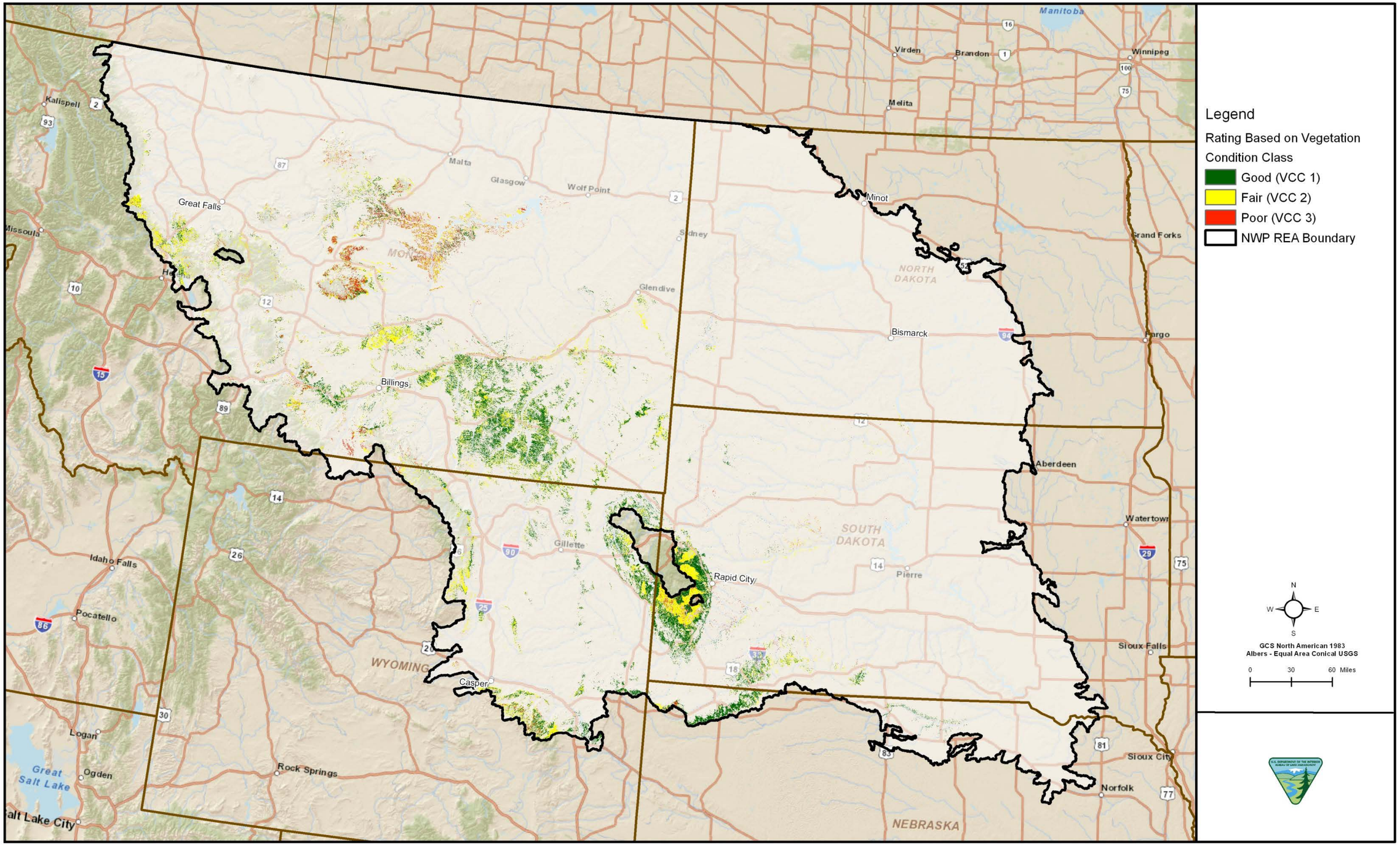

Figure D-1-3. Northwestern Plains Evergreen Vegetation Condition Class

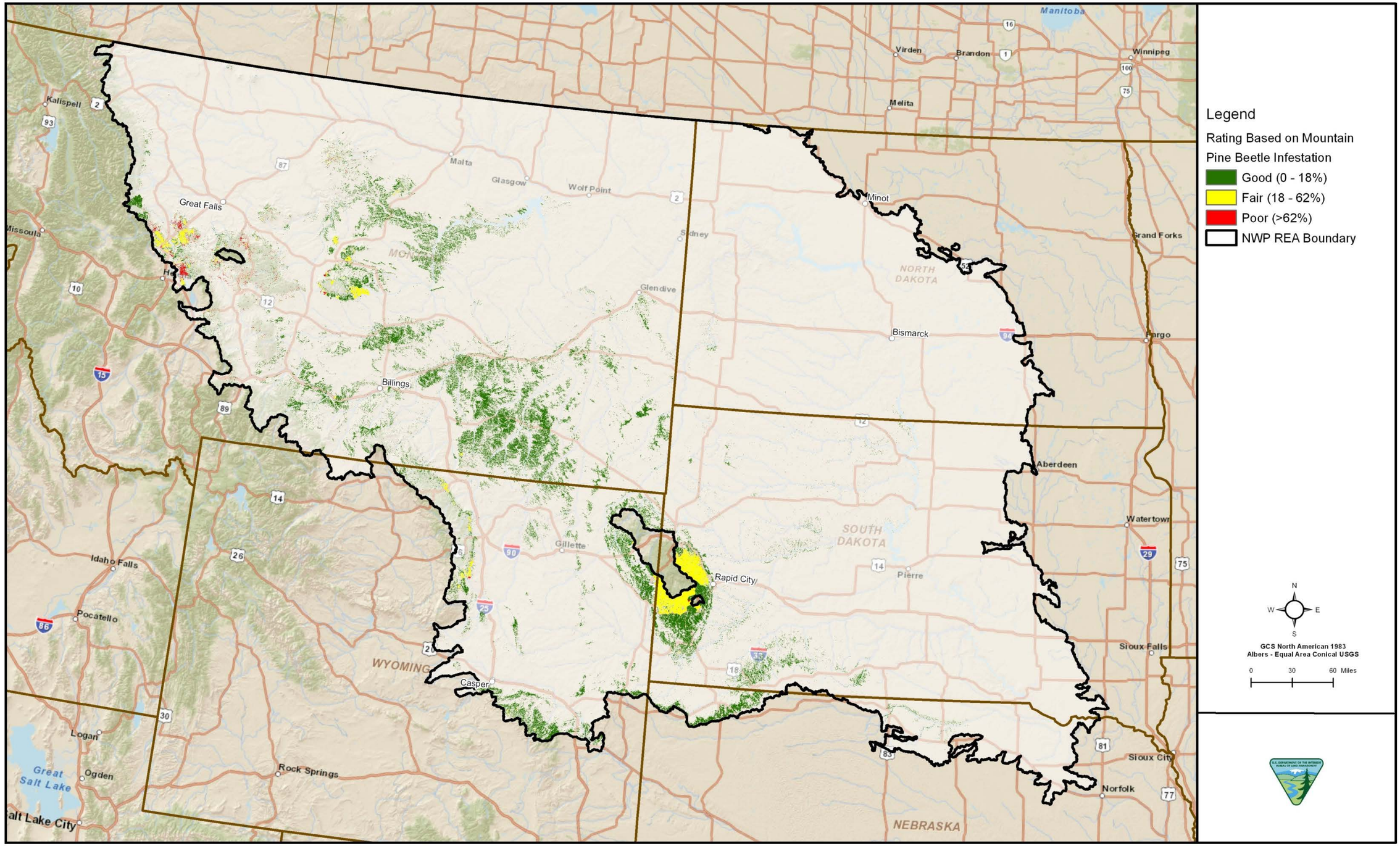

Figure D-1-4. Northwestern Plains Evergreen Mountain Pine Beetle Infestation

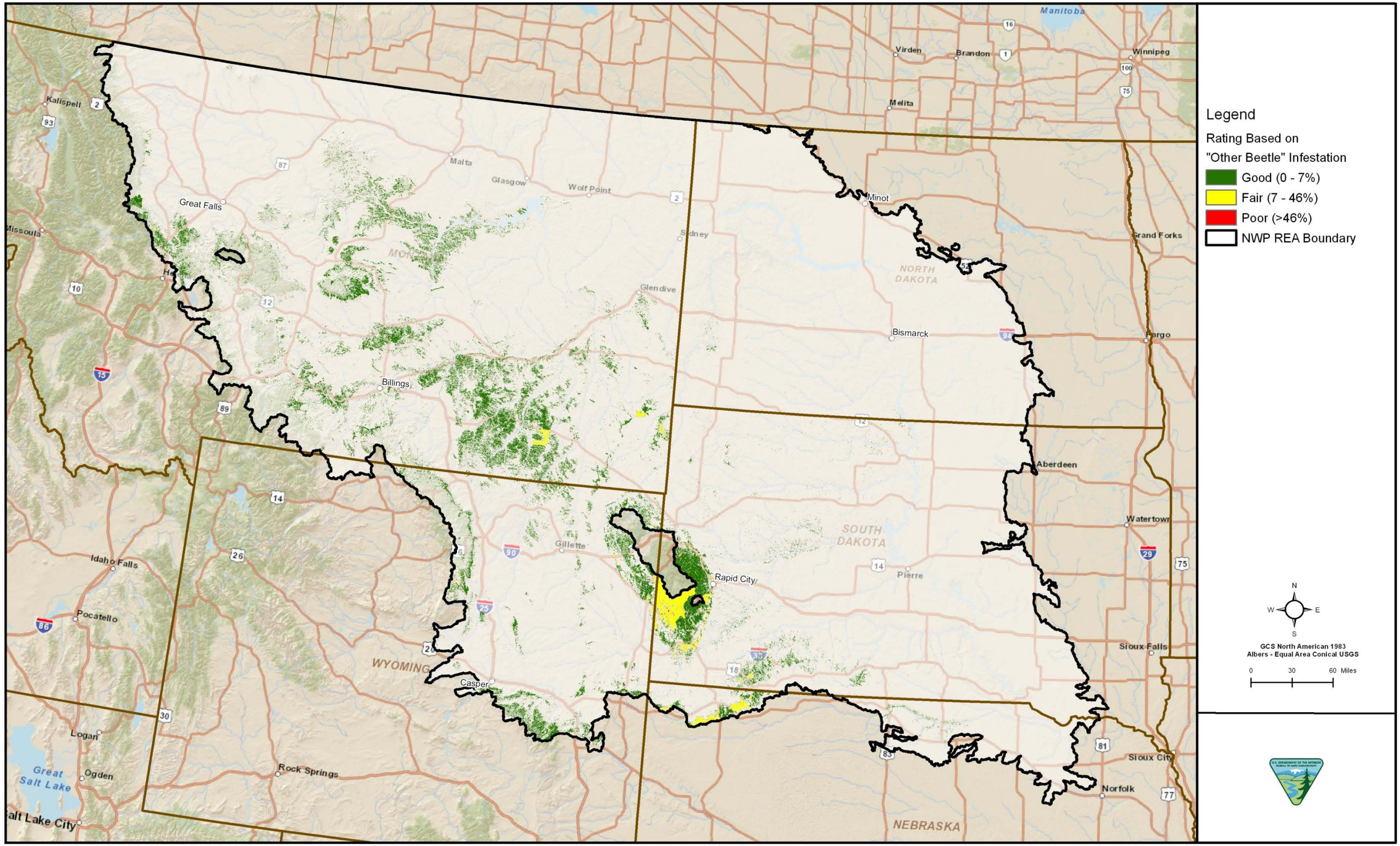

Figure D-1-5. Northwestern Plains Evergreen "Other Beetle" Infestation

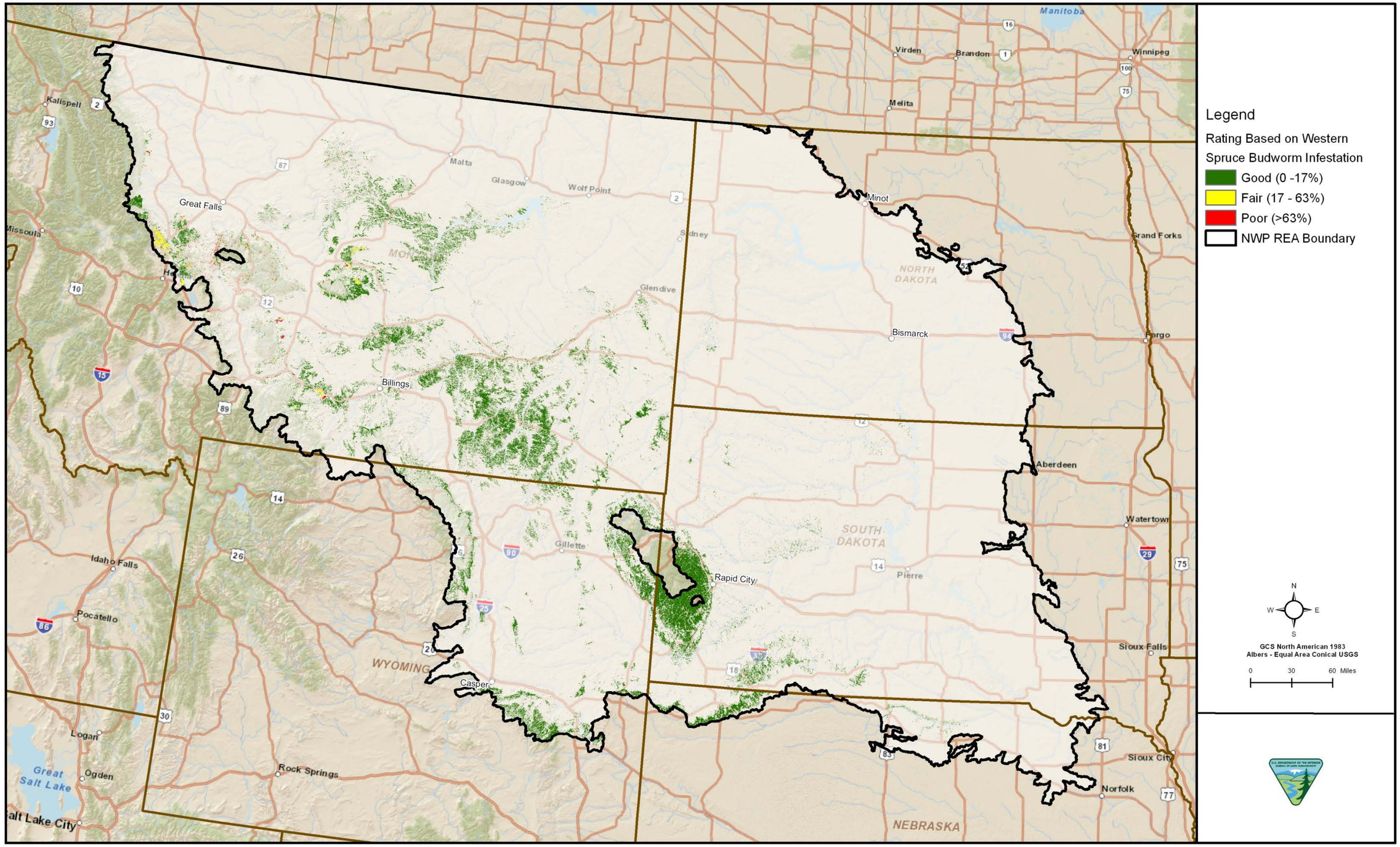

Figure D-1-6. Northwestern Plains Evergreen Western Spruce Budworm Infestation

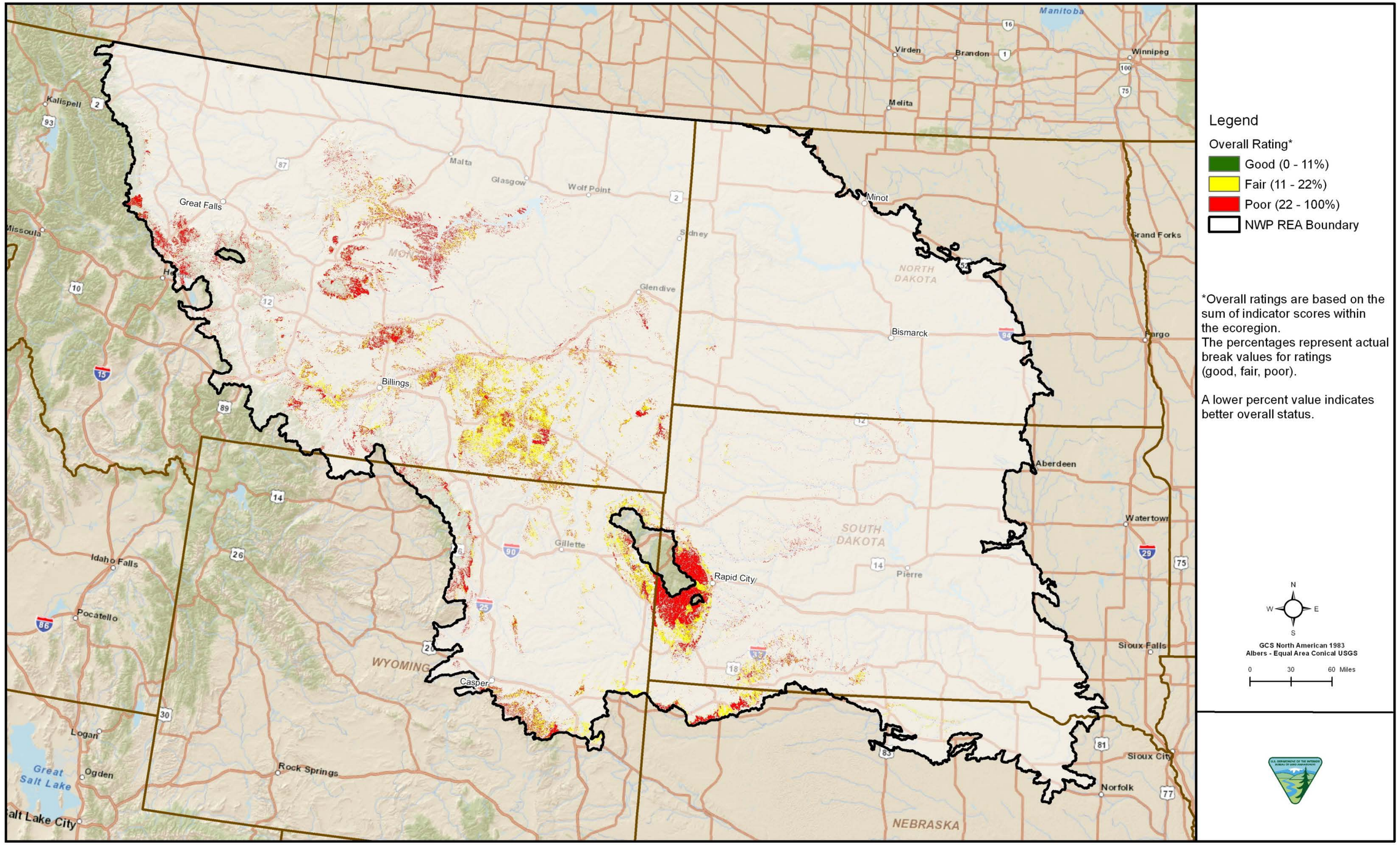

Figure D-1-7. Northwestern Plains Evergreen Current Status

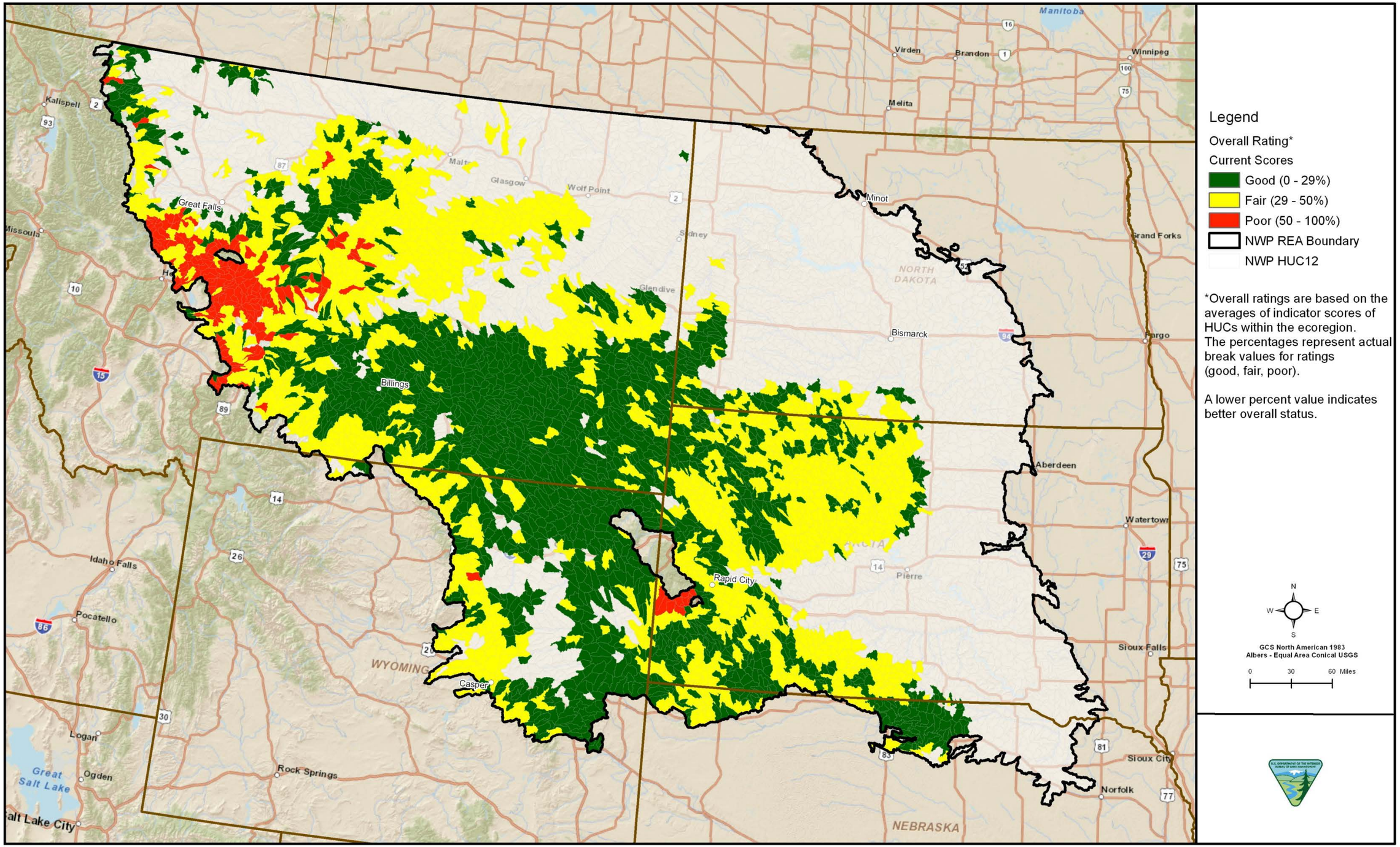

Figure D-1-8. Northwestern Plains Evergreen Current Status by 6th Level Hydrologic Unit Code

