APPENDIX F

DATA QUALITY EVALUATION IN THE NORTHWESTERN PLAINS

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1.0 DATA QUALITY EVALUATION

The Rapid Ecoregional Assessment (REA) process requires that relevant spatial data be identified and evaluated for accuracy prior to implementation of use for the modeling to be completed as part of Task 3. The purpose of this evaluation is to ensure that the data used in the modeling process is appropriate to derive a suitable outcome in the analysis stage. The goal of the evaluation process is to determine the best datasets available from public and private entities, and to provide results that could be replicated among all states within the Northwestern Plains ecoregion. Because of the scale of the ecoregion, the data evaluation process focused on data that were accurate and attributable at a landscape level.

A large number of datasets have been acquired and data acquisition and evaluation will continue through to Phase I, Task 3, of the Bureau of Land Management (BLM) REA process. Geospatial data are currently being evaluated using a multi-stage approach (Figure 1-1). After completing a comprehensive data search, geospatial analysts perform a standard data evaluation, identify any gaps within the data and document associated weaknesses of the individual datasets. Each dataset is compared and documented for quality and usability against the 11 BLM criteria identified from the 2008 U.S. Department of the Interior (DOI) Data Quality Management Guide. With the exception of the 17 datasets defined as "required" in the statement of work (SOW) Attachment 6.2 list of data layers provided by BLM, Science Applications International Corporation (SAIC) will provide a data quality evaluation (DQE) for each dataset.

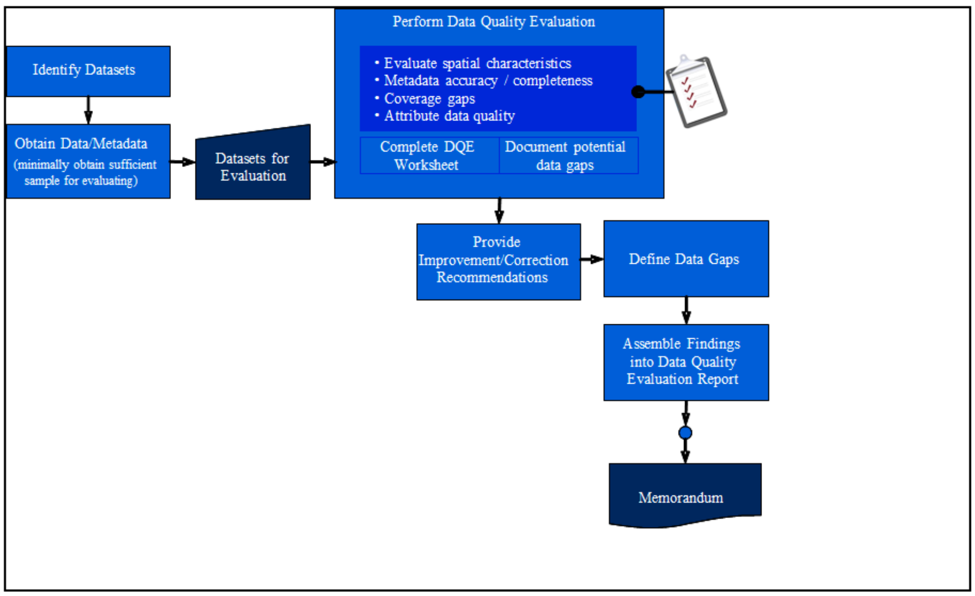

Figure F-1. Data Quality Evaluation Process

An initial DQE is a requirement and deliverable in the Data Evaluation Task. The objective of the DQE is ensuring the data are the right type and quality to meet REA objectives. The data are compared to the 11 criteria mentioned above to provide information to the Assessment Management Team (AMT) so they have a reasonable understanding data are available to answer the management questions (MQs). In cases in which the only available dataset may score "low," the AMT would be included in the discussion of whether it is "correct enough" to use. However, in many cases dealing with data on both conservation elements (CEs) and change agents (CAs), SAIC has been given instruction with the AMT on what data are available and to be used to meet the REA objectives.

All of the spatial data were opened in ArcGIS to verify that the datasets were not corrupt and were applicable to this ecoregion. The data were opened and viewed in geographic information system (GIS) to determine the geographic extent, coverage, and scale of the data relative to the ecoregion extent. Spatial accuracy and extent of coverage are then determined through the use of two specific established GIS datasets. Data are then compared against imagery data that are readily available through Environmental Systems Research Inst. Inc. (ESRI). This imagery offers quality resolution and exists at a scale suited for use as a comparative model of spatial accuracy. In addition to the imagery, SAIC accessed ESRI StreetMap data, which features high quality street layers in the form of vector data. Combining the StreetMap data with the ESRI imagery provides a high quality spatially referenced display of a base map on which to view and assess the quality of spatial features collected. The combination of both base map layers enables the GIS analysts to compare acquired dataset features relative to vegetation, topography, linear man-made features, and other pertinent datasets. This method allows for an objective method of spatial analysis.

In addition to observable spatial accuracy, attribute tables were evaluated to determine if attribute information is relevant for that particular dataset. The level of detail associated with the attributes varies widely among the various data sources. For example, species occurrence data from one source could contain attribute information such as county location, frequency, population, etc. but the same data from a different source might not contain frequency or population attribute information. The attribute information can be used in the modeling phase of the process, and will often assist the analyst in determining which features should be included in each stage of the analysis.

Metadata offer additional information relating to the spatial reference, accuracy, creation, workflow, and dynamics of a GIS data layer. Federal Geographic Data Committee (FGDC) compliant data must contain metadata as part of the data source information. Metadata were either acquired as part of the GIS data layer, or as additional files paired with the data. The information contained within the metadata file is often relevant to the data quality itself. Therefore, each dataset that was acquired throughout this process was examined to determine the quality of the associated metadata. Figure F-1 illustrates the DQE process that will be used for datasets throughout the REA process. Table F-1, below, contains the evaluation criteria that will be used in the DQE process.

Table F-1. Data Quality Evaluation Criteria from BLM Data Quality Management Guide

Data Quality Evaluation	Description	Software	Method
Validity	The degree to which data conform to their definitions, domain values, and business rules.	ArcCatalog	If there are domains, check to see if they are used properly (geodatabase only). Check attributes for strange entries (email column with a phone number.
Non-Duplication	The degree to which there are no redundant occurrences of the same real world object or event.	ArcCatalog	Export attributes to Excel and use 'Remove Duplicates' to find if there are any identical records.
Completeness	The degree to which the required data are known. This includes having the required data elements (the facts about the object or event), having the required records, and having the required values.	ArcCatalog	Rate how complete the attributes are filled in. Note some spatial data standards have many fields that will never all be filled in.
Relationship Validity	The degree to which related data conform to the associate business rules.	ArcCatalog	Review the attributes to see if the values in each column are logically connected. Does one column give a sighting count of 2 with other columns tracking male, female, juveniles, etc. have totals that do not equal 2?
Consistency	The degree to which redundant facts are equivalent across two or more databases in which the facts are maintained.	ArcCatalog	If the dataset being evaluated is part of a series of datasets from the same source with redundant data, is the redundant data the same.
Concurrency	The timing of updates to ensure that duplicate data stored in redundant files are equivalent. This is a measure of the data float (the time elapsed from the initial acquisition of the data in one file or table to the time they are propagated to another file or table).	ArcCatalog	Open the metadata viewer and review the date of data acquisition and process steps to see if the data were processed and made available in a timely fashion. This would minimize the chance of something changing and making the data irrelevant.

Table F-1. Data Quality Evaluation Criteria from BLM Data Quality Management Guide (Continued)

Data Quality Evaluation	Description	Software	Method
Timeliness	The degree to which data are available to support a given information consumer or process when required.	ArcCatalog	Open the metadata view and review the date of acquisition, update frequency, etc. Was it collected recently? Is it year two of a ten year project? How accurately does it represent the current condition?
Spatially Accurate	The degree to which data accurately reflect the real-world object or event being described. Includes spatial, temporal and thematic accuracy.	ArcCatalog ArcMap	Look for data collection methods (GPS, type accuracy) and when the data were collected. In ArcMap, overlay the layer with ESRI Roads/StreetMap, detailed county layer, or aerial imagery (NAIP, Seamless, etc.). Do the positions make sense to reflect the scale that the data will be used?
Thematic Accuracy	The degree to which the attributes represented in the map are reflective of reality on the ground.	ArcCatalog	In ArcCatalog, review the metadata details for accuracy information used in the layer. Is there a threshold or confidence interval that the data needed to exceed to be classified a certain way? Does that same threshold or interval match the requirements for it to be used in the REA?
Precision	The degree to which data are known to the right level of detail (e.g., the right number of decimal digits to the right of the decimal point). Includes spatial, temporal and thematic precisions.	ArcCatalog	In ArcCatalog, review the attributes to see if the proper fields are used for numbers to ensure enough accuracy in recording results. This will be most notable for latitude and longitude (should have at least six decimal points). If there are less the three decimal points the data may not be worthwhile using due to accuracy. Look at other columns storing numeric data. Is the precision acceptable for this data type (precipitation measurements, etc.)?
Derivation Integrity	The correctness with which derived data are calculated from their base data.		In ArcCatalog, review the metadata to see what the original data are based on or level of accuracy it has. Was the trail digitized off an aerial image or topographic map? Did the roads layer use ESRI Streetmap or Tiger roads layer for its origins. In ArcMap, add the layer along with the original basemap layer. Do they still line up or did it get bumped along the way?

Each data quality criterion was given a score from 0-4 (0 = unknown, 1= low, 2 = moderate, 3 = high, 4 = very high) for a total possible score of forty-four. A detailed description of the scoring criteria for each DQE category is available in Appendix A. This section contains an explanation of the rational used to select a score based on the DQE categories listed in Table F-1. The totaling of the eleven data quality criteria allowed for a quantitative comparison of all the criteria. One additional item SAIC is tracking is the relative dataset coverage across the ecoregion. This information was not included in the dataset total score, as some species distributions do not cover the entire ecoregion; however, it is another criterion that can be used for comparing datasets where applicable. A subset of the preliminary results of the data quality evaluation can be viewed in Table F-2.

Table F-2. Data Quality Evaluation Summary (Subset) for Northwestern Plains Ecoregion

REA Use	ISO Category	Category	Dataset Name	Source	Score (Out of 44)	Notes
CA Development (Energy)	Utilities/Comm	Renewable Energy	Biomass (2005)	NREL	35	Coverage for the entire United States at the county level, good metadata
CA Development (Energy)	Utilities/Comm	Renewable Energy	Biomass (2008)	NREL	21	Coverage for the entire United States at the county level, no metadata
CA Development (Energy)	Utilities/Comm	Renewable Energy	Potential Geothermal Area	NREL	18	Partial Ecoregion Coverage
CA Development (Energy)	Utilities/Comm	Renewable Energy	Transmission Lines	FEMA	19	Full United States coverage, limited attributes
CE Greater Sage Grouse	Biota	Greater Sage Grouse	Sage Grouse Core Area	BLM	34	

APPENDIX G

ECOLOGICAL INTACTNESS IN THE NORTHWESTERN PLAINS

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1.0 ECOLOGICAL INTACTNESS

Ecological integrity is defined as “the ability of ecological systems to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within a region” (Parrish et al. 2003). Functional organization refers to the dominant ecological characteristics and processes that “occur within their natural (or acceptable) ranges of variation and can withstand and recover from most perturbations” (Parrish et al. 2003). An ecosystem with ecological integrity should be relatively unimpaired across a range of ecological attributes and spatial and temporal scales (De Leo and Levin 1997). In this Rapid Ecoregional Assessment (REA), the term ecological intactness (EI) is used to describe the ecological integrity at the ecoregion scale.

The purpose of the EI analysis (EIA) was to summarize the overall current conditions of the ecoregion based on the overall “intact” areas found within the region. The EIA is different from the coarse-filter/fine-filter conservation element (CE) approach in that intactness is not based on management questions (MQs), but rather on the intactness of the ecosystem regardless of the importance to managers. A coarse-filter/fine-filter CE approach is inherent in the implementation of EIA (Unnasch et al. 2009); however, through a series of discussions with the Assessment Management Team (AMT), the Bureau of Land Management (BLM), and U.S. Geological Survey (USGS) EIA team, it was determined that the EIA would assess two generalized land cover classes; terrestrial systems and aquatic/riparian/wetland systems.

The EIA was conducted using methods developed by Faber-Langendoen et al. (2006) and Faber-Langendoen et al. (2009). An index of EI was determined based on metrics of biotic and abiotic condition, size, and landscape context. Each metric was rated by comparing measured values with the expected values under relatively unimpaired conditions (i.e., operating within the natural range of variation). A rating or score for individual metrics, as well as an overall index of EI was conducted to provide a large-scale assessment of ecosystem condition.

The EIA was conducted using Environmental Systems Inst. Inc. (ESRI) ArcGIS Spatial Analyst tool following a similar spatial analysis approach used by the State of Montana (Vance 2009). The EIA focused primarily on three main components used in the EI spatial analysis: vegetation cover, hydrology, and anthropogenic effect. The data and scoring methods used in the terrestrial EI analyses focused on the 5th level Hydrologic Unit Code (HUC) as the reporting unit. Because the data used in the aquatic EIA were at a finer scale, the initial analysis was completed at the 6th level HUC and then rolled up to the 5th level HUC as the reporting unit.

A species richness (total number of CEs) value for each 5th level HUC was calculated using the fine-filter CEs for each land cover class which allowed for a comparison of areas with high CE richness to areas with high EI.

Ecological assessments at the landscape level are completely reliant on existing data quality and availability and must be denoted as such so that field managers and others understand the limitations of these assessments. The information from this assessment should only be used to initiate additional step-down analysis. The GIS output products should not be used to make management decision below the 5th level HUC.

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2.0 ECOLOGICAL INTACTNESS ANALYSIS

The intent of the EIA was to describe, quantify, and assess the "natural" areas within the ecoregion. A method of obtaining data for natural areas based on existing vegetation and/or hydrology was required prior to the application of metrics and scoring analysis. The modeling approach focused on identifying areas of high ecological value based on minimal anthropogenic effect and contiguous natural/native vegetation types. The aquatic EI approach differed from terrestrial in that the natural aquatic layer was already available in the form of National Hydrography Dataset (NHD) data. This was the only dataset available for the entire ecoregion and was treated as a natural aquatic layer.

2.1 TERRESTRIAL ECOLOGICAL INTACTNESS ANALYSIS APPROACH

Figure G-1 shows the conceptual model that was used to summarize the analysis conducted for the terrestrial EI. The EI method started with the identification of intact native or natural areas throughout the Northwestern Plains to create geospatial data displaying relative "naturalness or native areas" of the current vegetation. The next step followed the Faber-Langendoen et al (2009) process for a Level I (remote sensing) assessment using key ecological attributes (KEAs) to evaluate those areas. The terrestrial habitat modeling for EI focused on use of land cover datasets (NLCD) to extract relevant information regarding large intact "natural or native" vegetation within each 5th level HUC. This factor was important in determining the EI score for each watershed and was used to account for the departure of each watershed from its "natural" state. The next step of the terrestrial EI was to apply a set of KEAs to the selected natural areas in order to obtain a score or relative ranking of the natural areas located throughout the ecoregion. Metrics developed for other regions such as those used in the state of Washington (WHCWG 2010) to assess patch quality and connectivity were also adapted to the EIA to the extent practicable.

2.1.1 Terrestrial Ecological Intactness Natural Vegetation

In order to complete the terrestrial EI analysis, an ecoregion-wide natural vegetation layer was required. The following steps (1-5) outline the spatial analytical approach that was used in this REA analysis to model the "natural" areas within the ecoregion:

1. Begin with an appropriate land cover (NLCD Vegetation) for the ecoregion.
2. Remove agricultural areas and other non-native habitat.
3. Remove additional anthropogenic effect (buffered road areas, energy production areas, superfund sites, mines, urban areas and other features associated with anthropogenic effects).
4. Remove fairly major landscape altered sites including wind development areas, coal mines, etc.
5. Overlay them on the raster grid map and create 120 meter (m) cell rasters. (120 m cells were used rather than 100 m cells to remain consistent with our 30 m rasters for all CEs.)

The 2006 NLCD land cover data layer from the Multi-resolution Land Characteristics Consortium (MRLC) was used as the primary data source for this process. This dataset is a 16-class land cover classification scheme that provided data coverage for the entire ecoregion. In order to create a natural vegetation data layer, specific vegetation types were derived from the attributes associated with the 30 m land cover raster. The vegetation types were extracted from the NLCD 2006 data layer and consolidated into a single natural vegetation data layer. The NLCD classifications extracted in this process were deciduous forest, evergreen forest, mixed forest, shrub/scrub, grassland/herbaceous, woody wetlands, and emergent herbaceous wetland. Wetlands were considered for potential use in the aquatic EI assessment rather than the terrestrial EI assessment, but were included in the terrestrial EI assessment because of their importance to terrestrial wildlife.

Data layers that were not selected for this process included modified vegetation (e.g. developed land and cultivated crops), open water, perennial ice/snow, and barren ground. Open water was removed from this analysis because of its association with aquatic integrity. Despite the potential for improved terrestrial habitat resulting from areas adjacent to open water, substantial variation in open water habitat quality exists. The man-made lakes included in this layer are considered “non-natural,” although there is potential for quality terrestrial habitat associations. The natural vegetation layers adjacent to these areas were included in the terrestrial analysis. Perennial ice/snow was removed as habitat because of inaccuracies in the classification of these data, low occurrence, and complexity in attributing ice/snow as a habitat asset for natural intactness. Barren ground was not used in this analysis because of its broad definition. Barren ground includes some natural habitat features such as talus areas and desert, but also includes strip mines and gravel pits. Additionally, it is not representative of vegetation type and only covers a small portion of the ecoregion.

Anthropogenic features were based primarily on vector data. The anthropogenic data layers were converted to 120 m rasters to create a 60m buffer on each side of linear features and for the radii of point features. This created a 120m buffer that was equivalent to one raster grid cell. These buffered areas were applied to the natural areas raster (based on the NLCD 2006 data) in the next step by removing the buffered anthropogenic areas from the final natural vegetation layer.

2.1.2 Terrestrial Key Ecological Attributes

Due to the scale of the REA and the timeframe associated with completion of the REA, the KEAs were based completely on readily available and processed imagery and existing geographic information system (GIS) coverages. The attributes and indicators associated with EI were categorized by size, landscape context, and condition following Unnasch et al. (2009). The KEAs for the terrestrial EIA are identified in Table G-1. The KEAs were applied after deducting agricultural and other anthropogenically altered areas from the total land cover of the region as described in Section 2.1.1.

Table G-1. Terrestrial Ecological Intactness Key Ecological Attributes

Category	Key Ecological Attribute	Indicator	Metric [1]			Data Source
			Poor = 3	Fair = 2	Good = 1	
Size	Size	Acres (Geometric Interval)	4 – 3,564	3,565 – 56,449	56,450 – 842,065	EI layer
	Connectivity	Natural Areas Neighborhood Analysis (km) (Natural Breaks)	0 - 23	24 - 41	42 - 63	EI layer
Condition	Fire Regime Departure	Vegetation Condition Class (VCC)	VCC 3	VCC 2	VCC 1	Fire Regime Condition Class (FRCC)/VCC
Landscape Context	Proximity to Development (m) (Based on spatial outputs. Mean and standard deviation)	Roads Proximity	0 - 637	638 – 3,209	3,210 – 18,242	Combined Anthropogenic Layer
		Transmission Line Proximity				
		Oil and Gas Well Proximity				
		Wind Turbine Proximity				
		Communication Tower Proximity				
		Railroads Proximity				

2.1.2.1 Size

The size of intact patch areas was considered as part of this analysis. This analysis was completed using the assumption that large areas of intact natural habitat can be an indicator of overall health of an ecosystem and in this case natural intact areas. These areas were calculated using the region group tool in ArcGIS spatial analyst. This tool enabled the cells in close aggregation to be counted and grouped. Figure G-2 presents the intact patch size areas for the terrestrial EI.

2.1.2.2 Connectivity

Connectivity is important to natural intact areas as it describes not only grouping of natural areas but also their relationship to one another spatially. Connectivity can be an indicator of the natural health of an area by generating data that indicate the proximity and pathways of similar natural habitat. This attribute was calculated using a neighborhood analysis. Neighborhoods were assessed in 1 kilometer (km) groups across the ecoregion based on the natural and non-natural data layers. This analysis was performed using a moving window to determine the relationship from one cell to the next, providing the natural areas connectivity output. Figure G-3 presents the connectivity assessment for the terrestrial EI.

2.1.2.3 Fire Regime

The Vegetation Condition Class (VCC) rating was used to assess the departure from natural conditions across the ecoregion. This dataset was used as a surrogate for habitat condition. Figure G-4 presents the VCC for the terrestrial EI.

2.1.2.4 Development

Development is a key change agent layer and threat to natural areas in this REA. It is one of the primary factors affecting natural intact areas. For this analysis, roads, transmission lines, oil wells, gas wells, wind turbines, communication towers, and railroad lines were combined into a 120 m cell development raster layer. Proximity to the development layer was assessed across the ecoregion. This output is presented on Figure G-5.

