APPENDIX F

DATA QUALITY EVALUATION

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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 Middle Rockies ecoregion. Because of the scale of the ecoregion, the data evaluation process focused on data that was 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 is 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.

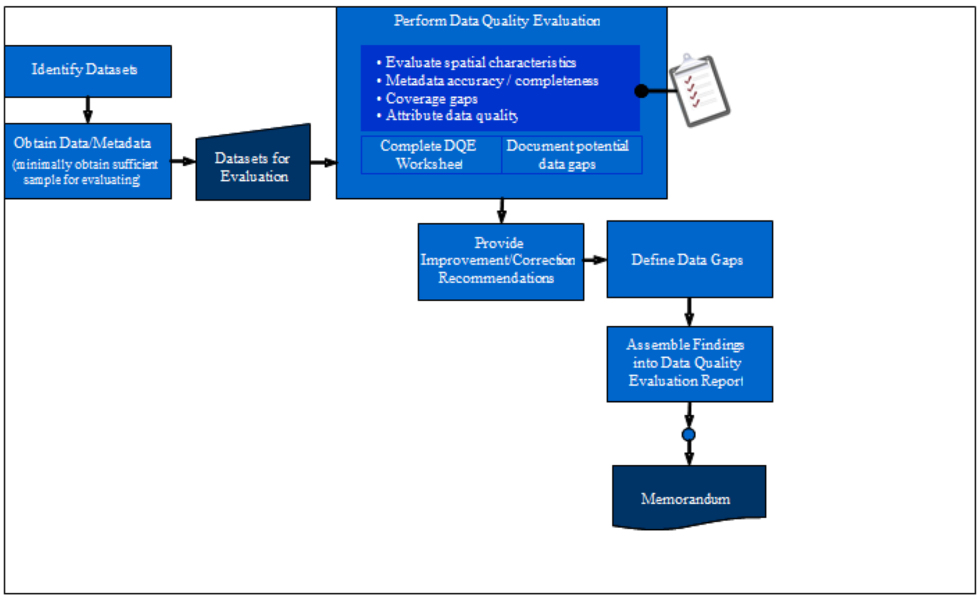

Figure F-1. Data Quality Evaluation Process

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 is compared to the 11 criteria mentioned above to provide information to the Assessment Management Team (AMT) so they have a reasonable understanding data is 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 was 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 feature 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 Middle Rockies 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

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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 has 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 5^{th} 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 6^{th} level HUC and then rolled up to the 5thlevel HUC as the reporting unit.

A species richness (total number of CEs) value for each 5^{th} 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 5^{th} 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 Middle Rockies 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. 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 used 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 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, significant 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 60 m 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.

2.1.1 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

KEA Category	Ecological Attribute	Indicator	Metric			Data Source
			Poor =3	Fair = 2	Good =1	
Size	Size (Acres)	Acres	3.5-10,110	10,111-189,843	189,844-3,385,999	EI layer (Geometric Interval)
	Connectivity (km)	Natural Areas Neighborhood Analysis	0-26	27-51	52-64	EI layer (Natural Breaks)
Condition	Fire Regime Departure	VCC	VCC 3	VCC 2	VCC 1	Fire Regime Condition Class (FRCC)/VCC
Landscape Context	Proximity to Development (m)	Roads, Transmission Lines, Oil & Gas Wells, Wind Turbines, Communication Towers, Railroads.	0-1,338	1,339-4,023	4,024-33,183	Combined Anthropogenic Layer (Based on spatial outputs. Mean and standard deviation.)

2.1.1.1 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.

2.1.1.2 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.

2.1.1.3 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.

2.1.1.4 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.

2.1.2 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 significantly skewed and that a mean value would appropriately represent the per HUC score. This resulted in a single output figure for each EI category for the entire ecoregion and presented on Figure G-6.

2.1.3 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 grizzly bear, greater sage-grouse (GRSG), golden eagle, mule deer, elk, bighorn sheep, Canada lynx, American marten, and the wolverine. Figure G-7 presents the species 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 for 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 EIs have 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 Middle Rockies ecoregion was completed using the 6^{th} level HUC as the analysis unit. The 6^{th} level HUC results were then averaged and rolled up to the 5^{th} 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	Metric			Data Source	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 of 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	> 3	1 - 3	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	Metric			Data Source	Citation
			Poor = 1	Fair = 2	Good = 3		
Context	Landscape Structure	Percent of Streams/ Shorelines 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 Riparian Corridor in Agricultural Use (Cropland)	>6%	3-6%	<3%	NLCD - 2006	Stagliano 2007
		Percent of HUC Impervious	>10%	6-10%	<6%	NLCD - 2006	Allan 2004 Table 1 from Appendix E page 142 of Annis et al. 2010. Wang et al. 2008
		Percent of Riparian Corridor in Impervious	>10%	5-10 %	<5%	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 1or 2 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 or 2 and the GAP status 1, 2, and 3 assessment was 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 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 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 presents 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 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 aquatic EI analyses focused on the 5th level HUC 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 KEAs (Table G-2) 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 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 significantly 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 spring/summer Chinook salmon, summer steelhead, sockeye salmon, fluvial Arctic grayling, bull trout, westslope cutthroat trout, and Yellowstone cutthroat trout. Figure G-22 presents the species richness by 5th level HUC for the aquatic EI.

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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 INTACNTESS 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 geographical areas within this ecoregion that consistently received good ratings (Figure G-6) are those areas that are protected to some degree through federal management and are therefore expected to score as areas of higher terrestrial intactness. These areas include the Bob Marshall Wilderness Area within the Flathead National Forest (Montana), Bridger National Forest (Wyoming and Idaho), Yellowstone National Park (Wyoming and Idaho), and southern portions of the Bighorn National Forest (Wyoming).

In other areas within the ecoregion, the habitat has been significantly altered from its natural level of intactness. Development drives most of the low ratings (Figure G-5) across the ecoregion while the habitat size (Figure G-2) is reduced throughout most of the region outside of Yellowstone National Park and Bighorn National Forest. VCC indicator ratings for fire regime departure were rated as poor for many of the BLM-managed land areas in the southeastern portion of the ecoregion (Figure G-4).

CE richness (total number of species) was calculated for the fine-filter CEs within the ecoregion using the distribution outputs developed for the fine-filter CE analyses. Two general areas as noted by the orange circles on Figure G-23 were identified within the ecoregion that had the highest CE richness. All of the fine-filter CEs (9 species) were identified occupying habitat in the Bridger National Forest south of Grand Tetons National Park and in a 5th level HUC west of the Beaverhead National Forest (Figure G-24). The terrestrial EI analysis indicated that the intactness of the Bridger National Forest is good (Figure G-25). However, the terrestrial EI analysis for the HUCs west of Beaverhead National Forest show a notable margin of HUCs with fair and poor intactness ratings within the central parts of the ecoregion (Figure G-25). Additional development near the Beaverhead National Forest could possibly threaten CE species populations as well as add pressure to populations within Yellowstone National Park.

Terrestrial EI was also evaluated for large tracts of BLM-managed lands within the ecoregion. Seven of the largest BLM-managed areas 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 and G-24. The EI analysis for these seven areas indicates that the EI is rated as fair and poor which could benefit from more detailed step-down analysis.

3.2 ECOLOGICAL INTACNTESS OF AQUATIC SYSTEMS

Results of the aquatic EI analysis showed substantial impairment across the ecoregion based on ratings of poor and fair throughout most of the ecoregion (Figure G-21). The watersheds that appear to be intact based on an EI rating of good are located within the Grand Teton and Yellowstone National Parks, as well as portions of the Bridger National Forest near these two parks, the Bob Marshall Wilderness, and the Charles M. Russell National Wildlife Refuge in the northern portion of the ecoregion (Figure G-21).