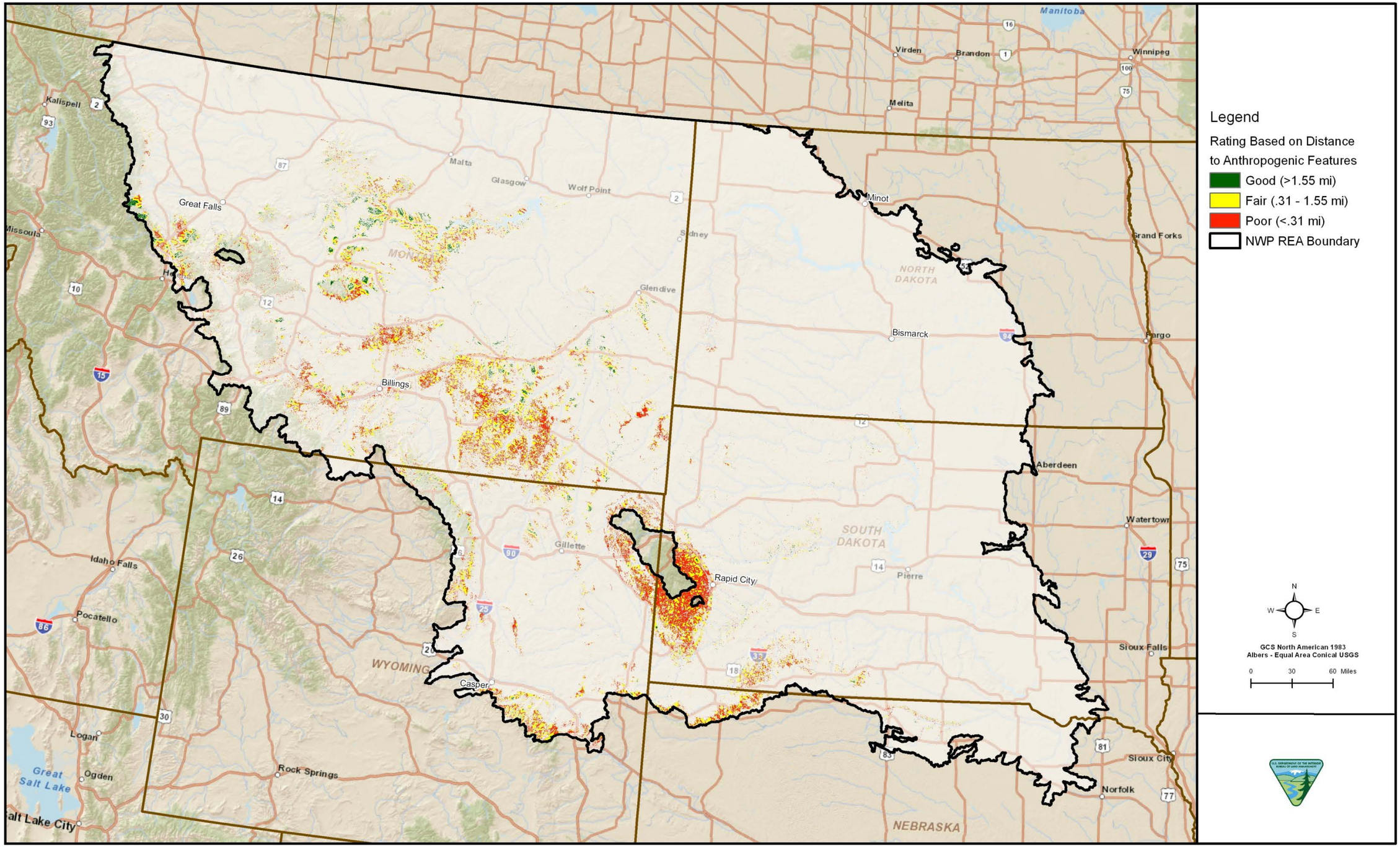

Figure D-1-9. Northwestern Plains Evergreen Fragmentation Potential

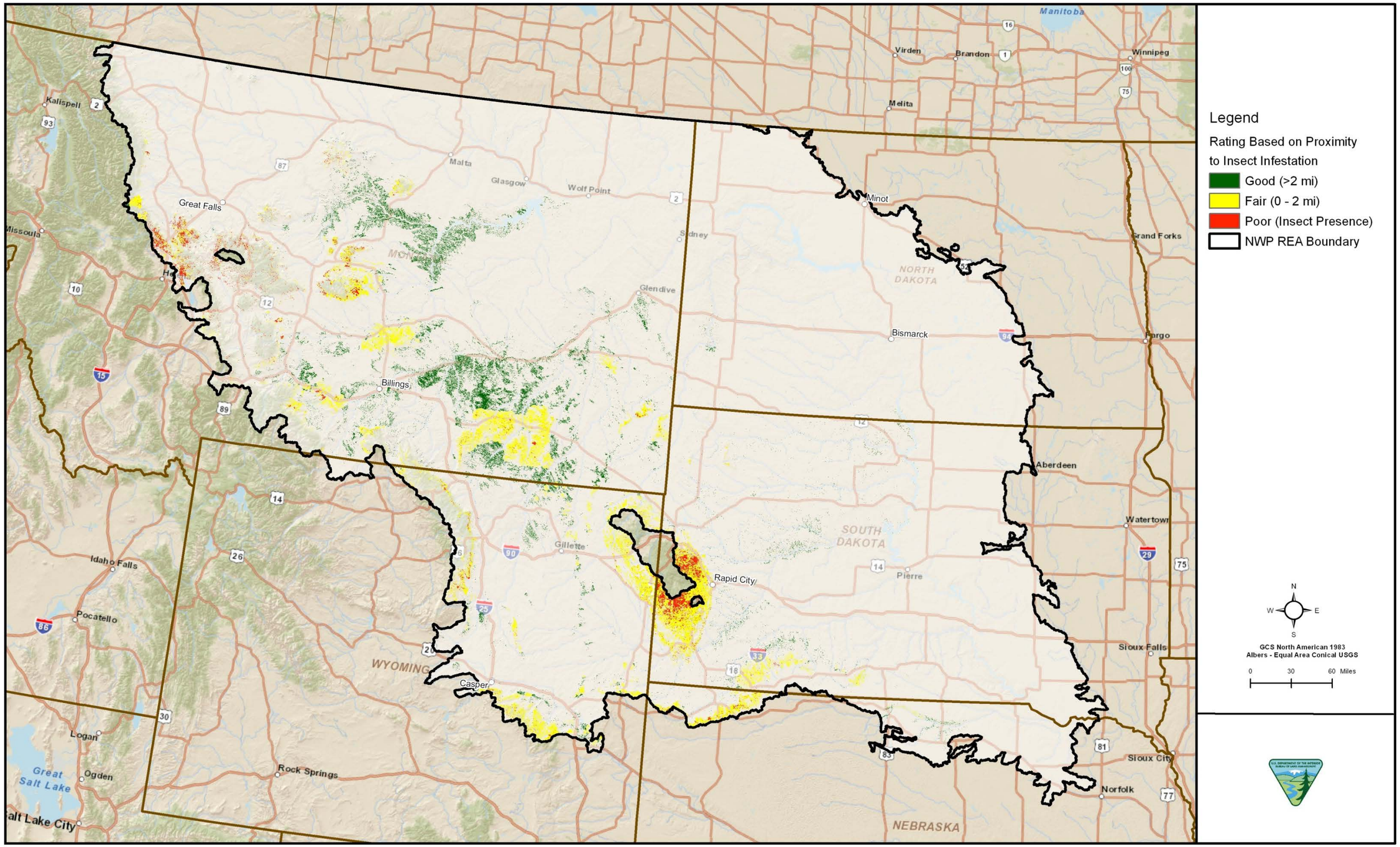

Figure D-1-10. Northwestern Plains Evergreen Insect Proximity Analysis

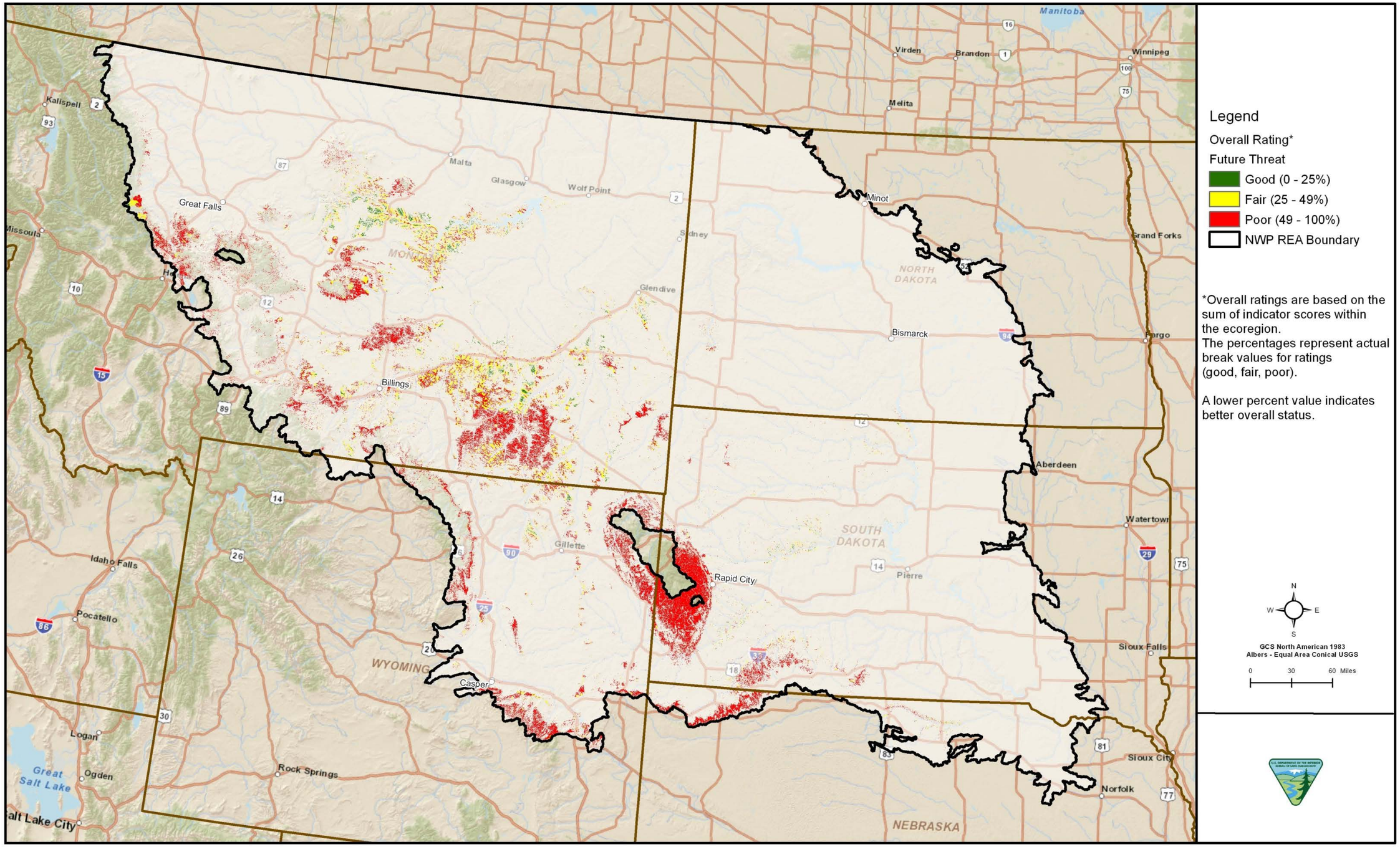

Figure D-1-11. Northwestern Plains Evergreen Future Threat

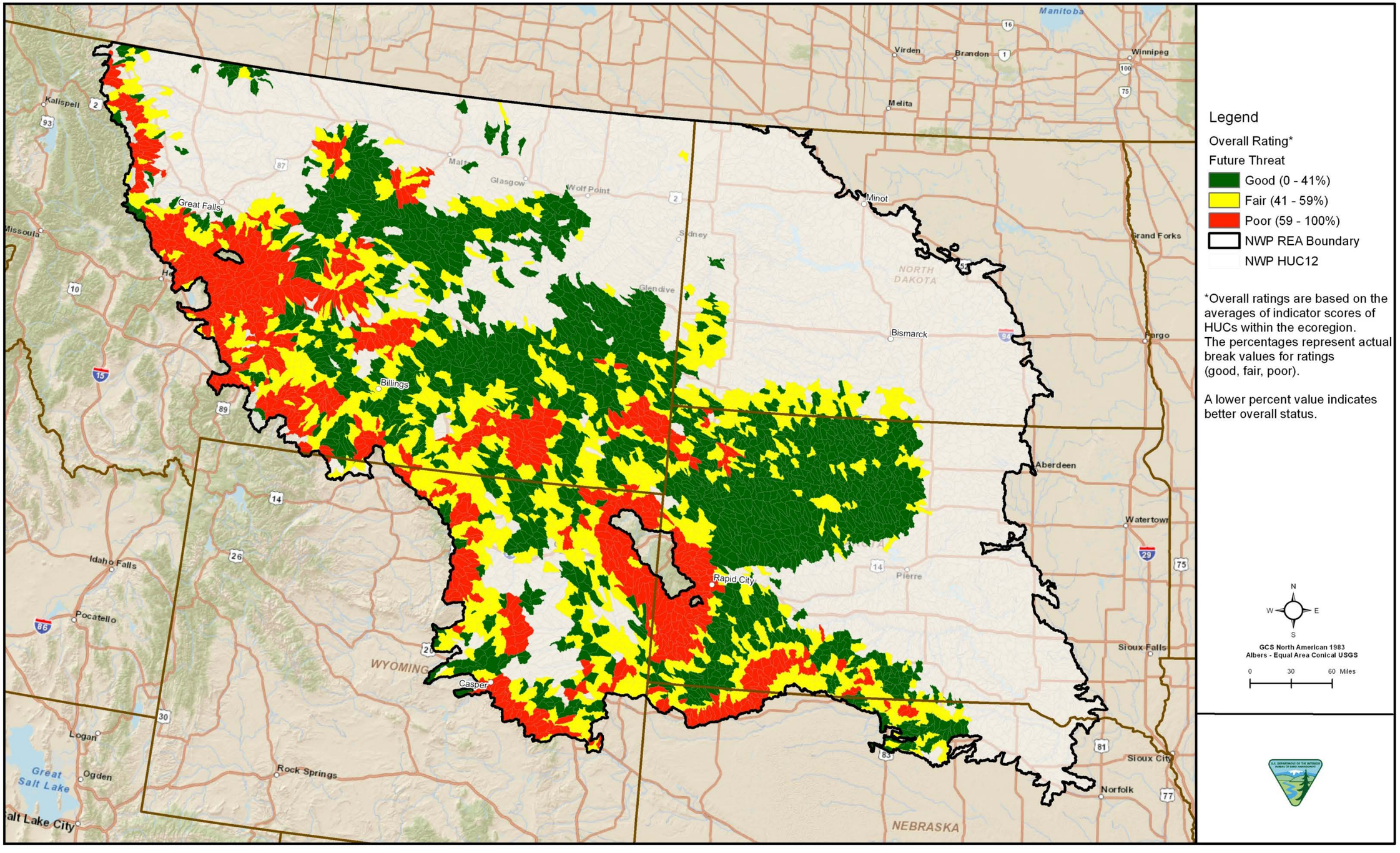

Figure D-1-12. Northwestern Plains Evergreen Future Threat by 6th Level Hydrologic Unit Code

APPENDIX D-2

DECIDUOUS FOREST WOODLANDS COARSE-FILTER CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The deciduous forest woodlands vegetation system encompasses less than one half (0.47) percent of the Northwestern Plains ecoregion. Because some of the Gap Analysis Program (GAP) Level 3 systems comprise very small portions of the Northwestern Plains ecoregion, it was necessary to combine them so that they would be representative of major forest and woodland systems in the Northwestern Plains. Originally, three categories of forest and woodland systems representing this coarse filter included 1) deciduous, 2) evergreen, and 3) riparian, with each of these categories containing representative GAP Level 3 systems as described below. The aggregation and crosswalk process for vegetation systems allows evaluation of a reduced number of coarse-filter conservation elements (CEs), while retaining the capability to evaluate nested geospatial data on every Level 3 mapping unit within or across divisions.

However, due to the fact that the major insect threats are quite different for evergreen and deciduous forests, it was necessary to run the change agent (CA) analysis on them separately.

The deciduous forest and woodland category is composed of the following GAP Level 3 systems: Rocky Mountain Aspen Forest and Woodland, Western Great Plains Dry Bur Oak Forest and Woodland, and Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland.

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 those 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 CA threats.

It should be noted that because of the general lack of threat data, only two CAs were analyzed for the deciduous forest CA analysis. CAs considered in this analysis include wildfire and development.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The Level 3 systems represented in this model are briefly described below.

2.1 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND

This system includes upland forests and woodlands dominated by quaking aspen trees (*Populus tremuloides*) without a significant conifer component (<25 percent relative tree cover). This system usually occurs as a mosaic of many plant associations and may be surrounded by a diverse array of other systems, including grasslands, wetlands, coniferous forests, etc. The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer (NatureServe 2011a).

Stands can occur on gentle to moderate slopes, in swales, or on level sites. At lower elevations, occurrences are found on cooler, north aspects and mesic sites. Elevations generally range from 1,493 to 2,743 meters (m) (4,900-9,000+ feet [ft]), but occurrences can be found at lower elevations in some regions. Soils are usually deep and well developed with rock often absent from the soil. Soil texture ranges from sandy loam to clay loams (Montana Field Guide 2012).

Climate is temperate with a relatively long growing season, typically cold winters, and deep snow. Distribution of this system is primarily limited by adequate soil moisture required to meet its high evapotranspirative demand, length of growing season, and temperatures. Mean annual precipitation where these systems occur is generally greater than 38 centimeters (15 inches) and typically greater than 51 centimeters (20 inches), except in semi-arid environments where occurrences are restricted to mesic microsites such as seeps or areas below large snow drifts (Montana Field Guide 2012).

Occurrences of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests (NatureServe 2011a). In recent years, many aspen stands have exhibited mortality from biotic vectors. These pathogens mainly infect clones already stressed by drought, insects, wind damage, heavy livestock and wildlife use, and similar factors (Montana Field Guide 2012).

2.2 WESTERN GREAT PLAINS DRY BUR OAK FOREST AND WOODLAND

This ecosystem includes bur oak (*Quercus macrocarpa*)-dominated upland woods of bluffs and ravines in upland areas of northern Nebraska, South Dakota, and northeastern Wyoming. This system often occurs as small-to-large patches on buttes, escarpments, and in foothill zones, usually on northerly-facing slopes. Vegetation includes larger trees and a sparsely-to-moderately vegetated herbaceous layer composed of prairie grasses or woodland (NatureServe 2011b). These woodlands tend to occur on relatively well-drained upland sites and usually maintain an open canopy cover, even in the absence of fire. In most sites, eastern red cedar (*Juniperus virginiana*) has filled in the gaps between and beneath the canopy trees and has replaced the native understory vegetation. These bur oak woodlands occur primarily on sandy to loamy soils formed in bedrock or, rarely, on eolian sands, though some may be present on silt loams in the central Nebraska loess hills (Rolfsmeier 2010).

This system occurs primarily in the unglaciated Great Plains on dry-to-drymesic moderately well-drained sandy loams and loams, formed either in Tertiary or Cretaceous sandstones, eolian sand, or loess. It occurs on moderate valley slopes, draws, and occasional lower slopes, primarily of northern or eastern aspect. It is usually associated with slopes of river bluffs or sides of ravines (Rolfsmeier 2010).

Fire is a primary historical factor in this system, and frequent low-intensity ground fires likely maintained an open canopy structure that could support oak regeneration. In the absence of fire, many open-canopy woodlands have become infested with eastern red cedar, which probably was a significant part of presettlement woods, though not in the abundance in which it presently occurs. Wind and ice storms, lightning, bison grazing, and insect outbreaks likely affected community structure historically (Rolfsmeier 2010).

Historically, higher cover of grass species occurred as these stands were more open due to more frequent fires. Few good examples of this system likely remain because of past timber harvesting and heavy grazing (NatureServe 2011b).

2.3 INTER-MOUNTAIN BASINS MOUNTAIN MAHOGANY WOODLAND AND SHRUBLAND

This ecological system occurs on rocky outcrops on south and southwestern aspects at 1,060-2,260 m (3,500-7,400 ft) and forms small-to-large patch stands on dry and rocky soils. In Montana, this shrubland system is dominated by curl-leaf mountain mahogany (*Cercocarpus ledifolius*). Conifers such as Douglas-fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*), and ponderosa pine (*P. ponderosa*) may also occur in some stands. Curl-leaf mountain mahogany is a slow-growing, drought-tolerant species that generally does not re-sprout after fire. Some shrubs may re-sprout following low-intensity fires, but these are typically low in vigor and do not persist. Regeneration is by seedling recruitment. High-intensity fires kill all standing shrubs and may also eliminate the seed bank on these sites. However, a lack of continuous fuels, sparse undergrowth, open stand structure, and low downed-wood accumulations contribute to a low fire frequency within this system.

Climate within this system's distribution range in Montana is typical of mid-continental regions with long severe winters and hot, dry summers. This system provides important winter range for deer and elk. Prolonged drought, potential for increased fire severity, and exotic species invasion are changing the dynamics of this system Montana Field Guide 2011).

3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

3.1 DATA IDENTIFICATION

The major datasets identified to map the distribution of the deciduous forest woodland CE were the GAP landcover and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) datasets. Both datasets have adequate coverage across the ecoregion and have been used in similar analyses. The deciduous forest woodland distribution datasets are further described in Table D-2-1.

Table D-2-1. Data Sources for the Deciduous Forest Woodlands Coarse-Filter Conservation Element Distribution Mapping for the Northwestern Plains Ecoregion

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	GAP Land Cover Northwest Regional Gap Analysis Program (ReGAP) North Central GAP	U.S. Geological Survey (USGS)	Raster (30-m)	Acquired	Yes
	LANDFIRE	LANDFIRE	Raster	Acquired	No
Soils Data	Soil Survey Geographic (SSURGO) State Soil Geographic (STATSGO2)	U.S. Department of Agriculture (USDA)	Polygon	Acquired	No

3.2 DISTRIBUTION MAPPING METHODS

To map distribution of deciduous forest woodlands in the Northwestern Plains ecoregion, Science Applications International Corporation (SAIC) used a mosaic of GAP data sources, including two of the National GAP landcover regions, the Northwest and North Central. The source data for the Northwest region was the Northwest Regional Gap Analysis Program (ReGAP) dataset, which improved upon the original Northwest GAP. The North Central region contains states that have not been covered by a ReGAP project. For these areas, the National GAP layer used data from the Landfire project to create a seamless layer. The GAP was developed to help answer questions about species biodiversity and species habitat (USGS 2010). Its overall goal is to assist resource managers in decision making when there is a lack of information about the full range of species on the landscape. Once the data were downloaded, the two datasets were merged together to form a continuous layer of vegetation data across the four states. The continuous data layer was then clipped to the Northwestern Plains ecoregion, at which point the Level 3 system was extracted for review by the Rolling Review Team (RRT) (Figure D-2-1).

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4.0 CONCEPTUAL MODEL

The current status and potential future threat analyses were based on the system-level model, selected environmental variables (Key Ecological Attributes [KEAs]) likely to be at risk from the CAs, and the availability of data.

4.1 SYSTEM-LEVEL MODEL

The system-level model for the Northwestern Plains deciduous forest woodland system illustrates the major drivers across the top (Figure D-2-2). The major drivers dictate where these vegetation systems occur throughout the ecoregion, while the CAs focus on what has potential to affect this CE over time. Below the CAs are the corresponding CA pathways that affect both the status and distribution of this CE across the Northwestern Plains ecoregion. Listed below the CA pathways are the three categories of size, context, and condition for development of the KEAs for this coarse filter CE. The KEAs were developed and refined through the rolling review process.

4.1.1 Wildfire

Like other deciduous forests, Aspen requires disturbance to regenerate and to become more established. Without disturbances like fire, Aspen is at risk to conifer encroachment. The high conifer mortality due to bark beetles is also increasing fuel loads, which could lead to more intense wildfires. These intense wildfires may be too severe for the Aspen stands to survive.

4.1.2 Development

In the Northwestern Plains, development is a moderate issue as compared to climate change and altered fire regimes. However, due to increasing population growth and urban-to-rural migration trends, fragmentation is a definite factor shaping the landscape. Development fragments deciduous forest woodland, degrading and reducing the amount of stands. Fragmentation from development and agricultural pressures reduces the viability of forest management and environmental benefits, such as ecological stability of flora and fauna (Daniels and Bowers 1997). The increase in small isolated patches and in space between forests decreases habitat connectivity and forest interior.

4.1.3 Climate Change

Drought has been known to cause the loss of seral aspen stands and contribute to a decline in aspen regeneration. In recent years, there have been dramatic die-offs of aspen. The phenomenon has been termed Sudden Aspen Decline (SAD). Due to lack of data, SAD was not included in the CA analysis. However, due to its importance to the species, a brief discussion is warranted.

SAD is characterized by rapid onset of mortality in which dying stands have little to no regeneration or recruitment. Recent research indicates that SAD is caused by several interacting factors including site-related factors (low elevations, south and south-west aspects, open stands), higher temperatures, and drought stress (Hogg et al. 2008; Rehfeldt et al. 2008; Worrall et al. 2008; Fairweather et al. 2008; St. Clair et al. 2010; Worrall et al. 2010). SAD has been highly correlated to hydrologic failures in trees due to drought. The region experienced a significant drought from 1999-2004, immediately prior to the current episode of aspen dieback (Hoffman 2008). The impacts of SAD are consistent with projected effects of climate change.

Surveys in the Intermountain Region have reported different patterns of aspen mortality, such as the prevalent damage agents and susceptibility of different stem sizes (Guyon and Hoffman 2011). Some stands experiencing dieback were still capable of regenerating, although recruitment may be below the threshold suggested for successful aspen recruitment (O'Brien et al. 2010). A rapid stand decline (SAD) noted in Colorado was not prevalent in Montana and northern Idaho surveys undertaken in the Northern Region (Steed and Kearns 2010). Patterns of mortality detected in ground survey plots indicated that mortality had occurred over many years. Nonetheless, aspen is declining in many areas of Montana and

southern Idaho (Idaho Department of Lands 2010), likely resulting from a combination of factors including increased conifer encroachment due to fire suppression, diseases and insects, and heavy ungulate grazing on regeneration. Drought may be an important factor in future mortality (Steed and Kearns 2010).

5.0 CHANGE AGENT ANALYSIS

A current status assessment was conducted on the deciduous forest woodland CE for the Northwestern Plains ecoregion with native 30-m raster data as the analysis unit. Based on the system-level model, KEAs were identified for the current status with a specific emphasis on the ability to measure impacts using existing geospatial data. 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.

Since the scale of the reporting unit is at the Hydrologic Unit Code (HUC) 12, a layer of 6th 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. The intermediate CA layers were then combined together to form a single layer outlining the current status or future threat status for each HUC.

Although numerous preliminary KEAs and indicators that may affect the deciduous forest woodland were initially identified in the early phases of the REA, not all were included in this analysis because either the attribute or indicator was not suitable for a landscape level analysis or because data are not available to support the analysis. The specific indicators that could not be modeled are identified with an asterisk on Figure D-2-2. Further information on the data gaps for these indicators are discussed in the respective CA analyses contained in Appendix C.

For the KEAs that were determined to be duplicative, some were pixel-based versus others being HUC-based, and others did not show any differentiation across the ecoregion. Table D-2-2 identifies the original KEAs and which were used in the final CA analysis.

Table D-2-2. Key Ecological Attributes Retained or Excluded

Category	Key Ecological Attribute	Explanation
1. Size	a. Size of Patches	This analysis was completed but not used because the RRT determined this was more of a fine-filter wildlife MQ.
2. Condition	a. Vegetation Condition Class (VCC)	Retained to show the vegetation and fire regime departure in the ecoregion.
	b. Invasive Species	Dropped due to insufficient data.
3. Structure	a. Fragmentation	Retained to show the fragmentation throughout the ecoregion.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

Table D-2-3 identifies the KEAs, indicators, and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion. The deciduous forest woodland process analysis is designed to create a series of intermediate layers that are primarily based on the wildfire and insect and disease outbreak CAs. The analysis is based on the geospatial data that was available.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

For each of the KEAs listed in Table D-2-3, a discussion of the indicator, metric, metric rank and value, data source(s), and references is provided. Only two indicators were used to assess the current threat status for the deciduous forest woodlands (Table D-2-3). This table was limited to size and landscape context based on spatially available attributes and key factors affecting deciduous forests 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. Equal weights were attributed to each metric in order to provide an overall score for all metrics combined, based on the reporting unit.

Table D-2-3. Key Ecological Attribute Table for the Deciduous Forest Woodlands Coarse-Filter Conservation Element for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation	Weight
			Poor = 3	Fair = 2	Good = 1			
Landscape Structure	Structure	VCC	VCC 3	VCC 2	VCC 1	LANDFIRE	RRT Guidance	0.50
	Fragmentation	Distance Decay Proximity to anthropogenic layer	<0.24 miles	0.24-0.81 miles	>0.81 miles	Integrated Climate and Land-Use Scenarios (ICLUS), Topologically Integrated Geographic Encoding and Referencing (TIGER)	RRT Guidance (Natural Breaks)	0.50

Analysis Unit = 30-m pixel
Reporting Unit = 6th level HUC

After much discussion, the deciduous forest woodland RRT decided not to include patch size in the threat assessment. The decision was primarily made because there is no literature on optimum patch size for deciduous forest woodland. All literature is focused on wildlife habitat requirements, which would be included in the fine-filter CE analysis.

5.1.1.1 Vegetation Condition Class

For landscape structure, the LANDFIRE Vegetation Condition Class (VCC) data were used to show changes in vegetation and fuels from their historical condition. For the Northwestern Plains, a group of subject matter experts (SMEs) went through an exercise to illustrate fire regime (frequency and severity) departure. The historic biophysical setting (BpS) was attributed with a current fire severity and frequency, and then compared with the reference (historic) fire frequency and severity for each type. From these data, we were able to develop a fire frequency departure map, a fire severity departure map, and then a composite map (which took the highest of either departure). This modified composite layer was used as the best indicator for potential threat to the deciduous forest woodland systems from an uncharacteristic fire.

The VCC layer was extracted to the deciduous forest woodland layer. The data were already categorical, so VCC departure 1 was good, VCC departure 2 was fair, and VCC departure 3 was poor. The deciduous forest woodland VCC layer is displayed on Figure D-2-3. Because of the characteristics of this ecoregion, deciduous forests are not a major vegetation component; therefore, the results of this analysis are difficult to discern at a landscape level. In general, the deciduous forests in northern Nebraska were the most prominent forests to return a good score. Many of the deciduous forests in South and North Dakota returned fair-to-poor scores for this metric.

5.1.1.2 Fragmentation

Originally, SAIC created a forest fragmentation index using a neighborhood analysis on the deciduous forest woodland layer. The analysis looked at each pixel that is classified as deciduous forest woodland and its neighbors. A 10x10 neighborhood was used for this analysis. There is no literature specific to the moving window size for this type of analysis. Several other windows were looked at, but the 10x10 window seemed most appropriate. The index is based on the number of deciduous forest pixels surrounding each other.

This was presented to the RRT, but it was decided to use a distance decay method to determine fragmentation based on the proximity to development. The Integrated Climate and Land-Use Scenarios (ICLUS) 2010 was used by extracting the urban, exurban, and industrial categories and then merging the Topologically Integrated Geographic Encoding and Referencing (TIGER) roads for the entire ecoregion. A Euclidean distance proximity analysis was run from this anthropogenic layer and then scored

(Figure D-2-4). To maintain consistency with other coarse filter analyses, scoring was based on KEAs from other coarse filters in the ecoregion. This original scoring was: poor = 0 – 0.5 kilometers (km); fair = 0.5 km – 2.5 km; and good = >2.5 km. However, due to the relatively small amount of deciduous forest woodland on the CA analysis, these were altered slightly using quantile breaks. The resulting scoring classifications can be found in Table D-2-3. As with the VCC, the output from this analysis is difficult to evaluate on a landscape scale. The deciduous forests in the Lewis and Clark and Helena National Forests generally returned a good result for this metric, but the remainder of the scattered deciduous forests throughout the ecoregion returned fair-to-poor results for this KEA.

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 deciduous forest woodland habitat for each HUC across the Northwestern Plains ecoregion. A method of aggregating scores was used to summarize overall threats with regard to deciduous forest woodland habitat quality. Individual threats can identify areas of potential risk to deciduous forest woodlands, but aggregated scores can provide important information with relation to areas where deciduous forest woodland might encounter multiple threats.

In order to create a combined score for each HUC unit based on varying levels of importance for each key attribute, it was necessary to aggregate the data through a weighting process. The weighted sum tool was used to combine each analysis input map to create an overall Current Status Map (Figure D-2-5). Equal weights were used when summing the threats for the deciduous forest woodland.

The resulting output gives each deciduous forest woodland 30-m pixel a score based on current status. Figure D-2-6 displays these results; red indicates areas of poor status, while green indicates areas rated at better current status based on the measured attributes.

The overall threat score for each 6th level HUC was assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. Statistics were run on the results from Figure D-2-5 to determine the average overall score. The overall result was then scored based on natural breaks. A higher overall threat score would result in a rating of “poor” for the HUC, indicating that there are existing threats to the forests based on the KEA metrics.

It should be noted that when displaying results at the 6th level HUC watershed, a few isolated 30-m pixels will determine the score for that watershed, thus potentially scoring a watershed as poor; however, this may be misrepresentative due to the lack of pixels classified as that vegetation type.

The results of the current status analysis based on the 6th level HUC for the ecoregion are presented in Figure D-2-6. The deciduous forests of the national forests in Nebraska (around the Black Hills) and those along the western border of this ecoregion generally returned good results for the overall analysis. The deciduous forests in North Dakota generally returned poor results for the overall current status analysis.

A summary of the current status ratings based on the CE distribution is provided in Table D-2-4. 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 77 percent of the 6th level HUC watersheds that intersect this forest distribution received an overall rating of fair or poor.

Table D-2-4 Summary of Current Status Ratings for the Deciduous Forest Woodland System

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	17,775	22.4
Fair	34,912	44.0
Poor	26,615	33.6

[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

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). Future spatial data for development was limited to potential energy development and climate change, as discussed in the development CA analysis presented in Appendix C-1. 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. Further details regarding the climate change analysis are provided in Appendix C-5.

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 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 therefore should be carefully applied to future estimates of their effect on coarse filters.

5.2.1 Development Change Agent

Future threat analysis for development was limited to potential energy development, as threats from modeled urban growth and potential agricultural development are not anticipated to affect this coarse-filter CE.

5.2.1.1 Wind Turbine Potential

Wind energy development does not appear to be a risk to forests because developers would more likely site wind farms on open lands where clearing would not be required. In addition, the minor amount of deciduous forests in this ecoregion are not located in areas with high wind potential. The wind turbine potential map is presented in Figure C-1-7. Higher elevations within this ecoregion would be more susceptible to the threat of wind turbine development do to the higher wind speed levels within these areas. However, limited accessibility to these areas could limit the range of wind turbine development to lower-elevation mountainous regions.

5.2.1.2 Oil Production Potential

The future analysis characterized potential oil production areas rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential effect 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. 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 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.

Based on the minor amount of deciduous woodlands in this ecoregion, it appears that this CE is not at risk from oil development.

5.2.1.3 Natural Gas Production Potential

The future analysis characterized potential gas production areas 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 effect of potential gas production areas on deciduous forests.

Most of the deciduous forests in this ecoregion are at low risk from potential gas production. The majority of potential gas production is limited to northeastern Wyoming. From an ecoregional scale, it does not appear that deciduous forests are at risk from future natural gas development.

5.2.1.4 Future Potential for Solar Development

This future potential analysis characterized the future potential for solar development based on the solar potential maps developed by National Renewable Energy Laboratory (NREL). Although these maps are very crude, the highest potential for solar development is shown to occur in northeastern Wyoming and southeastern Montana in areas outside of the deciduous forests distribution area. It does not appear that deciduous forests are at risk from future solar development.

5.2.1.5 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). As mentioned in the previous oil and gas sections, with the exception of areas in northeastern Wyoming, northwestern North Dakota, and northeastern Montana, the majority of the deciduous forests are at a low risk to fossil fuel development.

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 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 the species by their effect on habitat availability. 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 deciduous forests, a limited approach must be taken in this analysis. The majority of the deciduous forests in the Northwestern Plains ecoregion are considered to be at low risk to the threat of renewable energy production.

5.2.2 Climate Change Future Threats

From a climate change perspective, temperature and precipitation are the factors that would most affect deciduous forests. 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 to 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), which could benefit deciduous forests.

Climate change presents many different issues relating to deciduous forests. 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.

Based on the analysis conducted for the ecoregion, as presented in Appendix C-5, temperature and precipitation changes appear to be minor in the deciduous forest areas of the Northwestern Plains. As mentioned previously, the SAD has been linked to drought. More precisely, stands located at lower elevations and on south/southwest facing aspects with localized higher temperatures are the most susceptible to SAD (U.S. Forest Service 2009).

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the deciduous forest woodland system would include those defined as part of the Terrestrial Biotic Resources category. The overall MQ was: Where are the important regionally significant terrestrial 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 deciduous forest woodland distribution model. 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 this REA.

6.1 HOW ARE DECIDUOUS FOREST WOODLANDS DISTRIBUTED OVER THE LANDSCAPE?

Figure D-2-1 maps the ReGAP deciduous forest and woodland systems across the ecoregion.

6.2 WHERE WILL CURRENT CONSERVATION ELEMENT VEGETATION TYPES BE AT GREATEST RISK FROM CHANGE AGENTS?

The full range of figures and analyses for the deciduous forest woodland can be used to answer this complex MQ. The models created throughout this process were created to directly address the effects of CAs on deciduous forest woodland systems. All of the CAs were addressed spatially and described in detail in this section, and all of the CAs were spatially attributed to the distribution of the deciduous forest woodland. Figure D-2-5 represents the sum of D-2-3 and D-2-4 by the 30-m analysis unit, while Figure D-2-6 represents the sum of all the threats at the 12-digit HUC reporting unit.

6.3 WHAT AREAS HAVE POTENTIAL FOR RESTORING CONSERVATION ELEMENT SPECIES HABITAT OR HABITAT CONNECTIVITY FOR CONSERVATION ELEMENT SPECIES, CURRENTLY AND IN THE FUTURE?

The fragmentation potential (Figure D-2-4) represents the potential for further fragmented deciduous forest woodlands. It can also be used to show areas where future restoration may be the most beneficial. The fragmentation potential shows areas where restoration could potentially connect larger stands together.

6.4 WHERE WILL CONSERVATION ELEMENTS BE AT RISK FROM ALTERED FIRE REGIMES? WHERE ARE AREAS WITH POTENTIAL TO SHOW FUTURE INCREASES OR DECREASES IN WILDFIRE FREQUENCY OR INTENSITY?

Figure D-2-3 represents the VCC for the deciduous forest woodlands. This figure represents changes in vegetation and fuels from their historical condition. For the Northwestern Plains, a group of SMEs went through an exercise to illustrate fire regime (frequency and severity) departure. The historic BpS was attributed with a current fire severity and frequency and then compared with the reference (historic) fire frequency and severity for each type. From these data, we were able to develop a fire frequency departure map, a fire severity departure map, and then a composite map (which took the highest of either departure). This modified composite layer was used as the best indicator for potential threat to deciduous forest woodlands from an uncharacteristic fire.

6.5 HOW AND WHERE ARE FREQUENCY AND SEVERITY OF OUTBREAKS EXPECTED TO CHANGE IN RESPONSE TO CLIMATE CHANGE AND OTHER CHANGE AGENTS SUCH AS CHANGE IN FIRE FREQUENCY?

The climate change analysis predicts an increase across the entire ecoregion; however, the analysis predicts a somewhat gradual gradient of higher temperatures from north to south. In addition, warming seasonal temperatures could increase the likelihood of more severe fires due to current fire regime departures.