2.1.3 Terrestrial Ecological Intactness Scoring

The data and scoring methods used in the terrestrial EI analyses focused on the 5th level HUC as the reporting unit. Intermediate layers were scored on a cell by cell basis to provide an accurate spatial picture of the ecoregional effect of each attribute. The KEAs (Table G-1) indicate the specific methods used in the analysis of each attribute and the method for determining their classification as good, fair, or poor condition. The overall final score was determined through summation of the values and reported at the 5th level HUC. The overall EI rating for each HUC was calculated based on the mean of aggregated scores for all attributes, and classified through the use of the natural breaks method. The mean was used for this part of the analysis because the data had been categorized by ratings of 1-3. This low number of indicators suggests that the data are not likely to be substantially skewed and that a mean value would appropriately represent the per HUC score. This resulted in a single output figure for the terrestrial ecosystems of the ecoregion. This output is presented on Figure G-6.

2.1.4 Terrestrial Ecological Intactness Conservation Element Richness

In order to provide an overall assessment of the current status of the ecoregion, CE richness was calculated for each 5th level HUC. CE richness for the terrestrial EI was calculated by summing the number of fine-filter terrestrial CEs occurring in each HUC based on the distribution outputs used for the fine-filter CE analysis. These species included the mule deer, greater sage-grouse (GRSG), golden eagle, grassland bird assemblage (Baird's sparrow, chestnut-collared longspur, McCown's longspur, Sprague's pipit, and swift fox) and the black-tailed prairie dog assemblage (black-tailed prairie dog [BTPD], ferruginous hawk, burrowing owl, mountain plover, and black-footed ferret). Figure G-7 presents the CE richness by 5th level HUC for the terrestrial EI.

2.2 AQUATIC ECOLOGICAL INTACTNESS ANALYSIS APPROACH

There are no standardized methods for conducting a Level I landscape assessment of EI of an aquatic ecosystem like those that have been developed for Level II and Level III Index of Biological Intactness protocols for the U.S. Environmental Protection Agency (USEPA) regulated activities (Faber-Langendoen et al. 2008, Vance 2009). Generally, landscape level aquatic EI has been assessed primarily through the extent, duration, and intensity of human alterations of the environment ("human footprint") with the effects attenuated through various buffer, decay, and distance models (Annis, et al. 2010, Gordon and Gallo 2011, Faber-Langendoen et al. 2008, Potyondy and Geier 2011, Roccio 2007, Stagliano 2007, Tiner 2004, Vance 2005, Vance 2009, Wang et al. 2008, Weitzell et al. 2003). Each of these studies had a different spatial scope with different data availability and the results have been reported in different ways. The value of a Level I landscape analysis may be in identifying where impacts are currently occurring (Vance 2005) or where they may occur in the future which makes a Level I EIA very useful for the purpose of this REA.

The aquatic EI analysis focused predominantly on the NHD, land cover and land use data layers to assess the overall threat to aquatic ecosystems in the ecoregion. The basic assessment relied on using GIS processes to score HUCs based on the KEAs. Thresholds for the scoring were derived from suggestions in the literature. Once the datasets were scored for each individual indicator, a simple additive method was used to combine the scores into an overall score for each HUC. The aquatic EI analysis for the Northwestern Plains ecoregion was completed using the 6th level HUC as the analysis unit. The 6th level HUC results were then averaged and rolled up to the 5th level HUC and classified as good, fair, or poor.

2.2.1 Aquatic Key Ecological Attributes

The attributes and indicators associated with aquatic EI were categorized by size, landscape context, and condition following Unnasch et al. (2009). The EI metrics from several wetland assessments developed by the Montana Natural Heritage Program (NHP), the U.S. Forest Service (USFS), and others (Vance 2005, Vance 2009, Wang et al. 2008, Joubert and Loomis 2005, Potyondy and Geier 2011) were used to the extent practicable given the ecoregion scale and the diverse and non-overlapping data sources. The KEAs for the aquatic EIA are presented in Table G-2.

Table G-2. Aquatic Ecological Intactness Key Ecological Attributes

Category	Key Ecological Attribute	Indicator / Unit of Measure	Metrics			Data Source	Rank Citation
			Poor = 1	Fair = 2	Good = 3		
Size	Habitat Size	Number of Dams in HUC	≥10	6–9	≤5	NID	Stagliano 2007
Condition	Habitat Quality	Percent of HUC in GAP Status 1 or 2	< 25%	25-60%	> 60 %	Protected Areas Database (PAD) Version 1.2 April 2011	Stagliano 2007
		Percent in GAP Status 1,2, or 3	< 25%	25-60%	> 60 %	PAD Version 1.2 April 2011	Stagliano 2007
		Percent of HUC Riparian Corridor with Natural Land Cover	<25%	25-80 %	>80%	NLCD - 2006	USDA 2011
	Water Quality	Number of Oil/Gas Wells	>20	10-20	0-9	BLM Oil and Gas Wells	Stagliano 2007
		Percent of Streams that are 303d Listed	>10%	1-9%	0%	NHD Plus Streams USEPA 303d List	USDA 2011
		Number of Mines	>2	1-2	0	USGS Mineral Resources Data System (MRDS)	Data Quantiles
		Number of Toxic Release Inventory (TRI) Sites	>1	1	0	USEPA Envirofacts Data - TRI class	Data Quantiles

Table G-2. Aquatic Ecological Intactness Key Ecological Attributes (Continued)

Category	Key Ecological Attribute	Indicator / Unit of Measure	Metrics			Data Source	Rank Citation
			Poor = 1	Fair = 2	Good = 3		
Context	Landscape Structure	Percent of Streams/ Shorelines of HUC that are within 40 Meters of Road	>2.5%	1-2.5%	< 1%	NHD Plus Streams, Water Bodies, Area Topologically Integrated Geographic Encoding and Referencing (TIGER) Roads 2010 - All Roads	Stagliano 2007
		Percent of HUC in Agricultural Use (Cropland)	>60%	30-60%	<30%	NLCD - 2006	Similar to Allan 2004.
		Percent of HUC Riparian Corridor in Agricultural Use (Cropland)	>6%	3-6%	<3%	NLCD - 2006	Stagliano 2007
		Percent Impervious	>10%	6-10%	<6%	NLCD - 2006	Allan 2004 Table 1 from Appendix E page 142 of Annis et al. 2010a. Wang et al. 2008
		Percent of Riparian Corridor in Impervious	>10%	5-10 %	<5%	NLCD - 2006	Wang et al. 2008 Joubert and Loomis 2005
		Population in HUC 12 per Square km	>300	100-300	<100	Landscan 2000 Global Population Database	Wang et al. 2008

2.2.1.1 Habitat Size

Habitat size is an important indicator of aquatic natural intactness. However, it is more difficult to identify relative to available NHD data, because these data are limited to linear features in most cases. Therefore size was assessed in the form of stream interruptions resulting from dam locations along aquatic linear features. The National Inventory of Dams (NID) data were used for this step of the analysis. This value was determined by applying a zonal statistics (sum) analysis per HUC to the NID data layer. The analysis values were classified using the values provided in Table G-2. Figure G-8 presents the habitat size for the aquatic EI.

2.2.1.2 Habitat Quality

Habitat quality was assessed in this analysis to determine the general health of the habitat surrounding aquatic areas. Because NHD layers are linear features, a surrogate was needed as an indicator of quality. Therefore this attribute was determined by the presence of Gap Analysis Program (GAP) status 1, 2, or 3 areas and riparian corridors with existing natural cover. The analysis of natural riparian areas is the best indicator available for aquatic habitat quality. The percent of HUC riparian corridor with natural land cover was determined by the percentage of natural riparian vegetation (based on NLCD 2006 data) within a HUC. The GAP status 1 and 2 and the GAP status 1, 2, and 3 assessments were applied by calculating the percentage of these cells within a HUC and classifying these outputs by the percentages in Table G-2. Figure G-9 presents the percentage of HUCs in Gap 1 or 2 for the aquatic EI.

2.2.1.3 Water Quality

Water quality was assessed directly and indirectly through the use of available data layers such as mines, oil and gas wells, 303d listed streams, and toxic release inventory (TRI) sites. An indirect relationship between water quality and terrestrial features focused on the abundance these features within a given HUC. The aquatic feature (303d listing) was represented ecoregion wide for comparison to the other analyses, but inherently is focused specifically on aquatic health. The number of mines, oil and gas wells and TRI sites were determined by applying a zonal statistics (sum) analysis per HUC to the NID data layer. The percentage of 303d listed streams assessment was applied by calculating the percentage of these cells within a HUC. The analysis values were classified using the values provided in Table G-2. Figures G-10 through G-14 present the water quality KEA results for riparian with natural land cover, the number of oil and gas wells, the percent of streams with 303d listing, number of mines, and the number of TRI sites, respectively.

2.2.1.4 Landscape Structure

Landscape structure was assessed through various surrogate data layers. The purpose of assessing landscape structure for aquatic ecosystems is to determine the effect of terrestrial landscape structure on aquatic habitat. Because data do not exist for a direct analysis of aquatic landscape structures, roads, agricultural areas, impervious surfaces, and population areas were analyzed relative to prevalence and proximity within the ecoregion. With the exception of population, these attributes were assessed by calculating the percentage of these cells within a HUC. The percent of streams/shorelines per HUC that are within 40 m of a road required an additional step. Prior to determining the percent of streams/shorelines within a HUC, the NHD stream layer was used to select all stream layers within 40 m of the Topologically Integrated Geographic Encoding and Referencing (TIGER) 2010 roads layer. The resulting layer was expressed by percentage of the HUC. The population attribute was determined by applying a zonal statistics (sum) analysis per HUC. The analysis values for all attributes were classified using the values provided in Table G-2. Figures G-15 through G-20 presents the landscape structure KEA results for percent of streams within 40 m of roads, percent of HUC in agricultural use, percent of HUC riparian corridor in agricultural use, percent in impervious cover, percent riparian corridor in impervious cover, and population per square kilometer, respectively.

2.2.2 Data Analysis and Scoring

The data and scoring methods used in the terrestrial and aquatic EI analyses focused on the 5th level HUC as the unit of analysis as well as the reporting unit. The aquatic EI was preliminarily analyzed at the 6th level HUC. Intermediate layers were scored on a cell by cell basis to provide an accurate spatial picture of the ecoregional effect of each attribute. The overall final score for aquatic EI was determined through summation of the values and reported at the HUC level. The overall EI rating for each HUC was calculated based on the mean of aggregated scores for all attributes, and classified through the use of the natural breaks method. The mean was used for this part of the analysis because the data had been categorized by ratings of 1-3. This low number of indicators suggests that the data are not likely to be substantially skewed and that a mean value would appropriately represent the per HUC score. This resulted in a single output figure for the aquatic ecosystems of the ecoregion. This output is presented on Figure G-21.

2.2.3 Aquatic Ecological Intactness Conservation Element Richness

In order to provide an overall assessment of the current status of the ecoregion, CE richness was calculated for each 5th level HUC. CE richness was calculated for the aquatic EI by summing the number of fine-filter aquatic CEs for each HUC based on distributions outputs used for the CE analyses. These species included the pearl dace, the northern redbelly dace x finescale dace hybrid, paddlefish, pallid sturgeon, and sauger. Figure G-22 presents the species richness by 5th level HUC for the aquatic EI.

3.0 RESULTS

The EI analysis provides an opportunity to not only evaluate current conditions of terrestrial and aquatic ecosystems across the ecoregion but also an opportunity to compare the relative intactness of those habitats at the 5th level HUC. Using a direct comparison of HUCs, the watersheds that are of the highest intactness within the ecoregion can be identified. Additionally, CE richness was calculated based on the distribution of the fine-filter CEs throughout the ecoregion to identify specific areas of the ecoregion that are most widely used by these key resources. A comparison between the areas of high intactness to areas of high CE richness provides important information for step-down analysis or more detailed future evaluation.

3.1 ECOLOGICAL INTACTNESS OF TERRESTRIAL SYSTEMS

The results of the terrestrial EI analysis indicated some clear patterns that are consistent with the quality of habitat within the ecoregion. The agricultural areas throughout the Missouri River Basin in eastern Montana and the Dakotas received predominantly poor terrestrial intactness scores as well as basins of the Marias and Milk Rivers in west-central Montana (Figure G-6). These ratings were driven primarily by low habitat size (Figure G-2) and low habitat connectivity (Figure G-4).

The foothill grasslands of western Montana, the central grasslands of Montana along the Yellowstone River, the grasslands within the Powder River basin of eastern Wyoming, and sagebrush steppe habitats south of Casper, Wyoming, were rated as good for terrestrial EI (Figure G-6). The sagebrush steppe and prairie grasslands in northwest and north central South Dakota also received good intactness scores, predominantly due to the size of intact landscapes. Certain geographical areas within the ecoregion consistently received good scores. Custer National Forest (Montana), Lewis and Clark National Forest (Montana), and Flathead National Forests (Montana) are indicative of fair to good with regard to connectivity, development and size (Figures G-4 through G-6).

CE richness was calculated for the fine-filter CEs within the ecoregion using the distribution outputs developed for the fine-filter CE analyses. CE richness was high throughout most of the Montana's Central Grasslands and Glaciated Northern Grasslands and the Powder River Basin in Wyoming as expected based on the selection and distribution of the fine-filter CEs (Figure G-23). Three general areas, as noted by the orange circles on Figures G-23 and G-25, were identified based on high CE richness but resulted in poor or fair EI ratings. Most notable is the Marais and Milk River basins in west-central Montana. These areas are impacted by both low connectivity and low habitat size however, the VCC rating for fire return departure substantially contributed to the poor EI rating (Figure G-3). Similar conditions also resulted in a poor EI rating south of Fort Peck Lake, MT (Figure G-25).

Several natural forests and natural grasslands are located in the south-central area of the ecoregion and include the Black Hills National Forest, the Thunder Basin National Grassland and the Buffalo Gap National Grassland (Figure G-24). The terrestrial EI ratings across most of these federal lands are rated as good; however, areas immediately surrounding these federal lands within southwestern South Dakota have low habitat size (Figure G-2).

Terrestrial EI was also evaluated for large tracts of BLM-managed lands within the ecoregion. Four of the largest BLM-managed lands across the ecoregion were compared to CE species richness. Areas with the highest species richness within these large tracts are noted by the blue circles on Figures G-23 through G-25. The EI analysis for two of the four areas indicates that the EI is rated as fair which would suggest areas of possible management concern for more detailed step-down analysis. The BLM-managed lands east of Custer National Forest and extending up the Yellowstone River valley to the Little Missouri National Grassland (Figure G-24) are within a larger area of the ecoregion with a good EI rating. Also, the BLM-managed lands north of Fort Peck Lake, Montana indicate that the terrestrial EI ranges from good to fair. These areas are recommended for additional site-specific assessments to target future management actions for the terrestrial habitats.

3.2 ECOLOGICAL INTACTNESS OF AQUATIC SYSTEMS

Aquatic EI results varied substantially across the ecoregion and generally showed lower EI overall (Figure G-21) for the aquatic habitats as compared to the terrestrial habitats of the ecoregion. The impact of agricultural areas associated with the Missouri River system in the ecoregion was substantial in the aquatic EI results. In Montana, the aquatic habitats of the Marias and Milk Rivers appear to be at risk from potential impacts associated with oil and gas wells and roadways. These areas also lack natural land cover and agricultural use within the riparian corridors is predominant (Figures G-10, G-11, G-15, G-16, and G-17). In North Dakota, and in particular, the Missouri River basin, a greater percentage of aquatic habitats was rated as poor with the exception of only a few watersheds within the south-central part of the state. Other stream segments in Montana and North Dakota were rated poor due to their inclusion on the USEPA 303d listing (Figure G-12).

In Wyoming, the aquatic EI was influenced by energy-related development. The aquatic EI resulted in a majority of the HUCs rated as fair with impacts associated with the number of mines, number of oil and gas wells, and roadways as major concerns. In contrast to the other states within the ecoregion, a greater percentage of good ratings for the aquatic EI resulted for HUCs in South Dakota, primarily along the Cheyenne and White Rivers (Figure G-6). This result is offset however, by the presence of poor and fair watersheds associated with the Missouri River (Figure G-28).

CE richness was calculated for the fine-filter CEs within the ecoregion using the distribution outputs developed for the CE analyses. CE richness was highest along Missouri River basin in central and eastern Montana based on the distribution of the big river fish and the prairie fish species (Figure G-22). Most of the Missouri River Basin in eastern Montana; however, received a poor aquatic EI rating (Figure G-28). These areas are likely threatened by agricultural impacts. This area would benefit from step-down analysis to better understand and estimate risks to aquatic habitats.

Two other areas of high CE richness as noted by the orange circles on Figures G-26 were identified in South Dakota’s White River region. The aquatic EI ratings for these areas were rated as fair (Figure G-28).

The aquatic EI was also evaluated for large tracts of BLM-managed lands within the ecoregion. Three BLM-managed areas with high CE richness as noted by the blue circles on Figures G-26 through G-28 were compared the aquatic EI ratings. The EI analysis for two of the three areas indicates that the EI is rated as good. The aquatic habitats within BLM-managed lands north of Fort Peck Lake, Montana, and associated with the Milk River were rated as poor. These areas would also be good candidates for more detailed step-down analysis additional site-specific assessments to target future management actions for aquatic habitats.

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APPENDIX G

FIGURES

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LIST OF FIGURES

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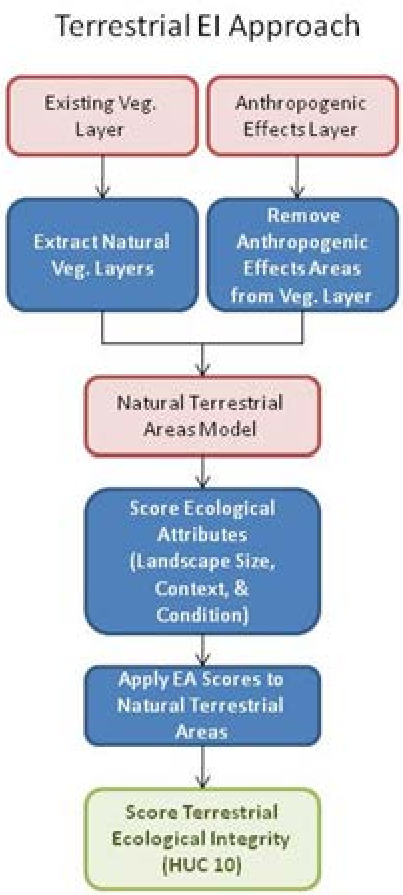

Figure G-1. Conceptual Model for the GIS Analytical Approach to Terrestrial Ecological Intactness