Several of the attributes used in the aquatic assessment that contributed to ratings of fair and poor across the ecoregion included the percentage of lands in GAP 1 or 2 status (Figure G-9), the USEPA 303d listing (Figure G-12), proximity to roadways (Figure G-15), and number of mines (Figure G-13). GAP codes of

1 and 2 are lands managed for permanent biodiversity protection, 3 designates multiple use lands that may support extractive uses, and 4 indicates no known mandate for permanent protection (USGS 2012). Therefore, the poor ratings over much of the ecoregion indicated that a low percentage of the lands and habitat are managed for permanent protection.

Aquatic CE richness was calculated for the fine-filter CEs within the ecoregion using the distribution outputs developed for the coldwater fish assemblage. The highest species richness of the ecoregion is noted on Figure G-26 in orange. The highest species richness is associated with the Salmon River and Lemhi River basins in eastern Idaho (Figure G-26). Other areas include the Red Rock River basin in southern Montana, the Big Hole River basin in west central Montana, and the Clark Fork River and Bitteroot River basins near Missoula, Montana (Figure G-26). The results of the aquatic EI analysis indicate that these areas were rated fair and poor (Figure G-28). BLM-managed areas along the Salmon and Lemhi Rivers and near the Beaverhead National Forest are quite extensive (Figure G-27) and, based on aquatic EI ratings of poor and fair, would indicate more detailed evaluation of these areas could be beneficial.

The aquatic EI was also evaluated for large tracts of BLM-managed lands within the ecoregion. Five of the largest BLM-managed areas across the ecoregion were compared to CE species richness. Areas with the highest CE richness within these large tracts are noted by the blue circles on Figures G-27 and G-26. Except for the Red Rock River basin in southern Montana, only one other CE species (the arctic grayling or Yellowstone cutthroat trout) was identified in these tracts of BLM lands within the ecoregion. The aquatic EI ratings for these five BLM tracts were rated as fair with the exception of the BLM lands along the Missouri River near the Charles M. Russell National Wildlife Refuge, which were rated as good (Figure G-27).

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APPENDIX G

FIGURES

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LIST OF FIGURES

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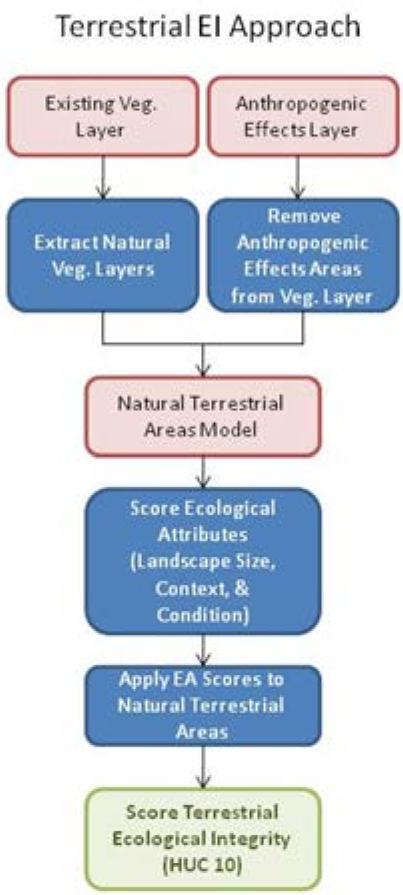

Figure G-1. Conceptual Model for the GIS Analytical Approach to Terrestrial Ecological Intactness