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APPENDIX D-2

FIGURES

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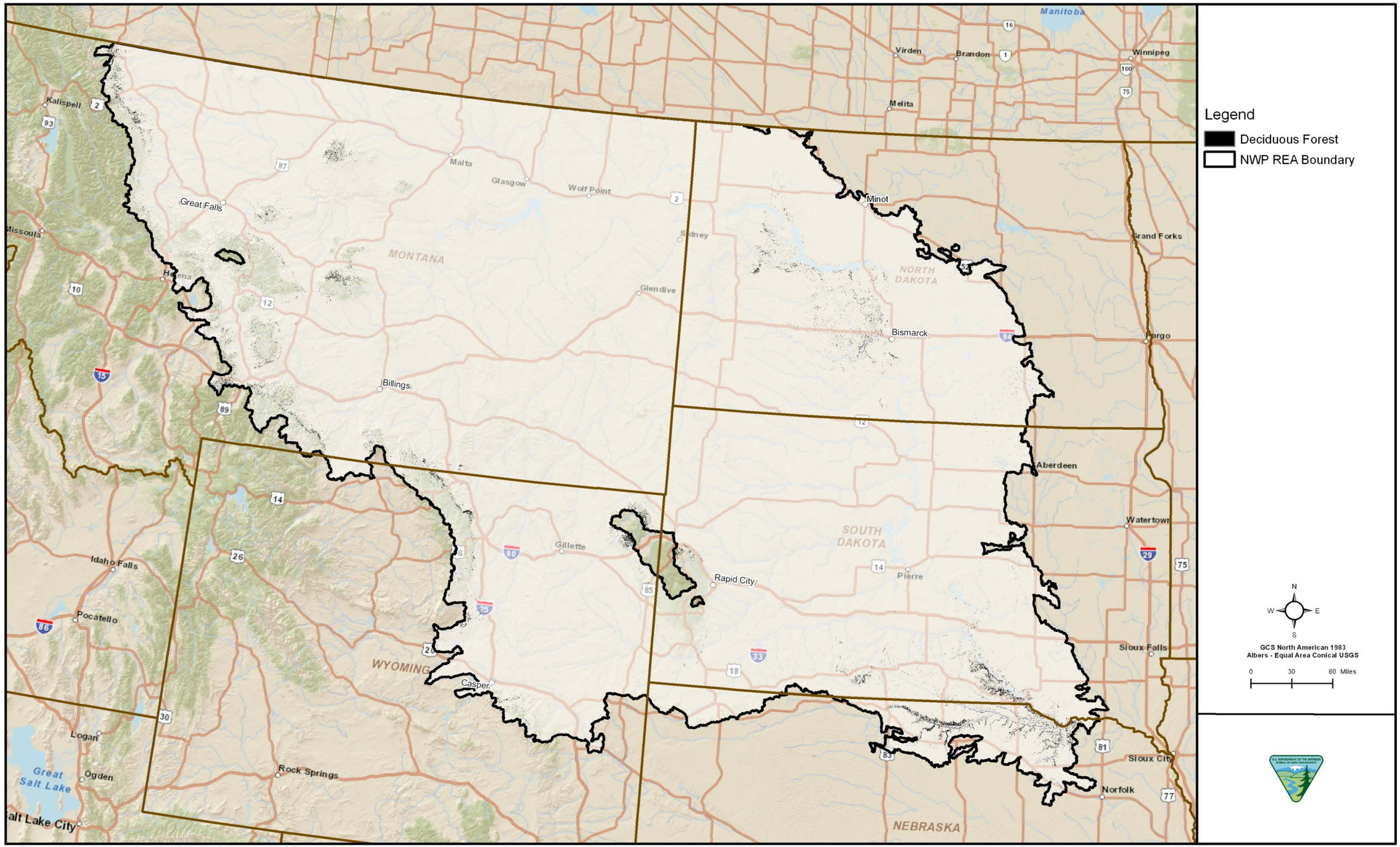

Figure D-2-1. Northwestern Plains Deciduous Forest Distribution

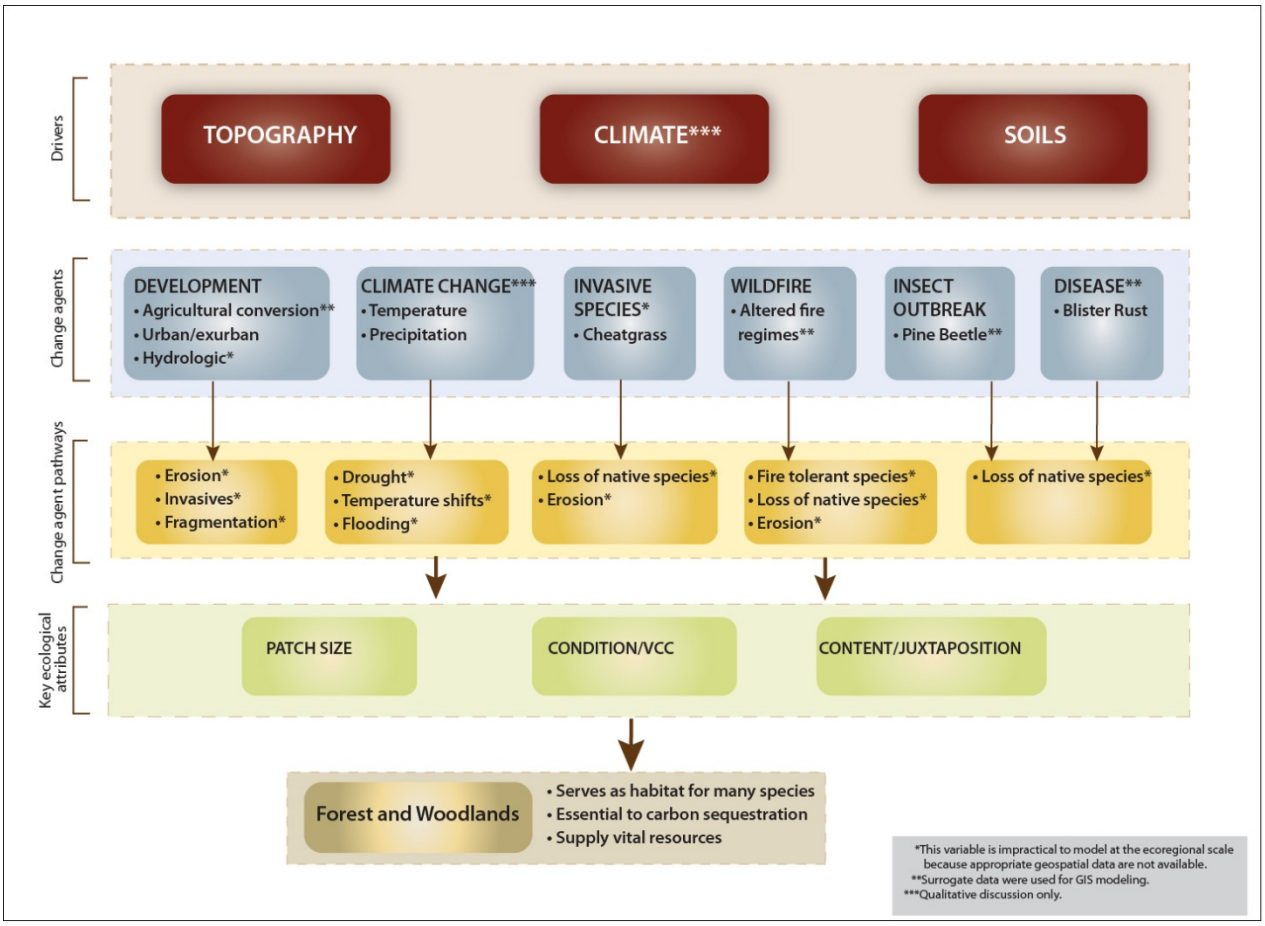

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Figure D-2-2. Northwestern Plains Deciduous Forest System-Level Model

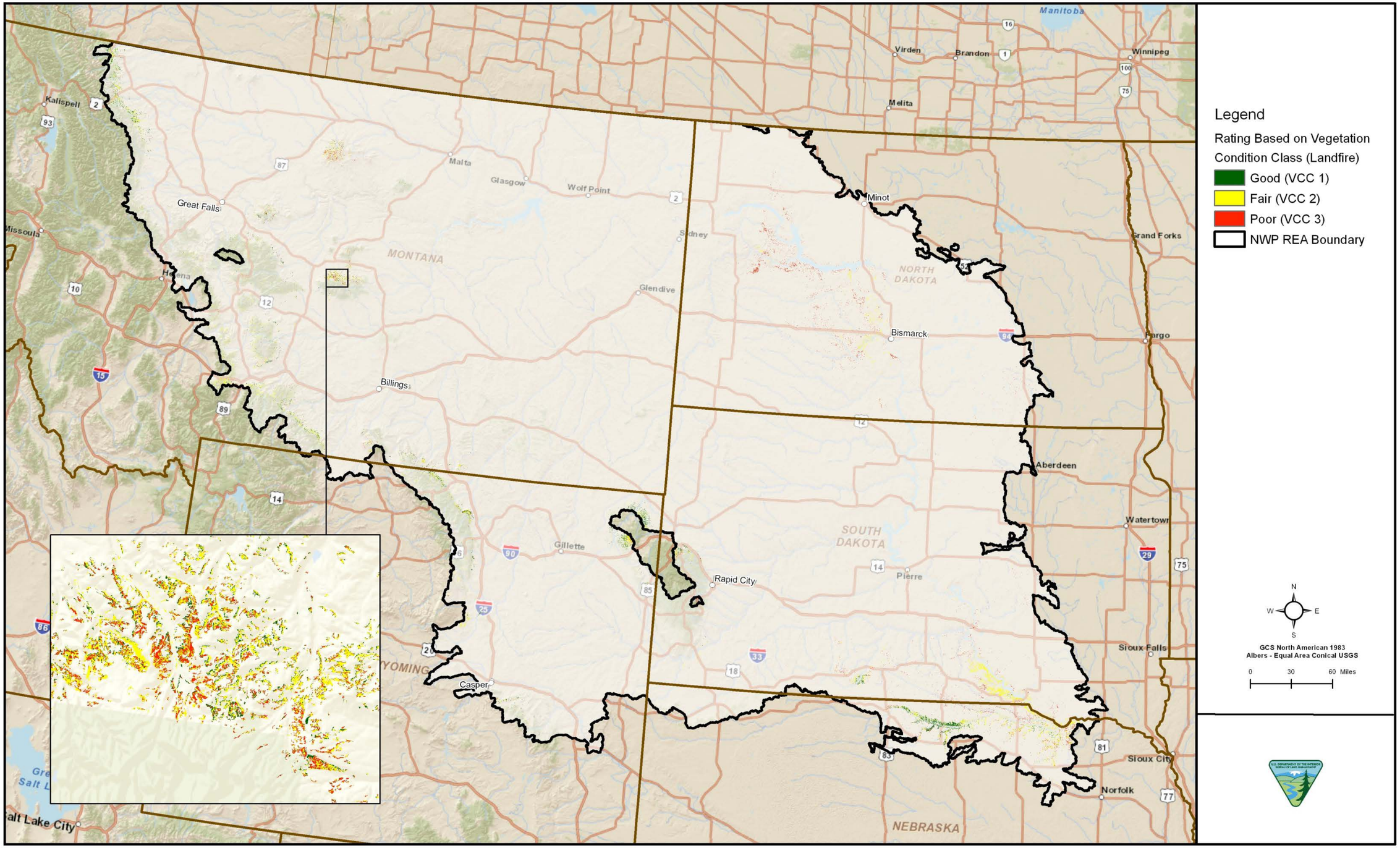


Figure D-2-3. Northwestern Plains Deciduous Forest Vegetation Condition Class

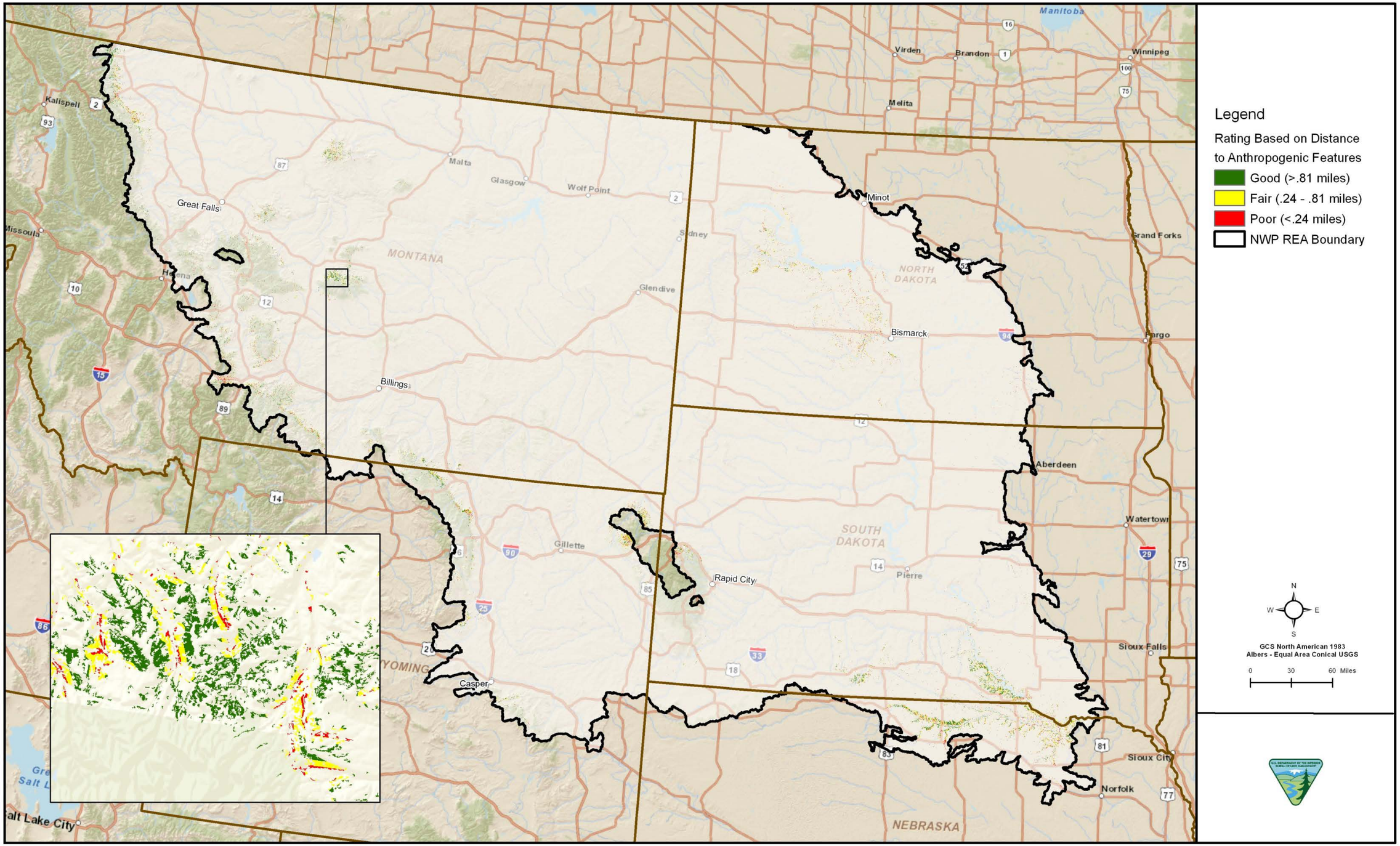


Figure D-2-4. Northwestern Plains Deciduous Forest Fragmentation

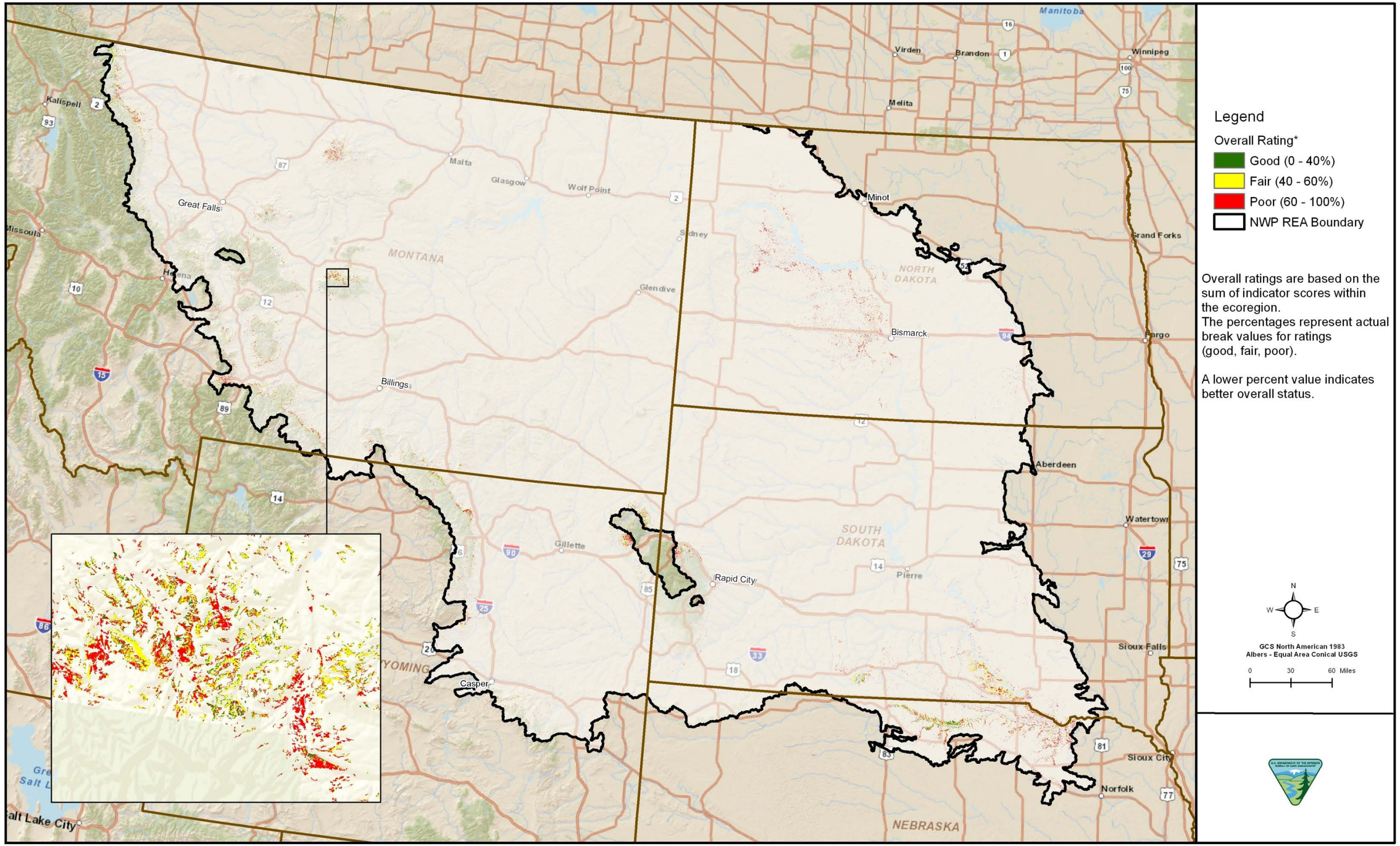
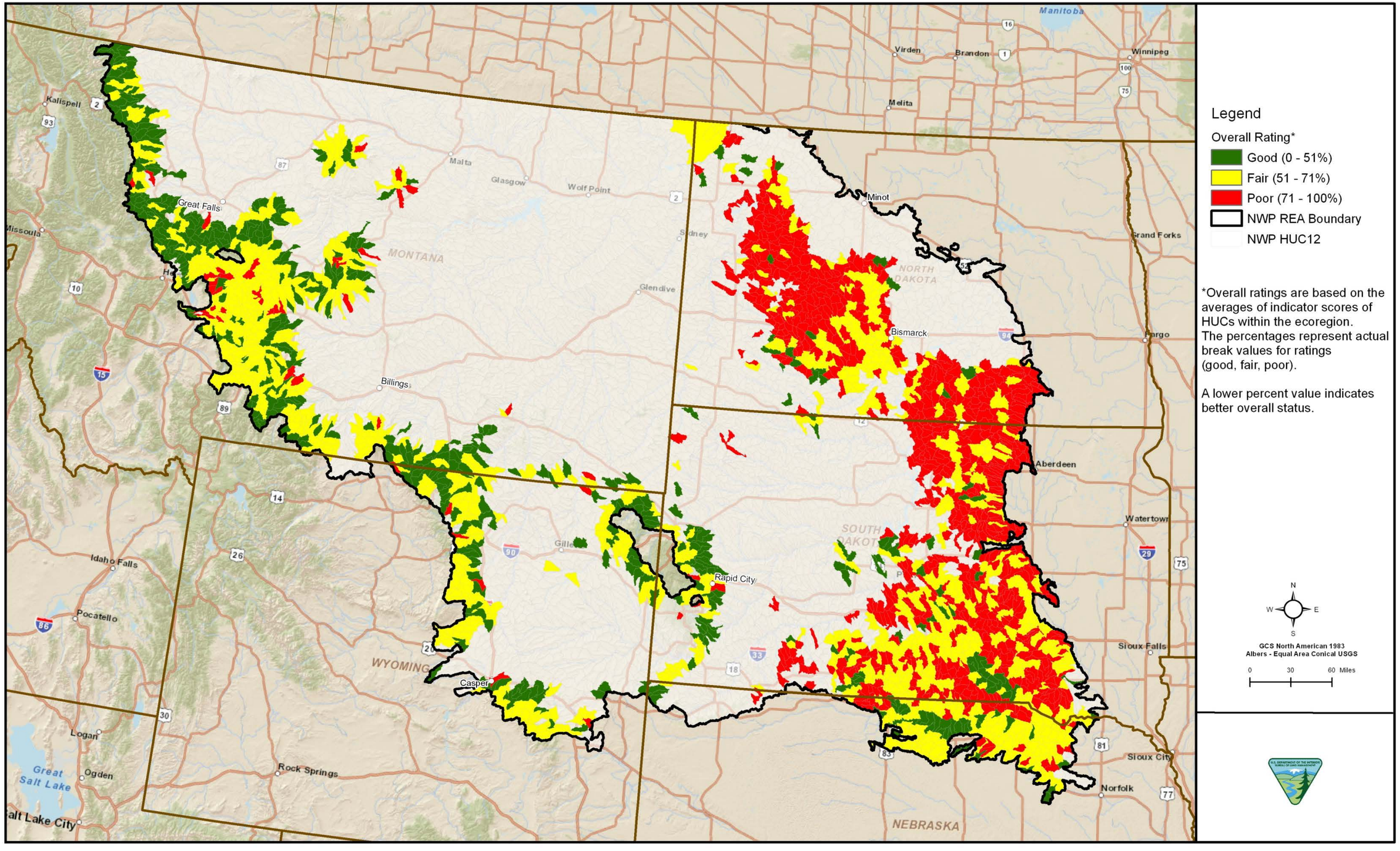


Figure D-2-5. Northwestern Plains Deciduous Forest Current Status



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APPENDIX D-3

GRASSLAND VEGETATION SYSTEMS COARSE-FILTER CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The grassland vegetation system encompasses nearly 40 percent of the Northwestern Plains ecoregion. The Northwestern Great Plains Mixedgrass Prairie; Western Great Plains Sand Prairie, and the Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland Level 3 systems dominate the grasslands of the Northwestern Plains ecoregion. This coarse-filter analysis will focus on these three Level 3 systems.

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 those 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. CAs considered in this analysis include wildfire and development.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The Level 3 systems represented by this coarse-filter CE are briefly described below.

2.1 NORTHWESTERN GREAT PLAINS MIXED-GRASS PRAIRIE

Located on uplands, slopes, and creek bottoms, this system covers much of the eastern two-thirds of Montana, interrupted only by wetland/riparian areas or sand prairies. Vegetation is a mixture of mid and short grasses with western wheatgrass (*Pascopyrum smithii*) usually dominant. Frequent fires and large numbers of migrating herbivores contributed to the historical diversity of plant species in this system (Montana Field Guide 2011a).

Fire and grazing are the primary drivers of this system. Drought can also impact it, in general favoring the shortgrass component at the expense of the mid-height grasses. Major threats include conversion to agricultural land uses, prolonged drought, and invasion by non-native species (Montana Field Guide 2011a).

2.2 WESTERN GREAT PLAINS SAND PRAIRIE

This system is found throughout the Western Great Plains. The largest and most intact example of this system is found within the Sandhills region of Nebraska and South Dakota. However, it is also common (though occurring in predominantly small patches) farther west into central and eastern Montana. Small occurrences of this system are found even further west along the Rocky Mountain Front. Graminoid species dominate the sand prairies, although relative dominance can change due to impacts of wind disturbance. Shrubs are occasionally found within the system but usually with less than 15 percent cover. The unifying and controlling feature for this system is that coarse-textured soils predominate and the dominant grasses such as big bluestem, sand bluestem, blue grama, and hairy grama are well-adapted to this condition (Montana Field Guide 2011b).

2.3 NORTHERN ROCKY MOUNTAIN LOWER MONTANE, FOOTHILL, AND VALLEY GRASSLAND

This system occurs at lower montane to foothill elevations in the mountains and large valleys. Precipitation ranges from 20-30 inches per year, much in the form of snow and spring rains. Vegetation in this system includes cool-season, perennial bunchgrasses and forbs, sometimes with a sparse shrub layer. This system ranges from small meadows to open parks surrounded by conifers within lower montane forests in the mountains surrounding the Columbia Basin, and as foothill and valley grasslands below the lower tree line (Crawford 2011).

A high-frequency fire regime, along with soil drought and herbivory, retards shrub and tree invasion resulting in a patchy distribution of shrubs and trees when present. Isolation of grassland patches by fragmentation may also limit seed dispersal of native shrubs, leading to persistence of the grassland (Crawford 2011).

Major threats to this system include invasion by non-native species, livestock practices, fire regime alteration, direct soil surface disturbance, and fragmentation (Crawford 2011).

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3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

3.1 DATA IDENTIFICATION

The major datasets identified to map the distribution of this CE were the Gap Analysis Program (GAP) and Regional Gap Analysis Program (ReGAP) landcover and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) datasets. Both datasets have adequate coverage across the ecoregion and have been used in similar analyses. The grassland distribution datasets are further described in Table D-3-1.

Table D-3-1. Data Sources for the Grassland Vegetation Systems Coarse-Filter Conservation Element Distribution Mapping for the Northwestern Plains

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	GAP Land Cover Northwest ReGAP North Central GAP	U.S. Geological Survey (USGS)	Raster (30-meter [m])	Acquired	Yes
	LANDFIRE	LANDFIRE	Raster	Acquired	No
Soils Data	Soil Survey Geographic (SSURGO) State Soil Geographic (STATSGO2)	U.S. Department of Agriculture (USDA)	Raster	Acquired	No

3.2 DISTRIBUTION MAPPING METHODS

To map distribution of the grassland coarse-filter CE in the Northwestern Plains ecoregion, Science Applications International Corporation (SAIC) used a mosaic of GAP data sources, including two of the National GAP landcover regions, the Northwest and North Central. The source data for the Northwest region was the Northwest ReGAP dataset, which improved upon the original Northwest GAP. The North Central region contains states that have not been covered by a ReGAP project. For these areas, the National GAP layer used data from the LANDFIRE project to create a seamless layer. The GAP was developed to help answer questions about species biodiversity and species habitat (USGS 2010). Its overall goal is to assist resource managers in decision making when there is a lack of information about the full range of species on the landscape. Once the data were downloaded, the two datasets were merged together to form a continuous layer of vegetation data across the four states. The continuous data layer was then clipped to the Northwestern Plains ecoregion, at which point the Level 3 systems were extracted for review by the Rolling Review Team (RRT) (Figure D-3-1).

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4.0 CONCEPTUAL MODEL

The current status and potential future threat analyses were based on the system-level model, selected environmental variables (Key Ecological Attributes [KEAs]) likely to be impacted by CAs, and the availability of data.

4.1 SYSTEM-LEVEL MODEL

The system-level model for the Northwestern Plains grassland system illustrates the major drivers across the top (Figure D-3-2). The major drivers dictate where these vegetation systems occur throughout the ecoregion, while the CAs focus on what has potential to affect this CE over time. Below the CAs are the corresponding CA pathways that affect both the status and distribution of this CE across the Northwestern Plains ecoregion. Listed below the CA pathways are the three categories of size, context, and condition for development of the KEAs for this coarse filter CE. The KEAs were developed and refined through the rolling review process.

4.1.1 Wildfire

Fire is a primary driver of grassland systems. Historically, frequent indigenous anthropogenic fires and large numbers of migrating bison and other herbivores contributed to plant species and plant community diversity within these systems. In the Northern Great Plains, pre-settlement fire frequency occurred at intervals ranging from 3 to 20 years (Umbanhowar 1996). The elimination of bison and frequent fire intervals disrupted plant community dynamics, leading to a decrease in plant community diversity. In the absence of fire, grassland systems may be susceptible to woody plant or cacti invasion. The dynamics of species changes in grassland systems is a function of climate, but the magnitude of these changes is greatly influenced by the intensity of fire frequency.

4.1.2 Development

In the Northwestern Plains, development is a moderate issue as compared to climate change and altered fire regimes. However, due to increasing population growth and urban-to-rural migration trends, fragmentation is a definite factor shaping the landscape. Development fragments grassland systems by separating contiguous areas of habitat into smaller patches isolated from one another. Fragmentation from development and agricultural pressures reduces the viability of management and environmental benefits, such as ecological stability of flora and fauna (Daniels and Bowers 1997). With increased agricultural practices, grassland systems that have been disturbed by previous cultivation or over-grazing may support large numbers of invasive or non-native plant species. However, this Rapid Ecoregional Assessment (REA) does not investigate grazing.

4.1.3 Climate Change

Climate change may pose major threats to grassland systems. Warming seasonal temperatures could increase the likelihood of more severe fires due to current fire regime departures. Changes in precipitation may cause prolonged extreme drought, reducing the density and cover of short grasses by as much as 80 percent and the bunchgrasses and native forbs to almost zero (Albertson 1937). During prolonged drought, native forbs are rapidly replaced by non-native invasive forbs.

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5.0 CHANGE AGENT ANALYSIS

A current status assessment was conducted on the grasslands CE for the Northwestern Plains ecoregion with native 30-meter (m) raster data as the analysis unit. Based on the system-level models, KEAs were identified for the current status analyses with a specific emphasis on the ability to measure impacts using existing geospatial data. 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.

Because the scale of the reporting unit is at the Hydrologic Unit Code (HUC) 12, a layer of 6th 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. The intermediate CA layers were then combined together to form a single layer outlining the current status or future threat status for each HUC.

Although numerous preliminary KEAs and indicators that may affect the grasslands were initially identified in the early phases of the REA, not all of these were included in this analysis because either the attribute or indicator was not suitable for a landscape level analysis or because data are not available to support the analysis. The specific indicators that could not be modeled are identified with an asterisk on Figure D-3-2. Further information on the data gaps for these indicators is discussed in the respective CA analysis contained in Appendix C.

For the KEAs that were determined to be duplicative, some were pixel-based versus others being HUC-based and others did not show any differentiation across the ecoregion. Table D-3-2 identifies the original KEAs and which of them were used in the final CA analysis.

Table D-3-2. Key Ecological Attributes Retained or Excluded

Category	Key Ecological Attribute	Explanation
1. Size	a. Size of Patches	This analysis was completed and included as a KEA used in the current status assessment.
2. Condition	a. Vegetation Condition Class (VCC)	Retained to show the fire return interval (FRI) for the ecoregion.
	b. Invasive Species	Dropped due to insufficient data.
3. Structure	a. Fragmentation	Added to show the fragmentation throughout the ecoregion.
	b. Connectivity	Retained to show potential habitat connectivity.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

Table D-3-3 identifies the KEAs, indicators, and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion. The grassland process analysis is designed to create a series of intermediate layers that are primarily based on the development and wildfire CAs. The analysis is based on the geospatial data that was currently available.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

For each of the KEAs listed in Table D-3-3, a discussion of the indicator, metric, metric rank and value, data source(s), and references is provided. Only two indicators were used to assess the current threat status for the grasslands (Table D-3-3). This table was limited to size and landscape context based on spatially available attributes and key factors affecting grasslands 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. Equal weights were attributed to each metric in order to provide an overall score for all metrics combined, based on the reporting unit.

Table D-3-3. Key Ecological Attributes for the Grassland Vegetation Systems Coarse-Filter Conservation Element for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation	Weight
			Poor = 3	Fair = 2	Good = 1			
Size	Patch Size	Acres	< 4,335	4,335-74,790	>74,790	ReGAP/ GAP	RRT Guidance (Geometric Interval classification)	0.25
Landscape Structure	Structure	Mean FRI (years)	0-5	5-15	15-30	LANDFIRE	RRT Guidance	0.25
	Fragmentation	Distance Decay Proximity to anthropogenic layer (m)	< 500 m	500 to 2,500 m	>2,500 m	Integrated Climate and Land Use Scenarios (ICLUS) Topologically Integrated Geographic Encoding and Referencing (TIGER)	Professional judgment; Herkert (1994); Johnson and Igl (2001).	0.25
	Connectivity	Percent of similar habitat (1 kilometer [km] neighborhood)	< 15%	15-30%	>30%	ReGAP/GAP		0.25

Analysis Unit = 30-m pixel
Reporting Unit = 6th level HUC

5.1.1.1 Patch Size

Patch size for the grassland coarse-filter CE was determined by finding acres of contiguous 30-m raster cells. After reviewing the patch size analysis, it appears an artifact of satellite imagery is to have a high number of isolated pixels and to overestimate large numbers of contiguous pixels. This results in large variations of values and made it difficult to score size based on appropriate sizes of grassland across the Northwestern Plains ecoregion. After much discussion with the RRT, it was decided to allow the data to dictate the scoring.

There are several ways to classify the data for scoring. The Jenk's Natural Breaks Method was used for this analysis. However, due to the issues with the variation in the size of patches, the Geometric Interval Classification was used. Geometric intervals are used to delineate classes based on groupings of data. Classes are identified by looking for groupings inherent in the data. The Geometric Interval Classification attempts to balance the changes in the middle values and the extreme values.