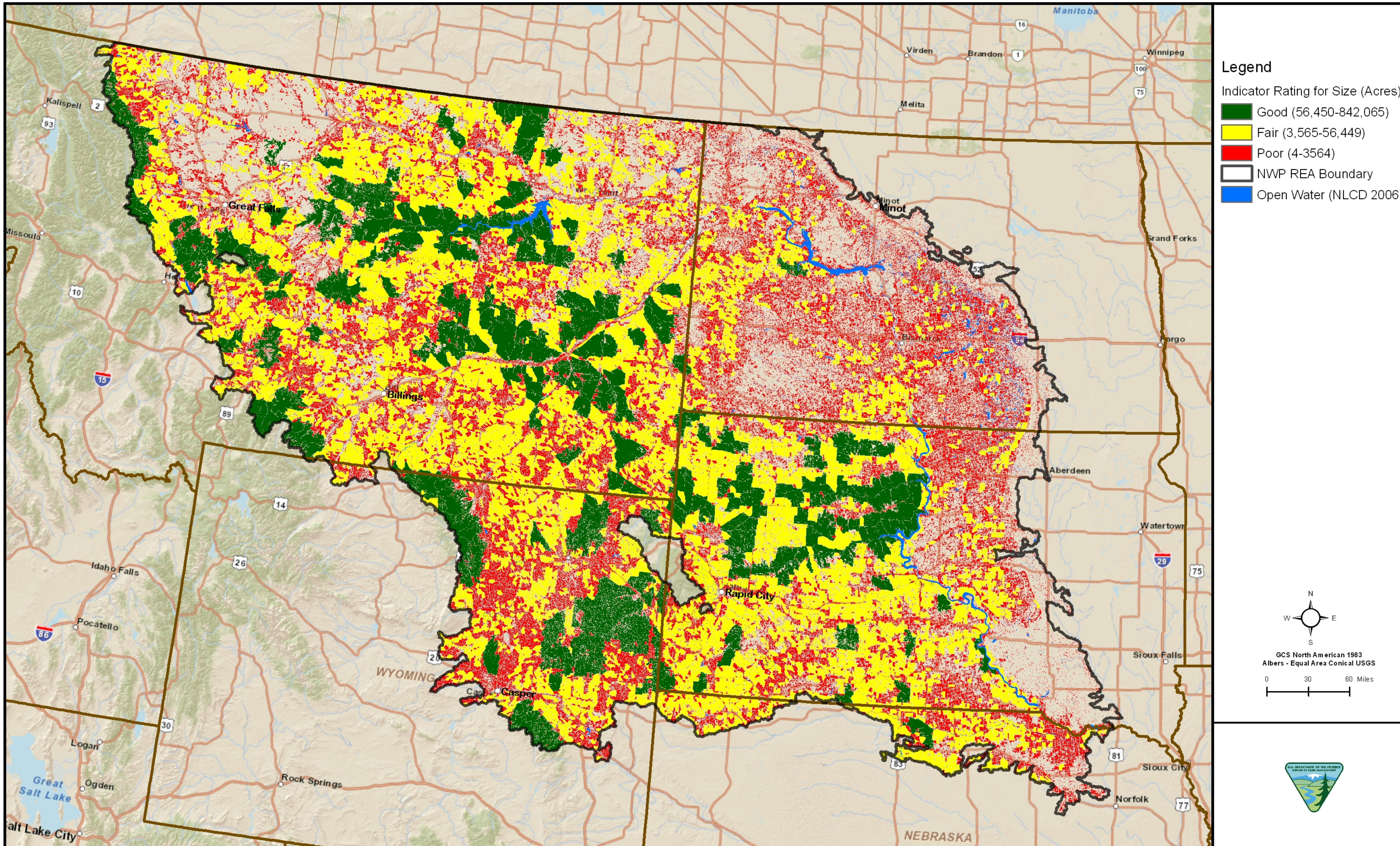

Figure G-2. Terrestrial Ecological Intactness Size

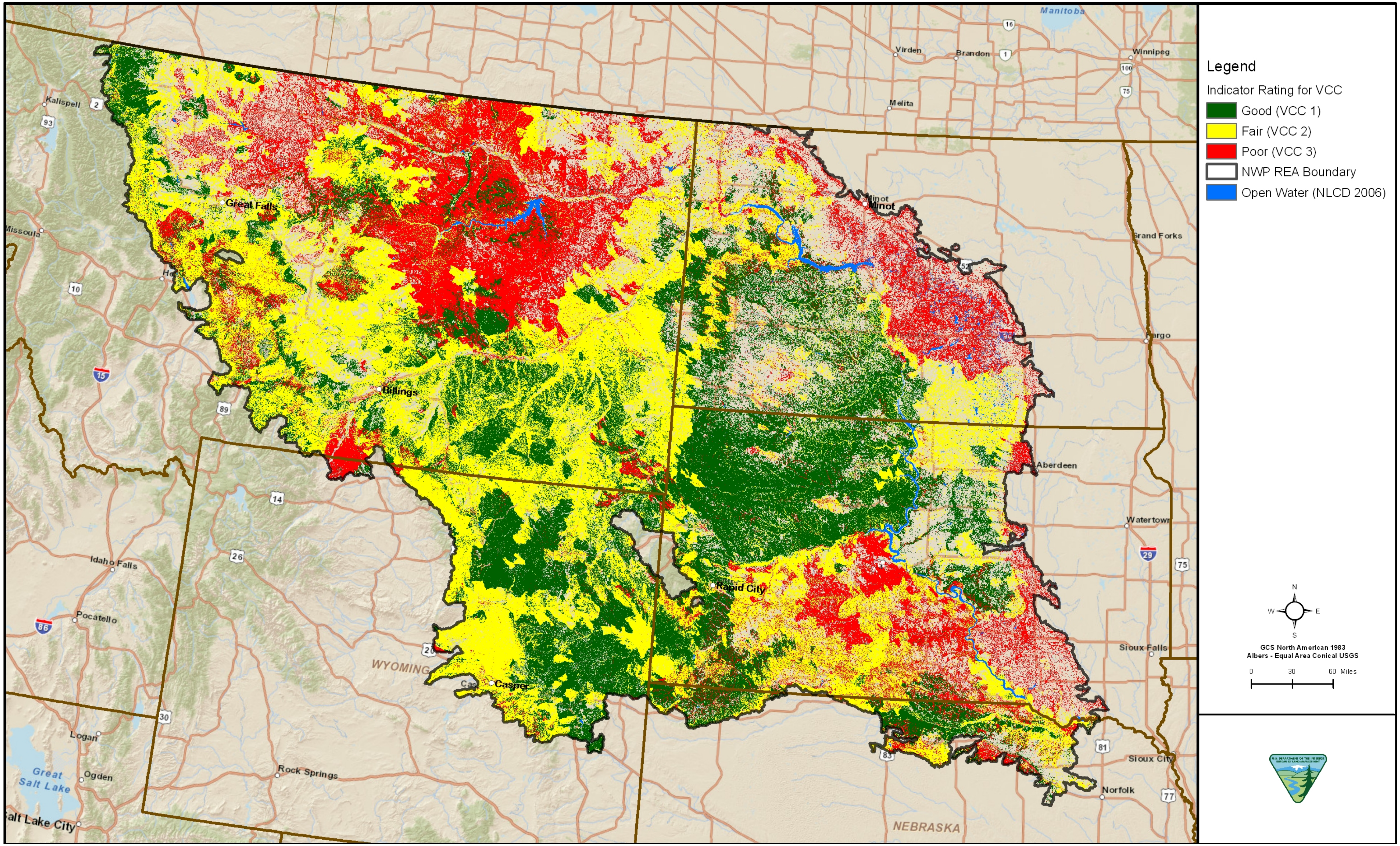

Figure G-3. Terrestrial Ecological Intactness Connectivity

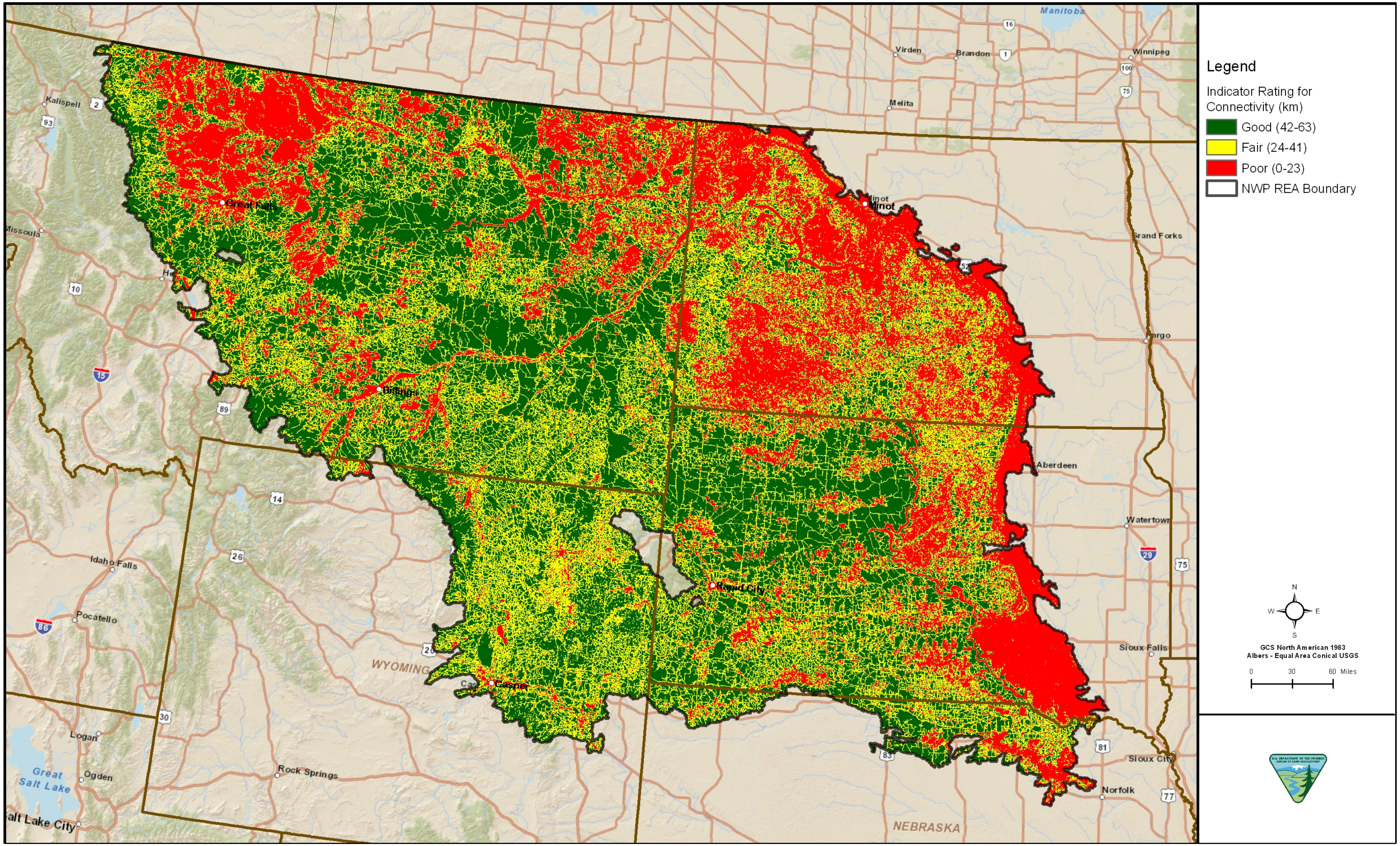

Figure G-4. Terrestrial Ecological Intactness VCC

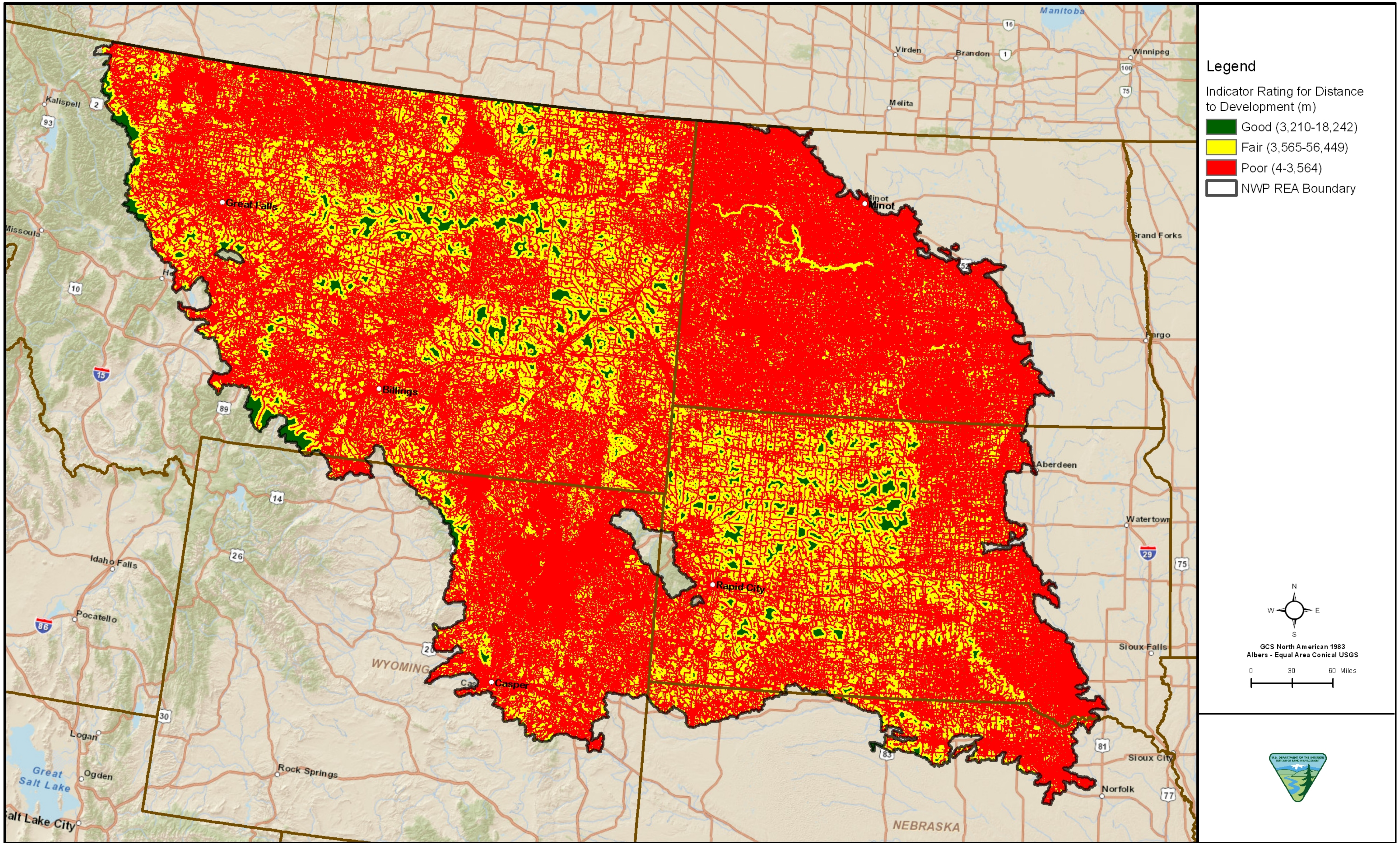

Figure G-5. Terrestrial Ecological Intactness Development

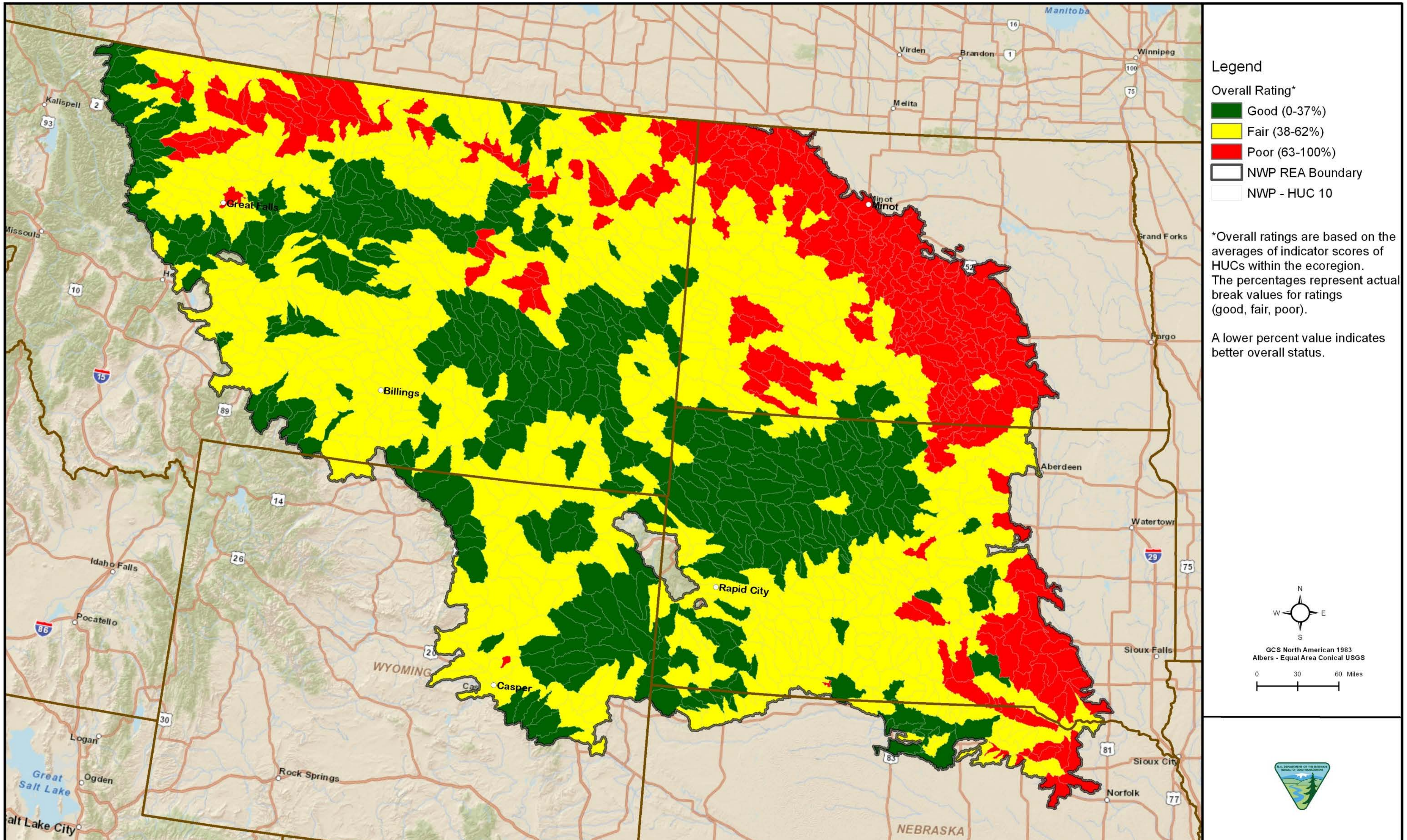

Figure G-6. **Terrestrial Ecological Intactness Overall Score**

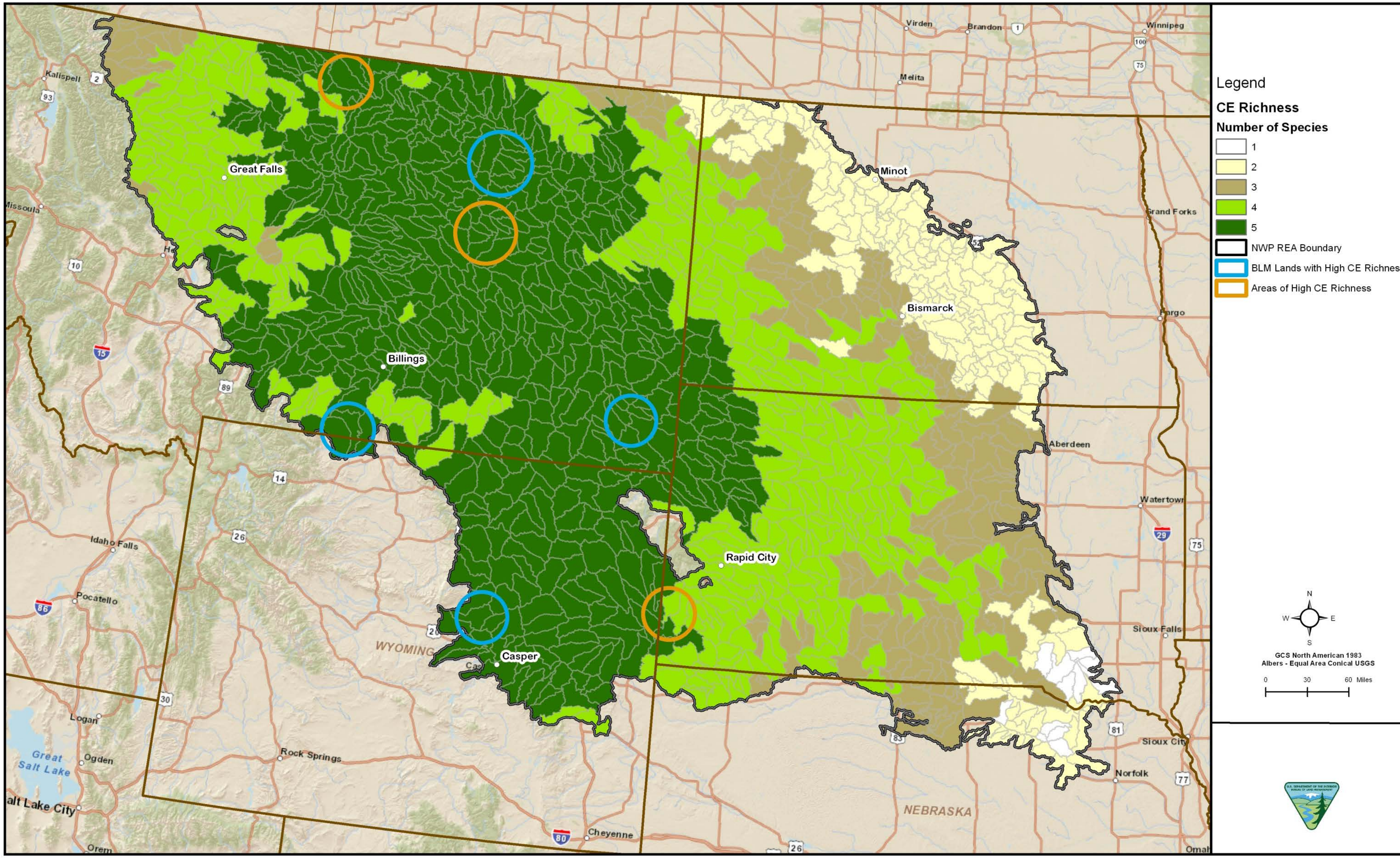

Figure G-7. **Terrestrial Ecological Intactness CE Species Richness**

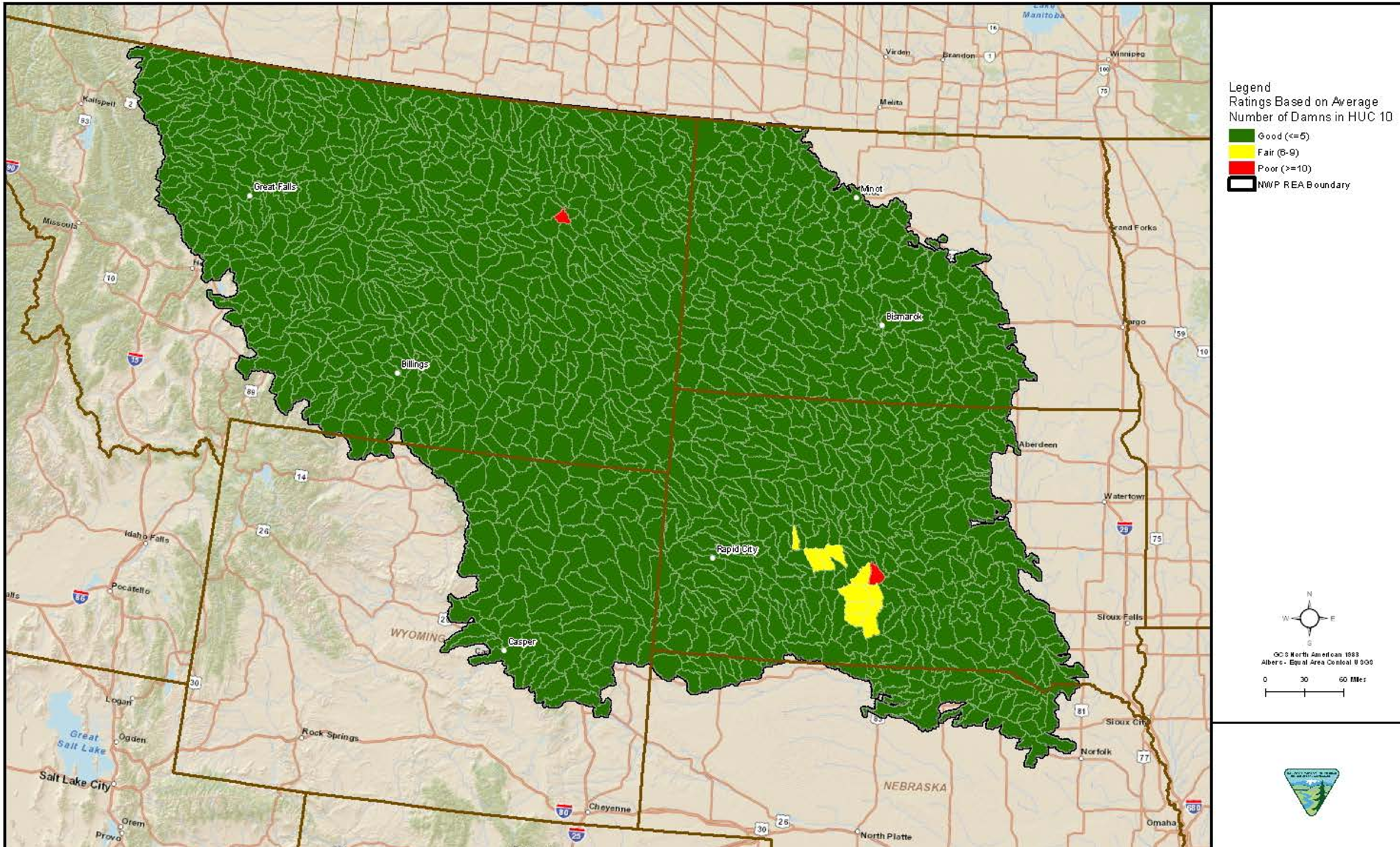

Figure G-8. **Aquatic Ecological Intactness Number of Dams in HUC**

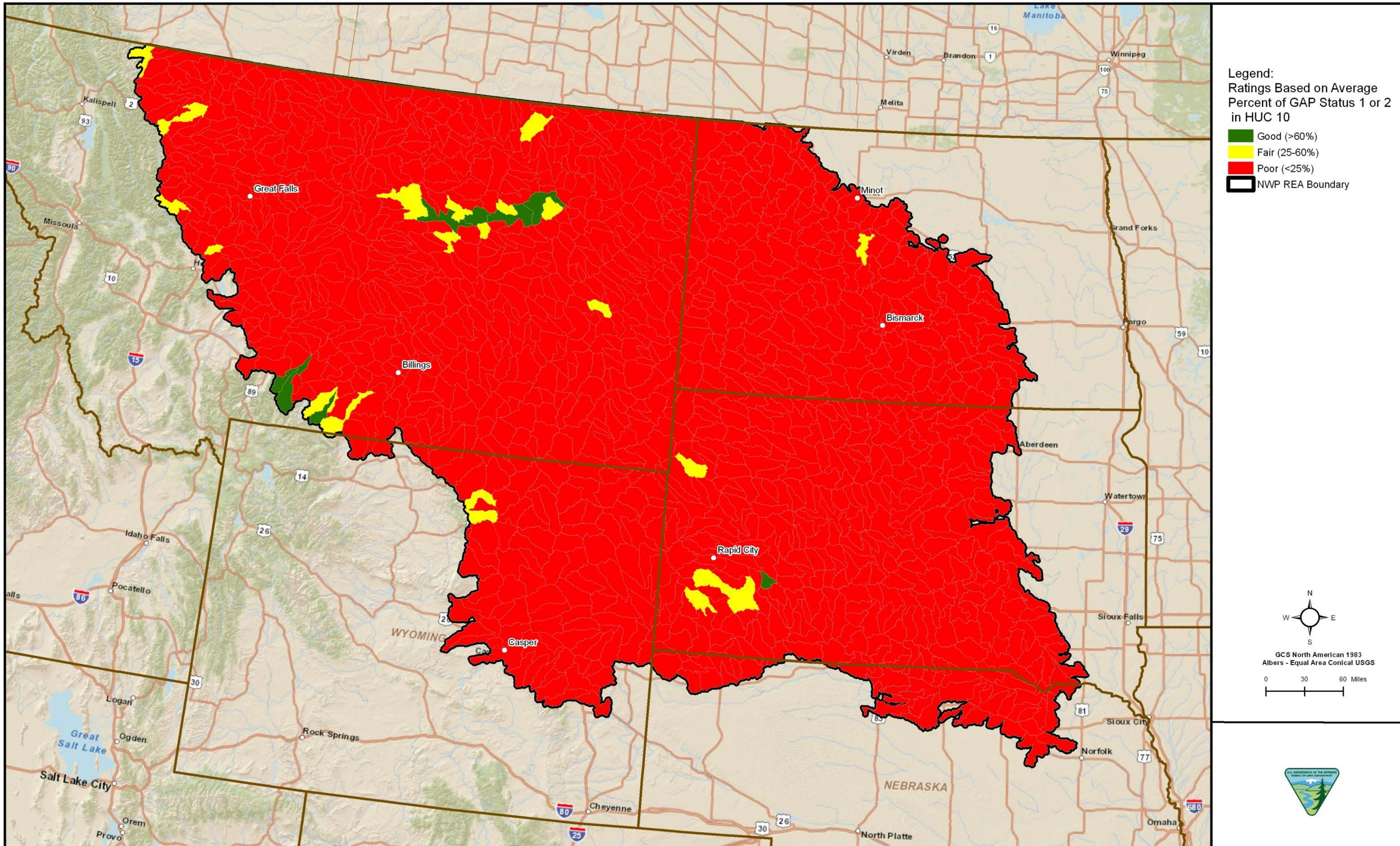

Figure G-9. Aquatic Ecological Intactness Percent of HUC GAP Status 1, 2, or 3

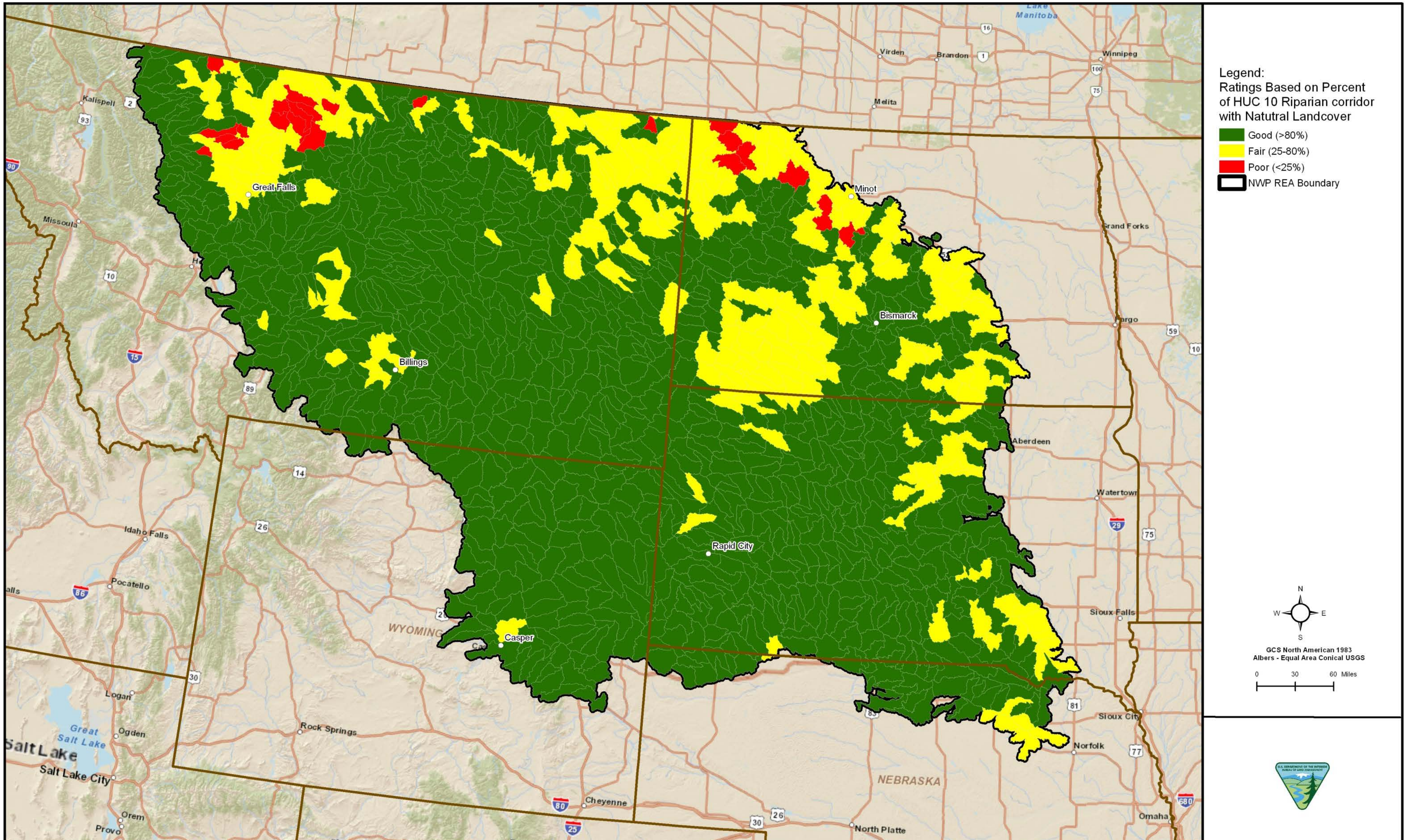

Figure G-10. Aquatic Ecological Intactness Percent of HUC Riparian with Natural Land Cover