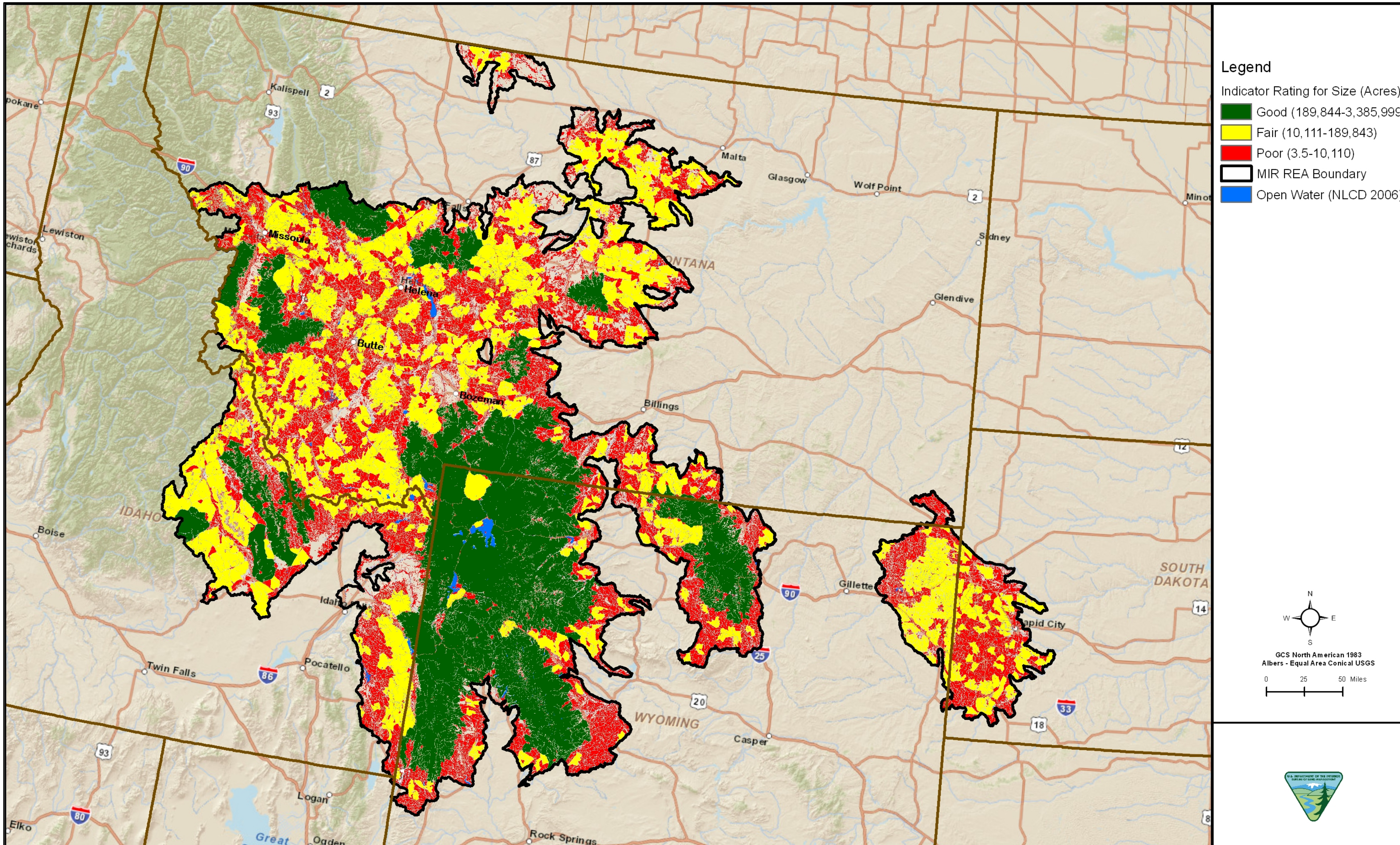

Figure G-2. **Terrestrial Ecological Intactness Size**

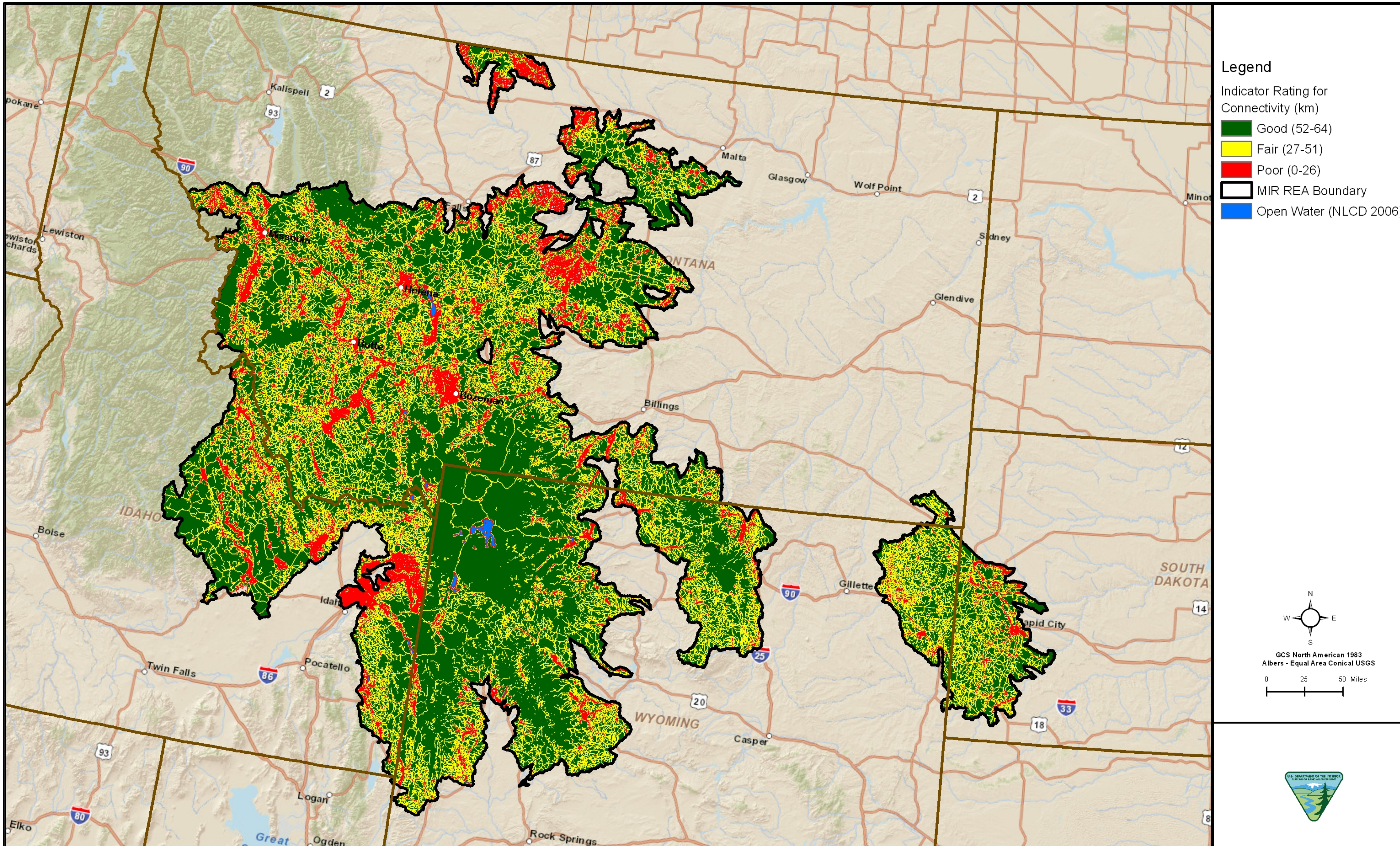

Figure G-3. Terrestrial Ecological Intactness Connectivity

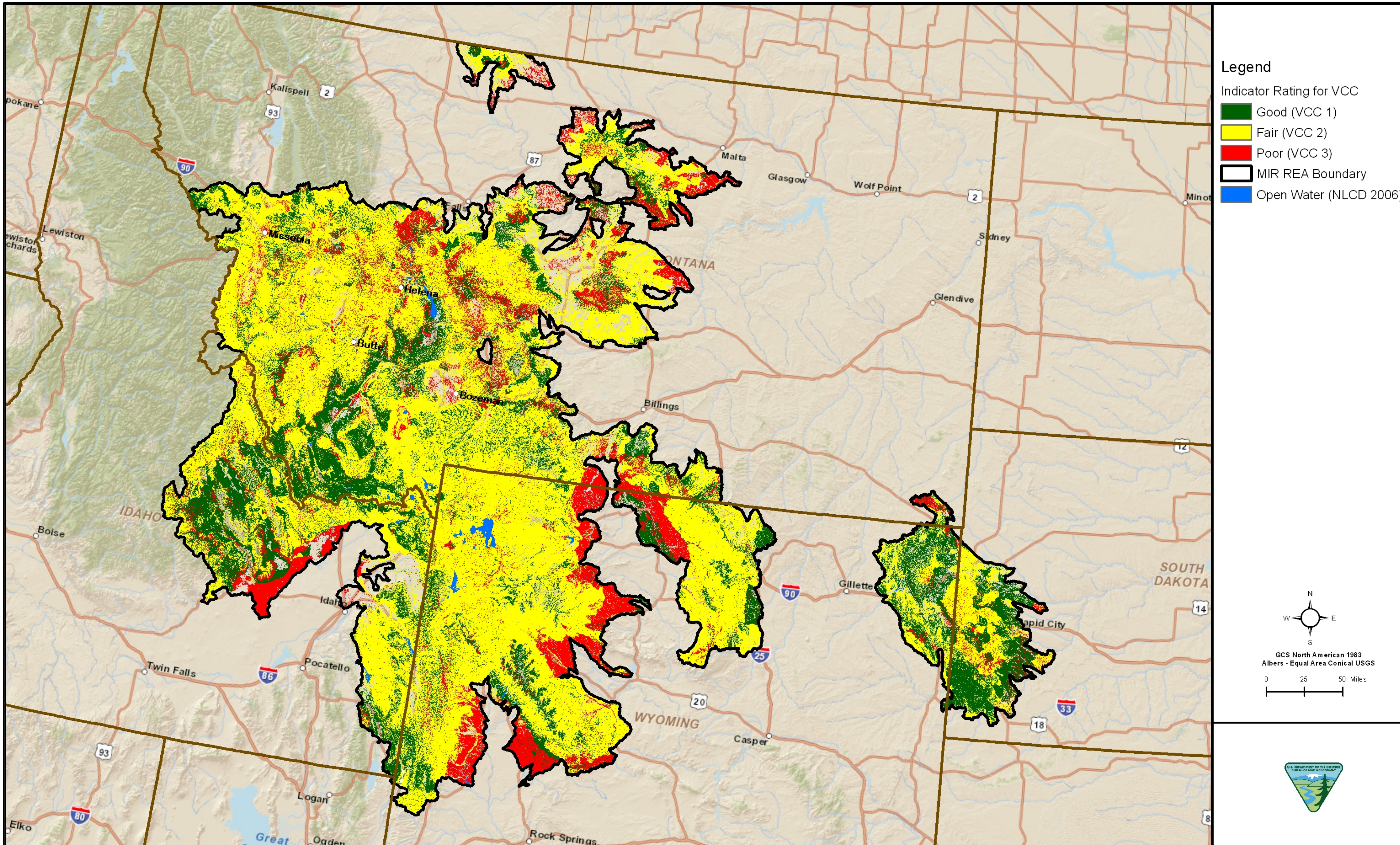