Figure D-3-3 is a graphical representation of patch size for the grassland coarse-filter CE. Red displays low scoring patches, while green shows higher scoring patches. The largest patches of grasslands appear to be located in northwest and north-central South Dakota around the areas of the Cheyenne and Standing Rock Indian Reservations and the Black Hills National Forest. Some of the national grasslands and national parks in North Dakota and Montana also returned good results for patch size.

5.1.1.2 Mean Fire Return Interval

LANDFIRE's mean fire return interval (FRI) was used to map the fire frequency for grasslands in the Northwestern Great Plains. The mean FRI quantifies the average period between fires under the historical fire regimes. These data were then used to score grassland FRIs based on the current fire frequency from

information provided by the RRT (Table D-3-4). The poor metric (0-5 years) indicates the likelihood of conversion to annual invasives; the fair metric (5-15 years) indicates some conversion to annual invasives; and the good metric (15-30 years) should cover the mean FRI range for most grasslands.

The fire frequency layer was extracted to the grassland layer, used in the grassland current status weighted summary analysis, and is shown on Figure D-3-4. The results of this analysis should be used with the understanding that this KEA is not known to be as accurate for grasslands as for forested areas. Based on the mean FRI from LANDFIRE and the metrics used for this KEA, no grassland areas of this ecoregion returned a result of good. Many of the grasslands in the Northwestern Plains returned a poor result because the interval was in the 0-5 year range.

5.1.1.3 Fragmentation

The Integrated Climate and Land Use Scenarios (ICLUS) 2010 was used by extracting the urban, exurban, and industrial categories and then merging the Topologically Integrated Geographic Encoding and Referencing (TIGER) roads for the entire ecoregion. A Euclidean distance proximity analysis was run from this anthropogenic layer. The proximity analysis was then extracted to the grassland coarse-filter CE (Figure D-3-5). This layer was then scored based on the assumption that grasslands closer to roads and urban areas are more fragmented (Table D-3-3). The fragmentation analysis returned a poor result for much of the ecoregion, with the exception of those areas mentioned as intact for the patch size metric.

5.1.1.4 Connectivity

The grassland coarse filter distribution layer was used to perform a neighborhood analysis to determine the extent of grassland within the 1-kilometer (km) neighborhood. The neighborhood analysis looks at the relationship of each pixel and the pixel surrounding it using a spatial analyst function. The resulting layer provided the percent grassland within the 1-km neighborhood. This layer was then extracted to the grassland coarse filter layer and scored based on the metrics in Table D-3-3 and presented on Figure D-3-6. Though ecoregion-wide fragmentation predominately scored poor, the connectivity analysis for the Northwestern Plains grassland systems returned a good result for grasslands, particularly those areas in South Dakota and the national forests, grasslands, and parks in the other states; although the grasslands displayed as fragmented in the fragmentation analysis, the distance between the patches may be relatively close in proximity, indicating the potential for connectivity.

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 grassland habitat for each HUC across this ecoregion. A method of aggregating scores was used to summarize overall threats with regard to grassland habitat quality. Individual threats can identify areas of potential risk to grasslands, but aggregated scores can provide important information with regard to areas where grasslands might encounter multiple threats.

In order to create a combined score for each HUC unit based on varying levels of importance for each key attribute, it was necessary to aggregate the data through a weighting process. The weighted sum tool was used to combine each analysis input map to create an overall Current Status Map (Figure D-3-7). Equal weights were used when summing the threats for the grasslands.

The resulting output scores each 30-m pixel based on current status. Figure D-3-7 displays these results; red indicates areas of poor status, while green indicates areas rated at better current status based on the indicators.

The overall threat score for each 6th level HUC was assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. Statistics were run on the results from Figure D-3-7 to determine the average overall score. The overall result was then scored based on natural breaks. A higher overall threat score would result in a rating of “poor” for the HUC, indicating that there are existing threats to grasslands based on the KEA metrics.

The results of the current status analysis based on the 6th level HUC for the ecoregion are presented on Figure D-3-8. As would be expected, the current status analysis returned good results for the grassland areas previously mentioned, with the remainder of the grassland areas in this ecoregion returning fair-to-poor results for the overall risk to the CAs.

A summary of the current status ratings based on the CE distribution is provided in Table D-3-4. 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 72 percent of the 6th level HUC watersheds that intersect the grassland distribution received an overall rating of fair or poor.

Table D-3-4. Summary of Current Status Ratings for the Grassland System

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	66,317	28.2
Fair	119,731	50.9
Poor	49,072	20.9

[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

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). The future threat analysis completed for the development CA is explained below. 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. Further details regarding the climate change analysis is provided in Appendix C-5.

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 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 coarse filters.

5.2.1 Development Change Agent

Future spatial data for development was 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 above, conversion of grasslands to agriculture is probably the most predominant current and future CA for grasslands. Grain prices will increase commensurate with world population levels, and the production of crops will need to increase accordingly. Because 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 to the analysis completed for the current status. Figure C-1-1 in Appendix C-1 shows the State Soil Geographic (STATSGO) soil classification types are 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-3-12 shows the results of the analysis, indicating the grasslands at risk from potential future agricultural land development. As would be expected in the Northwestern Plains ecoregion, most of the

agricultural areas (current and future) are located throughout the Missouri River valley. Most of the grasslands in this area have already been converted to agriculture, so the impact to grasslands in the Missouri River valley is anticipated to be minimal. However, large blocks of grasslands in central and northern South Dakota are at risk of being converted based on their soil types. Grasslands in southwest North Dakota also appear to be at risk of conversion to agriculture. Grasslands in Montana, Wyoming, and Nebraska appear to be at a lower risk, with the bottom lands along major tributaries having the highest potential for conversion. Thus, grasslands in this ecoregion appear to be at risk from future agricultural development.

5.2.1.2 Future Growth of Urban Areas

Urban growth has the potential to affect grasslands habitat similar to agricultural development. In the Northwestern Plains ecoregion, minor portions of grasslands are currently in close proximity to urban/suburban populations.

The ICLUS model is a universally accepted model created by the U.S. Environmental Protection Agency (USEPA) for use in future climate change modeling and 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 to a near-term time period. The ICLUS urban area footprint for 2060 was used to calculate the proximity to agricultural lands. Figure C-1-2, 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 much of a risk to this CE as agriculture. The highest growth density appears to be west of Rapid City, South Dakota; this area does not contain dense grasslands.

5.2.1.3 Wind Turbine Potential

The U.S. Fish and Wildlife Service (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 are presumably going to 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 turbine locations were based on the availability of suitable wind speeds.

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 on Figure C-1-7, Future Wind Projections. Wind Power Classes were characterized as good, fair, or poor for direct comparison to the current wind condition.

The potential threats to grasslands relative to future wind energy development are presented on Figure C-1-7. Higher elevations within the Northwestern Plains ecoregion are more susceptible to the threat of 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 mountainous regions. Grasslands in elevated areas located east and west of the Missouri River valley appear to be at risk from the development of wind farms. Most of these areas appear to be in South Dakota, with some areas in south-central North Dakota also having high potential for wind farms. In addition to the physical disturbance that wind turbines can have on grasslands, bird mortality is also a concern. Grasslands 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 spatial distribution of grasslands and mid-level elevation wind turbine potential overlap is apparent. There is a potential risk to grasslands within the eastern portion of the ecoregion if wind turbine production increases in these areas.

5.2.1.4 Oil Production Potential

The future analysis characterized potential oil production areas rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential effect of future oil production activities. 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. Although these areas are based on oil density data, the application of these data to future potential well site activity is unknown. 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.

Grasslands in western North Dakota and northeastern Montana appear to be at high risk from potential oil production. However, based on review of this map, the risk to grasslands in South Dakota appears to be relatively low.

Based on review of the oil production potential, it does appear that grasslands located in northeastern Wyoming, western North Dakota, and eastern Montana are at high risk from potential oil production. However, the vast grasslands of South Dakota appear to be at a lower risk.

5.2.1.5 Natural Gas Production Potential

This future analysis characterized potential gas production areas 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 effect of potential gas production areas on grasslands.

With the exception of grasslands in northeastern Wyoming, most of the grasslands in this ecoregion are at low risk from potential gas production. The majority of potential risk from gas production is limited to northeastern Wyoming. There is also an area in north-central Montana that has high potential risk for natural gas development. However, from an ecoregional scale, it does not appear that grasslands are at a high risk of future natural gas development.

5.2.1.6 Future Potential for Solar Development

This future potential analysis characterized the future potential for solar development based on the solar potential maps developed by NREL. Although these maps are very crude, the highest potential for solar development is shown to occur in northeast Wyoming and southeast Montana. Although the grassland coarse-filter distribution shows grasslands in this area, the majority of the grasslands in this ecoregion appear to be at low risk from development of solar farms.

5.2.1.7 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). As mentioned in the preceeding oil and gas sections, with the exception of areas in northeastern Wyoming, northwestern North Dakota, and northeastern Montana, the majority of the grasslands are at a low risk to fossil fuel development.

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 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 the species by their effect on habitat availability. 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 grasslands, a limited approach must be taken in this analysis. The majority of the grasslands in the Northwestern Plains ecoregion are considered to be at a low to moderate risk from potential renewable energy production.

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 grasslands. 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 to 75 millimeter [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 grasslands. 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. Increases in spring temperatures and decreases in precipitation levels are the factors that would most likely threaten grasslands.

Based on review of the climate delta maps (Appendix C-5) for the March through June time periods, it does not appear that temperature increases or precipitation decreases will negatively affect this coarse filter. However, the combined impacts of increased temperatures, localized drought, and conversion of lands to agricultural uses could negatively affect grasslands in the future.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for grassland systems would include those defined as part of the Terrestrial Biotic Resources category. The overall MQ was: Where are the important regionally significant terrestrial 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 grassland distribution model. Several examples of how the REA can be used to answer MQs are provided below to demonstrate the functionality of the REA and to provide an opportunity to discuss data gaps that were identified during this REA.

6.1 HOW ARE GRASSLAND SYSTEMS DISTRIBUTED OVER THE LANDSCAPE?

Figure D-3-1 maps the ReGAP grasslands across the ecoregion.

6.2 WHERE WILL CURRENT CONSERVATION ELEMENT VEGETATION TYPES BE AT GREATEST RISK FROM CHANGE AGENTS?

The full range of figures and analyses for grassland systems 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 systems. All of the CAs were addressed spatially and described in detail in this section, and all of the CAs were spatially attributed to the distribution of the grassland. Figure D-3-7 represents the sum of Figures D-3-3 through D-3-6 by the 30-m analysis unit, while Figure D-3-8 represents the sum of all the threats at the 12-digit HUC reporting unit.

6.3 WHAT AREAS HAVE POTENTIAL FOR RESTORING CONSERVATION ELEMENT SPECIES HABITAT OR HABITAT CONNECTIVITY FOR CONSERVATION ELEMENT SPECIES, CURRENTLY AND IN THE FUTURE?

The fragmentation potential (Figure D-3-5) represents the potential for further fragmented grassland systems. It can also be used to show areas where future restoration may be the most beneficial. The fragmentation potential shows areas where restoration could potentially connect larger stands together.

6.4 WHERE WILL CONSERVATION ELEMENTS BE AT RISK FROM ALTERED FIRE REGIMES? WHERE ARE AREAS WITH POTENTIAL TO SHOW FUTURE INCREASES OR DECREASES IN WILDFIRE FREQUENCY OR INTENSITY?

Figure D-3-4 represents the VCC for the grassland systems. This figure represents changes in vegetation and fuels from their historical condition. For the Northwestern Plains, a group of subject matter experts (SMEs) went through an exercise to illustrate fire regime (frequency and severity) departure. The historic biophysical setting (BpS) was attributed with a current fire severity and frequency and then compared with the reference (historic) fire frequency and severity for each type. From these data, we were able to develop a fire frequency departure map, a fire severity departure map, and then a composite map (which took the highest of either departure). This modified composite layer was used as the best indicator for potential threat to grassland systems from an uncharacteristic fire. These maps should be used with caution, as this metric is known to be less precise in grassland systems.

6.5 HOW AND WHERE ARE FREQUENCY AND SEVERITY OF OUTBREAKS EXPECTED TO CHANGE IN RESPONSE TO CLIMATE CHANGE AND OTHER CHANGE AGENTS SUCH AS CHANGE IN FIRE FREQUENCY?

The climate change analysis predicts slight temperature increases across the entire ecoregion; however, this analysis predicts a somewhat gradual gradient of higher temperatures from north to south. In addition, warming seasonal temperatures could increase the likelihood of more severe fires due to current fire regime departures.

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APPENDIX D-3

FIGURES

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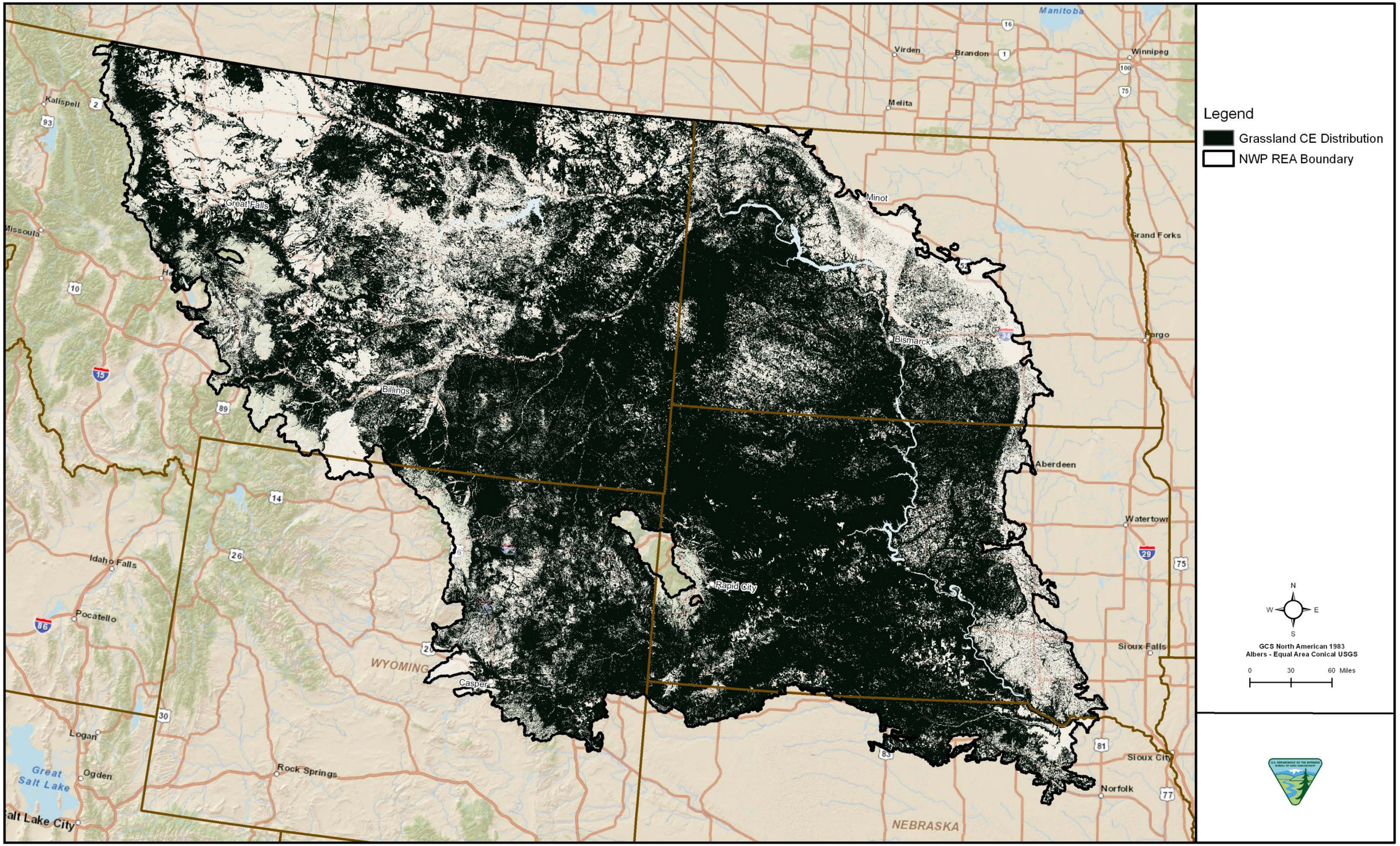
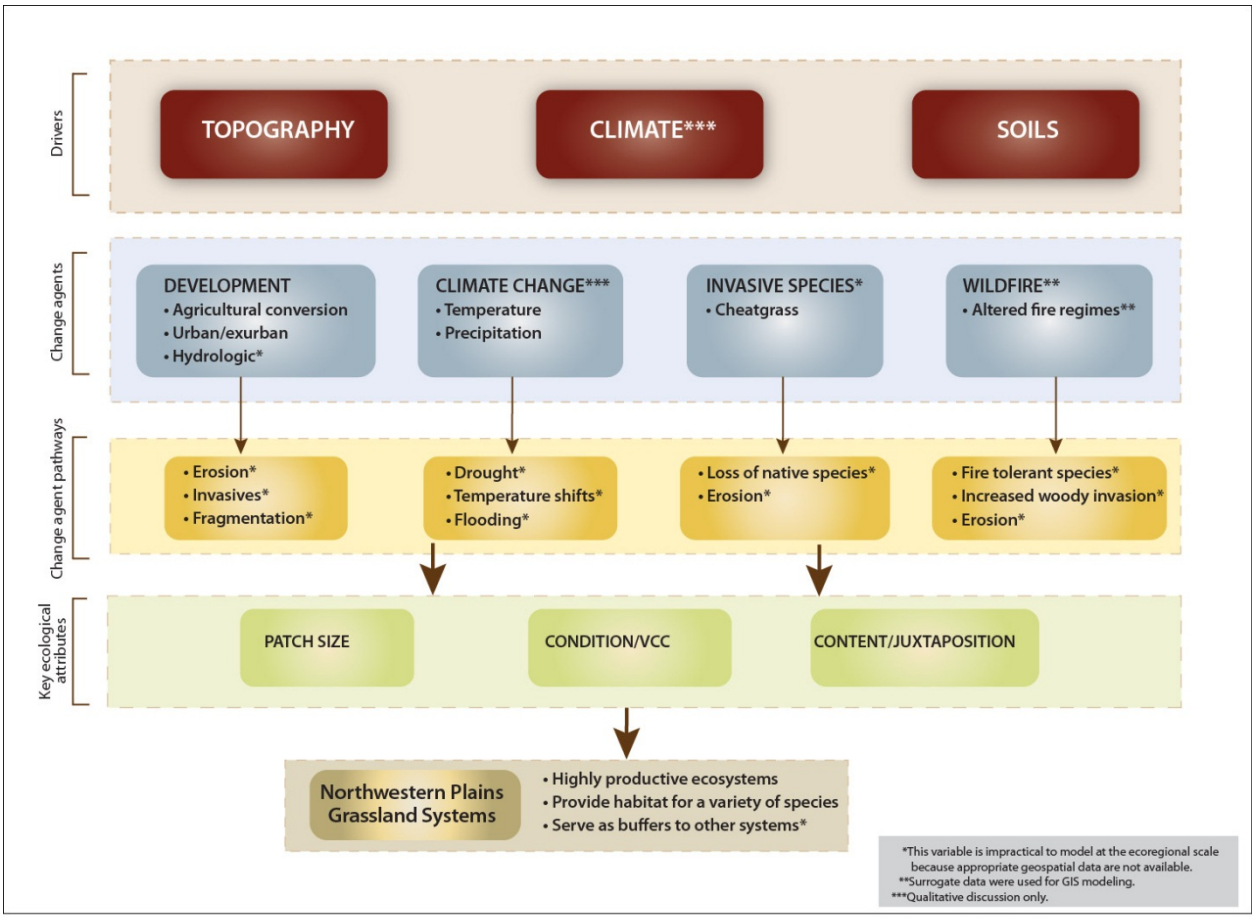


Figure D-3-1. Northwestern Plains Grassland Distribution



Northwestern Plains Grassland Systems

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Figure D-3-2. Northwestern Plains Grassland System-Level Conceptual Model