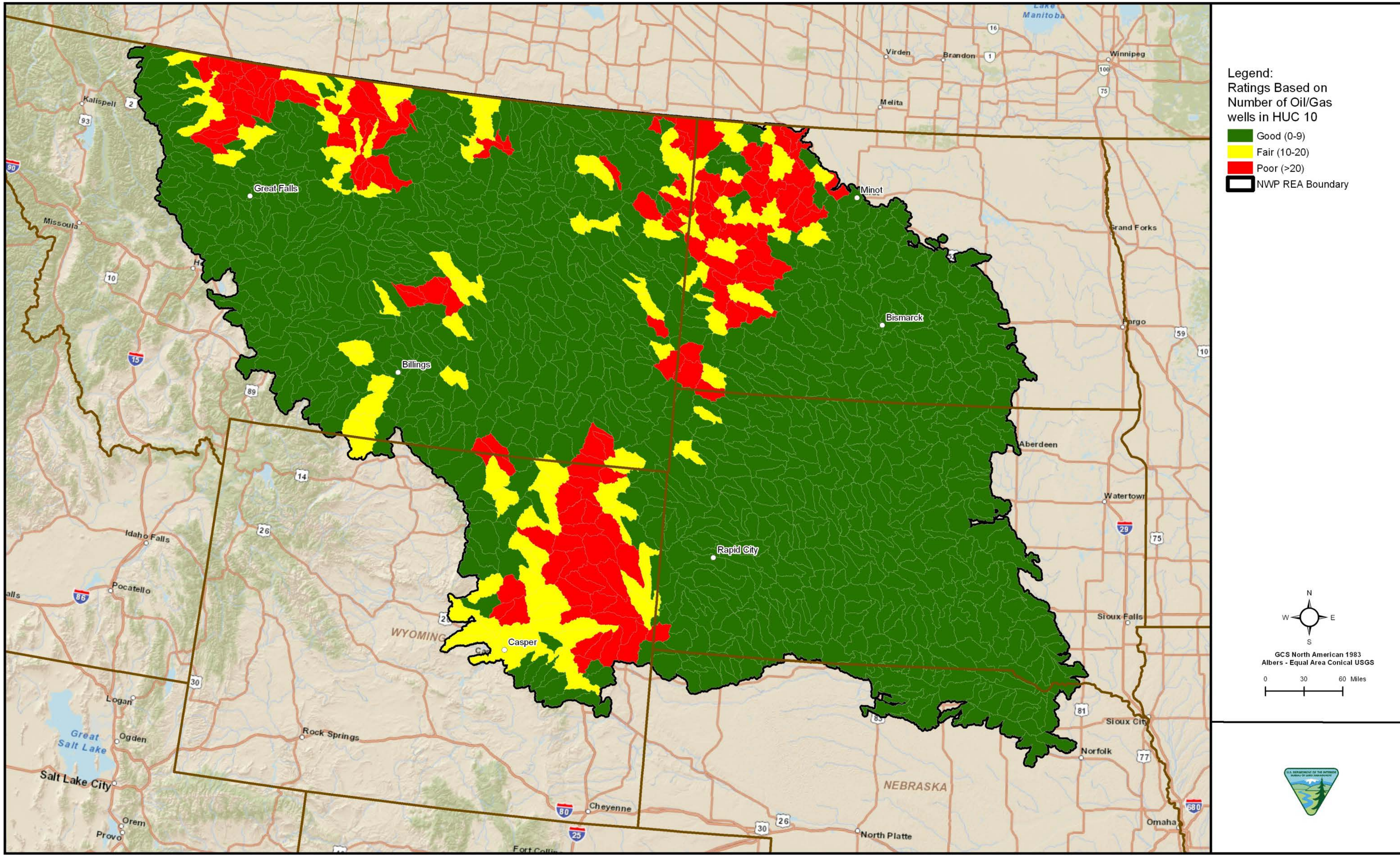

Figure G-11. Aquatic Ecological Intactness Number of Oil and Gas Wells

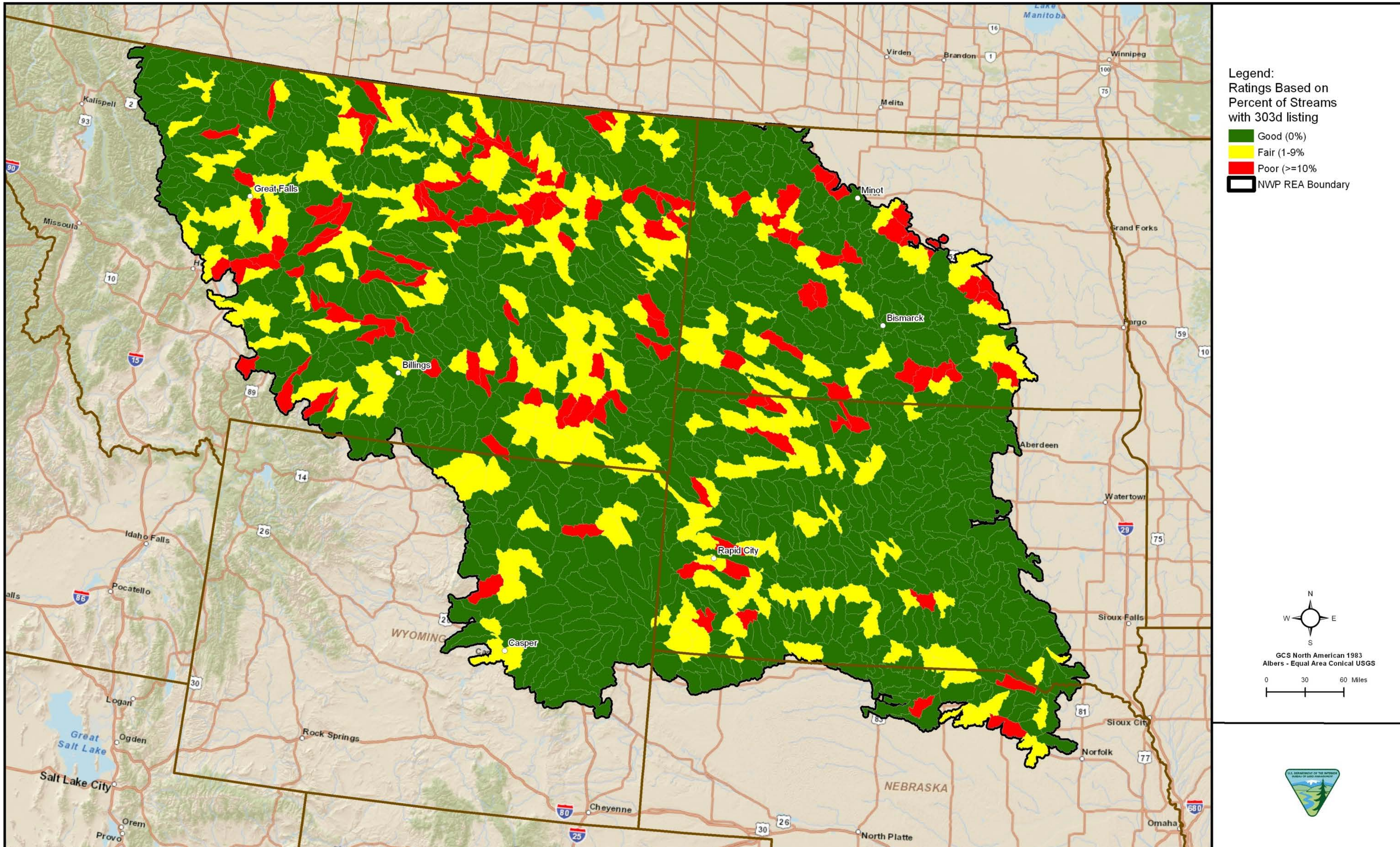

Figure G-12. Aquatic Ecological Intactness Percent of Streams 303d Listing

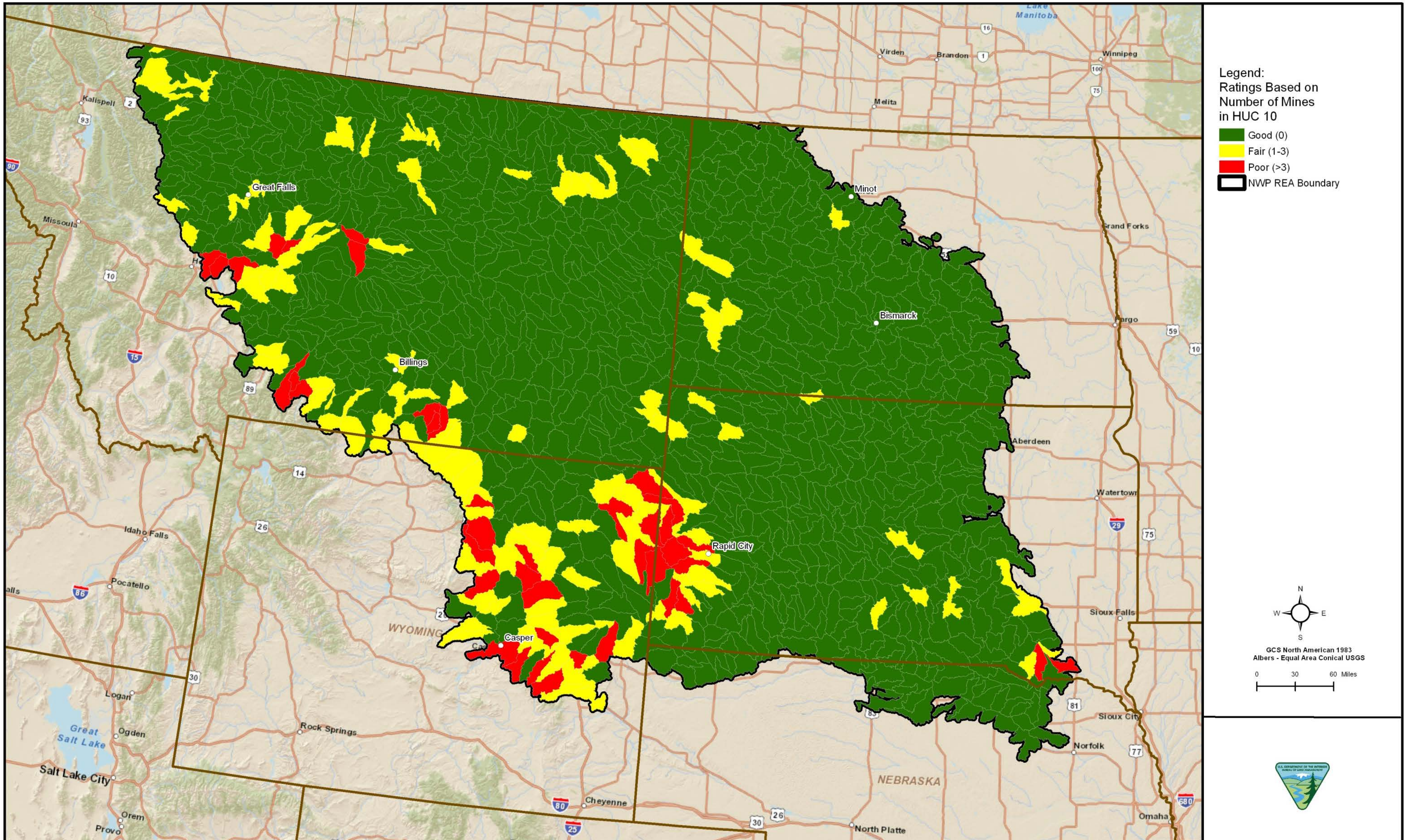

Figure G-13. Aquatic Ecological Intactness Number of Mines

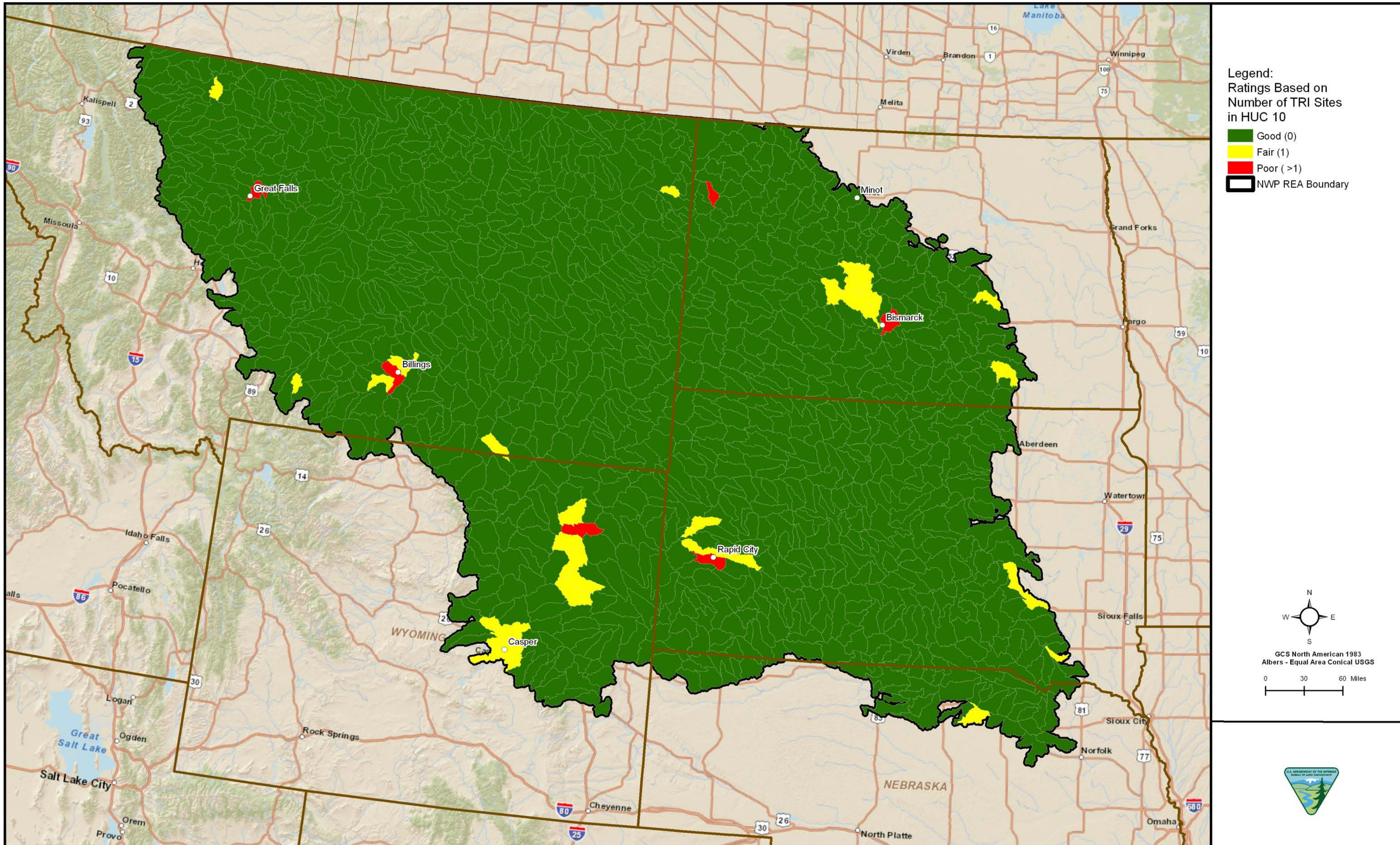

Figure G-14. Aquatic Ecological Intactness Number of TRI Sites

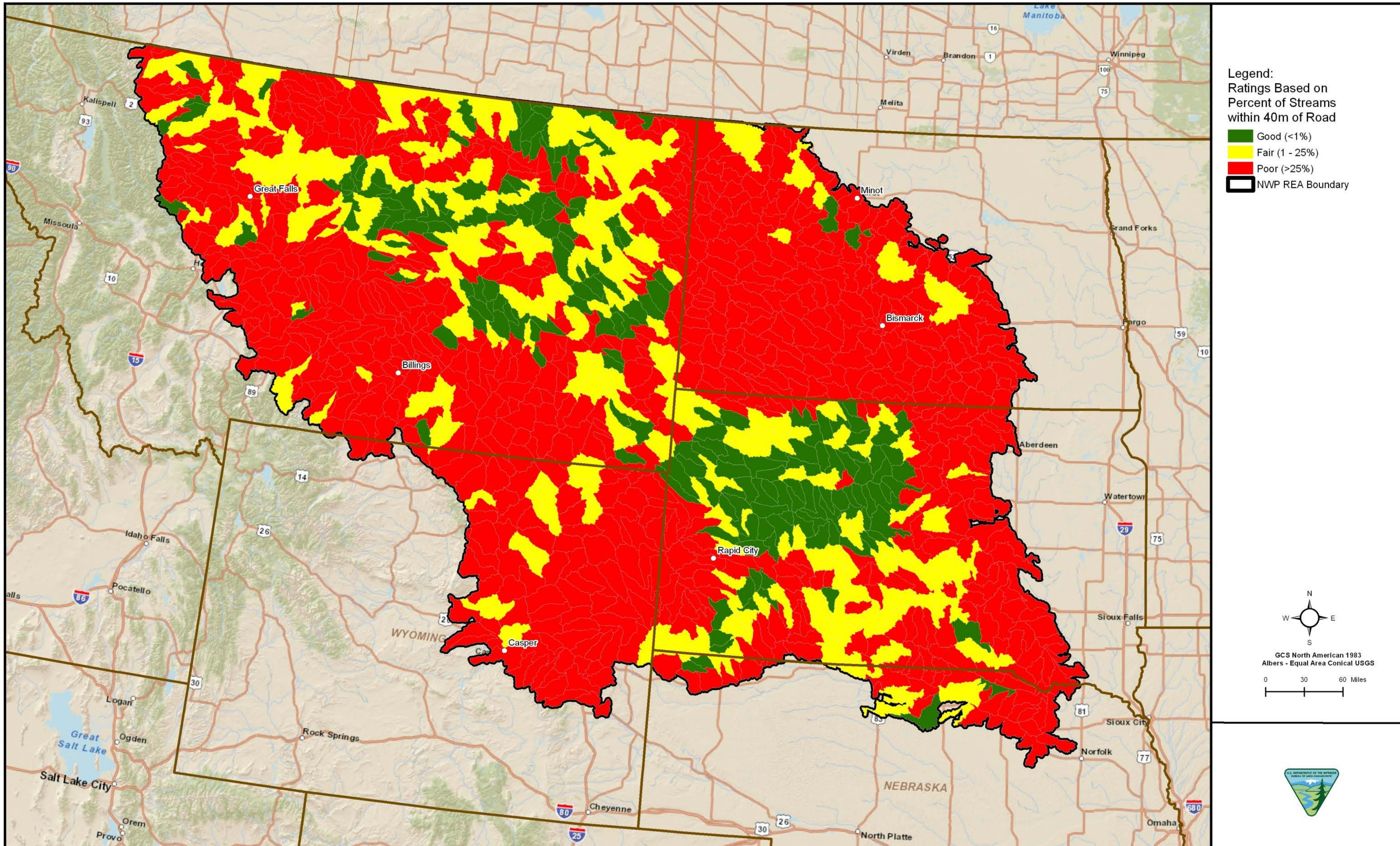

Figure G-15. Aquatic Ecological Intactness Percent of Streams within 40m of Road