Figure G-4. **Terrestrial Ecological Intactness VCC**

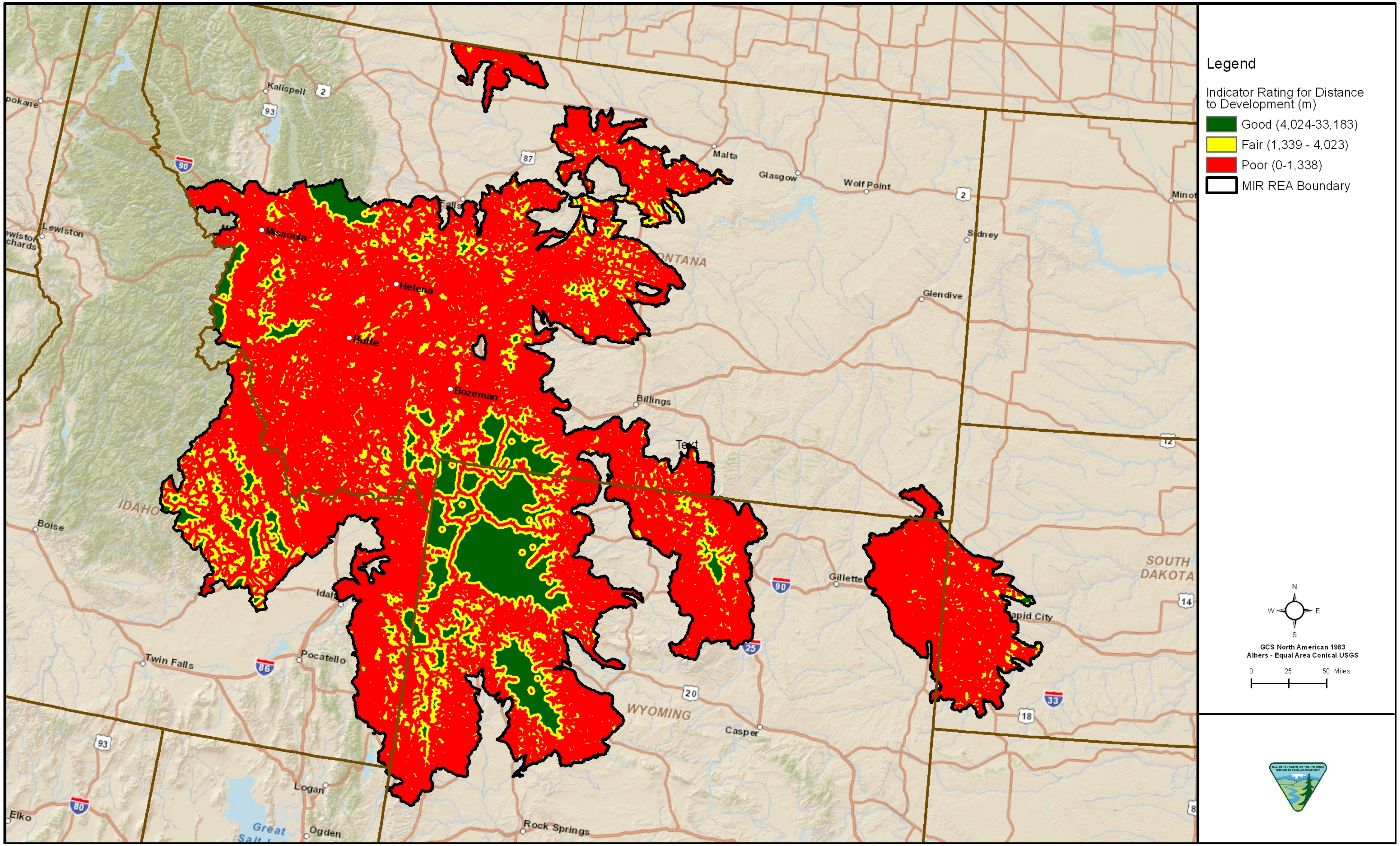

Figure G-5. Terrestrial Ecological Intactness Development

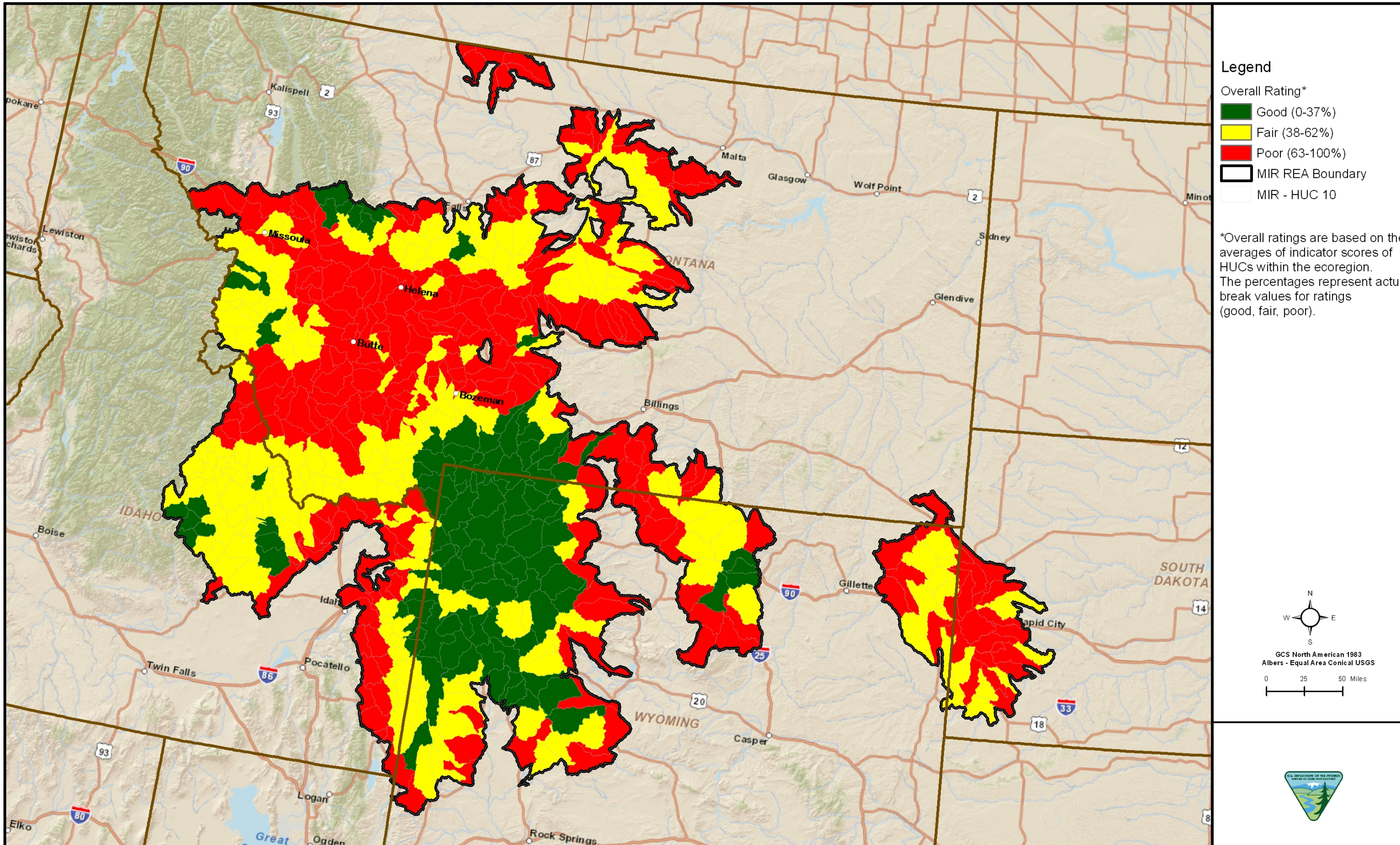

Figure G-6. Terrestrial Ecological Intactness Overall Score