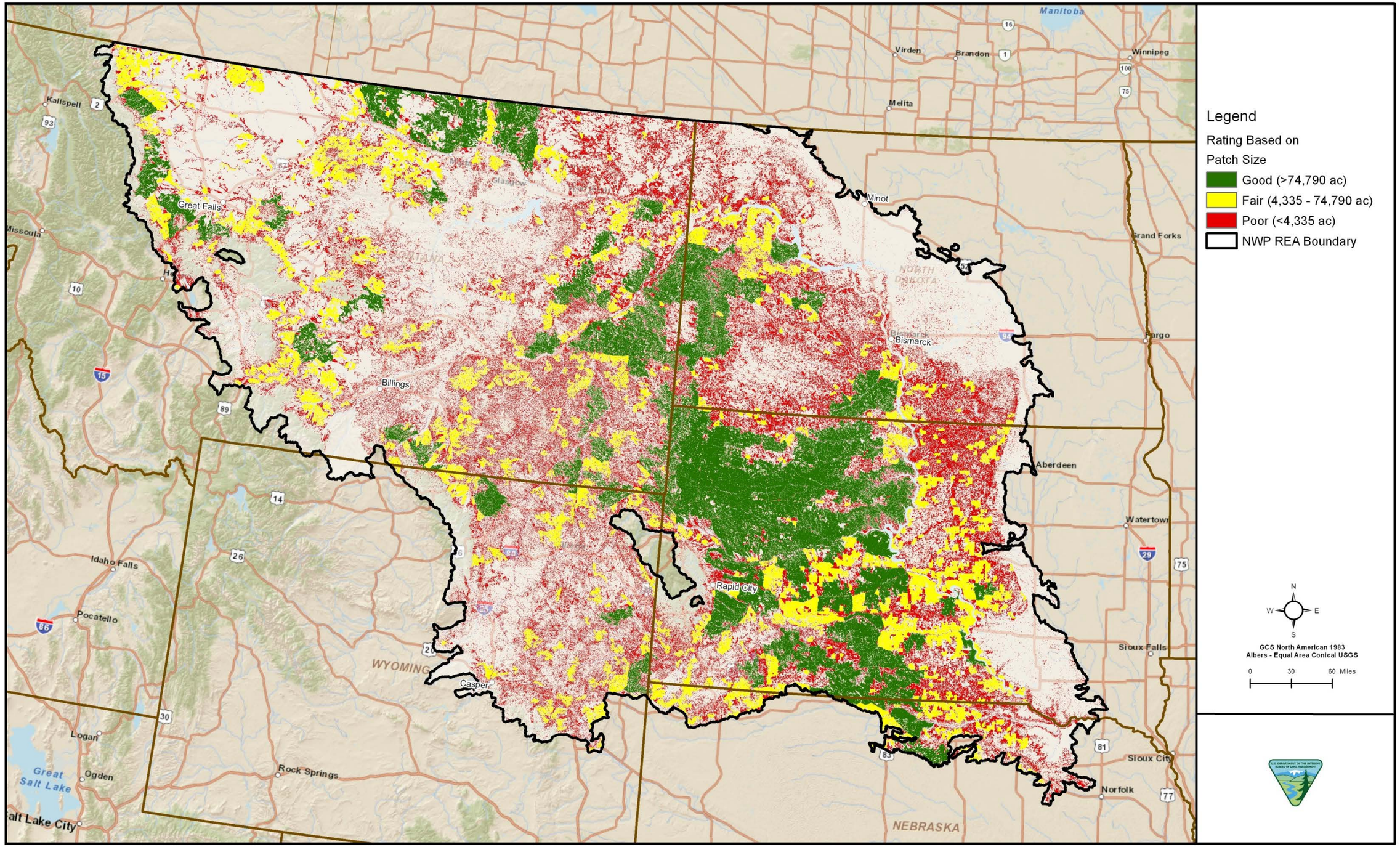

Figure D-3-3. Northwestern Plains Grassland Patch Size

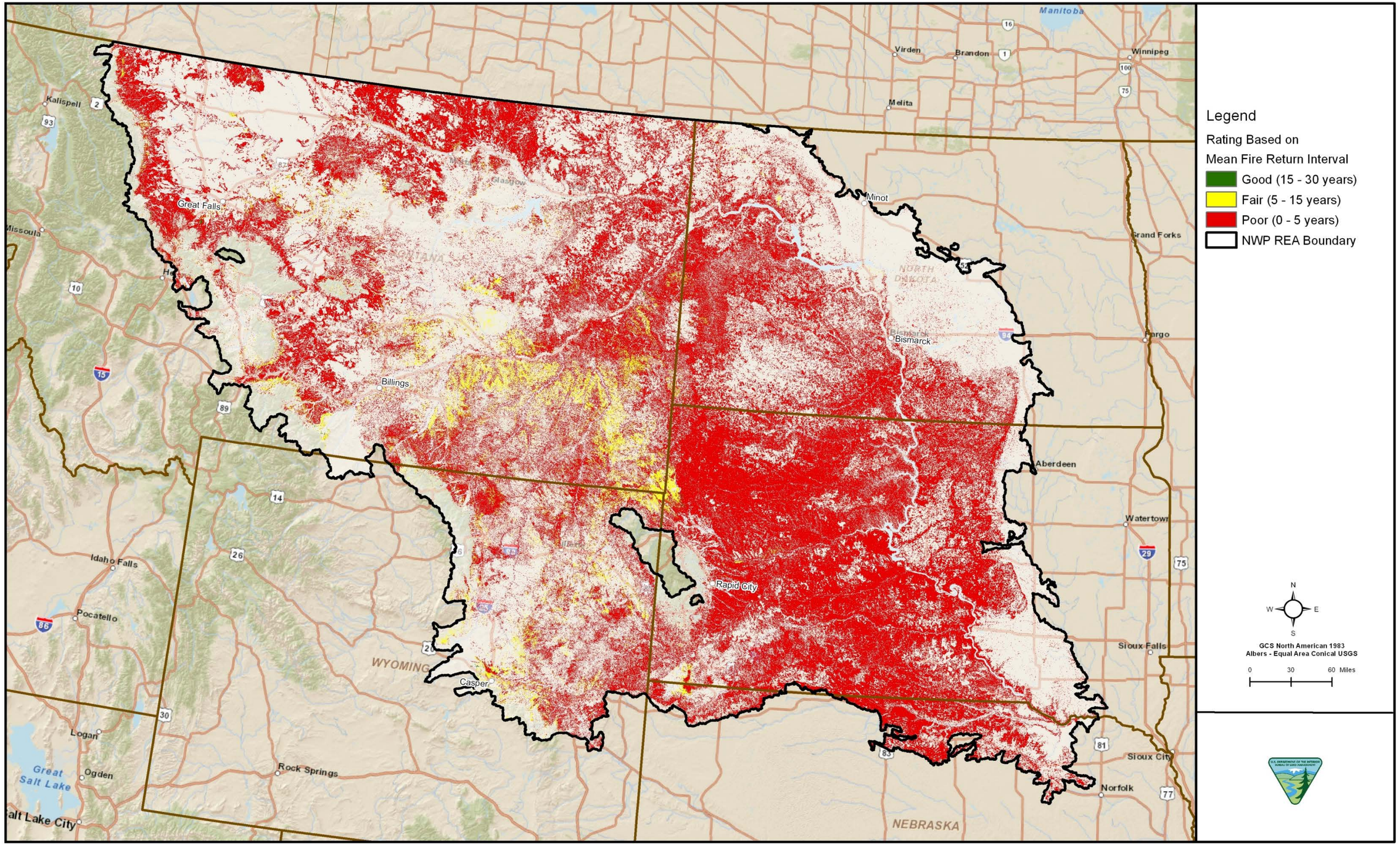

Figure D-3-4. Northwestern Plains Grassland Mean Fire Return Interval

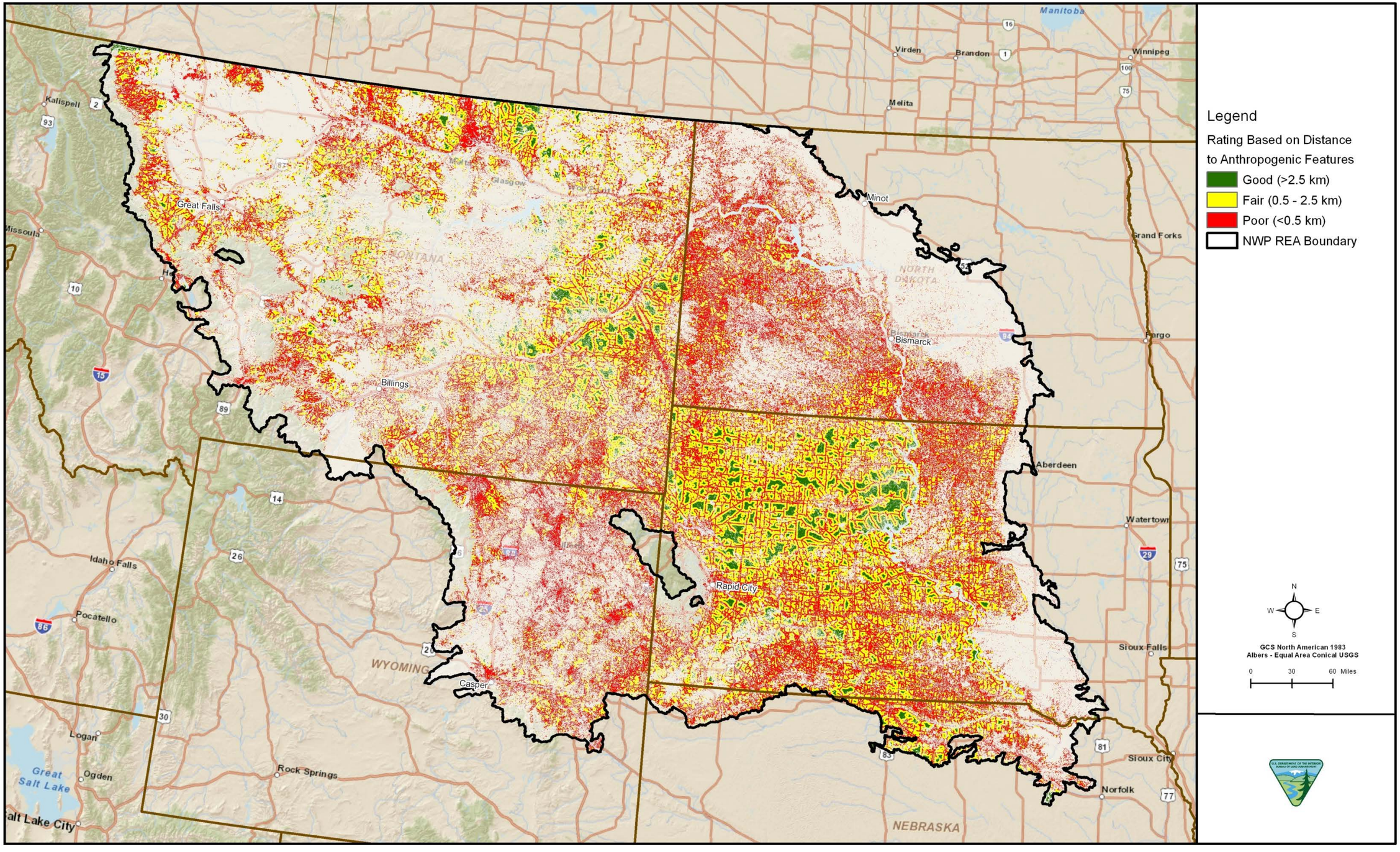

Figure D-3-5. Northwestern Plains Grassland Fragmentation

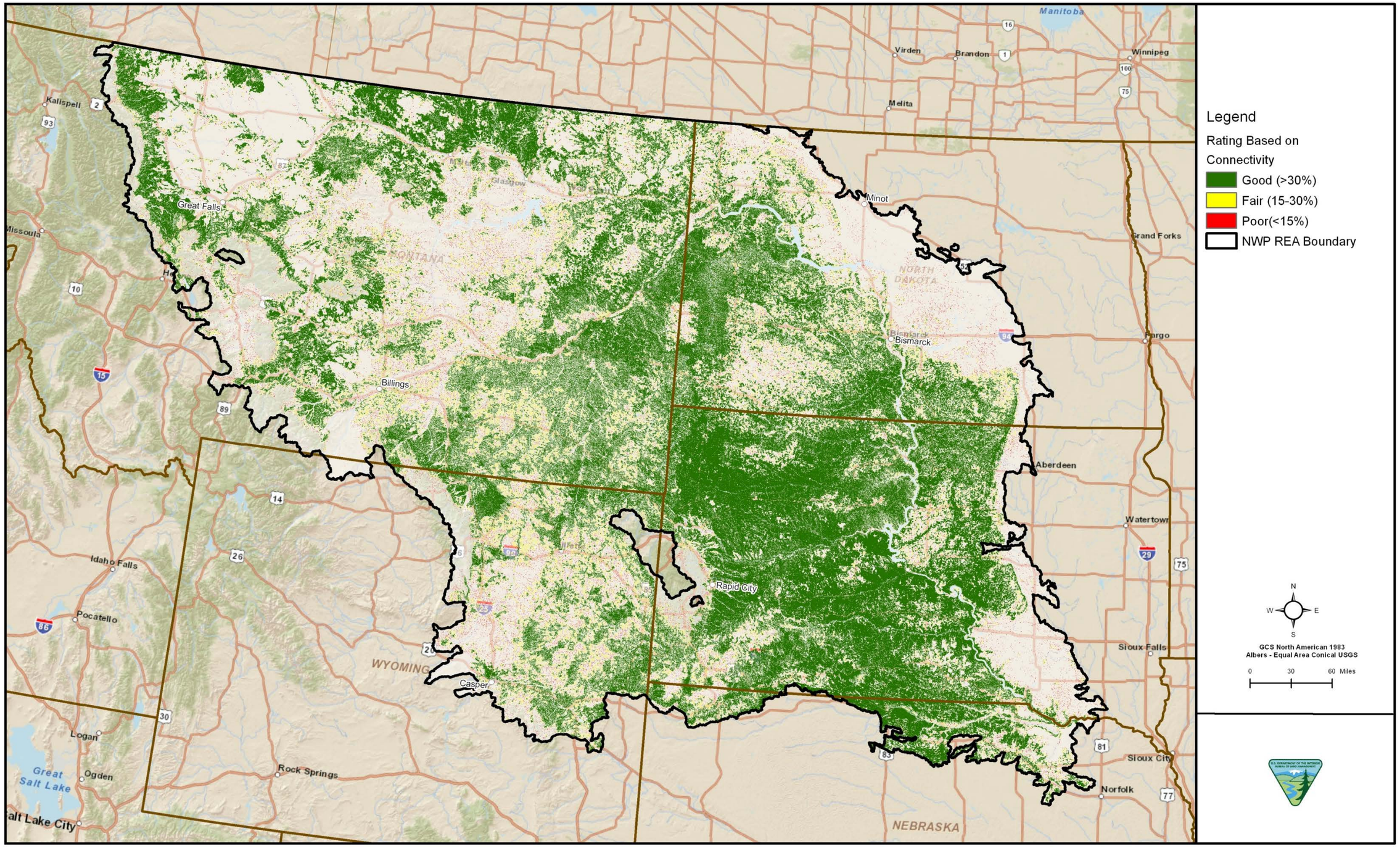

Figure D-3-6. Northwestern Plains Grassland Connectivity

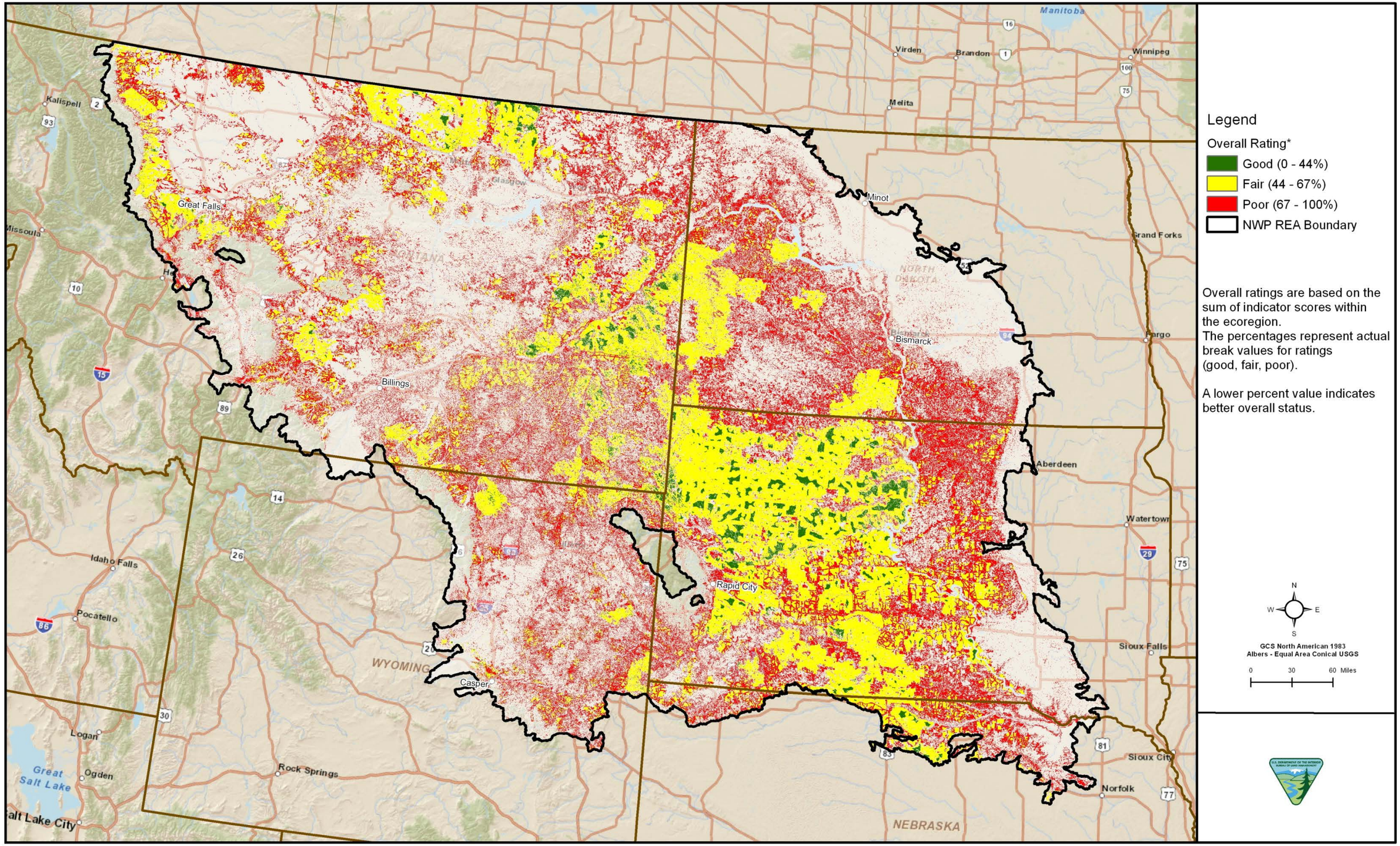

Figure D-3-7. Northwestern Plains Grassland Current Status

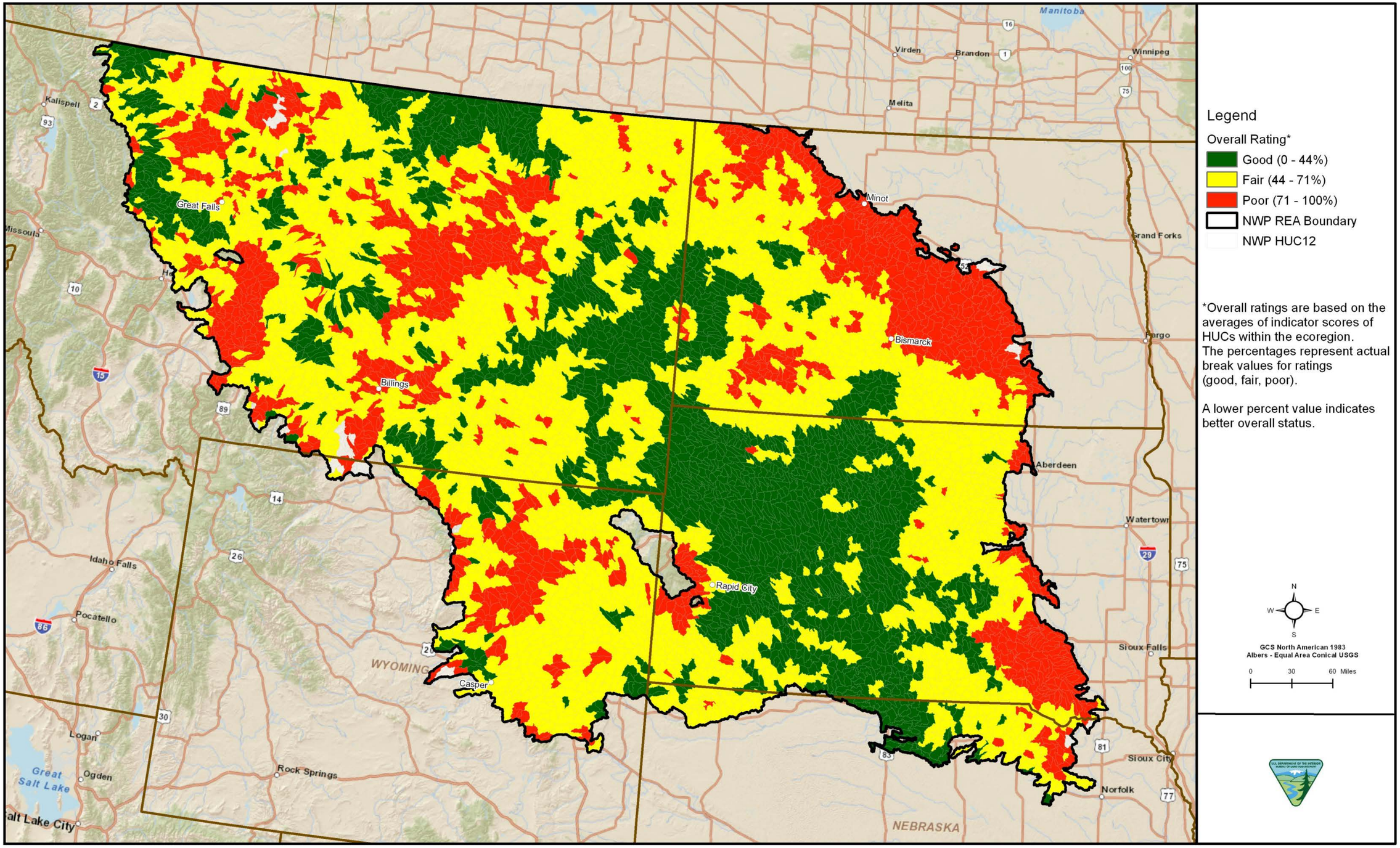

Figure D-3-8. Northwestern Plains Grassland Current Status by the 6th Level Hydrologic Unit Code

APPENDIX D-4

SHRUBLAND AND SAVANNA VEGETATION SYSTEMS COARSE-FILTER CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

Shrubland and savanna vegetation systems encompass nearly 15 percent of the Northwestern Plains ecoregion. Because some of the Gap Analysis Program (GAP) Level 3 systems comprise very small portions of this ecoregion, it was necessary to combine them so that they would be representative of major shrubland and savanna systems in the Northwestern Plains. As described below, this coarse-filter analysis focused on one GAP Level 3 System: Inter-Mountain Basins Big Sagebrush Steppe. The aggregation and crosswalk process for vegetation systems allows evaluation of a reduced number of coarse-filter conservation elements (CEs), while retaining the capability to evaluate nested geospatial data on every Level 3 mapping unit within or across divisions.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The Level 3 system represented in this analysis is briefly described below.

2.1 INTER-MOUNTAIN BASINS BIG SAGEBRUSH STEPPE

This system occurs as extensive matrix types on level-to-gently rolling plains, plateaus, sideslopes, and toeslopes, and as small and large patches in dissected landscapes such as breaks and badlands. Vegetation is sagebrush dominant, with perennial herbaceous components typically contributing greater than 25 percent vegetative cover, and consists mostly of rhizomatous and bunch-form grasses, with a diversity of perennial forbs (Montana Field Guide 2011a).

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3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

3.1 DATA IDENTIFICATION

The major datasets identified to map the distribution of the shrubland and savanna CE were the GAP landcover and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) datasets. Both datasets have adequate coverage across the ecoregion and have been used in similar analyses. The shrubland and savanna distribution datasets are further described in Table D-4-1.

Table D-4-1. Data Sources for the Shrubland and Savanna Coarse-Filter Conservation Element Distribution Mapping for the Northwestern Plains Ecoregion

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	GAP Land Cover Northwest Regional Gap Analysis Program (ReGAP) North Central GAP	U.S. Geological Survey (USGS)	Raster (30-meters [m])	Acquired	Yes
	LANDFIRE	LANDFIRE	Raster	Acquired	No
Soils Data	Soil Survey Geographic (SSURGO) State Soil Geographic 2 (STATSGO2)	U.S. Department of Agriculture (USDA)	Raster	Acquired	No No

3.2 DISTRIBUTION MAPPING METHODS

To map distribution of shrubland and savanna in the Northwestern Plains ecoregion, Science Applications International Corporation (SAIC) used a mosaic of GAP data sources, including two of the national GAP landcover regions, the northwest and north central. The source data for the northwest region was the northwest Regional Gap Analysis Program (ReGAP) dataset, which improved upon the original northwest GAP. The north central region contains states that have not been covered by a ReGAP project. For these areas, the national GAP layer used data from the LANDFIRE project to create a seamless layer. The GAP was developed to help answer questions about species biodiversity and species habitat (USGS 2010). Its overall goal is to assist resource managers in decision making when there is a lack of information about the full range of species on the landscape. Once the data were downloaded, the two datasets were merged together to form a continuous layer of vegetation data across the four states. The continuous data layer was then clipped to the Northwestern Plains ecoregion, at which point the Level 3 system was extracted for review by the Rolling Review Team (RRT) (Figure D-4-1).

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4.0 CONCEPTUAL MODEL

The current status and potential future threat analyses were based on the system-level model, selected environmental variables (Key Ecological Attributes [KEAs]) likely to be at risk from the change agents (CAs), and the availability of data.

4.1 SYSTEM-LEVEL MODEL

The system-level model (Figure D-4-2) for the Northwestern Plains shrubland and savanna systems illustrates the major drivers across the top. The major drivers dictate where these vegetation systems occur throughout the ecoregion, while the CAs focus on what has potential to affect this CE over time. Below the CAs are the corresponding CA pathways that affect both the status and distribution of this CE across the Northwestern Plains ecoregion. Listed below the CA pathways are the three categories of size, context, and condition for development of the KEAs for this coarse filter CE. The KEAs were developed and refined through the rolling review process.

4.1.1 Wildfire

Fire and grazing constitute the primary dynamics affecting shrubland and savanna systems, although drought has also caused impacts to this system in the past decade. The natural fire regime of sagebrush systems maintains a patchy distribution of shrubs, so steppe systems would be typical in disturbance-free areas. However, shrubs increase following heavy grazing and/or with fire suppression. Heavy grazing can lead to a decrease in native bunchgrasses and an increase in exotic grasses and other species. Historically, fire impacts shrublands at a frequency of every 50-100 years, but these systems persist for longer periods. All shrub species regenerate following low-to-moderate intensity fires by re-sprouting from the root systems. Fire suppression may have allowed an invasion of trees into some of these shrubland and savannas, but in many cases sites are too xeric for tree growth. Under present conditions, the fire regime is mixed severity and more variable, with stand-replacing fires being more common in adjacent forested habitats.

4.1.2 Development

In this ecoregion, development is a moderate issue as compared to climate change and altered fire regimes in shrubland and savanna systems. Development issues within this system include areas where there may be extensive energy (e.g. fossil fuel and renewable) development. Energy development directly affects this coarse filter by construction and road clearing through shrublands. This type of development is known to not only directly affect shrublands through the conversion of these habitats to developed habitats, but also through indirect effects such as increasing the spread of invasive species.

4.1.3 Climate Change

Shifts in temperature and precipitation will have not only direct impacts on shrublands, but also will exacerbate many of the existing stresses to these ecosystems. Climate change has the potential to change the dynamics of shrubland systems and exacerbate wildfire. An increase in temperature could result in earlier and longer fire seasons (Westerling et al. 2006). Threats such as fragmentation and habitat loss, poor management, invasive species, and altered fire regimes have the potential to cause shrubland and savanna systems to become more vulnerable to the impacts of climate change over time.

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5.0 CHANGE AGENT ANALYSIS

Although changes caused by development, climate change, wildfire, and invasive species all affect shrubland and savannas in similar ways, the severity of the response of each system to CAs is different. However, for the purposes of this Rapid Ecoregional Assessment (REA), each of the CAs will be assumed to have similar responses to this shrubland and savanna CE; therefore, separate discussion on the effects of the CAs on each of the systems is not necessary.

The natural fire regime of these ecological systems have been greatly altered; therefore, shrub cover can be highly variable (Wright et al. 1979). The natural fire regime of shrubland and savanna systems maintains a patchy distribution of shrubs, so the general aspect of the vegetation is steppe shrubland and savanna. In the absence of natural fire, periodic low intensity prescribed burns can be used to maintain and restore this system to similar pre-settlement conditions. Low-intensity prescribed fire is used to reduce sagebrush cover in order to increase herbaceous forage and improve habitat quality for greater sage-grouse (GRSG) and other wildlife by creating a mosaic of burned and unburned patches (Montana Field Guide 2011a). Threats include invasion by non-native species, livestock practices, fire regime alteration, direct soil surface disturbance, and complexes of prairie dog towns. Changes to the system dynamics increase fire potential, severity, and spread (Montana Field Guide 2011b).

Once the system-level model was 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.

Table D-4-2. Key Ecological Attributes Retained or Excluded

Category	Key Ecological Attribute		Explanation
1. Size	Size of Patches		Data were used to illustrate where the large patches of this vegetation type are located.
2. Condition	a.	Mean Fire Return Interval (FRI)	Mean FRI was used to quantify the average period between fires to describe one component of the historical fire regime.
	b.	Invasive Species	Data Gap - No analysis completed.
3. Structure	a.	Fragmentation	Proximity to show anthropogenic disturbance.
	b.	Connectivity	A moving window analysis was used to show juxtaposition of blocks of shrubland across the landscape.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

Table D-4-3 identifies KEAs, indicators, and metrics that were used to evaluate factors affecting this CE across the ecoregion. The shrubland and savanna process analysis is designed to create a series of intermediate layers that are primarily based on the development and wildfire CAs. The analysis is based on the geospatial data that was currently available.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

For each of the KEAs listed in Table D-4-3, a discussion of the indicator, metric, metric rank and value, data source(s), and references is provided. Only two indicators were used to assess the current threat status for the shrubland and savanna system (Table D-4-3). This table was limited to size and landscape context based on spatially available attributes and key factors affecting shrubland and savannas 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. Equal weights were attributed to each metric in order to provide an overall score for all metrics combined, based on the reporting unit.

Table D-4-3. Key Ecological Attribute Table for the Shrubland Vegetation Systems Coarse-Filter Conservation Element for the Northwestern Plains Ecoregion

Category	Attribute	Indicator/ Unit of Measure	Metric			Data Source	Weight
			Poor = 3	Fair = 2	Good = 1		
Size	Patch Size	Acres	<3,361	3,361-57,993	>57,993	ReGAP	0.25
Condition	Habitat Condition	Mean FRI	0-10 years	10-20 years	20-25 years	Vegetation Condition Class (VCC)	0.25
Context	Fragmentation	Distance to anthropogenic	<0.5 kilometers (km)	0.5 km-2.5 km	>2.5 km	Linear Features; Power Lines; Oil and Gas Wells Pads, ReGAP	0.25
	Connectivity	Distance to similar habitat	<15 percent	15-30 percent	>30 percent	ReGAP	0.25

All analysis units were 30-m pixels and reporting units were Hydrologic Unit Code (HUC) 12.

5.1.1.1 Patch Size

Patch size for the shrubland and savanna coarse-filter CE was determined by finding acres of contiguous 30-meter (m) raster cells. After reviewing the patch size analysis, it appears an artifact of satellite imagery is to have a high number of isolated pixels and to overestimate large number of contiguous pixels. This results in large variations of values and made it difficult to score size based on appropriate sizes of shrubland and savanna across the Northwestern Plains ecoregion. After much discussion with the RRT, it was decided to allow the data to dictate the scoring.

There are several ways to classify the data for scoring. The Jenk's Natural Breaks method was used for this analysis. However, due to the issues with the variation in the size of patches, the Geometric Interval Classification was used. Geometric intervals are used to delineate classes based on groupings of data. Classes are identified by looking for groupings inherent in the data. The Geometric Interval Classification attempts to balance the changes in the middle values and the extreme values.

Figure D-4-3 is a graphical representation of patch size for the shrubland and savanna coarse-filter CE. Red displays low scoring patches, while green shows higher scoring patches. In general, the patch size KEA analysis returned good results for shrubland and savanna areas in northeastern Wyoming and east central Montana. The shrubland and savanna areas in southeastern Montana generally returned poor scores for the patch size KEA.

5.1.1.2 Mean Fire Return Interval

The LANDFIRE's Mean Fire Return Interval (FRI) was used to map the fire frequency for shrublands in this ecoregion. The Mean FRI quantifies the average period between fires under the historical fire regimes. These data were then used to score shrubland fire return intervals based on the current fire frequency from information provided by the RRT (Table D-3-4). The poor 0-10 year metric indicates the likelihood of conversion to annual invasive grasslands, the fair 10-20 year metric indicates some conversion to annual invasive grasslands, and the good 20-25 year metric should cover the mean fire interval range for most shrublands.

The fire frequency layer was extracted to the shrubland and savanna layer and used in the shrubland and savanna current status weighted summary analysis (shown on Figure D-4-4). The Mean FRI metric for shrubland and savanna systems is not thought to be as accurate for these systems as it might be for forested areas; therefore, the results of this analysis should be used with that information in consideration. Overall, the shrubland and savanna systems returned poor results for this KEA analysis; virtually no shrubland and savannah areas returned a good result. Shrubland and savannah areas around the Lewis and Clark National Forest returned fair scores for this KEA analysis.

5.1.1.3 Fragmentation

The Integrated Climate and Land-Use Scenarios (ICLUS) 2010 were used by extracting the urban, exurban, and industrial categories, and then merging the Topologically Integrated Geographic Encoding and Referencing (TIGER) roads for the entire ecoregion. A Euclidean distance proximity analysis was run from this anthropogenic layer. The proximity analysis was then extracted to the shrubland and savanna coarse-filter CE (Figure D-4-5). This layer was then scored based on the assumption that shrubland and savanna closer to roads and urban areas are more fragmented (Table D-4-3). The majority of the shrublands and savannas in northeastern Wyoming returned poor scores for the fragmentation KEA. The shrublands and savannas around the Lewis and Clark National Forest returned good-to-fair scores for this analysis.

5.1.1.4 Connectivity

The shrubland and savanna coarse filter distribution layer was used to perform a neighborhood analysis to determine the extent of shrubland and savanna within the 1 kilometer (km) neighborhood. The neighborhood analysis looks at the relationship of each pixel and the pixel surrounding it using a spatial analyst function. The resulting layer provided the percent shrubland and savanna within the 1-km neighborhood. This layer was then extracted to the shrubland and savanna coarse-filter layer and scored based on the metrics contained in Table D-4-3 and presented on Figure D-4-6. The results of this analysis returned good results for nearly all of the shrubland savannah areas in this ecoregion. Many of the scattered shrubland and savanna areas in southeastern Montana returned good-to-fair scores for the connectivity analysis. Many of these areas may have scored fair-to-poor in the fragmentation analysis but are close in proximity, indicating the potential for connectivity.

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 shrubland and savanna habitat for each Hydrologic Unit Code (HUC) across this ecoregion. A method of aggregating scores was used to summarize overall threats with regard to shrubland and savanna habitat quality. Individual threats can identify areas of potential risk to shrublands and savannas, but aggregated scores can provide important information with relation to areas where shrublands and savannas might encounter multiple threats.

In order to create a combined score for each HUC unit based on varying levels of importance for each key attribute, it was necessary to aggregate the data through a weighting process. The weighted sum tool was used to combine each analysis input map to create an overall Current Status Map (Figure D-4-7). Equal weights were used when summing the threats for the shrubland and savanna.

The resulting output gives each shrubland and savanna 30-m pixel a score based on current status. Figure D-4-7 displays these results; red indicates areas of poor status, while green indicates areas currently at better status based on the measured attributes.

The overall CA score for each 6th level HUC was assigned a current habitat quality rating of good, fair, or poor based on the natural breaks method. Statistics were run on the results from Figure D-4-7 to determine the average overall score. The overall result was then scored based on natural breaks. A higher overall threat score would result in a rating of poor for the HUC, indicating that there are existing threats to shrubland and savanna based on the KEA metrics.

The results of the current status analysis based on the 6th level HUC for the ecoregion are presented on Figure D-4-8. In general, this analysis unfortunately indicates a poor current status for the majority of the shrubland savanna systems of this ecoregion. In areas where shrubland savanna systems are concentrated from the patch size analysis, the overall score predominantly returned good results. Additionally, the review of the results of the overall current status analysis is interesting in that many small areas of shrub savanna in western North Dakota return poor current status scores. These very small patches of shrubland and savanna tend to skew the results of the current status analysis and make it appear worse than it actually is. This is one of the inherent problems with rolling the analysis up to the watershed level. Figure

D-4-7 shows the pixel-based results and provides a clearer picture of the results of the analysis as compared to when it is rolled up to the HUC level.

A summary of the current status ratings based on the CE distribution is provided in Table D-4-4. 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 77.6 percent of the 6th level HUC watersheds that intersect the shrubland and savanna systems distribution received an overall rating of fair or poor.

Table D-4-4. Summary of Current Status Ratings for the Shrubland and Savanna Systems

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	33,229	22.5
Fair	52,526	35.6
Poor	61,992	42.0

[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

Future threats were evaluated for development for a short-term time horizon (5-10 years) and for climate change for a long-term time duration (50-year; 2050-2069). Future spatial data for development was limited to potential energy development and climate change, as discussed in the development CA analysis contained in Appendix C-1.

Most of these areas have been connected to agriculture, so the risk to shrubland and savanna systems in the Missouri River Valley is anticipated to be minimal. However, large blocks of shrubland and savanna in central northern South Dakota have the potential to be converted based on their soil type. Shrubland and savanna in southwest North Dakota also appear to be at risk for conversion to agriculture. Shrubland and savanna in Montana, Wyoming, and Nebraska appear to be at a lessor risk, with the bottom lands along major tributaries at the highest risk to potential conversion.

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. Further details regarding the climate change analysis are provided in Appendix C-5.

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 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 therefore should be carefully applied to future estimates of their effect on coarse filters.

5.2.1 Development Change Agent

Future spatial data for development was 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 above, conversion of shrubland and savanna to agriculture is probably the most predominant current and future CA for shrubland and savanna systems. Grain prices will increase commensurate with world population levels, and the production of crops will need to equally increase. 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 to that which was completed for the current status. Figure C-1-1 in Appendix C-1 shows the State Soil Geographic

(STATSGO) soil classification 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 C-1-1 shows the results of the analysis, indicating the potential risk from future agricultural land development. As would be expected in this ecoregion, most of the agricultural areas (current and future) are located throughout the Missouri River Valley. Thus, the shrubland and savanna systems are at risk to agriculture in the future.

5.2.1.2 Future Growth of Urban Areas

Minor portions of shrubland and savanna are currently in close proximity to urban/suburban populations in this ecoregion.

The ICLUS model is a universally accepted model created by the U.S. Environmental Protection Agency (USEPA) for use in future climate change modeling and 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. Figure C-1-2, Future Urban Growth Potential, shows the results of the analysis. The highest density of growth appears to be near Rapid City, South Dakota; however, this area does not contain dense shrubland or savanna systems.

Based on review of the map, it does not appear that urban growth is as great a risk to this CE as agriculture.

5.2.1.3 Oil Production Potential

The future analysis characterized potential oil production areas rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential effect 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 effect of potential oil production areas on shrubland and savannas.

Shrubland and savanna systems appear to be at high risk in northeastern Wyoming from potential oil development. Additionally, areas in eastern Montana and western South Dakota are also at a high risk from potential oil production. Shrubland and savanna habitat in other areas of the ecoregion are not at high risk from this CA.

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 this ecoregion. 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 Natural Gas Production Potential

The future analysis characterized potential gas production areas 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 effect of potential gas production areas on shrubland and savanna systems.

With the exemption of northeastern Wyoming, most of the shrubland and savanna systems in this ecoregion are at a low risk from gas production. The majority of potential future gas production is limited to northeastern Wyoming. Western North Dakota and eastern Montana have a moderate potential for risk from natural gas development, but from an ecoregional scale it does not appear that shrubland and savanna systems are at a future risk from 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 National Renewable Energy Laboratory (NREL). Although these maps are very crude, the highest potential for solar development is shown to occur in northeastern Wyoming and southeastern Montana. While a good portion of shrubland and savanna distribution occurs within fair areas for potential solar development, shrubland and savanna systems appear to be at low risk at the ecoregional level.

5.2.1.6 Wind Turbine Potential

The U.S. Fish and Wildlife Service (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 are presumably going to 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 turbine locations were based on the availability of suitable wind speeds.

Data characterized by the 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. Wind Power Classes were characterized as low, moderate, or high for direct comparison to the current wind condition.

The potential threats to shrubland and savanna systems relative to future wind energy development are presented on Figure C-1-7. Higher elevations within this ecoregion are at a higher risk from potential 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 mountainous regions. In addition to the physical disturbance that wind turbines can have on shrubland and savanna, bird mortality is also a concern with the development of new wind farms. The development of wind farms near shrublands, grasslands, and wetlands, which the majority of our nation's waterfowl migrate through, should be considered when future wind farms are planned for development in this area.

5.2.1.7 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). As mentioned in the preceding oil and gas section, shrubland and savanna systems within northeastern Wyoming are at the highest risk for fossil fuel development.

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 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 the species by their effect on habitat availability. 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 shrubland and savanna systems, a limited approach must be taken in this analysis. The majority of the shrubland and savanna systems in the Northwestern Plains ecoregion are at low risk from potential renewable energy production. However, shrubland and savanna systems in northeastern Wyoming are 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 shrubland and savanna systems. Climate change presents many different issues relating to shrubland and savanna. 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.

Based on the analysis conducted for the ecoregion as presented in Appendix C-5, temperature and precipitation changes appear to be minor in the areas where shrublands occur in the Northwestern Plains. However, the combined risks of increased temperatures, localized drought, and conversion of lands to agricultural uses could negatively affect shrubland and savanna systems in the future.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the shrubland and savanna system would include those defined as part of the Terrestrial Biotic Resources category. The overall MQ was: Where are the important regionally significant terrestrial features, functions, and services across the ecoregional landscape? This MQ was considered in implementing the geographic information system (GIS) analyses. Emphasis was placed on the spatial relationship of attributes mentioned in the MQs and the shrubland and savanna system distribution model. Several examples of how the REA can be used to answer MQs are provided below to demonstrate the functionality of the REA and to provide an opportunity to discuss data gaps that were identified during this REA.

6.1 HOW IS SHRUBLAND AND SAVANNA DISTRIBUTED OVER THE LANDSCAPE?

Figure D-4-1 maps the ReGAP sparse vegetation across the ecoregion.

6.2 WHERE WILL CURRENT CONSERVATION ELEMENT VEGETATION TYPES BE AT GREATEST RISK FROM CHANGE AGENTS?

The full range of figures and analyses for the shrubland and savanna system can be used to answer this complex MQ. The models created throughout this process were created to directly address the effects of CAs on the shrubland and savanna system. These CAs were addressed spatially and described in detail in this section, and all of the CAs were spatially attributed to the distribution of the shrubland and savanna. Figure D-4-7 represents the sum of Figures D-4-4 through D-4-6 by the 30-m analysis unit, while Figure D-4-8 represents the sum of all the threats at the 12-digit HUC reporting unit.

6.3 WHAT AREAS HAVE POTENTIAL FOR RESTORING CONSERVATION ELEMENT SPECIES HABITAT OR HABITAT CONNECTIVITY FOR CONSERVATION ELEMENT SPECIES, CURRENTLY AND IN THE FUTURE?

The fragmentation potential (Figure D-4-5) represents the potential for further fragmented shrubland and savanna systems. It can also be used to show areas where future restoration may be the most beneficial. The fragmentation potential shows areas where restoration could potentially connect larger shrublands together.