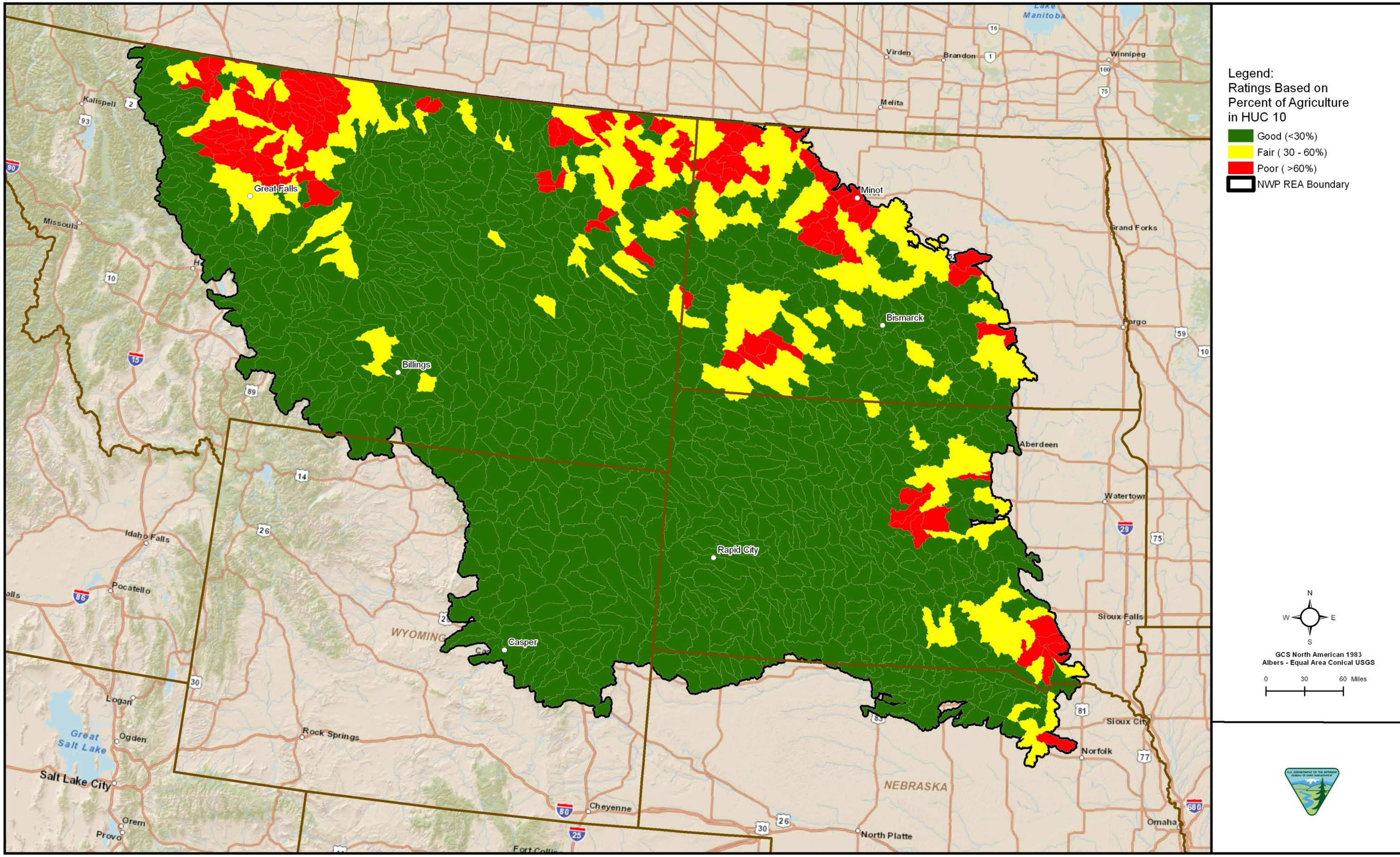

Figure G-16. Aquatic Ecological Intactness Percent of HUC in Agricultural Use

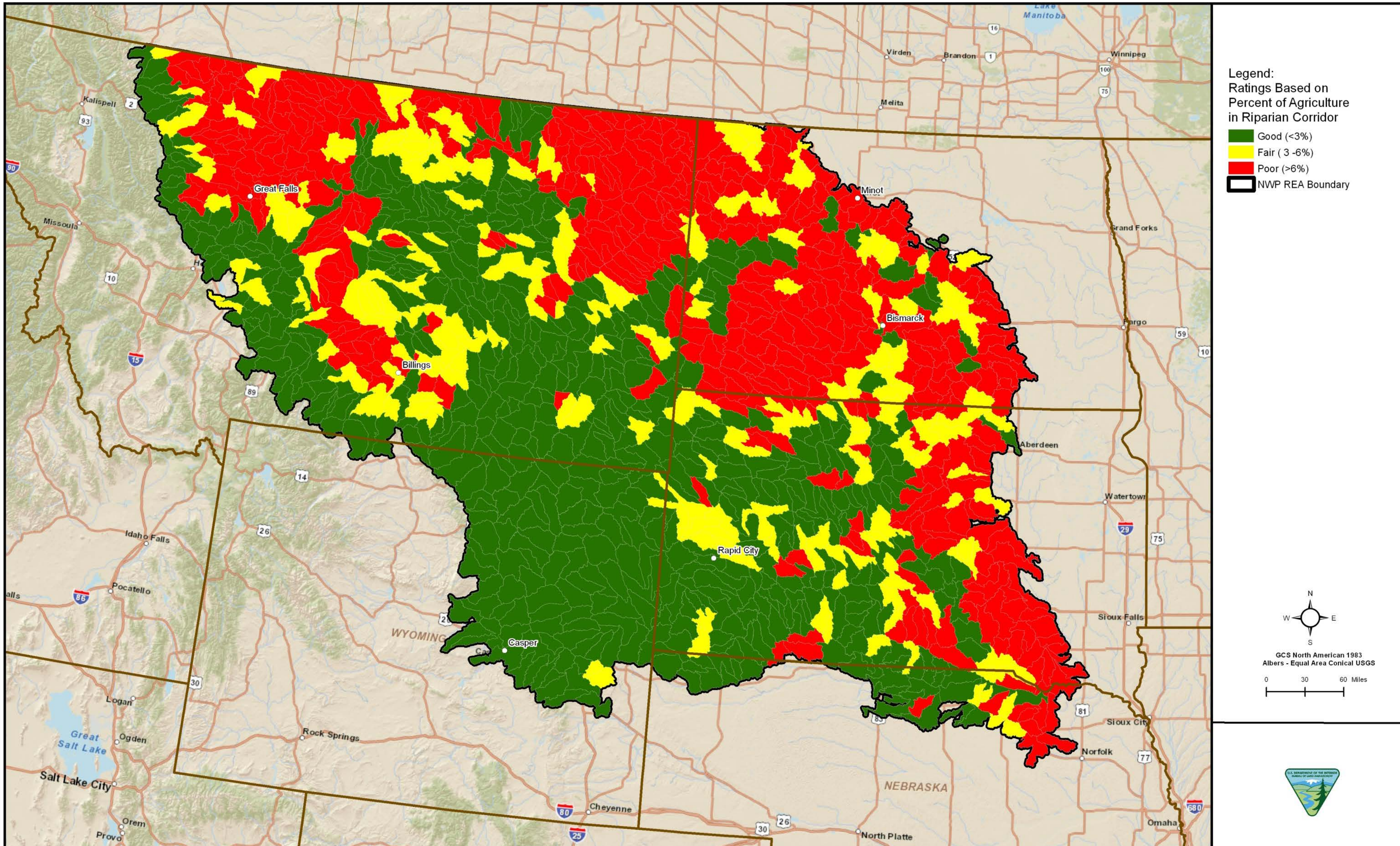

Figure G-17. Aquatic Ecological Intactness Percent of HUC Riparian Corridor in Agricultural Use

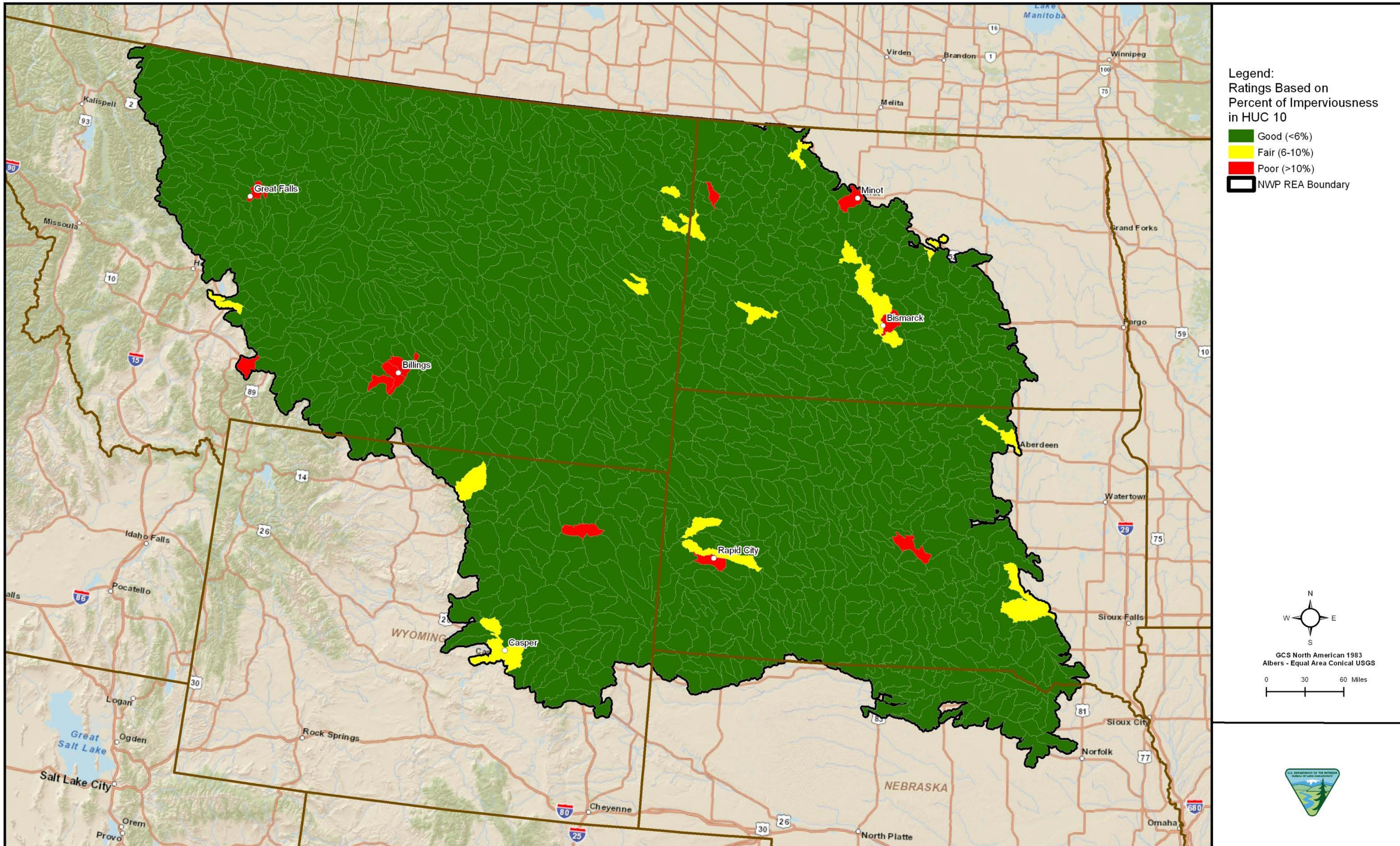

Figure G-18. Aquatic Ecological Intactness Percent Impervious

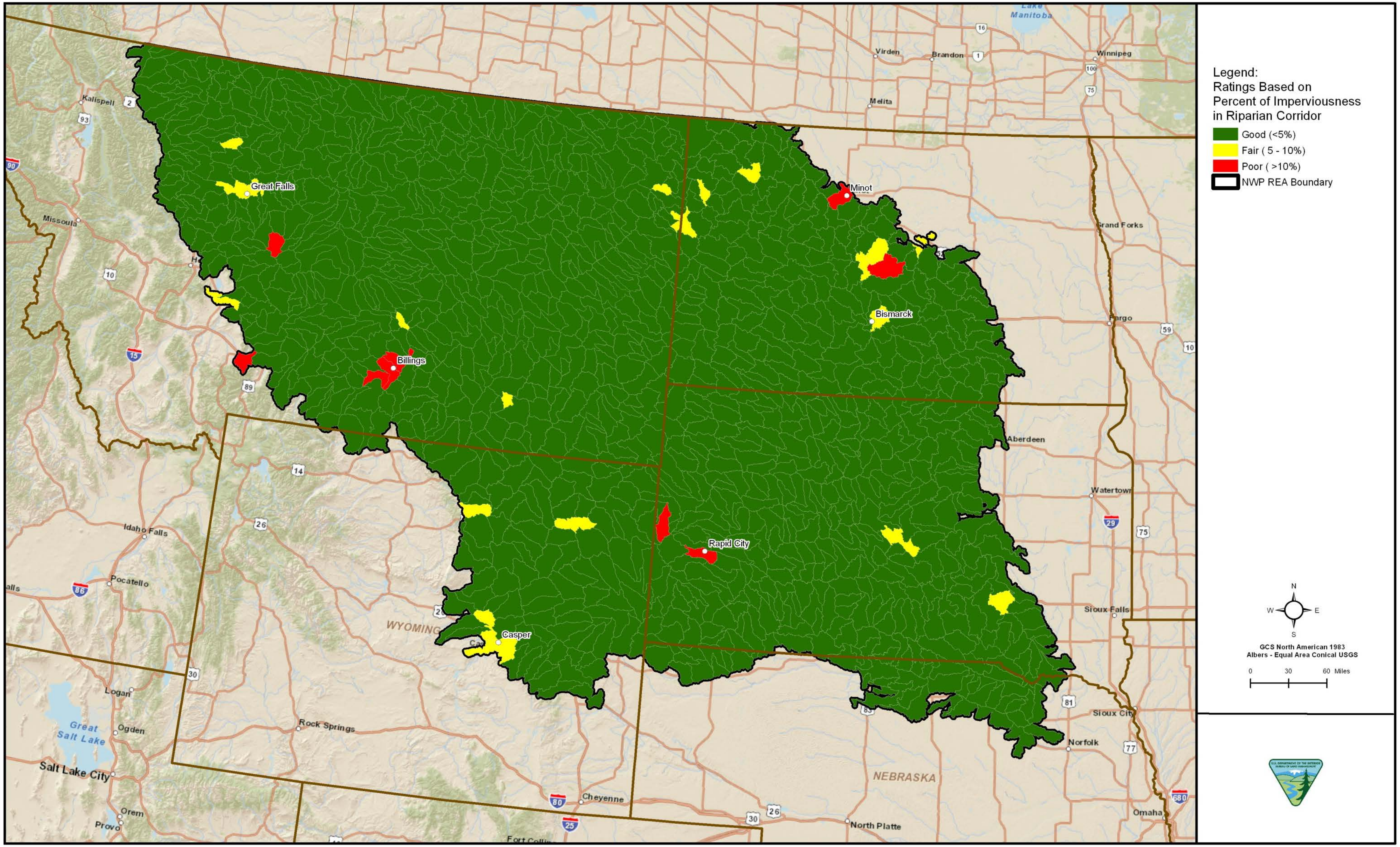

Figure G-19. Aquatic Ecological Intactness Percent of Riparian Corridor in Impervious