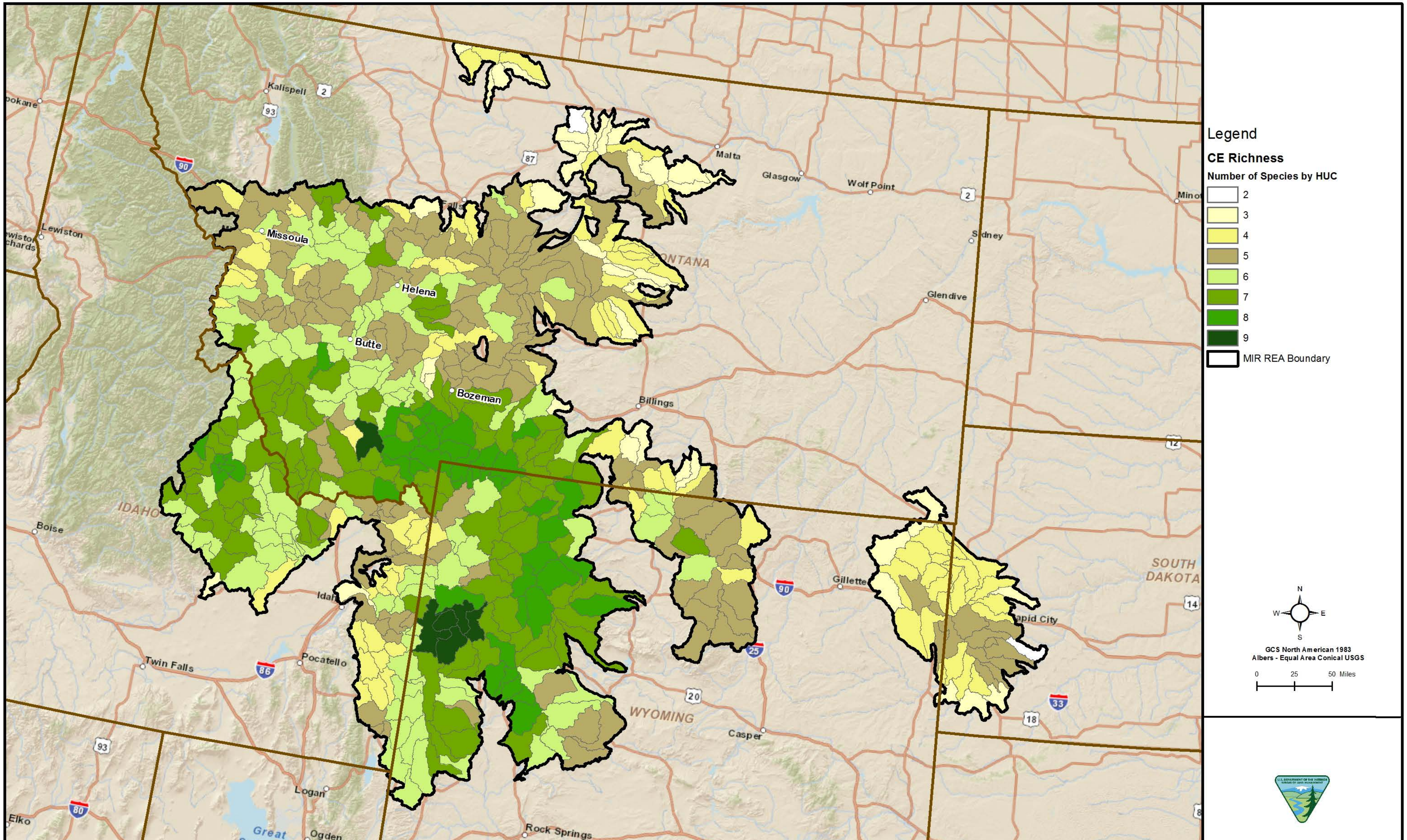

Figure G-7. **Terrestrial Ecological Intactness CE Species Richness**

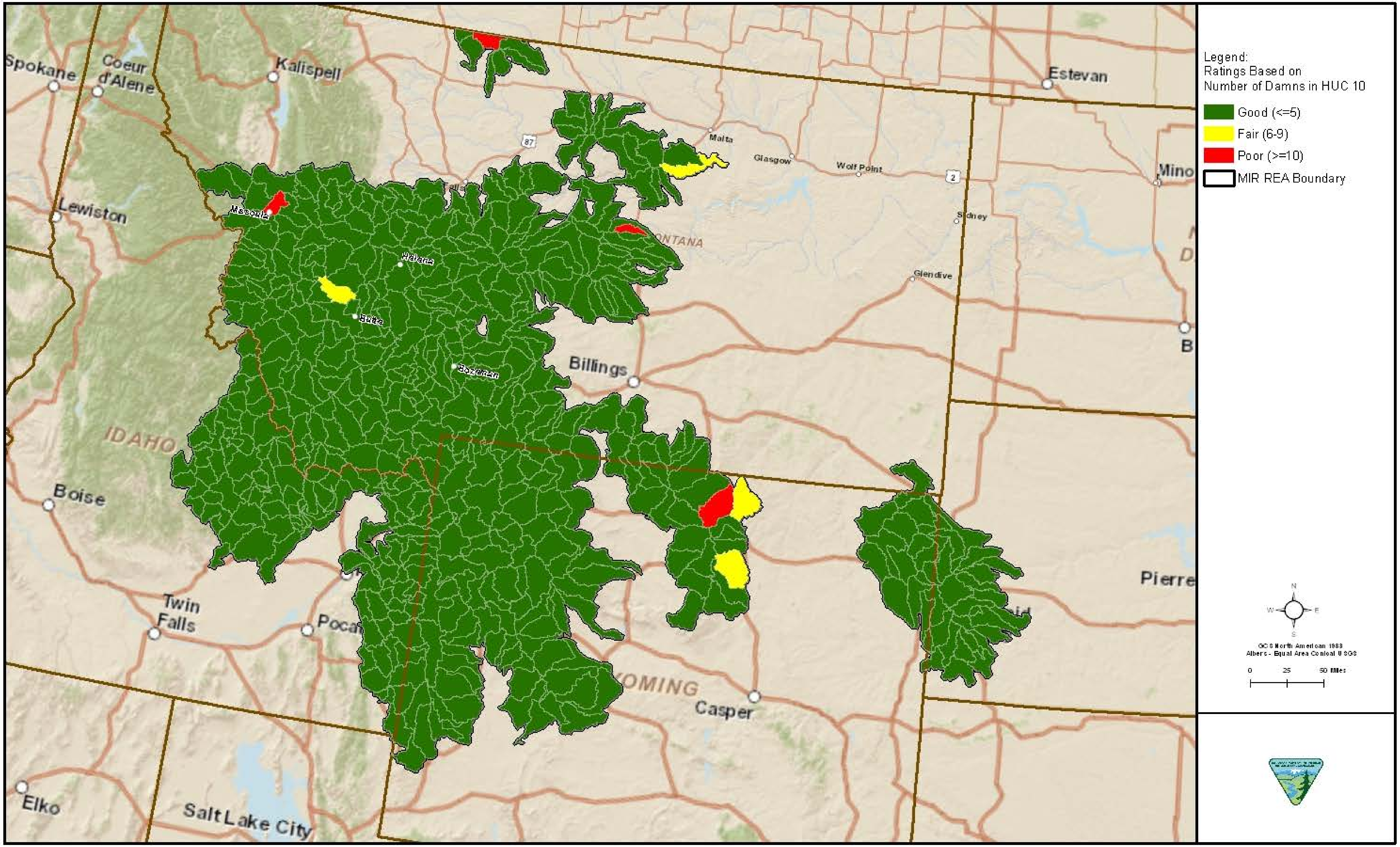

Figure G-8. Aquatic Ecological Intactness Number of Dams in HUC