6.4 WHERE WILL CONSERVATION ELEMENTS BE AT RISK FROM ALTERED FIRE REGIMES? WHERE ARE AREAS WITH POTENTIAL TO SHOW FUTURE INCREASES OR DECREASES IN WILDFIRE FREQUENCY OR INTENSITY?

Figure D-4-4 represents the VCC for the shrubland and savanna systems. This figure represents changes in vegetation and fuels from their historical condition. For the Northwestern Plains, a group of subject matter experts (SMEs) went through an exercise to illustrate fire regime (frequency and severity) departure. The historic biophysical setting (BpS) was attributed with a current fire severity and frequency and was then compared with the reference (historic) fire frequency and severity for each type. From these data, we were able to develop a fire frequency departure map, a fire severity departure map, and then a composite map (which took the highest of either departure). This modified composite layer was used as the best indicator for potential threats to shrubland and savanna systems from an uncharacteristic fire. These maps should be used with caution as this metric is known to be less precise in shrubland and savanna systems.

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APPENDIX D-4

FIGURES

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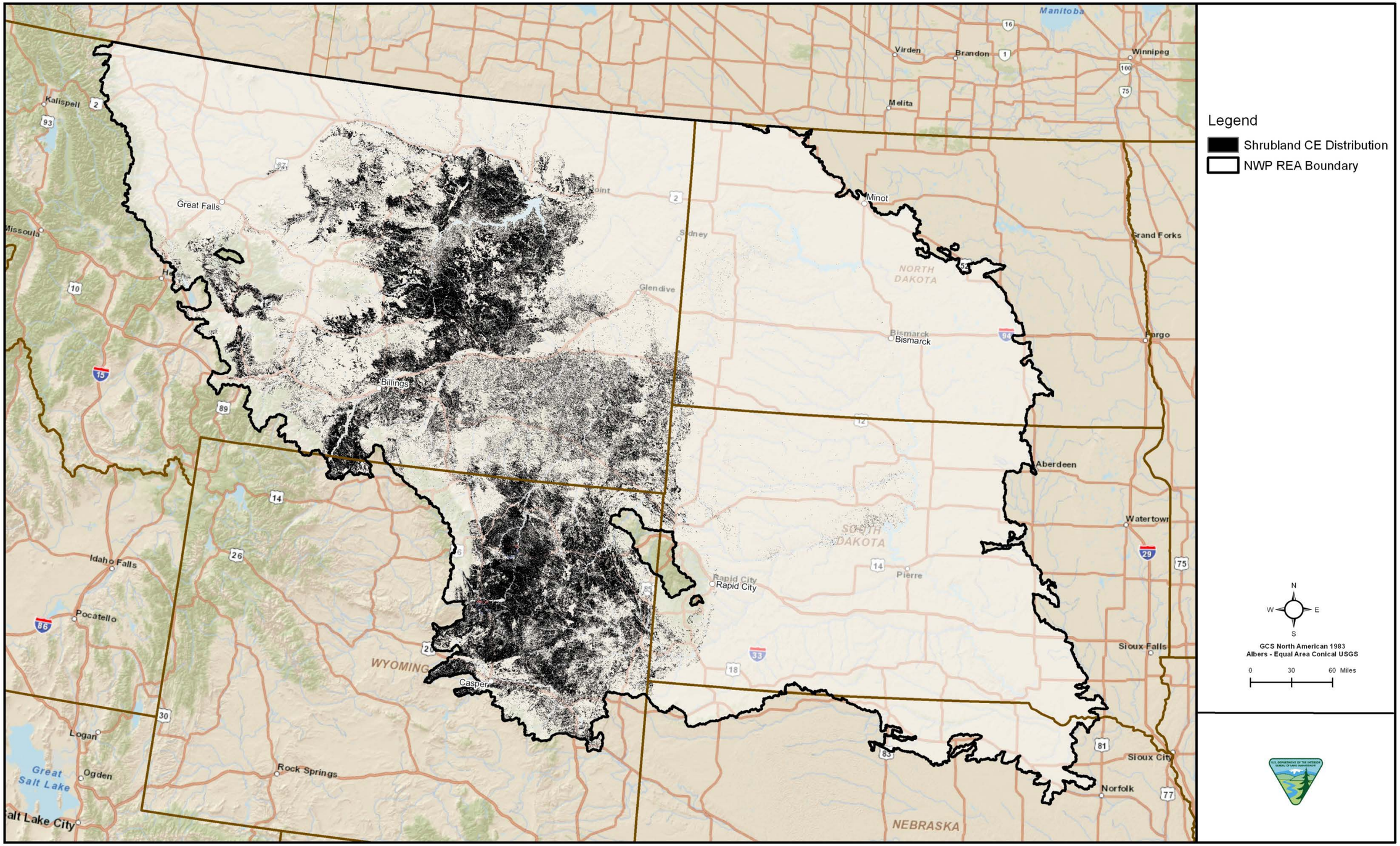
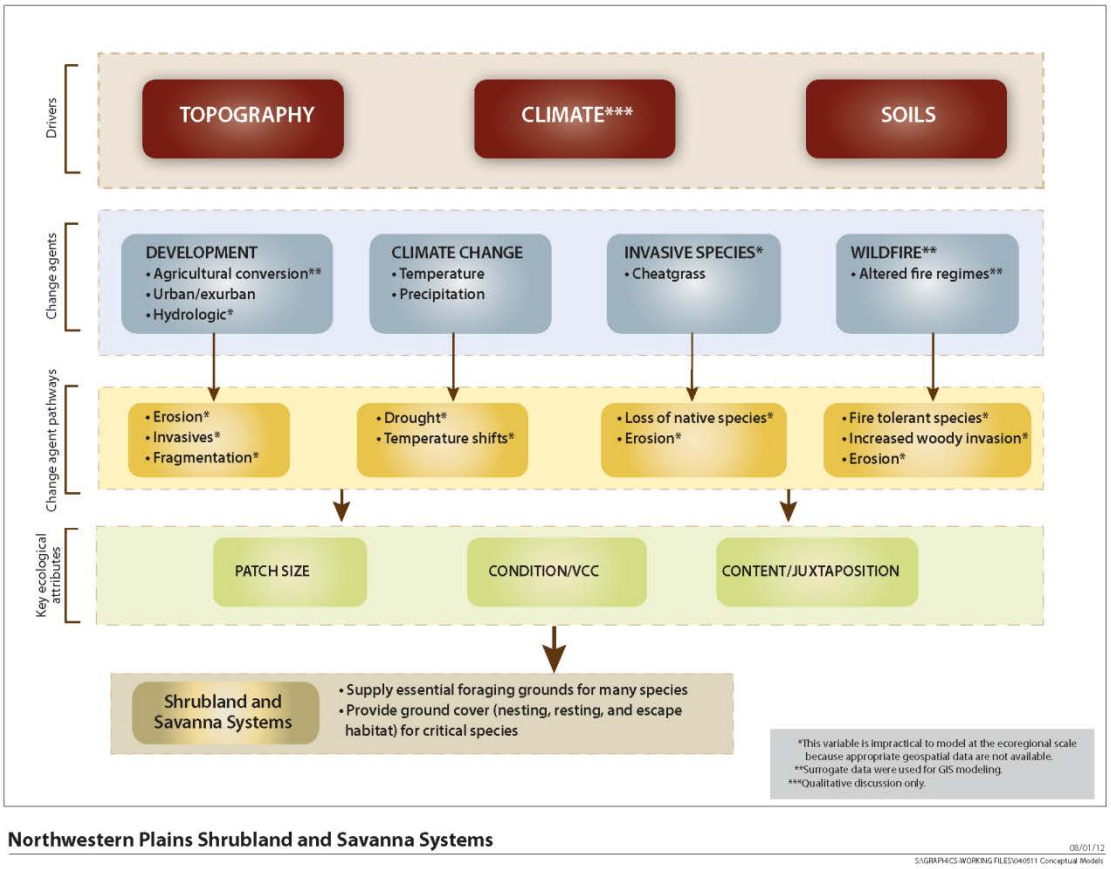


Figure D-4-1. Northwestern Plains Shrubland and Savanna Distribution



Northwestern Plains Shrubland and Savanna Systems

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Figure D-4-2. Northwestern Plains Shrubland and Savanna System-Level Model

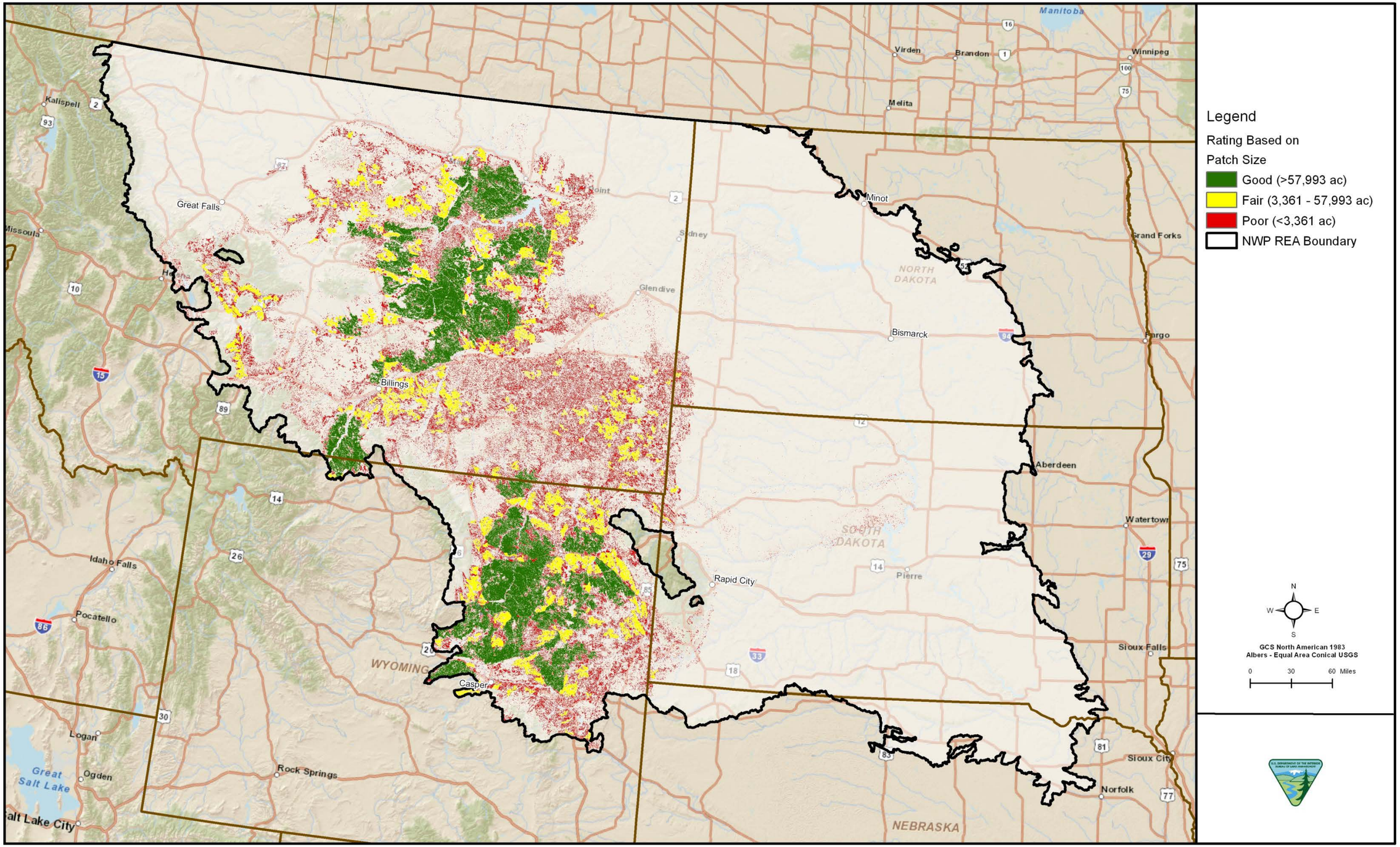

Figure D-4-3. Northwestern Plains Shrubland and Savanna Patch Size

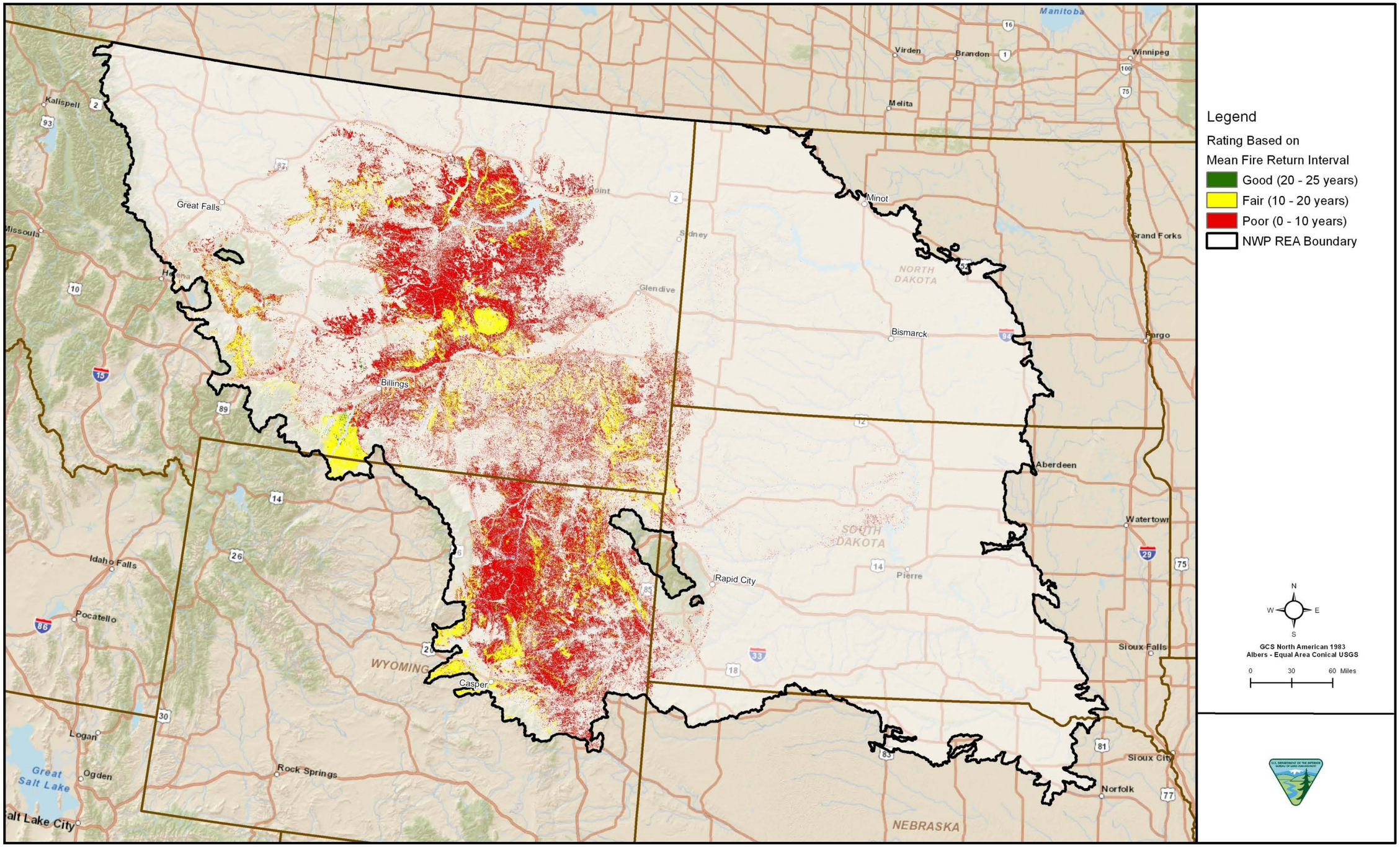

Figure D-4-4. Northwestern Plains Shrubland and Savanna Mean Fire Return Interval

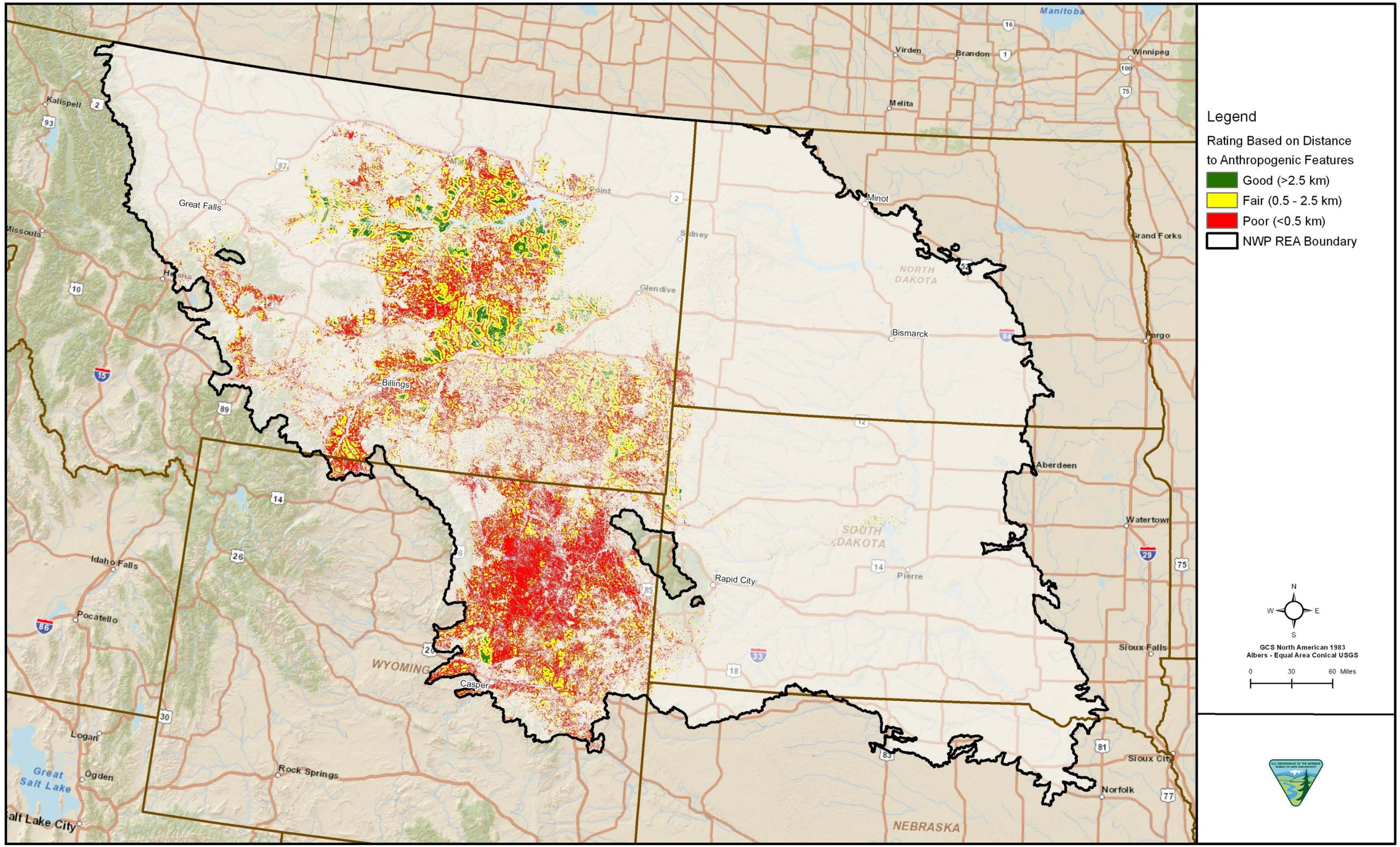

Figure D-4-5. Northwestern Plains Shrubland and Savanna Fragmentation

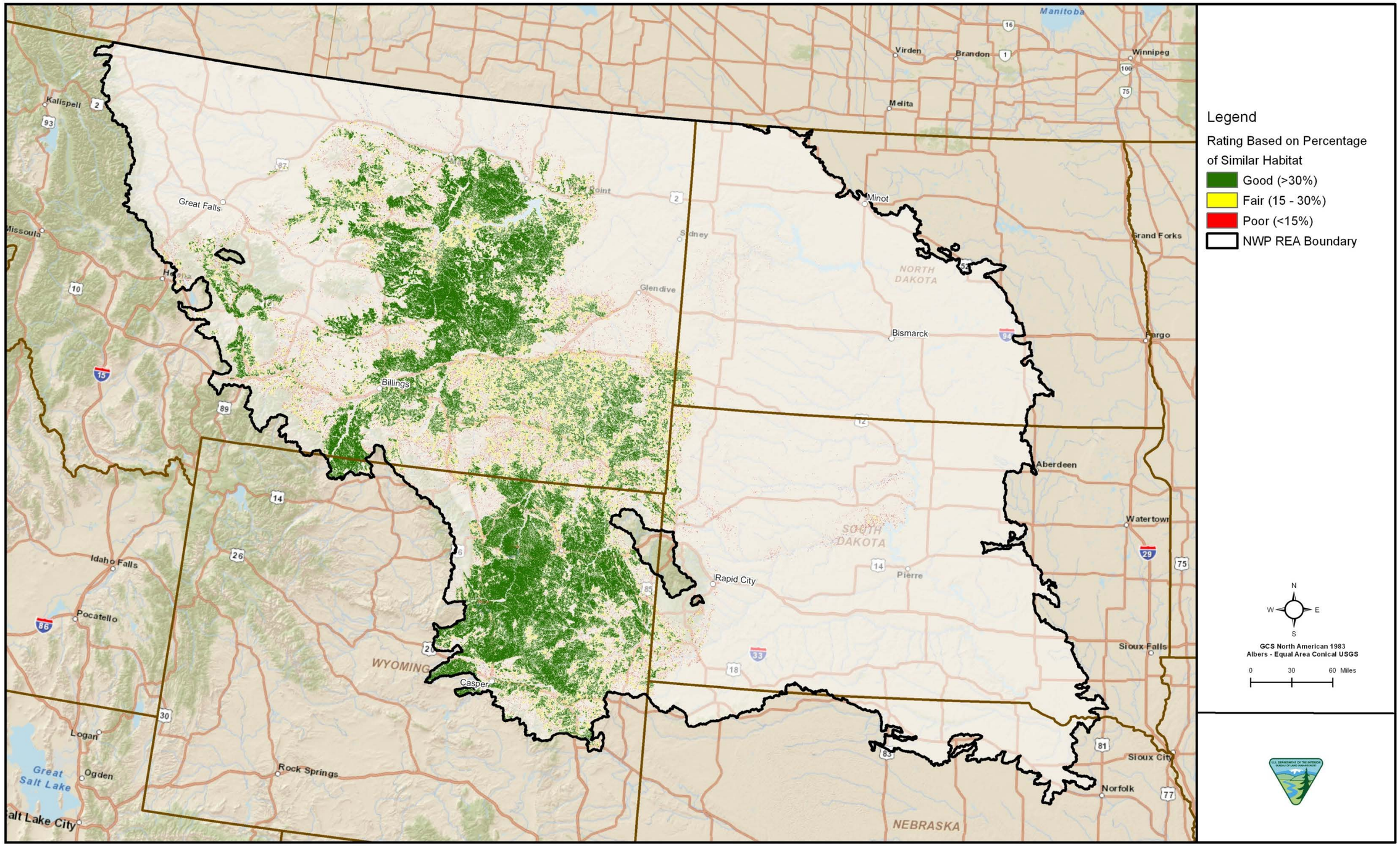

Figure D-4-6. Northwestern Plains Shrubland and Savanna Connectivity

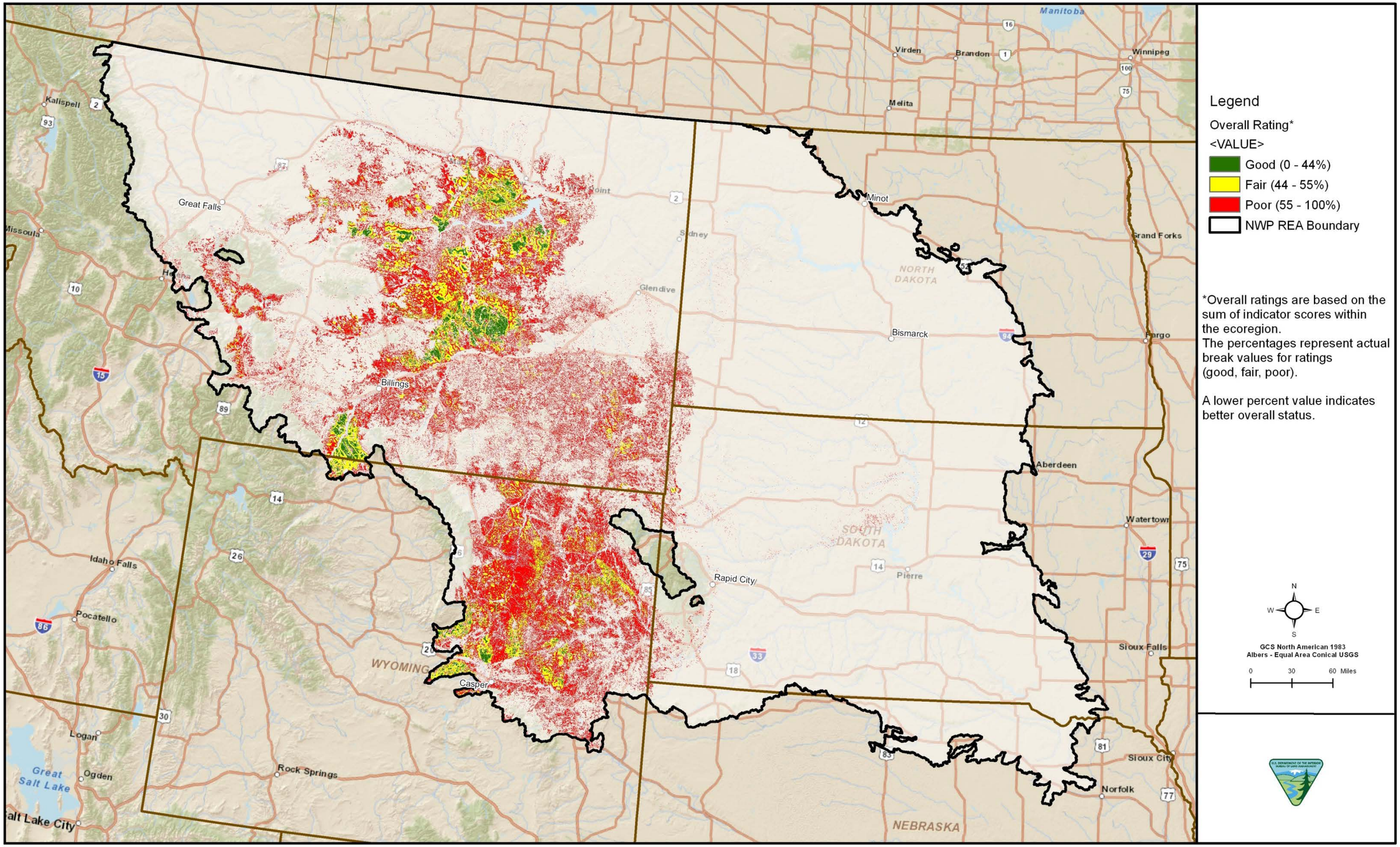

Figure D-4-7. Northwestern Plains Shrubland and Savanna Current Status

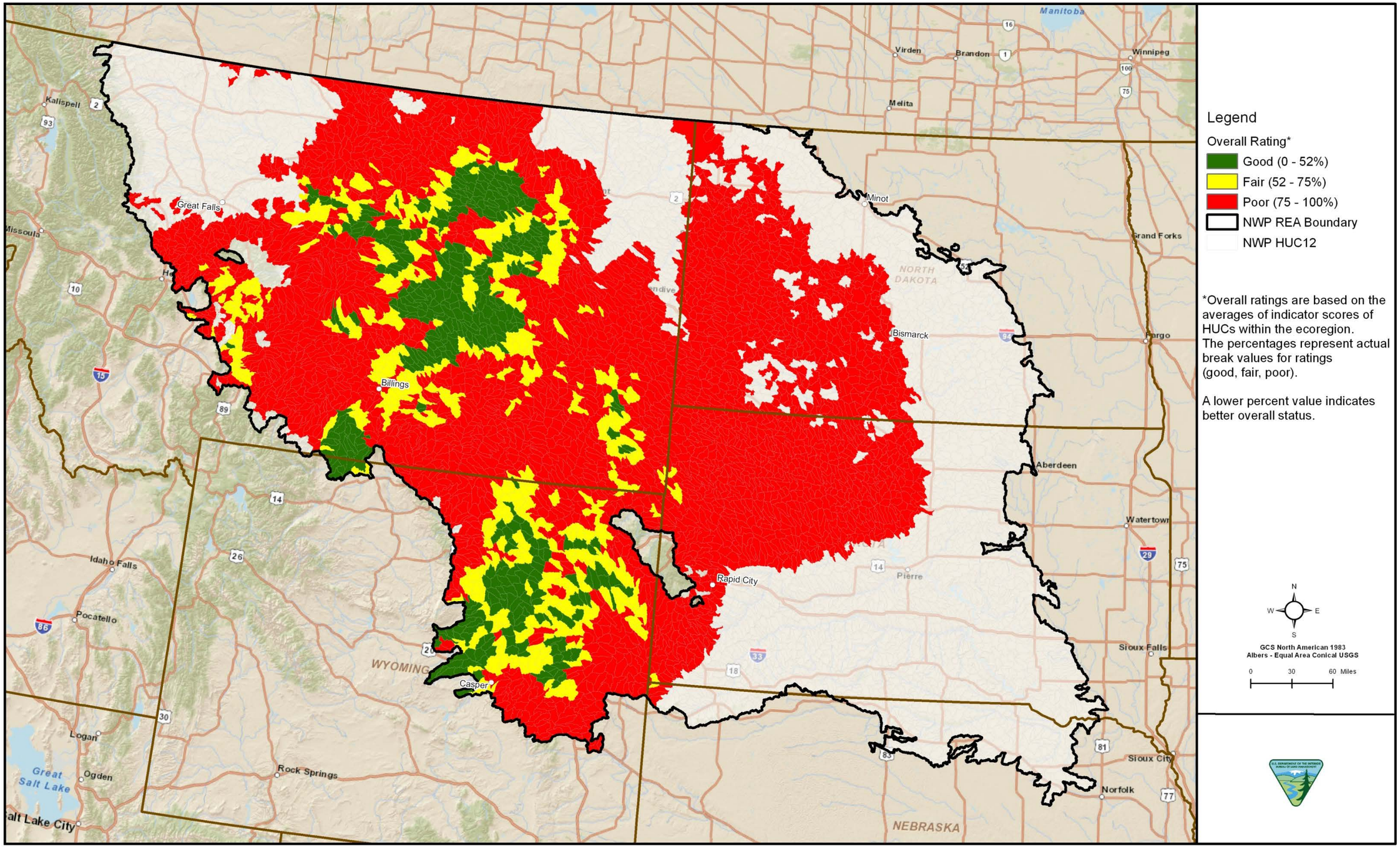

Figure D-4-8. Northwestern Plains Shrubland and Savanna Current Status by 6th Level Hydrologic Unit Code

APPENDIX D-5

SPARSE VEGETATION AND NATURAL BARREN AREAS COARSE-FILTER CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

Sparse vegetation and natural barren areas encompass approximately 2 percent of the entire Northwestern Plains ecoregion, making it one of the smallest vegetation systems in the ecoregion. Because some of the Gap Analysis Program (GAP) Level 3 systems comprise very small portions of this ecoregion, it was necessary to combine them so that they would be representative of major sparse vegetation and natural barren area systems in the Northwestern Plains. The coarse-filter analysis for sparse vegetation and natural barren areas originally focused on one GAP Level 3 system, the Southwestern Great Plains Canyon (Badlands). However, after developing a map of this system and visualizing the minor amount of the ecoregion encompassed by this system, the Assessment Management Team (AMT) directed Science Applications International Corporation (SAIC) to also include the Western Great Plains Badland Level 3 system. The aggregation and crosswalk process for vegetation systems allows evaluation of a reduced number of coarse-filter conservation elements (CEs), while retaining the capability to evaluate nested geospatial data on every Level 3 mapping unit within or across divisions.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The Level 3 systems represented in this analysis are briefly described below.