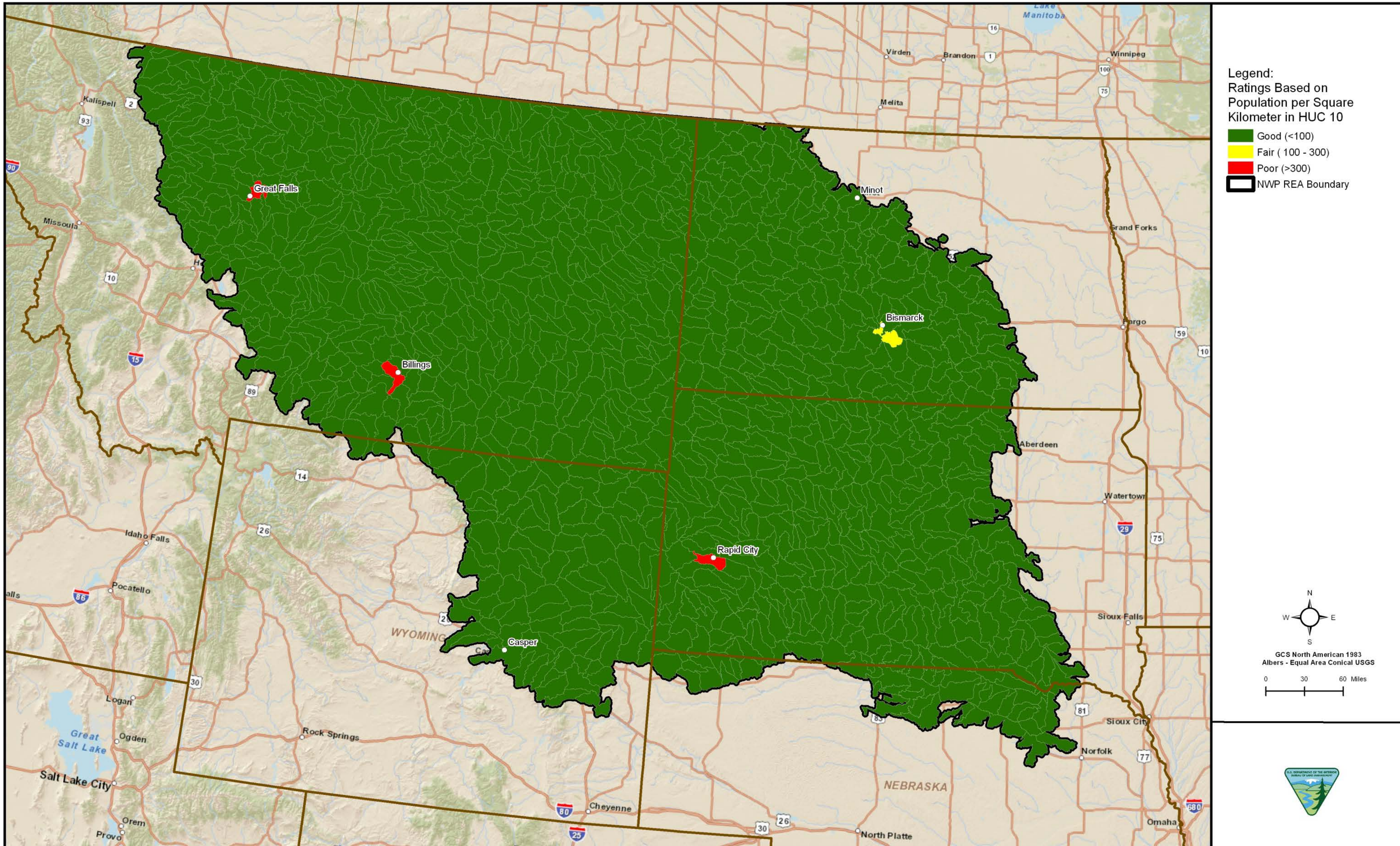

Figure G-20. Aquatic Ecological Intactness Population per Square km

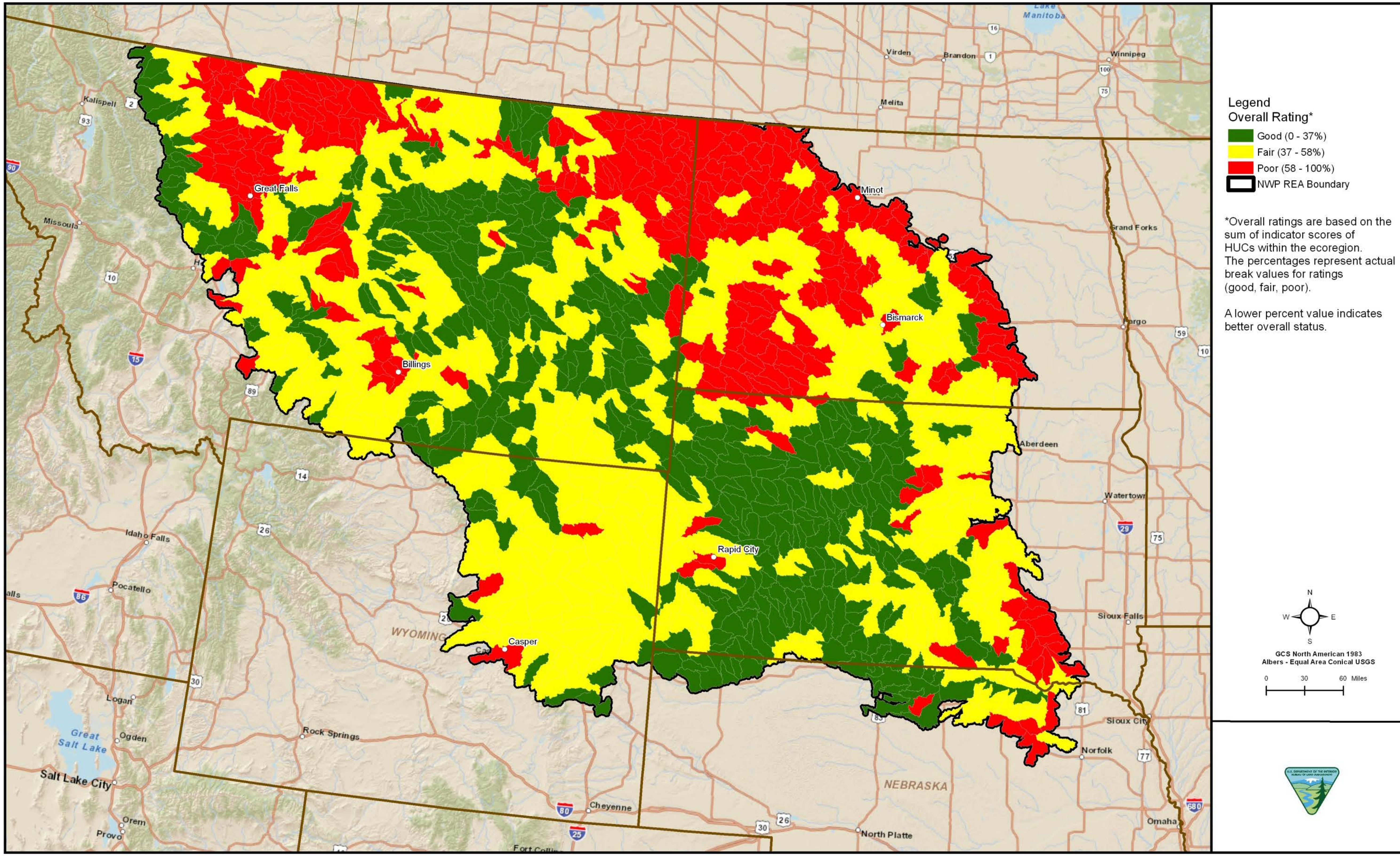

Figure G-21. Aquatic Ecological Intactness Overall Score

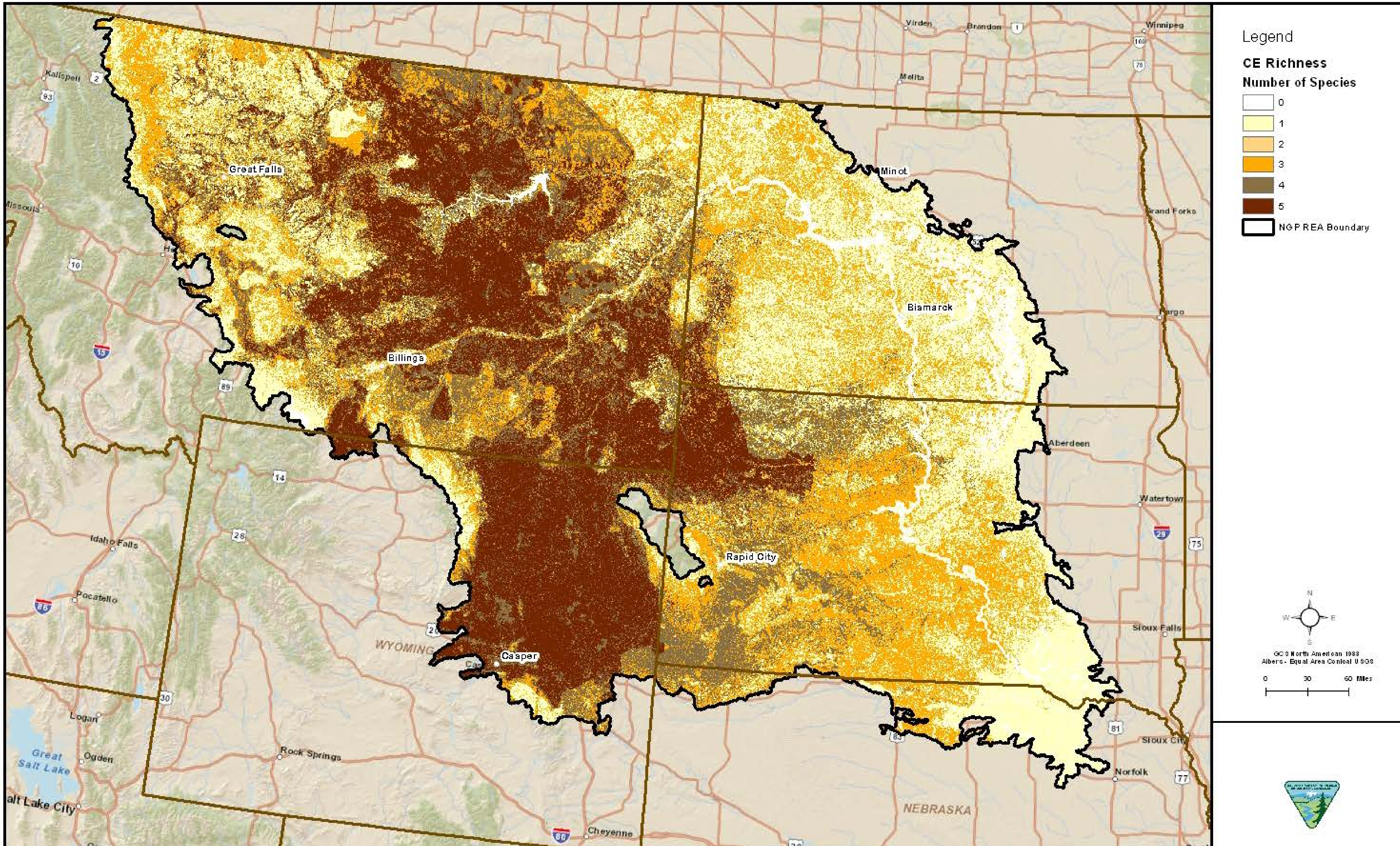

Figure G-22. Aquatic Ecological Intactness CE Species Richness

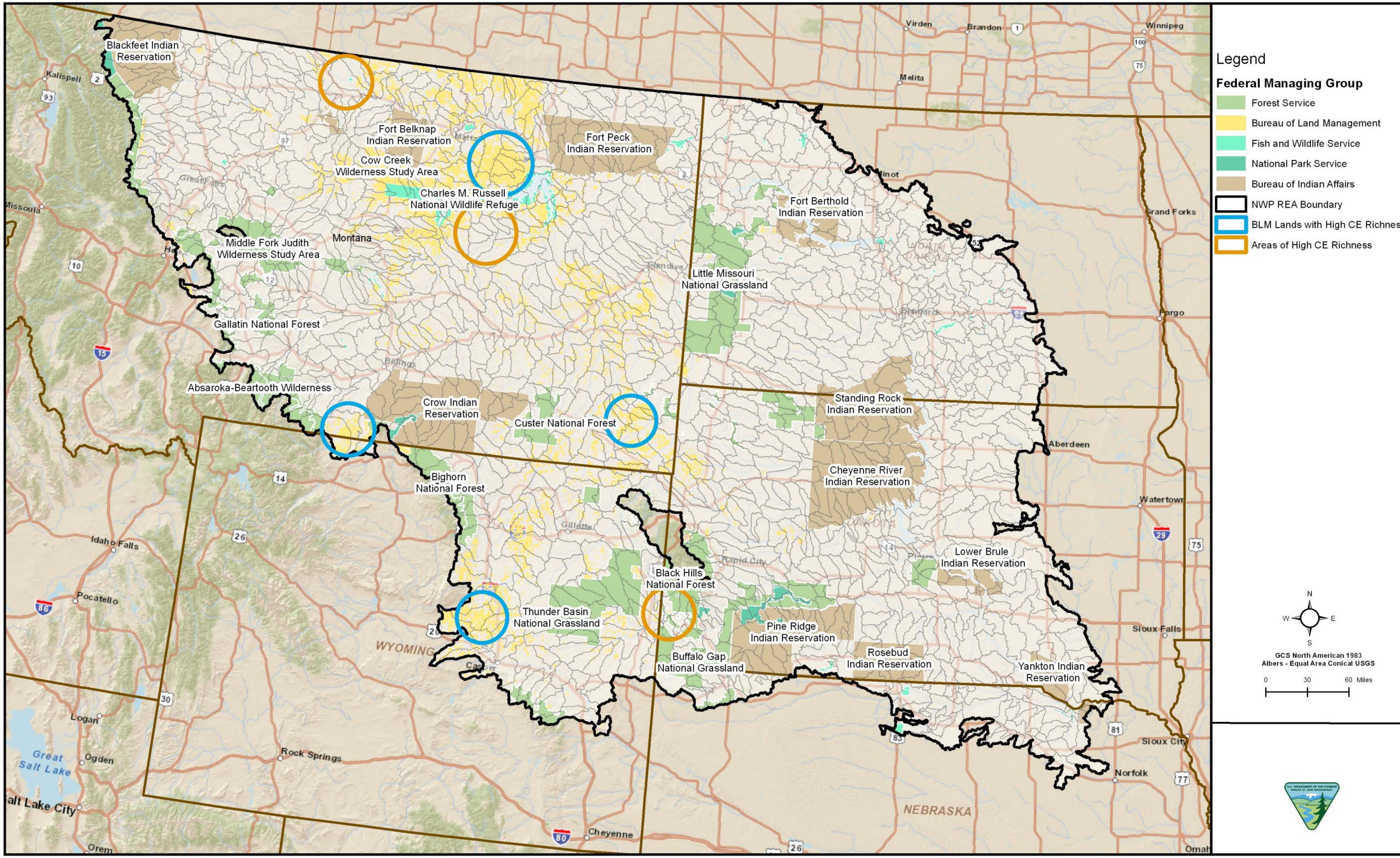

Figure G-23. Terrestrial Ecological Intactness CE Richness Concentration Analysis by HUC

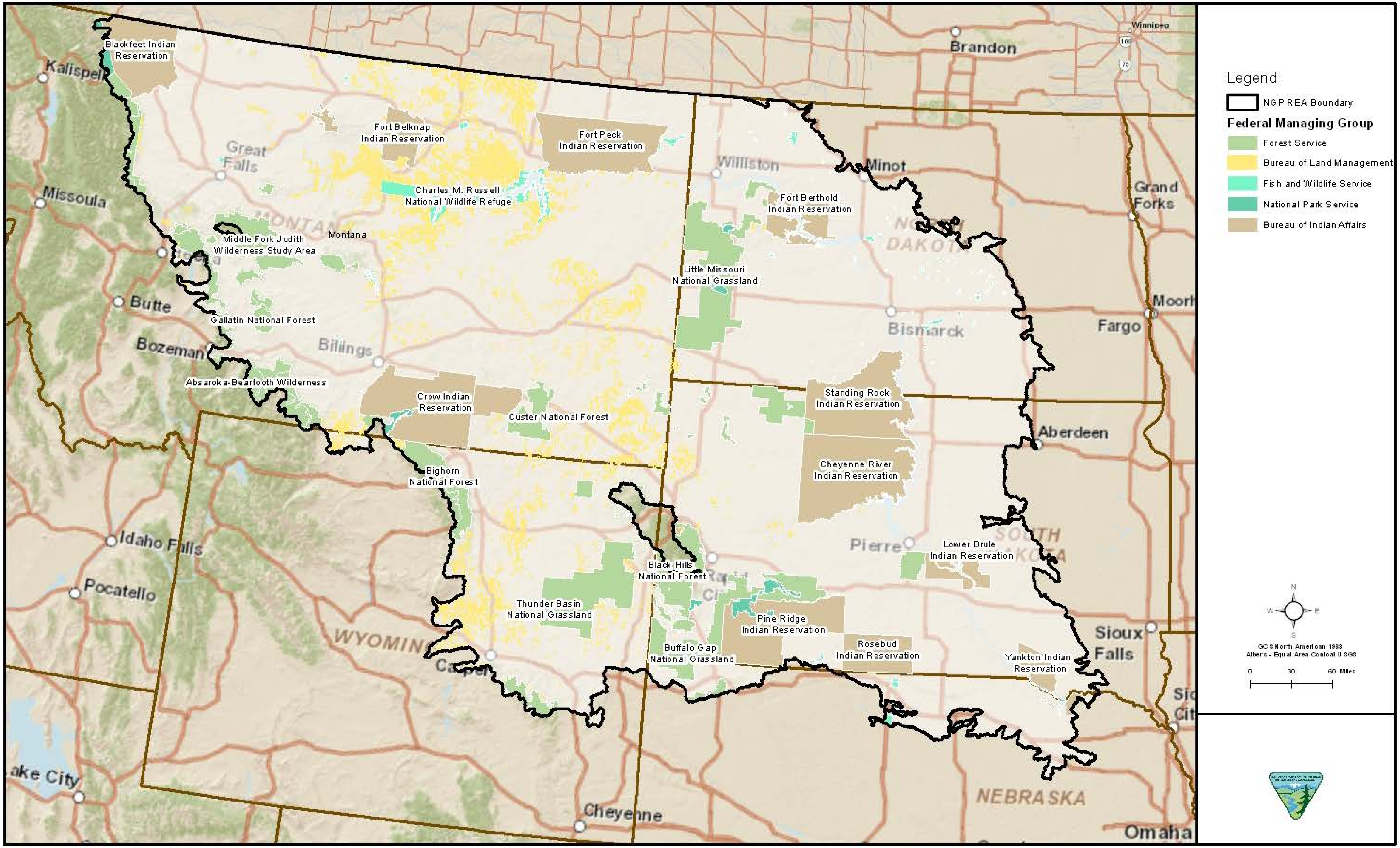

Figure G-24. Terrestrial Ecological Intactness Federally Managed Lands with CE Richness