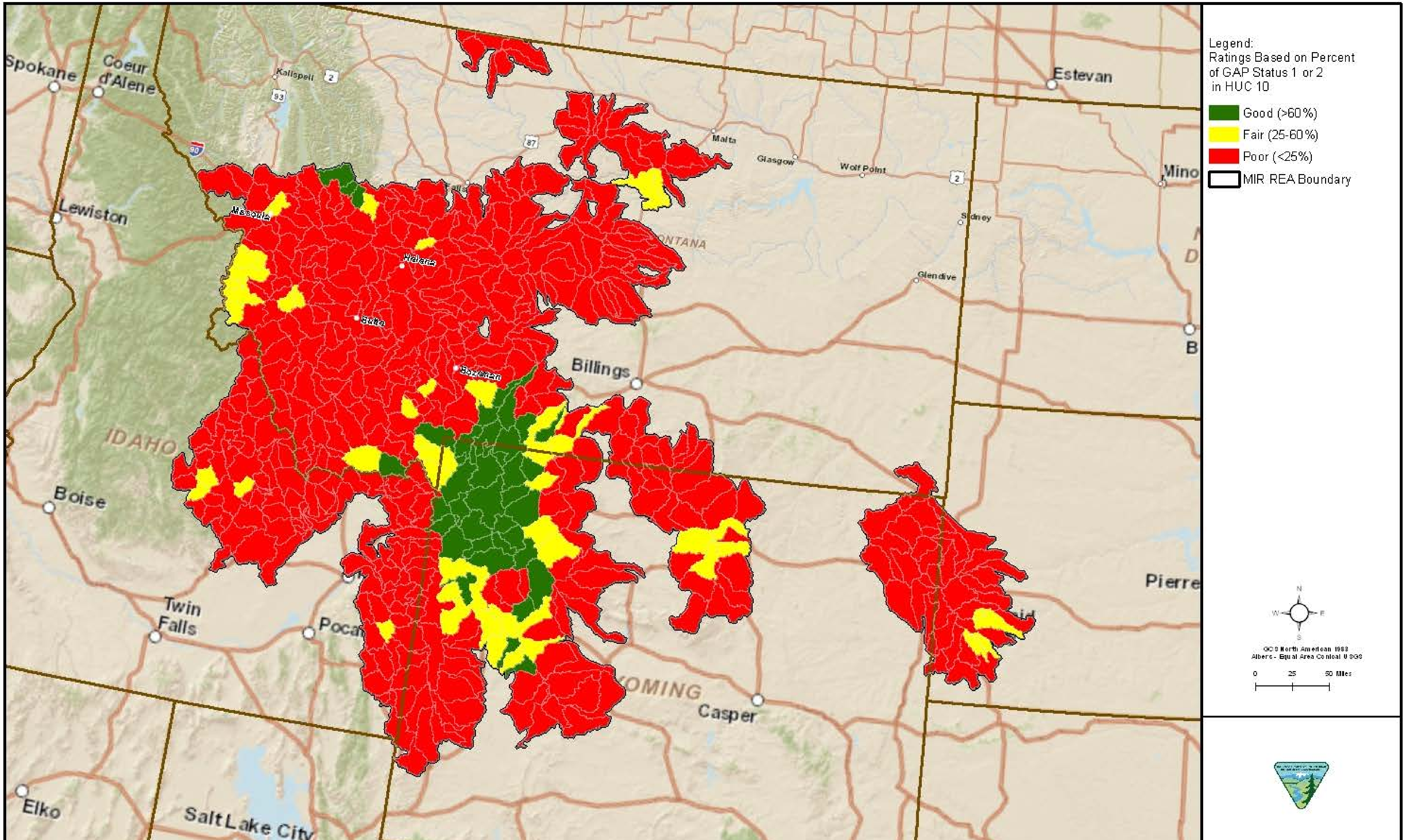

Figure G-9. Aquatic Ecological Intactness Percent of HUC GAP Status 1 or 2

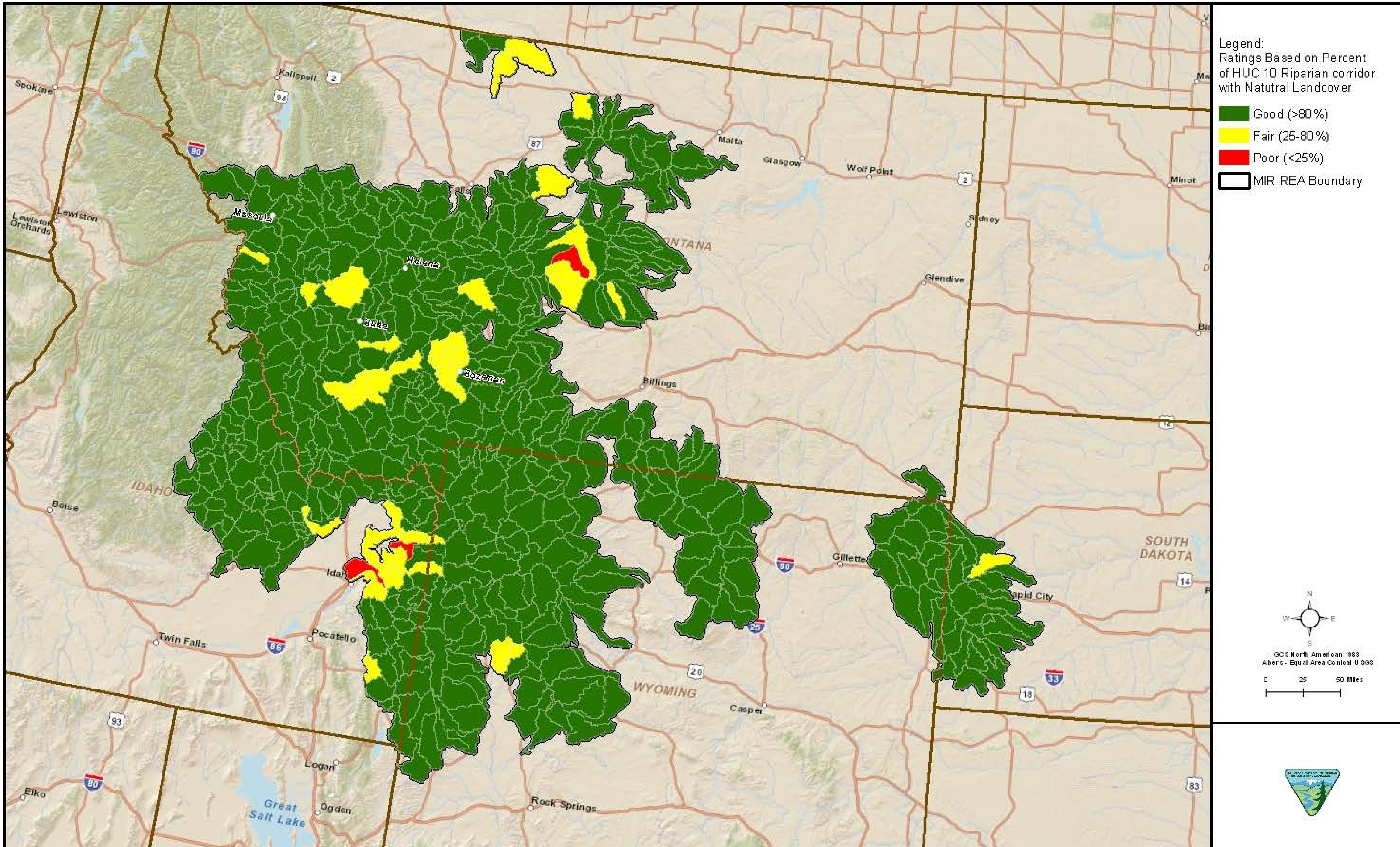

Figure G-10. Aquatic Ecological Intactness Percent of HUC Riparian with Natural Land Cover