2.1 SOUTHWESTERN GREAT PLAINS CANYON (BADLANDS)

This system occurs in both perennial and intermittent-stream canyons of the Southwestern Great Plains. The mosaic of soil types which have developed from sandstone, limestone, basalt, and shale parent materials create a complex mosaic of sparse vegetation, shrublands, and woodlands within the canyon system (Shaw et al. 1989). Although the system combines many elements from Southern Rocky Mountains Juniper Woodland and Savanna, Southern Rocky Mountains Lower Montane-Foothills Shrubland, Western Great Plains Shortgrass Prairie, and other shrublands, the varied geology, diverse soil types, and topographic dynamics together form a distinct ecological system with complex characteristic of the canyons and dissected mesas of the Southwestern Great Plains.

Vegetation varies both regionally and locally depending on latitude, aspect, slope position, and substrate, and can range from riparian vegetation to xeric or mesic woodlands and shrublands (Colorado Natural Heritage Program 2011a).

2.2 WESTERN GREAT PLAINS BADLANDS

This system occurs within the mixed grass and sand prairie regions of the ecoregion on eroded uplands, slopes, and creek bottoms. Soils are extremely dry and highly erodible. This system is recognized by its rugged, rocky character and the relative absence of vegetative cover. A variety of dryland shrubs and patches of sagebrush (*Artemisia spp.*) are known to occur in this system. Land use is limited, except for off-highway vehicle recreation and incidental grazing. Infrequent but torrential rains and off-highway vehicle (OHV) use can cause substantial erosion of this system.

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3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

3.1 DATA IDENTIFICATION

The major datasets identified to map the distribution of the riparian CE were the GAP landcover and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) datasets. Both datasets have adequate coverage across the ecoregion and have been used in similar analyses. The sparse vegetation and natural barren areas distribution datasets are further described in Table D-5-1.

Table D-5-1. Data Sources for the Sparse Vegetation and Natural Barren Areas Conservation Element Distribution Mapping for the Northwestern Plains Ecoregion

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	GAP Land Cover Northwest Regional Gap Analysis Program (ReGAP) North Central GAP	U.S. Geological Survey (USGS)	Raster (30-meter [m])	Acquired	Yes
	LANDFIRE	LANDFIRE	Raster	Acquired	No
Soils Data	Soil Survey Geographic (SSURGO) State Soil Geographic (STATSGO2)	U.S. Department of Agriculture (USDA)	Raster	Acquired	No No

3.2 DISTRIBUTION MAPPING METHODS

To map distribution of sparse vegetation and natural barren areas in the Northwestern Plains ecoregion, SAIC used a mosaic of GAP data sources, including two of the National GAP landcover regions, the Northwest and North Central. The source data for the Northwest region was the Northwest Regional Gap Analysis Program (ReGAP) dataset, which improved upon the original Northwest GAP. The North Central region contains states that have not been covered by a ReGAP project. For these areas, the National GAP layer used data from the LANDFIRE project to create a seamless layer. The GAP was developed to help answer questions about species biodiversity and species habitat (USGS 2010). Its overall goal is to assist resource managers in decision making when there is a lack of information about the full range of species on the landscape. Once the data were downloaded, the two datasets were merged together to form a continuous layer of vegetation data across the four states (Figure D-5-1). The continuous data layer was then clipped to the Northwestern Plains ecoregion, at which point the Level 3 systems were extracted for review by the Rolling Review Team (RRT) (Figure D-5-3).

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4.0 CONCEPTUAL MODELS

The current status and potential future threat analyses were based on the system-level model, selected environmental variables (Key Ecological Attributes [KEAs]) likely to be at risk from the change agents (CAs), and the availability of data.

4.1 SYSTEM-LEVEL MODEL

The system-level model for the Northwestern Plains sparse vegetation and natural barren area systems illustrate the major drivers across the top (Figure D-5-2). The major drivers dictate where these vegetation systems occur throughout the ecoregion, while the CAs focus on what has potential to affect this CE over time. Below the CAs are the corresponding CA pathways that may affect both the status and distribution of this CE across the Northwestern Plains ecoregion.

4.1.1 Wildfire

In the Northwestern Plains, fire is not a primary driver of sparse vegetation and natural barren systems. Vegetation is very bare and may be naturally absent in some places. Fire intensity and size determine the reaction of vegetation. Fire is generally spread by eolian activity and reduces vegetation cover. Vegetation response generally depends on climate, topography, soil moisture, site condition, timing of fire, propagule availability, and severity of wind (Washington Natural Heritage Program 2007). Typically, fire occurrence within these systems increases annual exotic plant abundance (Brown et al. 2000).

4.1.2 Development

Development is not a primary issue to sparse vegetation and natural barren area systems within the Northwestern Plains. These systems are distinguished by the active erosion and soil characteristics that act to maintain sparse vegetation and natural barren areas. Effects from development may include unnatural erosion, compaction, and altered species composition. Fragmentation from roads, OHVs, and human development (e.g., oil and gas), if present, is limited to a small area and may cause an increase in non-native plants.

4.1.3 Climate Change

Sparse vegetation and natural barren area systems are distinguished by the active erosion and soil characteristics that act to maintain sparse vegetation and natural barren areas. Communities associated with this ecological system are adapted to highly erodible soils that may be dry throughout the growing season. They may also occur on shallow soils, with parent material and/or shale bedrock formation close to the surface. Generally, the plant communities will be drought tolerant, grazing resistant, and winter hardy, and will be tolerant of managed grazing practices or light-intensity fires (Montana Field Guide 2011).

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5.0 CHANGE AGENT ANALYSIS

Climate change, wildfire, and invasive species would not affect this coarse-filter CE in the same ways as other systems due to the general lack of vegetation. Out of all the CAs, development has the greatest potential to affect this coarse-filter CE. Development has the potential to cause substantial erosion and creation of impermeable surface with associated runoff.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

No KEAs were initially developed. As a proxy to potential impacts of OHVs, roads were used to complete a proximity analysis. Areas of greater road densities indicate greater human activity, and therefore are an indicator of landscape context. The effect of roads on this CE includes habitat loss or fragmentation, erosion, and introduction of invasive species.

Road density models were created in ArcGIS based on the number of roads per square kilometer (km^2). Topologically Integrated Geographic Encoding and Referencing (TIGER) data for all road types were used to create this layer, which was then clipped to the Northwestern Plains ecoregion boundary. The limitations of the TIGER data are discussed in previous memorandums, but the variation in road attributes among states precluded an efficient method of selecting roads by size and/or type. Linear features were buffered so that all layers are polygons that can be used in geographic information system (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 12-digit Hydrologic Unit Code (HUC) was calculated and relative rank of good, fair, or poor based on the CE-specific scoring was determined.

The road density analysis is presented in Figure D-5-3. It appears that there is a low risk associated with roadways in the sparse vegetation habitats of this ecoregion.

5.2 FUTURE THREAT ANALYSIS

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). Future spatial data for development was limited to potential energy development and climate change, as discussed in the development CA analysis presented in Appendix C-1.

Climate change was modeled based on a 15-kilometer (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. Further details regarding the climate change analysis is provided in Appendix C-5.

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 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 coarse filters.

5.2.1 Development

Future threat analysis for development was limited to potential energy development, as threats from modeled urban growth and potential agricultural development are not anticipated to affect this coarse-filter CE.

The future analysis characterized potential oil production areas rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential effect 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. 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.

From an ecoregional scale, it does not appear that sparse vegetation systems are at risk from future oil or gas development (Figure C-1-5). The majority of potential gas production is limited to northeastern Wyoming. Additionally, future renewable energy potential (Figure C-1-8) also appears to present a low risk to sparse vegetation habitats.

5.2.2 Climate Change

In general, the Regional Climate Model version 3 (RegCM3) model for the annual data, as presented in Figure C-5-1, indicates a large annual precipitation increase in the southeastern area of the ecoregion, and a moderate increase across the rest of the ecoregion. The RegCM3 data shows that the Northwestern Plains could experience a temperature increase of between 1.9 to 2.3degrees Celsius (°C) (Figure C-5-7).

As a semi-arid region, infrequent summer thunderstorms occur that loosen and quickly erode the existing soil and sediments. Future climate changes that may result in more extreme environmental conditions, including temperature increases, could accelerate erosion processes, and may restrict vegetation growth or recovery.

6.0 MANAGEMENT QUESTIONS

The relevant management questions (MQs) for the sparse vegetation and natural barren area systems would include those defined as part of the Terrestrial Biotic Resources category. The overall MQ was: Where are the important regionally significant terrestrial 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 sparse vegetation and natural barren area systems model. 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 this REA.

6.1 HOW ARE SPARSE VEGETATION AND NATURAL BARREN AREAS DISTRIBUTED OVER THE LANDSCAPE?

Figure D-5-1 maps the ReGAP sparse vegetation and natural barren areas across the ecoregion.

6.2 WHERE WILL CURRENT CONSERVATION ELEMENT VEGETATION TYPES BE AT GREATEST RISK FROM CHANGE AGENTS?

As a proxy to the potential risk of road construction and OHVs, an analysis of roads overlaid with sparse vegetation and natural barren area systems distribution was used to complete a proximity analysis (Figure D-5-3).

Additionally, future threat analysis for potential energy development was assessed and is shown on Figure C-1-5.

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APPENDIX D-5

FIGURES

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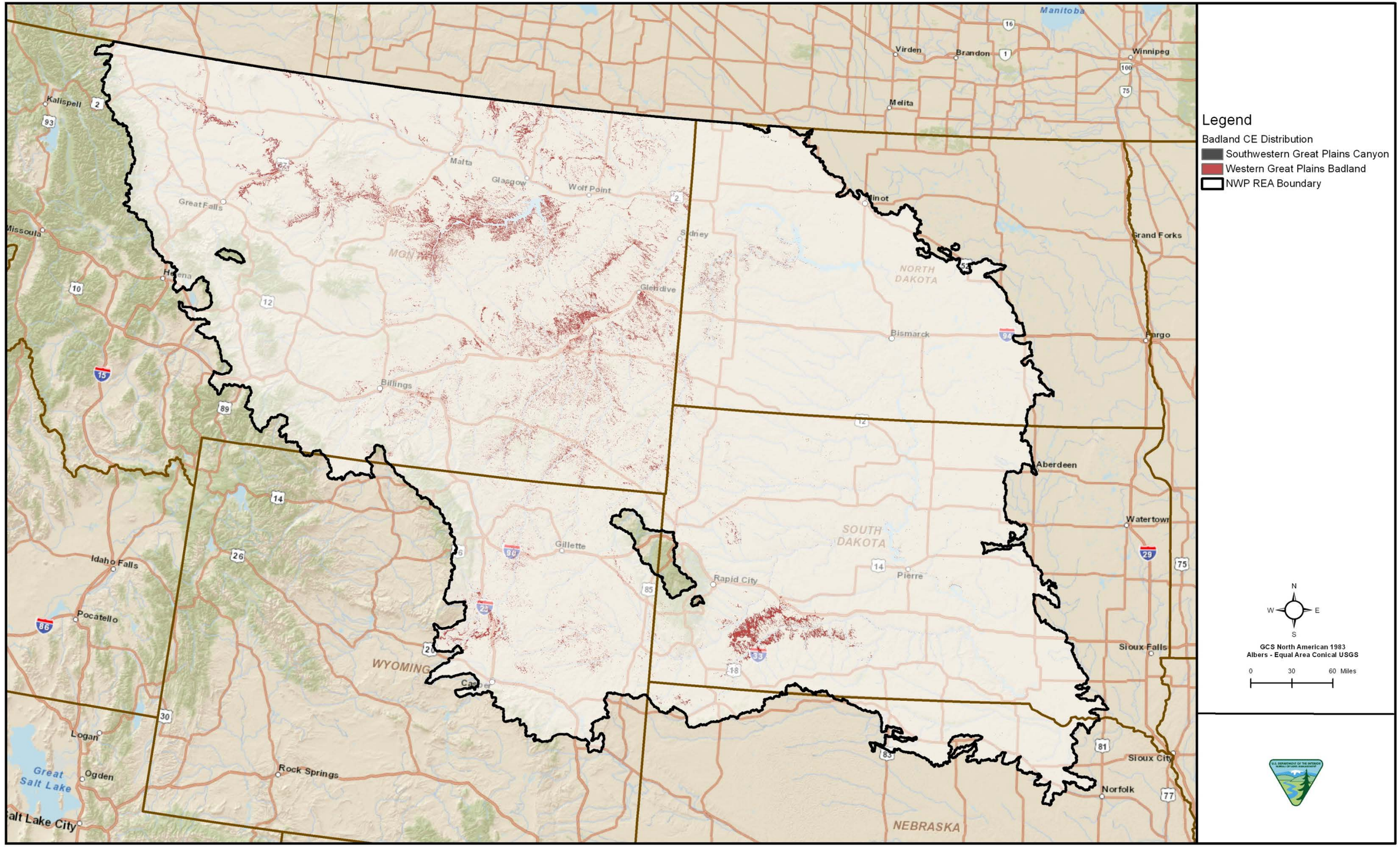
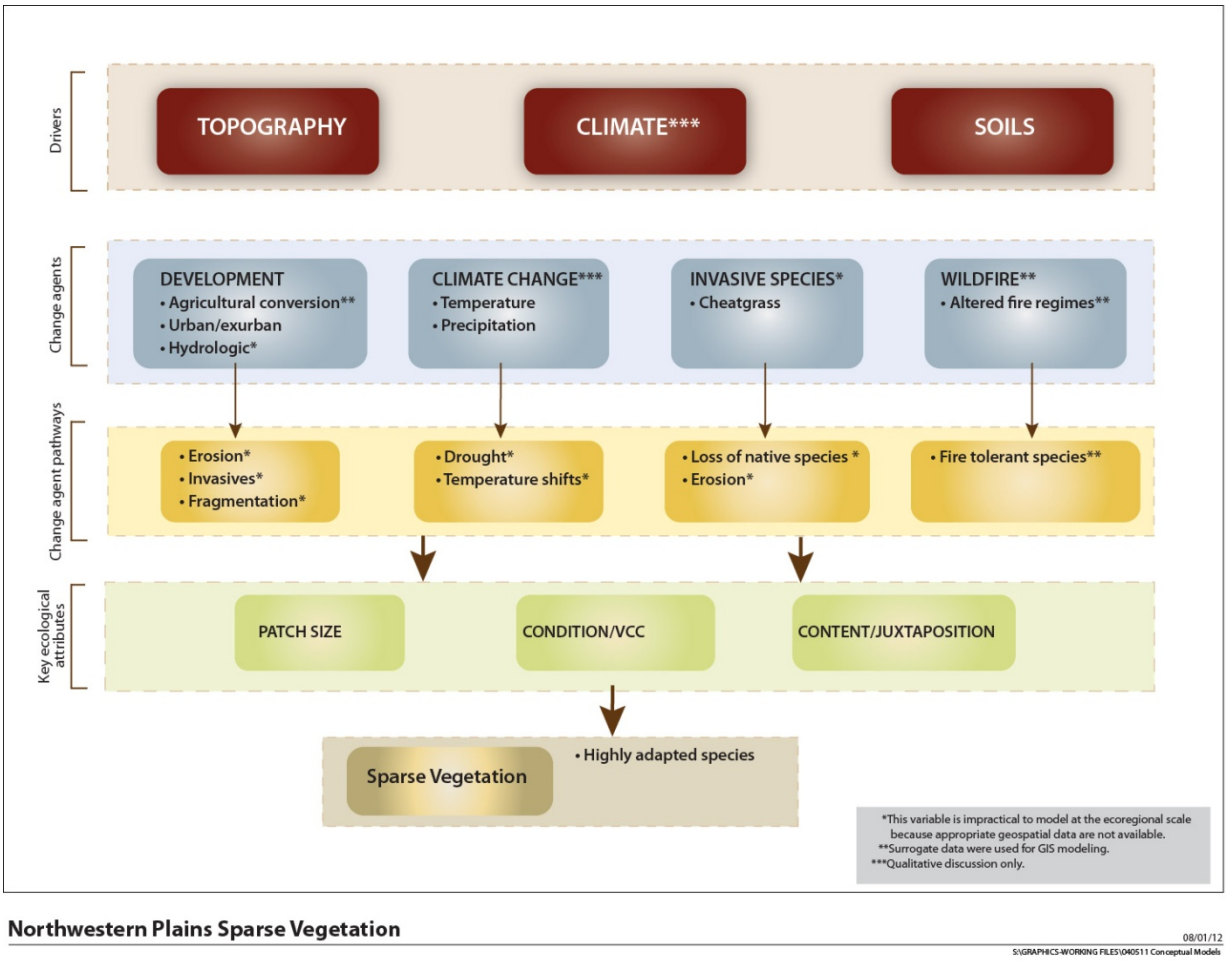


Figure D-5-1. Northwestern Plains Sparse Vegetation and Natural Barren Area Distribution



Northwestern Plains Sparse Vegetation

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Figure D-5-2. Northwestern Plains Sparse Vegetation and Natural Barren Areas System-Level Model

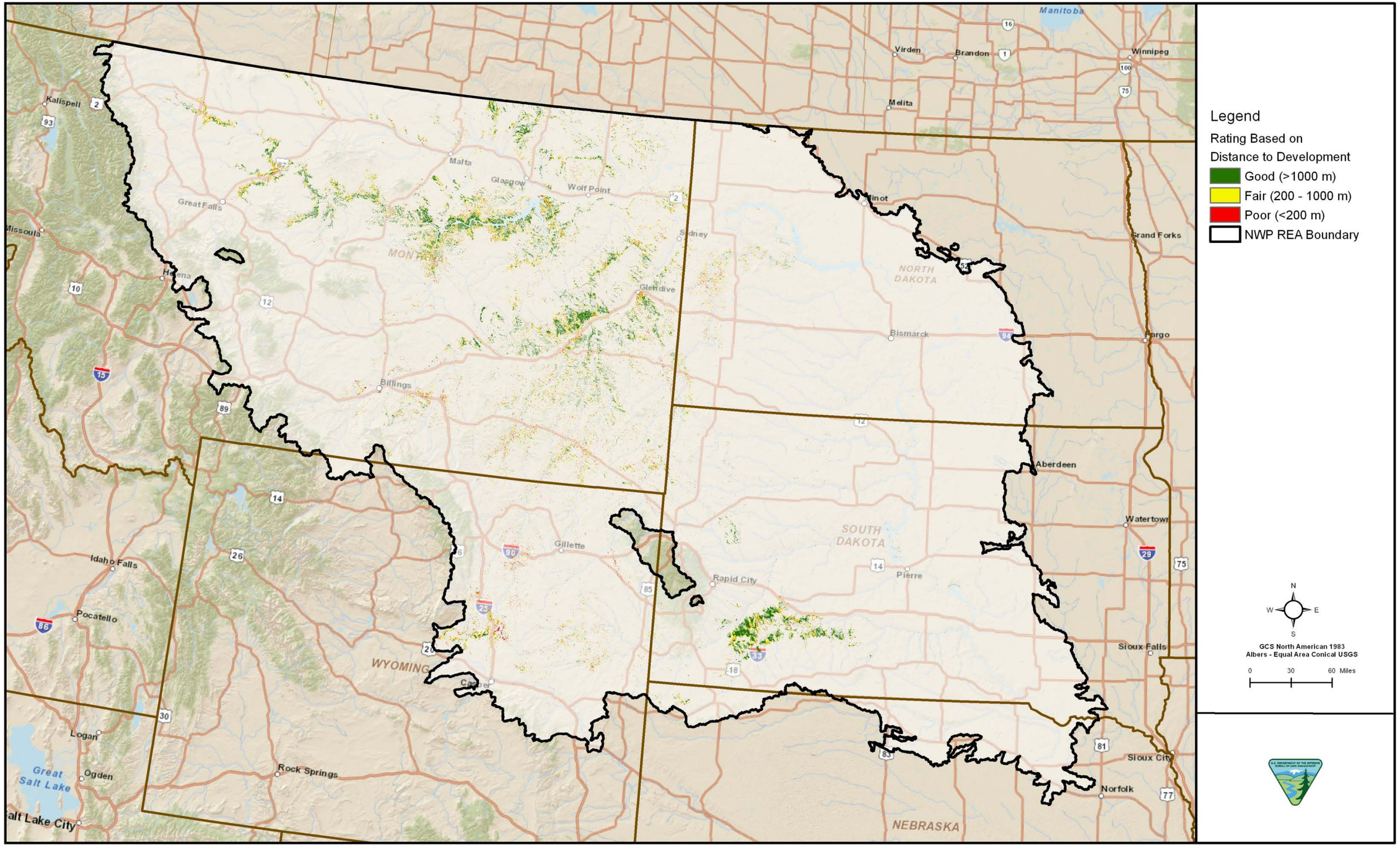

Figure D-5-3. Northwestern Plains Sparse Vegetation and Natural Barren Areas Distance to Development

APPENDIX D-6

RIPARIAN FOREST WOODLANDS COARSE-FILTER CONSERVATION ELEMENT ANALYSIS FOR THE NORTHWESTERN PLAINS ECOREGION

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1.0 INTRODUCTION

The riparian forest woodland vegetation system encompasses approximately three percent of the Northwestern Plains ecoregion. The Northwestern Plains riparian coarse-filter conservation element (CE) is mainly comprised of deciduous forest woodland areas along streams and rivers, but also includes shrublands and flats throughout the ecoregion. Because some of the Gap Analysis Program (GAP) Level 3 systems comprise very small portions of this ecoregion, it was necessary to combine them so that they would be representative of major forest and woodland systems in the Northwestern Plains. Originally, three categories of forest and woodland systems, including this coarse-filter CE, were to be combined. These included: 1) riparian, 2) evergreen and 3) riparian, with each of these categories containing representative GAP Level 3 systems as described below. However, after initiating the evaluation it was apparent that the riparian system needed to be evaluated separate from the other systems.

There were significant data gaps in performing a change agent (CA) analysis for riparian vegetation systems. The most significant risk to riparian areas is invasive species such as Tamarisk and Russian Olive. As discussed in Appendix C-3, invasive species were found to be a significant data gap. Grazing is also a major threat to riparian areas; however, this Rapid Ecoregional Assessment (REA) does not investigate grazing.

The riparian forest woodland category was composed of the following GAP Level 3 systems: Western Great Plains Wooded Draw and Ravine, Western Great Plains Floodplains, Northwestern Great Plains Riparian, Western Great Plains Riparian Woodland and Shrubland, and Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland.

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 those 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 CA threats. CAs considered in this analysis include wildfire and development.

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2.0 CONSERVATION ELEMENT DESCRIPTION

The Level 3 systems represented in this assemblage are briefly described below.

2.1 WESTERN GREAT PLAINS WOODED DRAW AND RAVINE

This system is typically associated with highly intermittent or ephemeral streams. It may occur on steep northern slopes or within canyon bottoms where soil moisture and topography produce higher moisture levels than are common throughout most of the area. Vegetation in this community is composed mostly of small trees with a dense understory of shrubs, sedges, and grasses (Montana Field Guide 2011a). Both domestic animals and wildlife use these systems readily, leading to trampling of vegetation and an increase in shrub domination. Fire is a secondary influence (Montana Field Guide 2011a).

2.2 WESTERN GREAT PLAINS FLOODPLAINS

These systems may occur as relatively broad and extensive forests, as seen along the lower stretches of the Missouri and Yellowstone Rivers, or more narrow bands, as seen along the Milk, Little Missouri, Tongue, and Powder Rivers. These are the big perennial rivers of the region, with hydrologic dynamics largely driven by snowmelt and rainfall originating in their headwater watersheds, rather than by local precipitation events. Cottonwoods make up the overstory, with willow species co-dominant in less disturbed occurrences (Montana Field Guide 2011b).

2.3 NORTHWESTERN GREAT PLAINS RIPARIAN

This Level 3 Ecosystem is comprised of the following three systems; Rocky Mountain Lower Montane Riparian Woodland and Shrubland, Western Great Plains Riparian Woodland and Shrubland, and Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland. These systems are found on alluvial soils in highly variable landscape settings, from confined, deep-cut ravines to wide, braided streambeds. The primary inputs of water to these systems include groundwater discharge, overland flow, and subsurface interflow from the adjacent upland.

Flooding is the key ecosystem process, creating suitable sites for seed dispersal and seedling establishment, and controlling vegetation succession. Communities within this system range from riparian forests and shrublands to tallgrass wet meadows and gravel/sand flats with vegetation similar to Great Plains Floodplain communities (Montana Fieldguide 2011c). Like floodplain systems, riparian systems are often subjected to overgrazing and/or agriculture, and can be heavily degraded, with salt cedar (*Tamarix ramosissima*) and Russian olive (*Eleagnus angustifolia*) replacing native woody vegetation and regrowth. Groundwater depletion and lack of fire have resulted in additional species changes (Montana Field Guide 2011c).

2.4 WESTERN GREAT PLAINS RIPARIAN WOODLAND AND SHRUBLAND

This system is located in the riparian areas of medium and small rivers and streams throughout the ecoregion. Dominant vegetation overlaps broadly with portions of large river floodplain systems, but the overall abundance of vegetation is generally lower. Vegetation is usually a mosaic of communities that are not always tree or shrub dominated. Communities within this system range from riparian forests and shrublands to tallgrass wet meadows and gravel/sand flats.

2.5 NORTHERN ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND

This system is found throughout the Rocky Mountain and Colorado Plateau regions. This system is generally comprised of a mosaic of multiple communities that are tree-dominated with a diverse shrub component. It is dependent on a natural hydrologic regime with annual to episodic flooding, so it is

usually found within the flood zone of rivers, on islands, sand or cobble bars, and along stream banks. It can form large, wide occurrences on mid-channel islands in larger rivers, or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains, swales and irrigation ditches. In some locations, occurrences extend into moderately high intermountain basins where the adjacent vegetation is sage steppe. Black cottonwood (*Populus balsamifera ssp. trichocarpa*) is the key indicator species (Montana Field Guide 2011d).

3.0 CONSERVATION ELEMENT DISTRIBUTION MAPPING

3.1 DATA IDENTIFICATION

The major datasets identified to map the distribution of the riparian CE were the GAP landcover and Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) datasets. Both datasets have adequate coverage across the ecoregion and have been used in similar analyses. The riparian forest distribution datasets are further described in Table D-6-1.

Table D-6-1. Data Sources for the Riparian Forest Woodlands Coarse-Filter Conservation Element Distribution Mapping for the Northwestern Plains Ecoregion

Data Needs	Dataset Name	Source Agency	Type/Scale	Status	Use in REA
Terrestrial Systems					
Ecological Systems	GAP Land Cover Northwest Regional Gap Analysis Program (ReGAP) North Central GAP	U.S. Geological Survey (USGS)	Raster (30-meter [m])	Acquired	Yes
	LANDFIRE	LANDFIRE	Raster	Acquired	No
Soils Data	Soil Survey Geographic (SSURGO) State Soil Geographic (STATSGO2)	U.S. Department of Agriculture (USDA)	Raster	Acquired	No No

3.2 DISTRIBUTION MAPPING METHODS

To map distribution of riparian forest woodland in the Northwestern Plains ecoregion, Science Applications International Corporation (SAIC) used a mosaic of GAP data sources, including two of the National GAP landcover regions, the northwest and north central. The source data for the Northwest region was the Northwest Regional Gap Analysis Program (ReGAP) dataset, which improved upon the original Northwest GAP. The North Central region contains states that have not been covered by a ReGAP project. For these areas, the National GAP layer used data from the LANDFIRE project to create a seamless layer. The GAP was developed to help answer questions about species biodiversity and species habitat (USGS 2010). Its overall goal is to assist resource managers in decision making when there is a lack of information about the full range of species on the landscape. Once the data were downloaded, the two datasets were merged together to form a continuous layer of vegetation data across the five states. The continuous data layer was then clipped to the Northwestern Plains ecoregion, at which point the Level 3 systems were extracted for review by the Rolling Review Team (RRT) (Figure D-6-1).

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4.0 CONCEPTUAL MODELS

The current status and potential future threat analyses were based on the system-level model, selected environmental variables (Key Ecological Attributes [KEAs]) likely to be impacted by CAs, and the availability of data.

4.1 SYSTEM-LEVEL MODEL

The system-level conceptual model for the Northwestern Plains riparian forest woodland system illustrates the major drivers across the top (Figure D-6-2). The major drivers dictate where these vegetation systems occur throughout the ecoregion, while the CAs focus on what has potential to affect this CE over time. Below the CAs are the corresponding CA pathways that affect both the status and distribution of this CE across the Northwestern Plains ecoregion. Listed below the CA pathways are the three categories of size, context, and condition for development of the KEAs for this coarse-filter CE. The KEAs were refined through the rolling review process.

4.1.1 Wildfire

Fire most likely once played a very important role in controlling the shrubby/woods components of these communities. Like other forest systems, fire suppression has and continues to cause change in this system. Fire suppression has resulted in riparian systems becoming choked with not only species that have not traditionally occurred in riparian systems, but also invasive species such as Russian Olive and tamarisk.

4.1.2 Development

In the Northwestern Plains riparian systems, development is a moderate issue as compared to climate change and altered fire regimes. However, due to increasing population growth and urban-to-rural migration trends, fragmentation is a definite factor shaping the landscape. Development fragments riparian forests, degrading and reducing the amount of stands. Fragmentation from development and agricultural pressures reduces the viability of forest management and environmental benefits, such as ecological stability of flora and fauna (Daniels and Bowers 1997). The increase in small isolated patches and in space between forests decreases habitat connectivity and forest interior.

4.1.3 Climate Change

Riparian areas throughout the ecoregion might be some of the first areas to show signs of stress from climate change. Warmer temperatures equal more conducive environments for invasives like tamarisk that actively soak up shallow ground water. Existing vegetation along streams not only provides refugia for a variety of wildlife, but also maintains the thermodynamics of streams and water bodies sheltered by riparian vegetation. As the riparian vegetation is replaced with non-native vegetation, the thermodynamics and wildlife habitat of these areas has the potential to be altered. Climate change-induced drought can significantly alter the vegetation systems of riparian areas.

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5.0 CHANGE AGENT ANALYSIS

A CA analysis was conducted on the riparian CE for the Northwestern Plains ecoregion with native 30-meter (m) raster data 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. 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.

Since the scale of the reporting unit is at the Hydrologic Unit Code (HUC) 12, a layer of 6th 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. The intermediate CA layers were then combined together to form a single layer outlining the current status or future threat status for each HUC.

Although numerous preliminary KEAs and indicators that may affect the riparian forests were initially identified in the early phases of the REA (as illustrated in Figure D-6-2), not all were included in this analysis because either the attribute or indicator was not suitable for a landscape-level analysis or because data are not available to support the analysis. The specific indicators that could not be modeled are identified with an asterisk on Figure D-6-2. Further information on the data gaps for these indicators are discussed in the respective CAs analyses contained in Appendix C.

5.1 CURRENT STATUS OF THE CONSERVATION ELEMENT

The RRT for this coarse-filter CE did not discuss any specific KEAs to evaluate the current status of this coarse-filter CE. In the absence of that, we evaluated the aquatic CA analysis for the fish assemblage for this ecoregion. Several of the KEAs identified in the aquatic CA analysis were specifically done within the riparian area. Those KEAs were adopted for that analysis to evaluate the current status of riparian areas.

Table D-6-2 identifies the KEAs, indicators, and metrics that were used to evaluate the CAs and pathways affecting this CE across the ecoregion. The riparian forest process analysis is designed to create a series of intermediate layers that are primarily based on the development CAs. The analysis is based on the geospatial data that was available.

Table D-6-2. Key Ecological Attributes for the Riparian Vegetation Systems Coarse-Filter Conservation Element for the Northwestern Plains Ecoregion

Category	Ecological Attribute	Indicator / Unit of Measure	Metric			Data Source	Citation
			Poor = 3	Fair = 2	Good = 1		
Landscape Structure	Fragmentation	Percent of Riparian Corridor with Natural Landcover	<25	>25-80	>80	National Land Cover Dataset (NLCD) - 2006	USDA 2011
		Percent of Riparian Corridor in Agricultural Use (cropland)	>6	>3-6	<3	NLCD - 2006	Stagliano 2007
Context	Development	Percent of Riparian Corridor in Impervious Cover	>10	>5-10	<5	NLCD - 2006	Wang et al. 2008

The riparian area used in the CA analysis was a 40-m buffer around both National Hydrography Dataset (NHD) streams and shorelines to create a single riparian area layer to use for riparian assessments. The buffering of the shorelines was to accurately represent riparian areas for wide rivers or reservoirs.