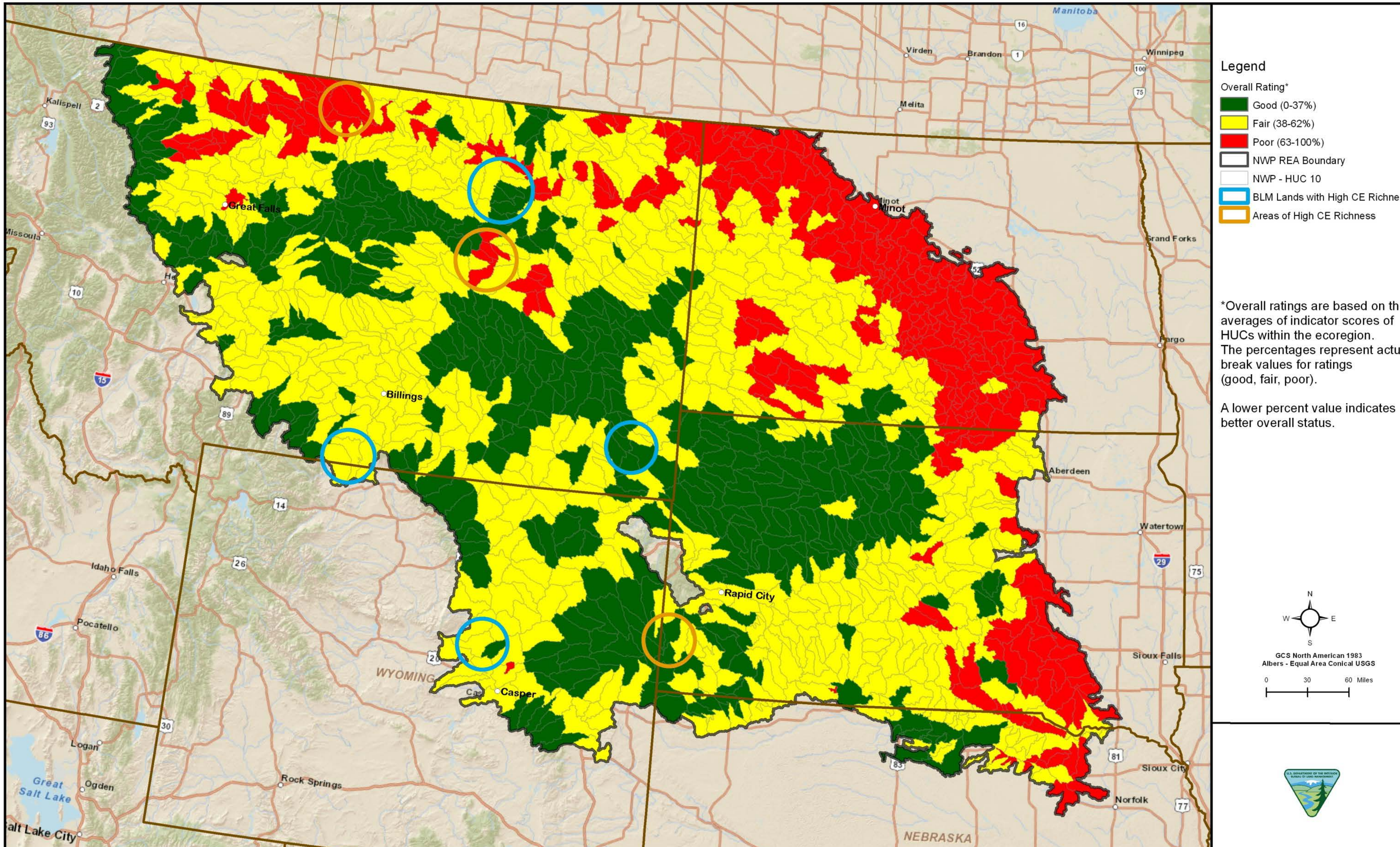

Figure G-25. Terrestrial Ecological Intactness CE Richness with Overall EI Score

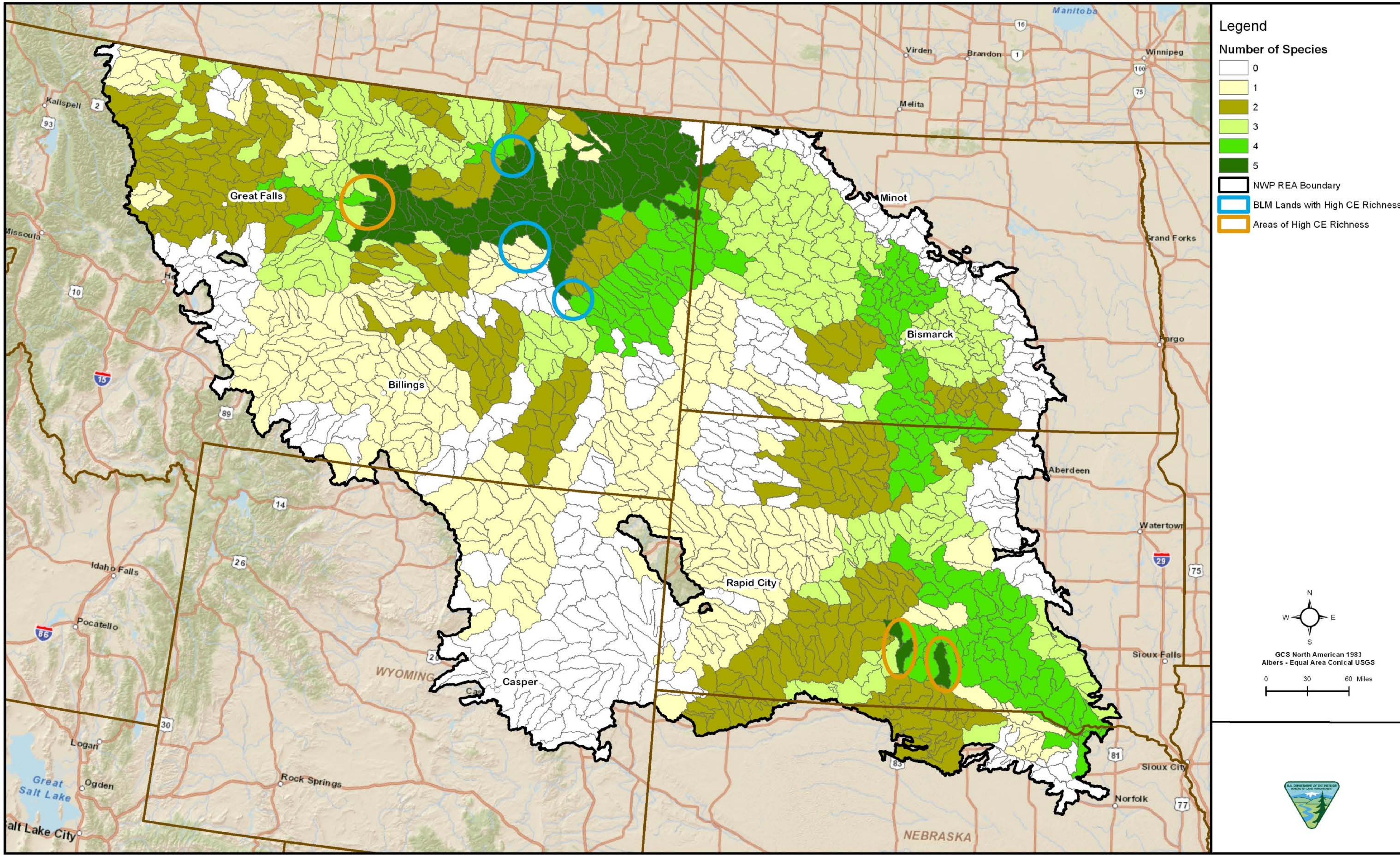

Figure G-26. Aquatic Ecological Intactness CE Richness Concentration Analysis by HUC

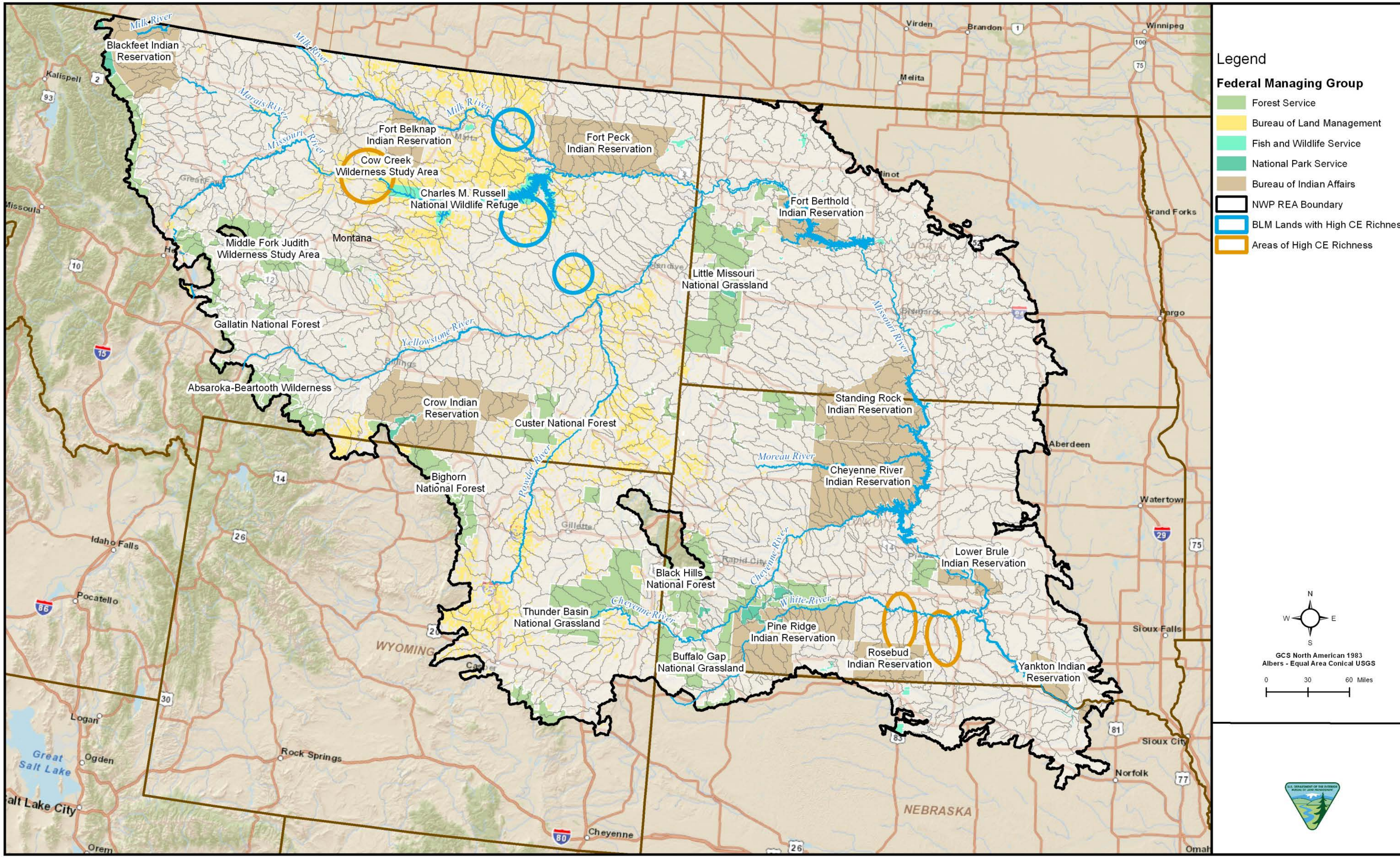

Figure G-27. Aquatic Ecological Intactness Federally Managed Lands with CE Richness

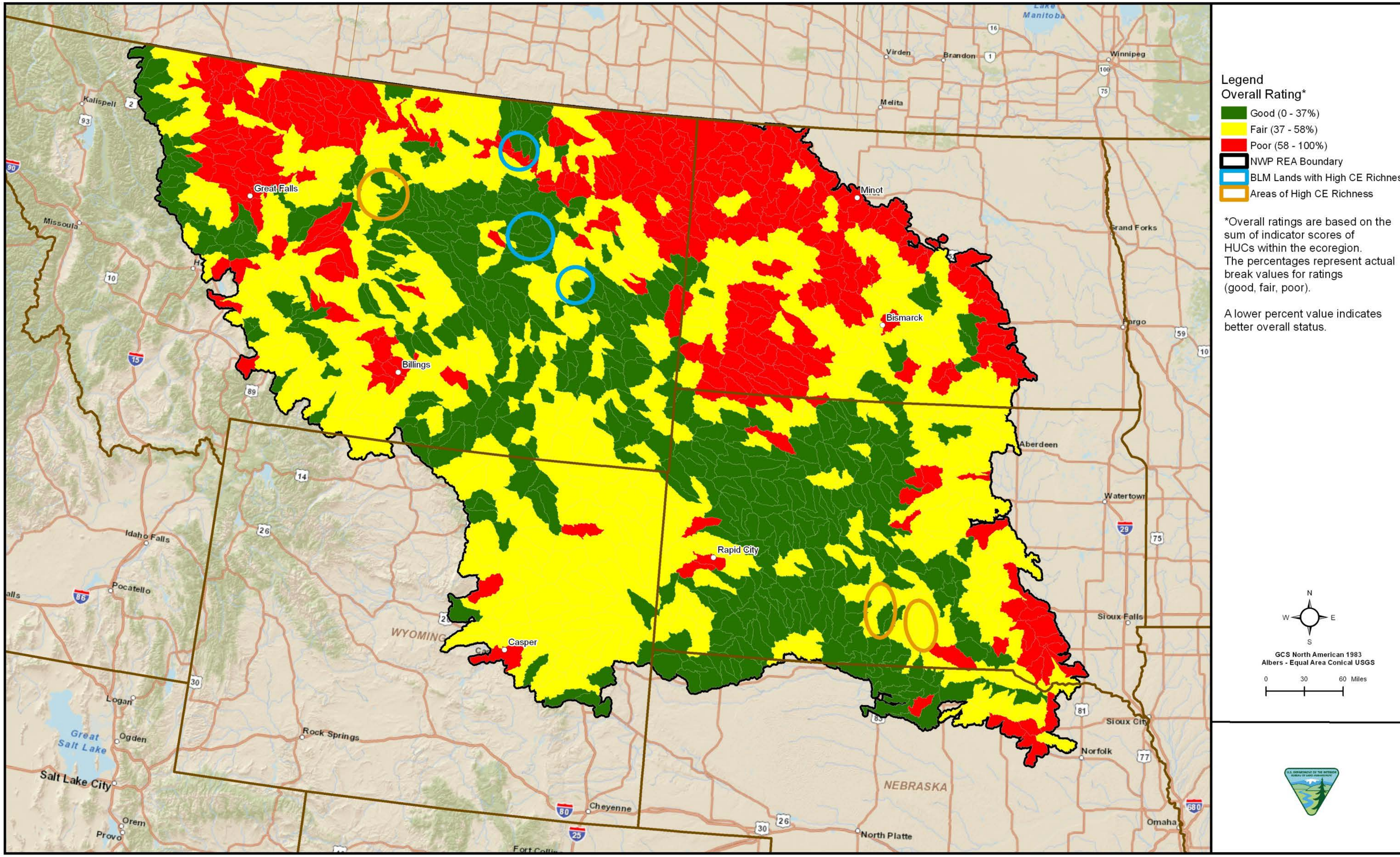

Figure G-28. Aquatic Ecological Intactness CE Richness with Overall EI Score

APPENDIX H

CLIMATE CHANGE VULNERABILITY INDEX DOCUMENTATION

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Northwestern Plains
Mule Deer NSCCVI

The NatureServe Climate Change Vulnerability Index

Release 2.1 *7 April 2011; Bruce Young, Elizabeth Byers, Kelly Gravuer, Kim Hall, Geoff Hammerson, Alan Redder*
With input from: *Jay Cordeiro, Kristin Szabo*
Funding for Release 2.0 generously provided by the Duke Energy Corporation.

** = Required field*

Geographic Area Assessed:	Northwestern Plains Ecoregion *
Assessor:	Sarah Bresnan
Species Scientific Name:	Odocoileus hemionus *
English Name:	Mule Deer
Major Taxonomic Group:	Mammal *
Relation of Species' Range to Assessment Area:	Entire range *
G-Rank:	G5
S-Rank:	
Check if species is an obligate of caves or groundwater aquatic systems:	

(Must be marked with an "X" for accurate scoring of these species.)

Assessment Notes (to document special methods and data sources)

S-Rank - NatureServe Explorer U.S. & Canada State/Province Status: Montana (S5), Wyoming (S5), North Dakota (SNR), South Dakota (S5), Nebraska (S5)

Section A: Exposure to Local Climate Change *(Calculate for species' range within assessment area)*

Temperature *

Severity	**Scope** (percent of range)
>5.5° F (3.1° C) warmer	8.659042
5.1-5.5° F (2.8-3.1° C) warmer	55.681001
4.5-5.0° F (2.5-2.7° C) warmer	35.617435
3.9-4.4° F (2.2-2.4° C) warmer	0.0425212
< 3.9° F (2.2° C) warmer	0
Total:	100 *(Must sum to 100)*

Hamon AET:PET Moisture Metric *

Severity	**Scope** (percent of range)
< -0.119	0
-0.097 - -0.119	3.314338
-0.074 - -0.096	49.55947
-0.051 - -0.073	47.09252
-0.028 - -0.050	0.033667
>-0.028	0
Total:	100 *(Must sum to 100)*

Section B: Indirect Exposure to Climate Change *(Evaluate for specific geographical area under consideration)*

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least three required)*

Factors that influence vulnerability	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) Exposure to **sea level rise**				X			
2) Distribution relative to **barriers**							
a) **Natural barriers**				X			
b) **Anthropogenic barriers**			X	X			
3) Predicted **impact of land use changes resulting from human responses** to climate change				X			

Section C: **Sensitivity**

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least 10 required)*	Effect on Vulnerability: Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Dispersal and movements**					X	X	
2) Predicted **sensitivity to temperature** and **moisture changes**							
a) Predicted **sensitivity to changes in temperature**							
i) **historical thermal niche**					X		
ii) **physiological thermal niche**				X			
b) Predicted **sensitivity to changes in precipitation, hydrology, or moisture regime**							
i) **historical hydrological niche**					X		
ii) **physiological hydrological niche**				X			
c) Dependence on a **specific disturbance regime** likely to be impacted by climate change				X			
d) Dependence on **ice, ice-edge, or snow-cover habitats**				X			
3) **Restriction to uncommon geological features or derivatives**					X		
4) **Reliance on interspecific interactions**							
a) Dependence on **other species to generate habitat**				X			
b) **Dietary versatility** (animals only)				X			
c) **Pollinator versatility** (plants only)							X
d) Dependence on **other species for propagule dispersal**				X			
e) Forms part of an **interspecific interaction** not covered by 4a-d				X			
5) **Genetic factors**							
a) Measured **genetic variation**							X
b) Occurrence of **bottlenecks** in recent evolutionary history *(use only if 5a is "unknown")*				X			
6) **Phenological response to** changing seasonal temperature and precipitation dynamics							X

Section D: **Documented or Modeled Response to Climate Change** *(Optional; May apply across the range of a species)*

Mark an "X" in all boxes that apply.

(Optional)	Effect on Vulnerability: Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Documented response** to recent climate change							X
2) Modeled **future (2050) change in population** or **range size**							X
3) **Overlap** of modeled future (2050) range with current range							X
4) Occurrence of **protected areas in modeled future (2050) distribution**							X

Northwestern Plains
Mule Deer NSCCVI

Climate Change Vulnerability Index

for Odocoileus hemionus in Northwestern Plains Ecoregion

Not Vulnerable/Increase Likely

Notes: **Species range may shift and perhaps leave the assessment area.**

Confidence in Species Information
Very High

* Histogram below

Definitions of Index Values

Extremely Vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.