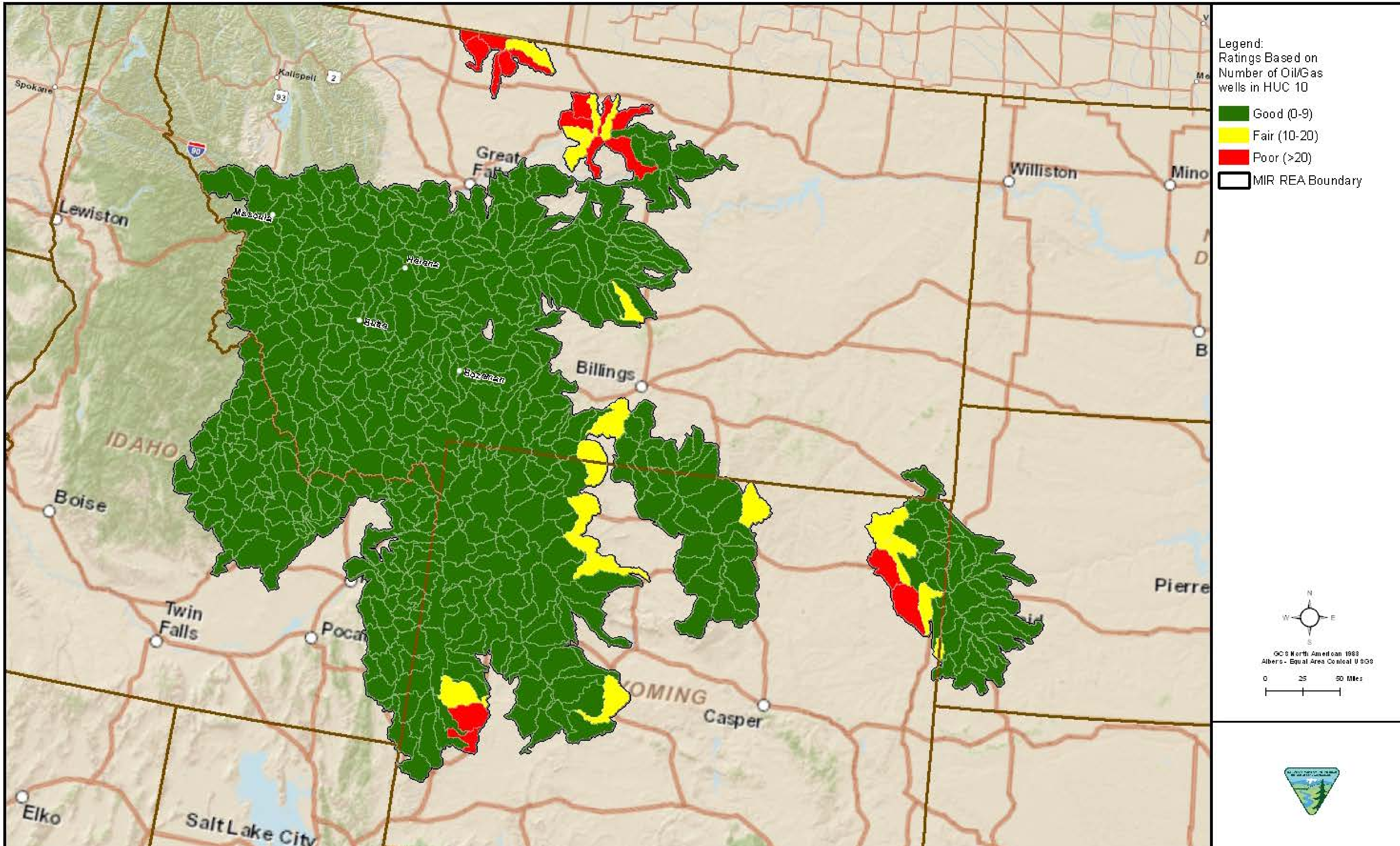

Figure G-11. Aquatic Ecological Intactness Number of Oil and Gas Wells

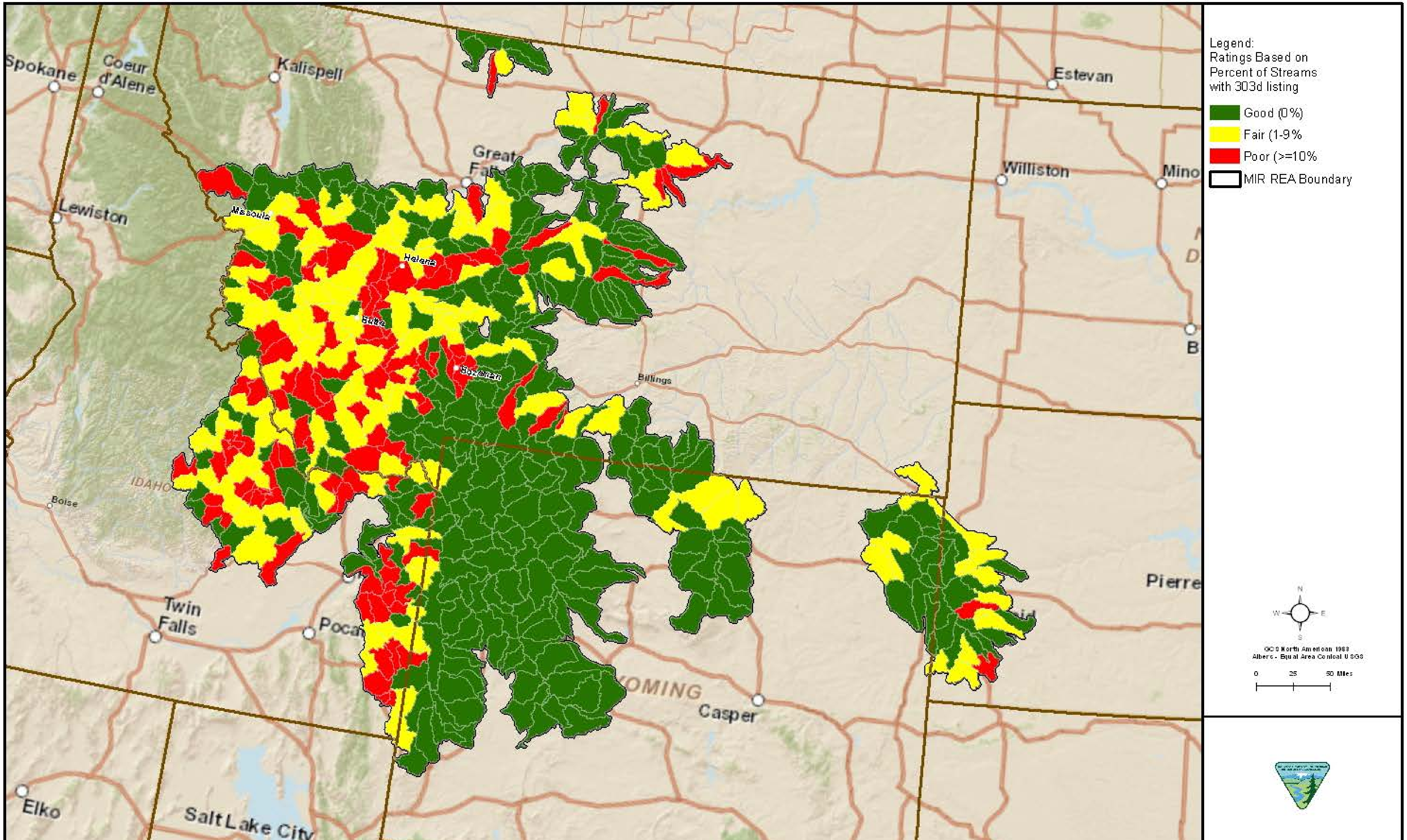

Figure G-12. Aquatic Ecological Intactness Percent of Streams 303d Listing