5.1.1 Key Ecological Attribute Data Analysis for Current Status

For each of the KEAs listed in Table D-6-2, a discussion of the indicator, metric, metric rank and value, data source(s), and references is provided. This table was limited to landscape context based on spatially available attributes and key factors affecting riparian areas 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. After evaluation of the riparian forests, it was decided not to include patch size in the current status assessment. The decision was made primarily because there is no literature on optimum patch size for riparian forests. All literature is focused on wildlife habitat requirements, which would be included in the fine-filter CE analysis.

Where possible, data gaps were identified for future data gathering efforts. In some cases, a proxy amenable to geospatial analysis has been identified. A data gap exists with regard to invasive species due to the current lack of large-scale geospatial datasets covering the ecoregion and the inability to identify a suitable surrogate.

5.1.1.1 Percent of Riparian Corridor with Natural Landcover

This KEA was included to show the relative fragmentation of riparian areas throughout the ecoregion. The metrics for this KEA were adopted from USDA 2011. The output from this KEA indicates that most of the riparian areas within the watersheds of agricultural areas are some of the most fragmented areas in the ecoregion (Figure D-6-3).

5.1.1.2 Percent of Riparian Corridor in Agricultural Use (cropland)

This KEA is similar to the previous KEA, but it only includes agricultural land uses from the National Land Cover Dataset (NLCD). This KEA was adopted from Stagliano (2007). The output for this KEA is shown on Figure D-6-4. This figure shows all of the watersheds within the Missouri River basin as rating poor for current status against this CA. In addition to the Missouri River basin, large riparian forest areas in Montana and North Dakota appear to currently include greater than 6 percent of agricultural use in the the 40-m riparian corridor.

5.1.1.3 Percent of Riparian Corridor in Impervious Cover

This KEA was developed to show the relative context of anthropogenic development near riparian areas. This KEA was adopted from a study in Michigan that was designed to show the potential impacts of impervious surface to water bodies (Wang et al. 2008). In addition, this KEA was used in the fish assemblage CA analysis. The results of this KEA analysis are quite different from the previous two in that there are only a few areas in this ecoregion that have relatively large impervious areas, and those are concentrated around the urban areas (Figure D-6-5). Therefore, the majority of the riparian areas in this ecoregion do not appear to currently be at risk from the development of impervious surfaces.

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 riparian forest habitat for each HUC across this ecoregion. A method of aggregating scores was used to summarize overall threats with regard to riparian forest habitat quality. Individual threats can identify areas of potential risk to riparian forests, but aggregated scores can provide important information with relation to areas where riparian forests might encounter multiple threats. However, the aggregated scores can also dilute the results if one of the KEAs overshadows the others, which is the case with the agricultural KEA. In order to create a combined score for each HUC unit based

on varying levels of importance for each key attribute, it was necessary to aggregate the data through a simple summation by HUC.

The summation combined each analysis input map to create an overall Current Status Map (Figure D-6-6). The overall current status map is very similar to the agricultural output map and, although much of the ecoregion appears to be at a low risk for the development CAs, the riparian areas located near agriculture are at the highest risk.

A summary of the current status ratings based on the CE distribution is provided in Table D-6-3. 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 46 percent of the 6th level HUC watersheds that intersect the riparian forest distribution received an overall rating of good, while approximately 54 percent received an overall rating of fair or poor.

Table D-6-3. Summary of Current Status Ratings for the Riparian Forest Woodland

Overall Rating by 6th Level HUC	Total Square Miles[a]	Percentage of Total Square Miles[a, b]
Good	108,977	46.1
Fair	61,743	26.1
Poor	67,080	28.4

[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

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). The future threat analysis for development was limited to agriculture and energy. 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. Further details regarding the climate change analysis are provided in Appendix C-5.

5.2.1 Development Change Agent

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

5.2.1.1 Agricultural Growth

Conversion of land to agriculture is one of the most predominant current and future CAs for this ecoregion. Because 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 to the analysis completed for the current status. Figure C-1-1 in Appendix C-1 shows the State Soil Geographic (STATSGO) soil classification types are 1 through 4. Although this information can be portrayed spatially, there is no way to temporally show this future threat. 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 current agricultural areas and projected future agricultural areas based on soil types. As would be expected, in the Northwestern Plains ecoregion most of the agricultural areas (current and future) are located throughout the Missouri River valley. Most of the land in this area has been converted to agriculture, so the risk to riparian forests in the Missouri River valley is anticipated to be low. However, there are large areas of riparian forests located along the other major tributaries in this ecoregion that have the same soil types and could be at a high risk of conversion to agriculture. Thus, the agriculture CA is a potential risk to riparian areas in the future.

5.2.1.2 Oil Production Potential

The future analysis characterized potential oil production areas rather than oil well locations (Figure C-1-4). These larger oil production extents were used to qualitatively assess the potential effect of future oil production activities. 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. Although these areas are based on oil density data, the application of these data to future potential well site activity is unknown. 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. The majority of riparian areas in this ecoregion do not appear to be at risk from oil production.

5.2.1.3 Natural Gas Production Potential

The future analysis characterized potential gas production areas 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 effect of potential gas production areas on riparian areas.

With the exception of riparian areas in northeastern Wyoming, most of the riparian areas in this ecoregion are at a low risk from potential gas production. The majority of potential gas production is limited to northeastern Wyoming. There is one area in north-central Montana that is at high risk from potential natural gas development, but from an ecoregional scale it does not appear that riparian areas are at risk from future natural gas development.

5.2.1.4 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). Although these maps are very crude (Figure C-1-6), the highest potential for solar development is shown to occur in northeastern Wyoming and southeastern Montana. Although the grassland coarse-filter distribution shows riparian areas in this area, the majority of the riparian areas in this ecoregion appear to be at low risk from potential development of solar farms.

5.2.1.5 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 are presumably going to 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 turbine locations were based on the availability of suitable wind speeds.

Data characterized by the 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 on Figure C-1-7, Future Wind Projections. Wind Power Classes were characterized as good, fair, or poor for direct comparison to the current wind condition. The potential threats to riparian areas relative to future wind energy development are presented on Figure C-1-7. Higher elevations within the Northwestern Plains ecoregion are more susceptible to the threat of 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 mountainous regions. Riparian areas located west of the Missouri River Valley appear to be at risk from the development of wind farms. Most of these areas appear to be in South Dakota, with some areas in south-central North Dakota also having high potential for wind farms. In addition to the physical disturbance that wind turbines can have on riparian areas, bird mortality is also a concern. The

development of wind farms near riparian areas should be considered as a potential risk when future wind farms are planned for development in this area. Although this assessment is primarily qualitative, the riparian areas at mid-level elevations are at risk from potential wind turbine development. There is potential for negative effects on riparian areas within the eastern portion of the ecoregion if wind turbine production increases in these areas.

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). As mentioned in the preceeding oil and gas sections, with the exception of areas in northeastern Wyoming, northwestern North Dakota, and northeastern Montana, the majority of the riparian areas do not appear to be at a high risk to fossil fuel development.

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 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 the species by their effect on habitat availability. 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 riparian areas, a limited approach must be taken in this analysis. The majority of the riparian areas in the Northwestern Plains ecoregion do not appear to be at a high risk for development from renewable energy production.

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 riparian areas. 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 to 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 riparian areas. 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 was an important factor.

Spring temperatures and precipitation levels are the factors that would most likely threaten the vegetation of riparian areas. The combined impacts of increased temperatures, localized drought, and conversion of lands to agricultural uses could negatively affect riparian areas in the future.

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6.0 MANAGEMENT QUESTIONS

The relevant MQs for the riparian forest woodlands system would include those defined as part of the Terrestrial Biotic Resources category. The overall MQ was: Where are the important regionally significant terrestrial 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 riparian forest distribution model. 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 this REA.

6.1 HOW ARE THE RIPARIAN FORESTS DISTRIBUTED OVER THE LANDSCAPE?

Figure D-6-1 maps the ReGAP riparian forest woodlands across the ecoregion.

6.2 WHERE WILL CURRENT CONSERVATION ELEMENT VEGETATION TYPES BE AT GREATEST RISK FROM CHANGE AGENTS?

The full range of figures and analyses for the riparian forest woodlands can be used to answer this complex MQ. The models created throughout this process were created to directly address the affects of CAs on the Riparian forests. All of the CAs were addressed spatially and described in detail in this section, and all of the CAs were spatially attributed to the distribution of the Riparian forest. Figure D-6-6 represents the sum of Figures D-6-3 through D-6-5 by the HUC 12 analysis unit.

6.3 WHAT AREAS HAVE POTENTIAL FOR RESTORING CONSERVATION ELEMENT SPECIES HABITAT OR HABITAT CONNECTIVITY FOR CONSERVATION ELEMENT SPECIES, CURRENTLY AND IN THE FUTURE?

The fragmentation potential (Figure D-6-3) represents the potential for further fragmented riparian forest woodlands. It can also be used to show areas where future restoration may be the most beneficial. The fragmentation potential shows areas where restoration could potentially connect larger stands together.

6.4 WHERE WILL CONSERVATION ELEMENTS BE AT RISK FROM ALTERED FIRE REGIMES? WHERE ARE AREAS WITH POTENTIAL TO SHOW FUTURE INCREASES OR DECREASES IN WILDFIRE FREQUENCY OR INTENSITY?

Figure C-2-7 shows the areas at risk to wildland fire. This figure represents changes in vegetation and fuels from their historical condition. For the Northwestern Plains, a group of subject matter experts (SMEs) went through an exercise to illustrate fire regime (frequency and severity) departure. The historic biophysical setting (BpS) was attributed with a current fire severity and frequency and then compared with the reference (historic) fire frequency and severity for each type. From these data, we were able to develop a fire frequency departure map, a fire severity departure map, and then a composite map (which took the highest of either departure). This modified composite layer was used as the best indicator for potential threat to riparian forest woodlands from an uncharacteristic fire.

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APPENDIX D-6

FIGURES

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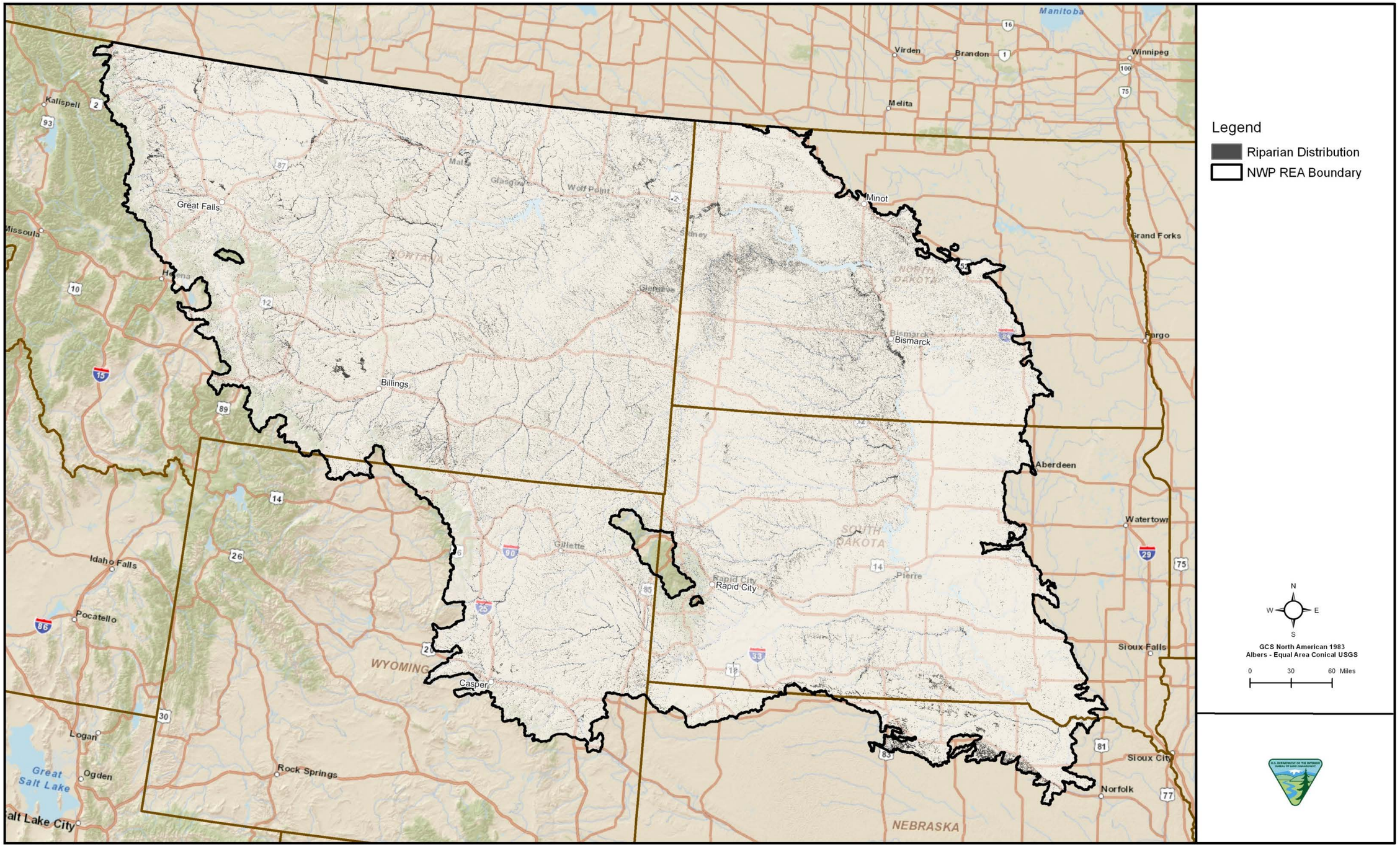

Figure D-6-1. Northwestern Plains Riparian Forest Distribution

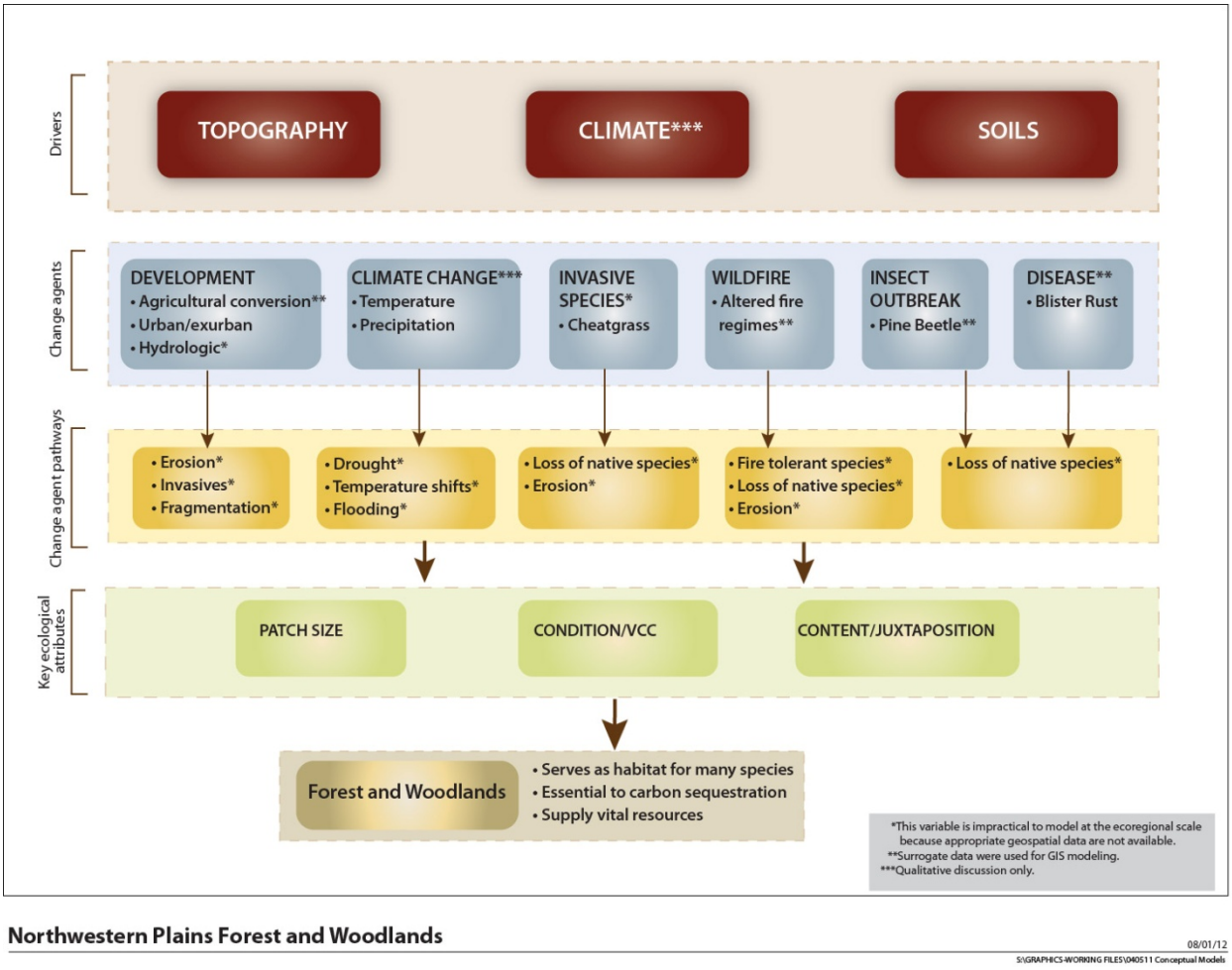

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Figure D-6-2. Northwestern Plains Riparian Forest System-Level Model

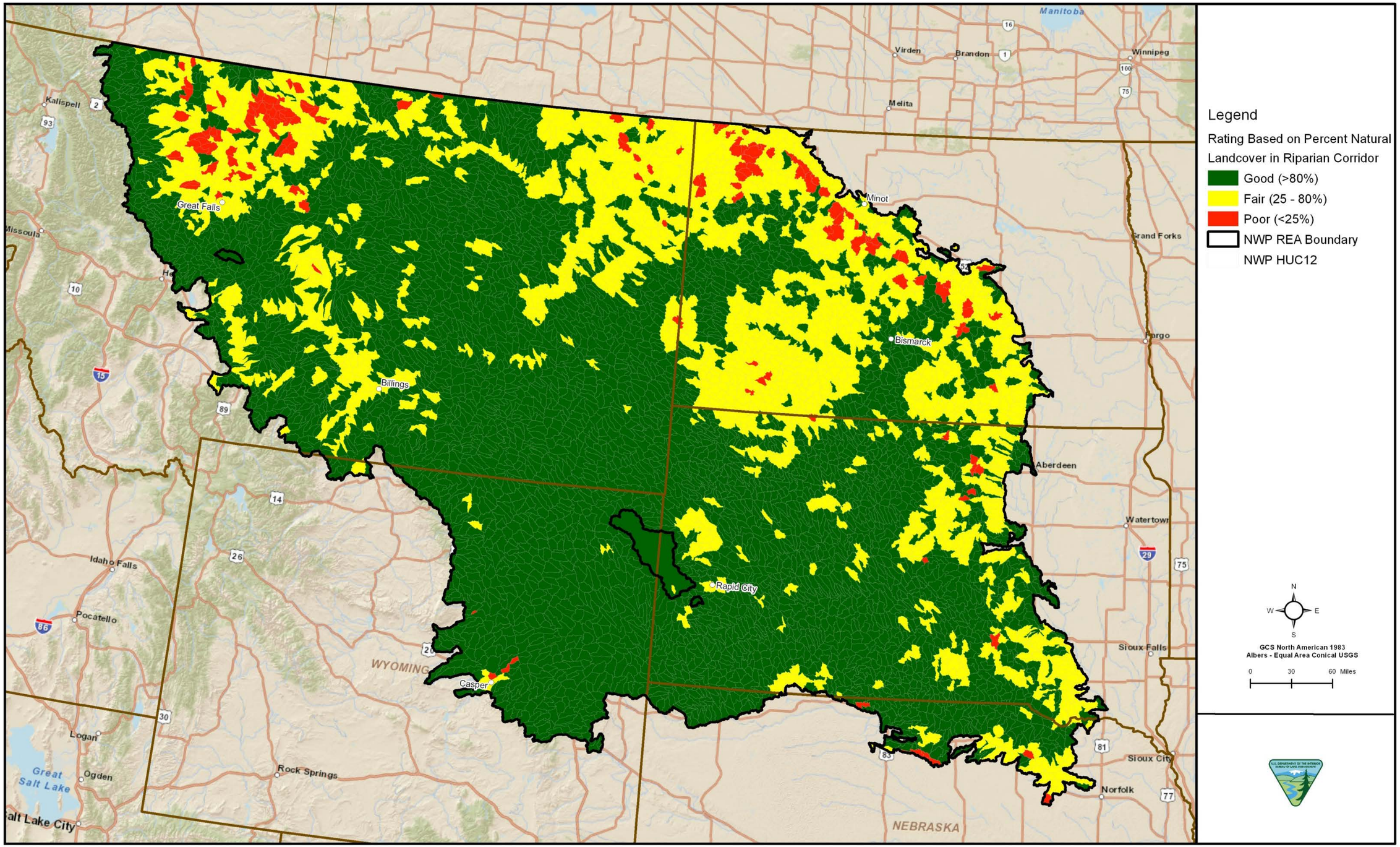

Figure D-6-3. Natural Landcover in Riparian Corridors

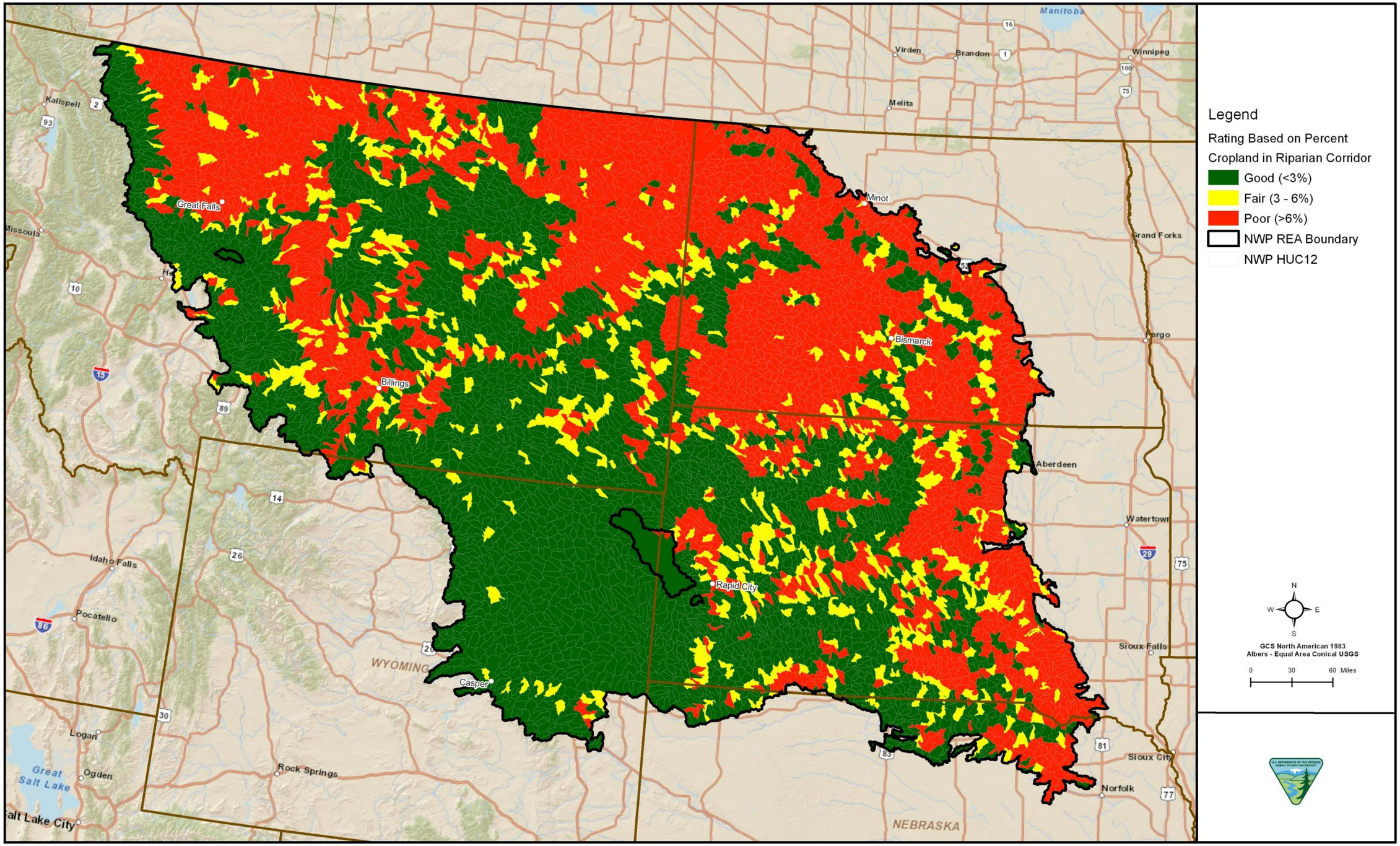

Figure D-6-4 Percent Cropland in Riparian Corridors

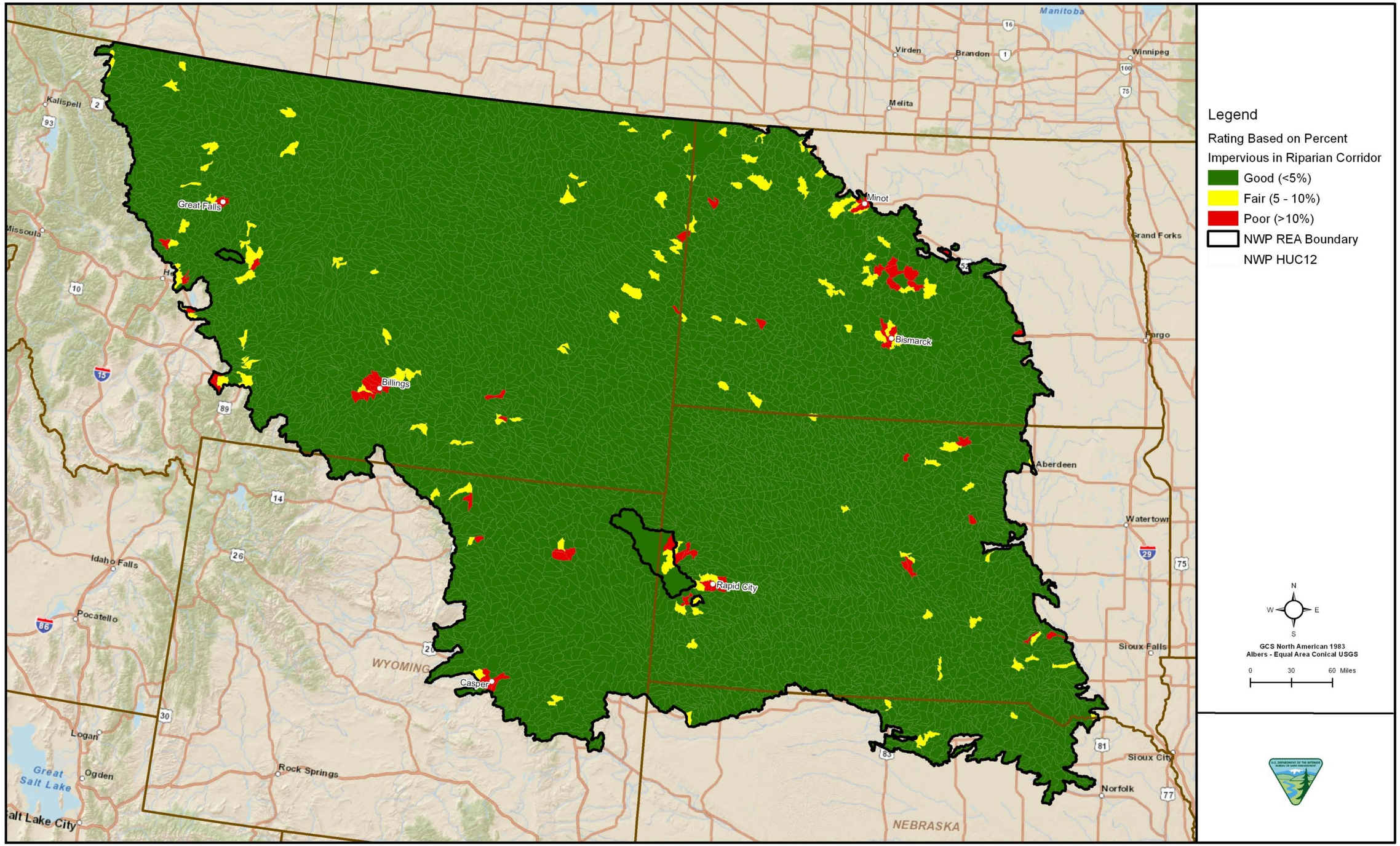

Figure D-6-5. Imperviousness in Riparian Corridors

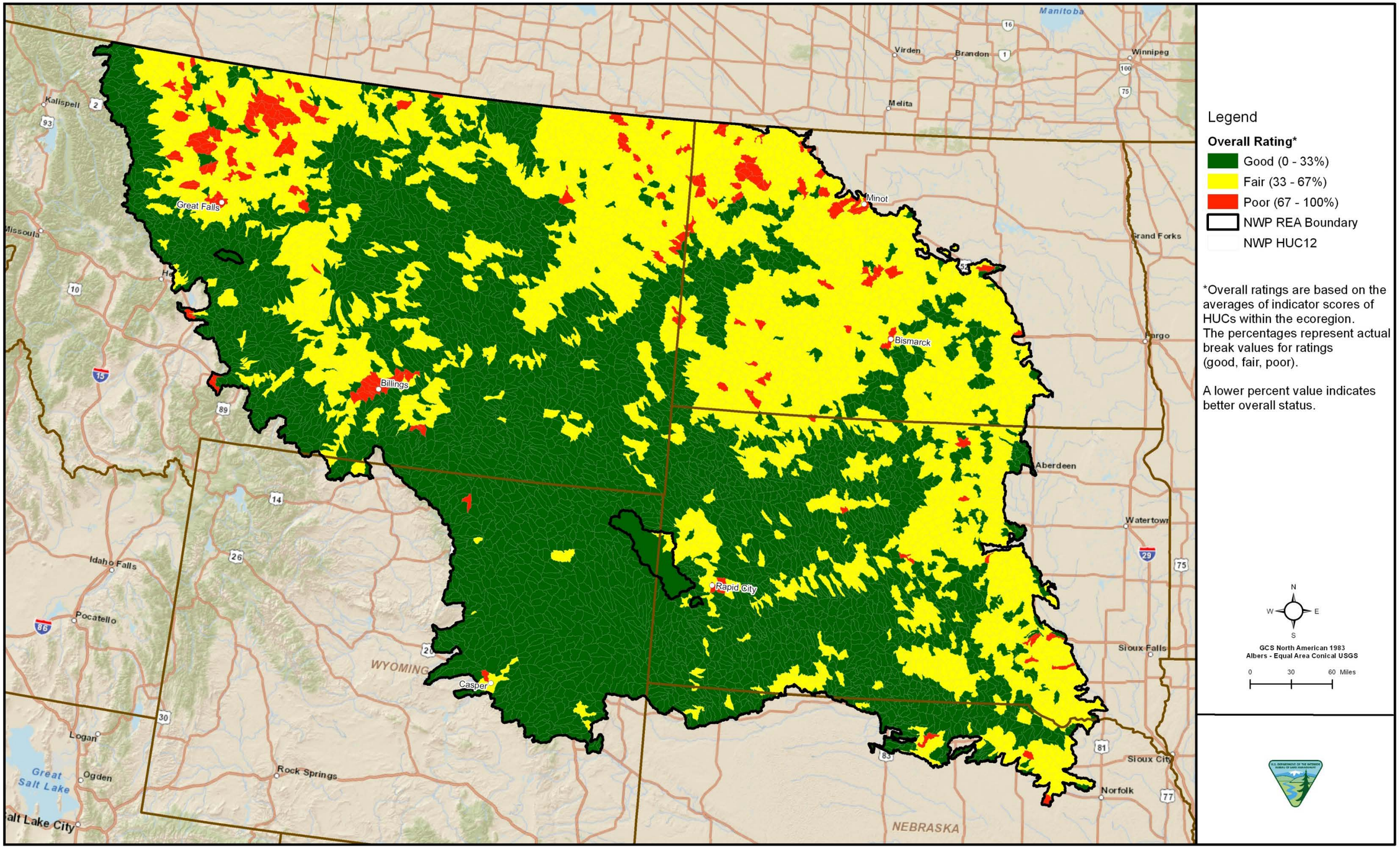

Figure D-6-6. Northwestern Plains Riparian Areas Current Status by Hydrologic Unit Code 12