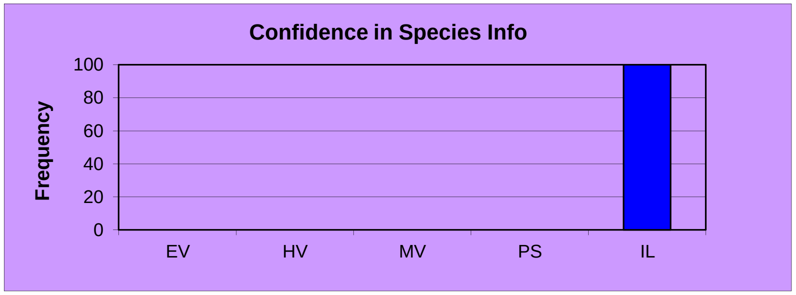
Highly Vulnerable (HV): Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.

Moderately Vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.

Not Vulnerable/Presumed Stable (PS): Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.

Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.



Results of a Monte Carlo simulation (1000 runs) of the data entered in the Index.

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The NatureServe Climate Change Vulnerability Index

Release 2.1 *7 April 2011; Bruce Young, Elizabeth Byers, Kelly Gravuer, Kim Hall, Geoff Hammerson, Alan Redder*
With input from: *Jay Cordeiro, Kristin Szabo*

Funding for Release 2.0 generously provided by the Duke Energy Corporation.

** = Required field*

Geographic Area Assessed:	Northwestern Plains Ecoregion *
Assessor:	Sarah Bresnan
Species Scientific Name:	Centrocercus urophasianus *
English Name:	Greater Sage-Grouse
Major Taxonomic Group:	Bird *
G-Rank:	G3G4
S-Rank:	
Relation of Species' Range to Assessment Area:	Center of range *
Check if species is an obligate of caves or groundwater aquatic systems:	

(Must be marked with an "X" for accurate scoring of these species.)

Assessment Notes (to document special methods and data sources)

S-Rank - NatureServe Explorer U.S. & Canada State/Province Status: Montana (S2), Wyoming (S4), North Dakota (S2), South Dakota (S2), and Nebraska (S1)

Section A: Exposure to Local Climate Change *(Calculate for species' range within assessment area)*

Temperature *

Severity	**Scope** (percent of range)
>5.5° F (3.1° C) warmer	24.7544
5.1-5.5° F (2.8-3.1° C) warmer	57.5526
4.5-5.0° F (2.5-2.7° C) warmer	17.693
3.9-4.4° F (2.2-2.4° C) warmer	0
< 3.9° F (2.2° C) warmer	0
Total:	100 *(Must sum to 100)*

Hamon AET:PET Moisture Metric *

Severity	**Scope** (percent of range)
< -0.119	13.919
-0.097 - -0.119	42.1471
-0.074 - -0.096	36.3474
-0.051 - -0.073	7.5723
-0.028 - -0.050	0.000143
>-0.028	0.014057
Total:	100 *(Must sum to 100)*

Section B: Indirect Exposure to Climate Change *(Evaluate for specific geographical area under consideration)*

Mark an "X" in all boxes that apply.

Effect on Vulnerability						
Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
			X			
		X	X			
		X				
		X				

Factors that influence vulnerability *(* at least three required)*

1) Exposure to **sea level rise**
2) Distribution relative to **barriers**
  a) **Natural barriers**
  b) **Anthropogenic barriers**
3) Predicted **impact of land use changes resulting from human responses** to climate change

Section C: **Sensitivity**

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least 10 required)*

Factor	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Dispersal and movements**				X			
2) Predicted **sensitivity to temperature** and **moisture changes**							
a) Predicted **sensitivity to changes in temperature**							
i) **historical thermal niche**					X		
ii) **physiological thermal niche**				X			
b) Predicted **sensitivity to changes in precipitation, hydrology, or moisture regime**							
i) **historical hydrological niche**					X		
ii) **physiological hydrological niche**				X			
c) Dependence on a **specific disturbance regime** likely to be impacted by climate change			X				
d) Dependence on **ice, ice-edge, or snow-cover habitats**				X			
3) **Restriction to uncommon geological features or derivatives**					X		
4) **Reliance on interspecific interactions**							
a) Dependence on **other species to generate habitat**		X	X				
b) **Dietary versatility** (animals only)				X			
c) **Pollinator versatility** (plants only)							X
d) Dependence on **other species for propagule dispersal**				X			
e) Forms part of an **interspecific interaction** not covered by 4a-d				X			
5) **Genetic factors**							
a) Measured **genetic variation**							X
b) Occurrence of **bottlenecks** in recent evolutionary history *(use only if 5a is "unknown")*			X				
6) **Phenological response to** changing seasonal temperature and precipitation dynamics		X	X				

Section D: **Documented or Modeled Response to Climate Change** *(Optional; May apply across the range of a species)*

Mark an "X" in all boxes that apply.

(Optional)

Factor	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Documented response** to recent climate change							X
2) Modeled **future (2050) change in population** or **range size**							X
3) **Overlap** of modeled future (2050) range with current range							X
4) Occurrence of **protected areas in modeled future (2050) distribution**							X

Climate Change Vulnerability Index

for Centrocercus urophasianus in Northwestern Plains Ecoregion

Moderately Vulnerable

Notes:

Confidence in Species Information
Low

* Histogram below

Definitions of Index Values

Extremely Vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.

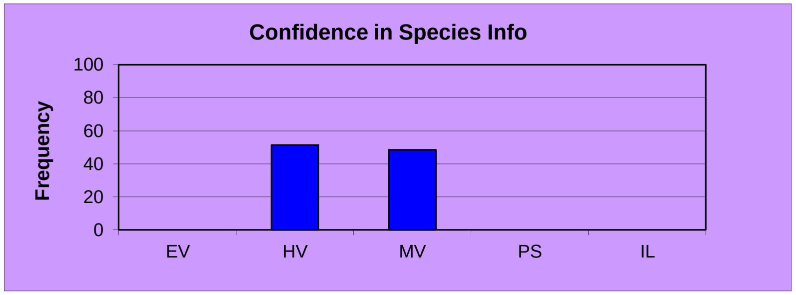
Highly Vulnerable (HV): Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.

Moderately Vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.

Not Vulnerable/Presumed Stable (PS): Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.

Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.



Results of a Monte Carlo simulation (1000 runs) of the data entered in the Index.

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The NatureServe Climate Change Vulnerability Index

Release 2.1 *7 April 2011; Bruce Young, Elizabeth Byers, Kelly Gravuer, Kim Hall, Geoff Hammerson, Alan Redder*

With input from: *Jay Cordeiro, Kristin Szabo*

Funding for Release 2.0 generously provided by the Duke Energy Corporation.

NatureServe

** = Required field*

Geographic Area Assessed:	Northwestern Plains Ecoregion *
Assessor:	Sarah Bresnan
Species Scientific Name:	Aquila chrysaetos *
English Name:	Golden Eagle
Major Taxonomic Group:	Bird *
Relation of Species' Range to Assessment Area:	Entire range *
G-Rank:	G5
S-Rank:	
Check if species is an obligate of caves or groundwater aquatic systems:	*(Must be marked with an "X" for accurate scoring of these species.)*

Assessment Notes (to document special methods and data sources)

S-Rank - NatureServe Explorer U.S. & Canada State/Province Status: Montana (S3), Wyoming (S3B, S3N), South Dakota (S3S4B,S3N), Nebraska (S3)

Section A: Exposure to Local Climate Change *(Calculate for species' range within assessment area)*

Temperature *

Severity	**Scope** (percent of range)
>5.5° F (3.1° C) warmer	0.2
5.1-5.5° F (2.8-3.1° C) warmer	78.7
4.5-5.0° F (2.5-2.7° C) warmer	20.8
3.9-4.4° F (2.2-2.4° C) warmer	0.3
< 3.9° F (2.2° C) warmer	0
Total:	100 *(Must sum to 100)*

Hamon AET:PET Moisture Metric *

Severity	**Scope** (percent of range)
< -0.119	0
-0.097 - -0.119	5.3
-0.074 - -0.096	53.4
-0.051 - -0.073	41.2
-0.028 - -0.050	0.1
>-0.028	0
Total:	100 *(Must sum to 100)*

Section B: Indirect Exposure to Climate Change *(Evaluate for specific geographical area under consideration)*

Mark an "X" in all boxes that apply.

Effect on Vulnerability

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
			X			
			X			
			X			
		X				

Factors that influence vulnerability *(* at least three required)*

1) Exposure to **sea level rise**
2) Distribution relative to **barriers**
  a) **Natural barriers**
  b) **Anthropogenic barriers**
3) Predicted **impact of land use changes resulting from human responses** to climate change

Section C: **Sensitivity**

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least 10 required)*

Factors that influence vulnerability	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Dispersal and movements**						X	
2) Predicted **sensitivity to temperature** and **moisture changes**							
a) Predicted **sensitivity to changes in temperature**							
i) **historical thermal niche**					X		
ii) **physiological thermal niche**				X			
b) Predicted **sensitivity to changes in precipitation, hydrology, or moisture regime**							
i) **historical hydrological niche**					X		
ii) **physiological hydrological niche**				X			
c) Dependence on a **specific disturbance regime** likely to be impacted by climate change			X				
d) Dependence on **ice, ice-edge, or snow-cover habitats**							X
3) **Restriction to uncommon geological features or derivatives**					X		
4) **Reliance on interspecific interactions**							
a) Dependence on **other species to generate habitat**				X			
b) **Dietary versatility** (animals only)				X			
c) **Pollinator versatility** (plants only)							X
d) Dependence on **other species for propagule dispersal**				X			
e) Forms part of an **interspecific interaction** not covered by 4a-d				X			
5) **Genetic factors**							
a) Measured **genetic variation**							X
b) Occurrence of **bottlenecks** in recent evolutionary history *(use only if 5a is "unknown")*				X			
6) **Phenological response to** changing seasonal temperature and precipitation dynamics				X			

Section D: **Documented or Modeled Response to Climate Change** *(Optional; May apply across the range of a species)*

Mark an "X" in all boxes that apply.

(Optional)

Factor	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Documented response** to recent climate change							X
2) Modeled **future (2050) change in population** or **range size**							X
3) **Overlap** of modeled future (2050) range with current range							X
4) Occurrence of **protected areas in modeled future (2050) distribution**							X

Climate Change Vulnerability Index

for Aquila chrysaetos in Northwestern Plains Ecoregion

Not Vulnerable/Increase Likely

Notes: **Species range may shift and perhaps leave the assessment area.**

Confidence in Species Information
Very High

* Histogram below

Definitions of Index Values

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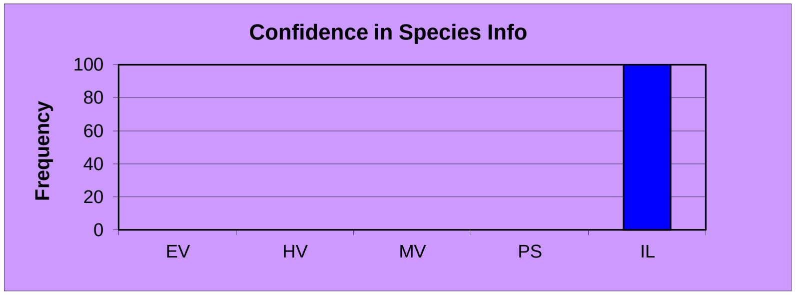
Highly Vulnerable (HV): Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.

Moderately Vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.

Not Vulnerable/Presumed Stable (PS): Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.

Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.



Results of a Monte Carlo simulation (1000 runs) of the data entered in the Index.

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The NatureServe Climate Change Vulnerability Index

Release 2.1 *7 April 2011; Bruce Young, Elizabeth Byers, Kelly Gravuer, Kim Hall, Geoff Hammerson, Alan Redder*
With input from: *Jay Cordeiro, Kristin Szabo*
Funding for Release 2.0 generously provided by the Duke Energy Corporation.

** = Required field*

Geographic Area Assessed:	Northwestern Plains Ecoregion	*
Assessor:	Sarah Bresnan	
Species Scientific Name:	Ammodramus bairdii	*
English Name:	Bairds's Sparrow	
Major Taxonomic Group:	Bird	*
Relation of Species' Range to Assessment Area:		*
G-Rank:	G4	
S-Rank:		
Check if species is an obligate of caves or groundwater aquatic systems:		*(Must be marked with an "X" for accurate scoring of these species.)*

Assessment Notes (to document special methods and data sources)

S-Rank - NatureServe Explorer U.S. & Canada State/Province Status: Montana (S3B), Idaho (), Wyoming (S1?B), North Dakota (SU), South Dakota (S2B), Nebraska (SNRN)

Section A: Exposure to Local Climate Change *(Calculate for species' range within assessment area)*

Temperature *

Severity	Scope (percent of range)
>5.5° F (3.1° C) warmer	0.7
5.1-5.5° F (2.8-3.1° C) warmer	56.5
4.5-5.0° F (2.5-2.7° C) warmer	42.8
3.9-4.4° F (2.2-2.4° C) warmer	0
< 3.9° F (2.2° C) warmer	0
Total:	100 *(Must sum to 100)*

Hamon AET:PET Moisture Metric *

Severity	Scope (percent of range)
< -0.119	0
-0.097 - -0.119	3.4
-0.074 - -0.096	73.9
-0.051 - -0.073	22.7
-0.028 - -0.050	0
>-0.028	0
Total:	100 *(Must sum to 100)*

Section B: Indirect Exposure to Climate Change *(Evaluate for specific geographical area under consideration)*

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least three required)*

Factor	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) Exposure to **sea level rise**				X			
2) Distribution relative to **barriers**							
a) **Natural barriers**				X			
b) **Anthropogenic barriers**				X			
3) Predicted **impact of land use changes resulting from human responses** to climate change							X

Section C: **Sensitivity**

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least 10 required)*

Factors that influence vulnerability	Effect on Vulnerability: Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Dispersal and movements**					X		
2) Predicted **sensitivity to temperature** and **moisture changes**							
a) Predicted **sensitivity to changes in temperature**							
i) **historical thermal niche**							X
ii) **physiological thermal niche**							X
b) Predicted **sensitivity to changes in precipitation, hydrology, or moisture regime**							
i) **historical hydrological niche**							X
ii) **physiological hydrological niche**							X
c) Dependence on a **specific disturbance regime** likely to be impacted by climate change				X			
d) Dependence on **ice, ice-edge, or snow-cover habitats**				X			
3) **Restriction to uncommon geological features or derivatives**					X		
4) **Reliance on interspecific interactions**							
a) Dependence on **other species to generate habitat**				X			
b) **Dietary versatility** (animals only)				X			
c) **Pollinator versatility** (plants only)							X
d) Dependence on **other species for propagule dispersal**				X			
e) Forms part of an **interspecific interaction** not covered by 4a-d				X			
5) **Genetic factors**							
a) Measured **genetic variation**							X
b) Occurrence of **bottlenecks** in recent evolutionary history *(use only if 5a is "unknown")*							X
6) **Phenological response to** changing seasonal temperature and precipitation dynamics							X

Section D: **Documented or Modeled Response to Climate Change** *(Optional; May apply across the range of a species)*

Mark an "X" in all boxes that apply.

(Optional)

Factor	Effect on Vulnerability: Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Documented response** to recent climate change							X
2) Modeled **future (2050) change in population** or **range size**							X
3) **Overlap** of modeled future (2050) range with current range							X
4) Occurrence of **protected areas in modeled future (2050) distribution**							X

Northwestern Plains
Bairds Sparrow NSCCVI

Climate Change Vulnerability Index

for Ammodramus bairdii in Northwestern Plains Ecoregion

Insufficient Evidence

Notes:

Confidence in Species Information

--

* Histogram below

Definitions of Index Values

Extremely Vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.

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Moderately Vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.

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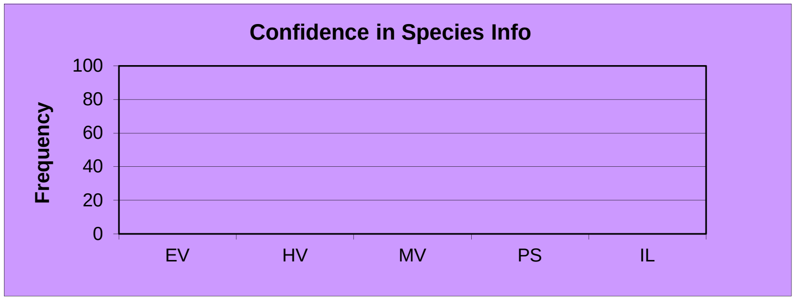
Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.



Results of a Monte Carlo simulation (1000 runs) of the data entered in the Index.

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The NatureServe Climate Change Vulnerability Index

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With input from: *Jay Cordeiro, Kristin Szabo*
Funding for Release 2.0 generously provided by the Duke Energy Corporation.

** = Required field*

Geographic Area Assessed:	Northwestern Plains Ecoregion *
Assessor:	Sarah Bresnan
Species Scientific Name:	Athene Cunicularia *
English Name:	Burrowing Owl
Major Taxonomic Group:	Bird *
Relation of Species' Range to Assessment Area:	*
G-Rank:	G4
S-Rank:	
Check if species is an obligate of caves or groundwater aquatic systems:	*(Must be marked with an "X" for accurate scoring of these species.)*

Assessment Notes (to document special methods and data sources)

S-Rank - NatureServe Explorer U.S. & Canada State/Province Status: Montana (S4), Wyoming (S3), North Dakota (SU), South Dakota (S3S4B), Nebraska (S5)

Section A: Exposure to Local Climate Change *(Calculate for species' range within assessment area)*

Temperature *

Severity	**Scope** (percent of range)
>5.5° F (3.1° C) warmer	1.5
5.1-5.5° F (2.8-3.1° C) warmer	60
4.5-5.0° F (2.5-2.7° C) warmer	38.5
3.9-4.4° F (2.2-2.4° C) warmer	0
< 3.9° F (2.2° C) warmer	0
Total:	100 *(Must sum to 100)*

Hamon AET:PET Moisture Metric *

Severity	**Scope** (percent of range)
< -0.119	0
-0.097 - -0.119	3
-0.074 - -0.096	53.55
-0.051 - -0.073	43.35
-0.028 - -0.050	0.1
>-0.028	0
Total:	100 *(Must sum to 100)*

Section B: Indirect Exposure to Climate Change *(Evaluate for specific geographical area under consideration)*

Mark an "X" in all boxes that apply.

Effect on Vulnerability

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown	Factors that influence vulnerability *(* at least three required)*
			X				1) Exposure to **sea level rise**
							2) Distribution relative to **barriers**
			X				a) **Natural barriers**
						X	b) **Anthropogenic barriers**
						X	3) Predicted **impact of land use changes resulting from human responses** to climate change

Section C: Sensitivity

Mark an "X" in all boxes that apply.

Factors that influence vulnerability *(* at least 10 required)*

Factors that influence vulnerability	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Dispersal and movements**							X
2) Predicted **sensitivity to temperature** and **moisture changes**							
a) Predicted **sensitivity to changes in temperature**							
i) **historical thermal niche**							X
ii) **physiological thermal niche**							X
b) Predicted **sensitivity to changes in precipitation, hydrology, or moisture regime**							
i) **historical hydrological niche**							X
ii) **physiological hydrological niche**							X
c) Dependence on a **specific disturbance regime** likely to be impacted by climate change							X
d) Dependence on **ice, ice-edge, or snow-cover habitats**							X
3) **Restriction to uncommon geological features or derivatives**							X
4) **Reliance on interspecific interactions**							
a) Dependence on **other species to generate habitat**			X				
b) **Dietary versatility** (animals only)				X			
c) **Pollinator versatility** (plants only)							X
d) Dependence on **other species for propagule dispersal**							X
e) Forms part of an **interspecific interaction** not covered by 4a-d							X
5) **Genetic factors**							
a) Measured **genetic variation**							X
b) Occurrence of **bottlenecks** in recent evolutionary history *(use only if 5a is "unknown")*							X
6) **Phenological response to** changing seasonal temperature and precipitation dynamics							X

Section D: Documented or Modeled Response to Climate Change *(Optional; May apply across the range of a species)*

Mark an "X" in all boxes that apply.

(Optional)

Factor	Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
1) **Documented response** to recent climate change							X
2) Modeled **future (2050) change in population** or **range size**							X
3) **Overlap** of modeled future (2050) range with current range							X
4) Occurrence of **protected areas in modeled future (2050) distribution**							X

Northwestern Plains
Burrowing Owl NSCCVI

Climate Change Vulnerability Index

for Athene Cunicularia in Northwestern Plains Ecoregion

Insufficient Evidence

Notes:

Confidence in Species Information

—-

* Histogram below

Definitions of Index Values

Extremely Vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.

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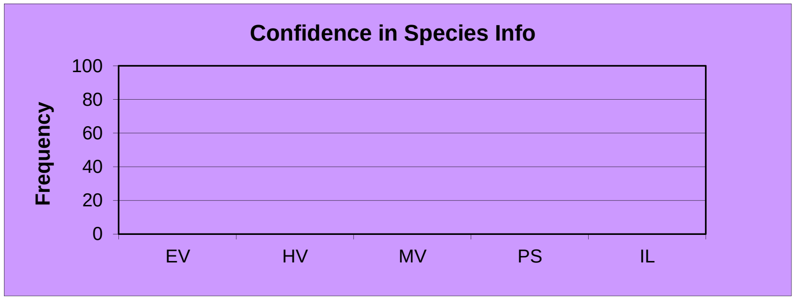
Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.



Results of a Monte Carlo simulation (1000 runs) of the data entered in the Index.

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Data Request Method

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

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

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

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

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

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