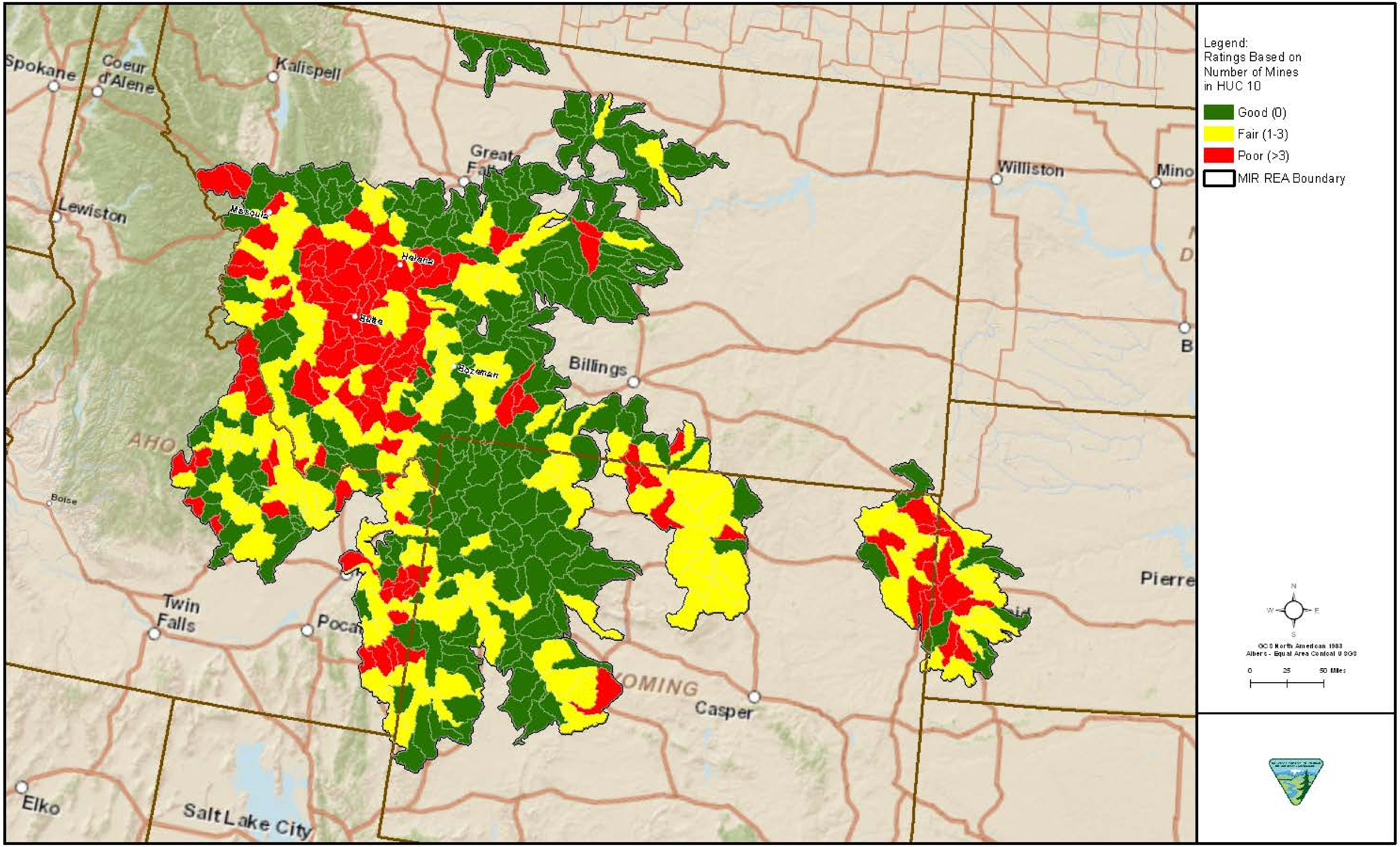

Figure G-13. Aquatic Ecological Intactness Number of Mines

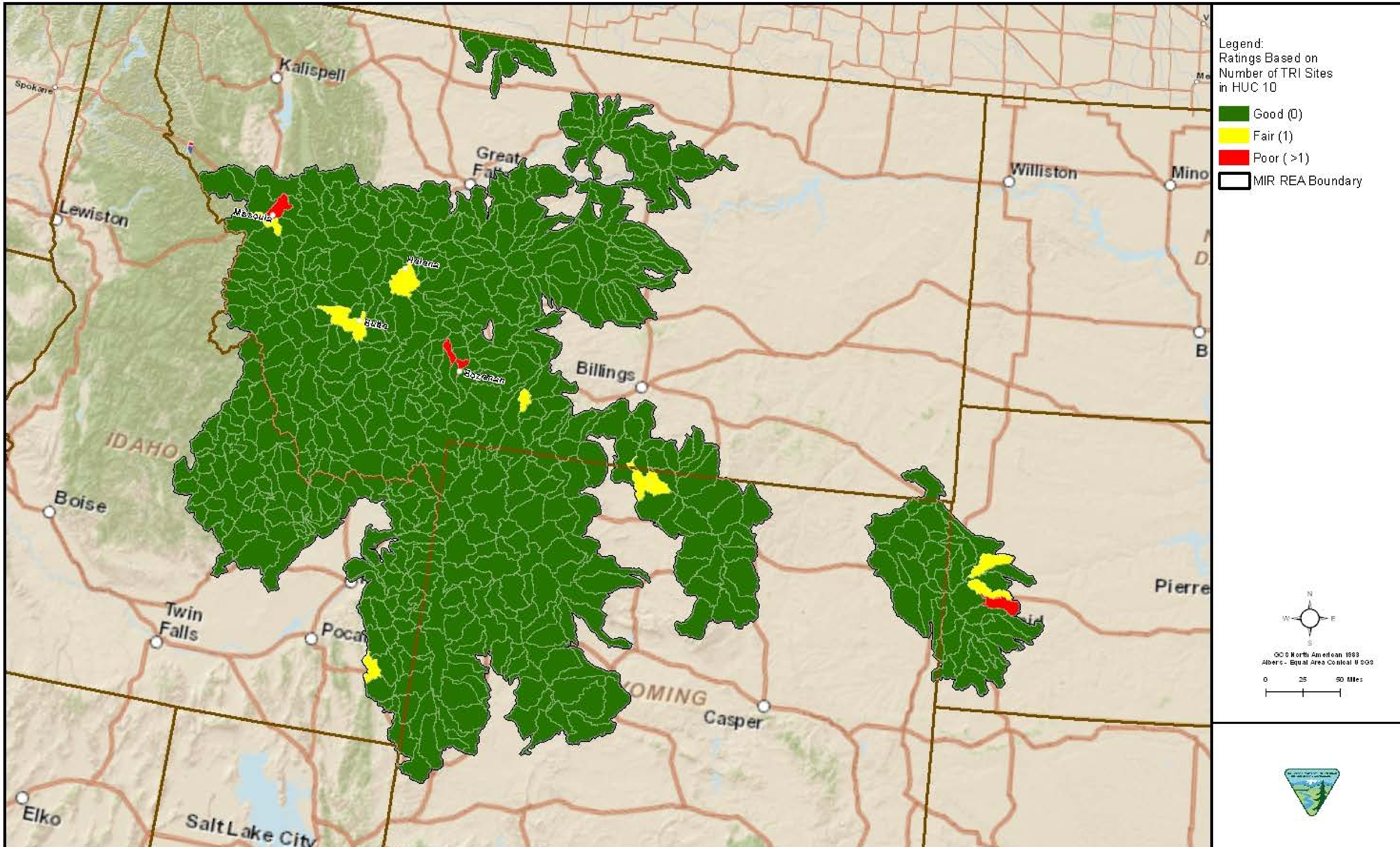

Figure G-14. Aquatic Ecological Intactness Number of TRI Sites

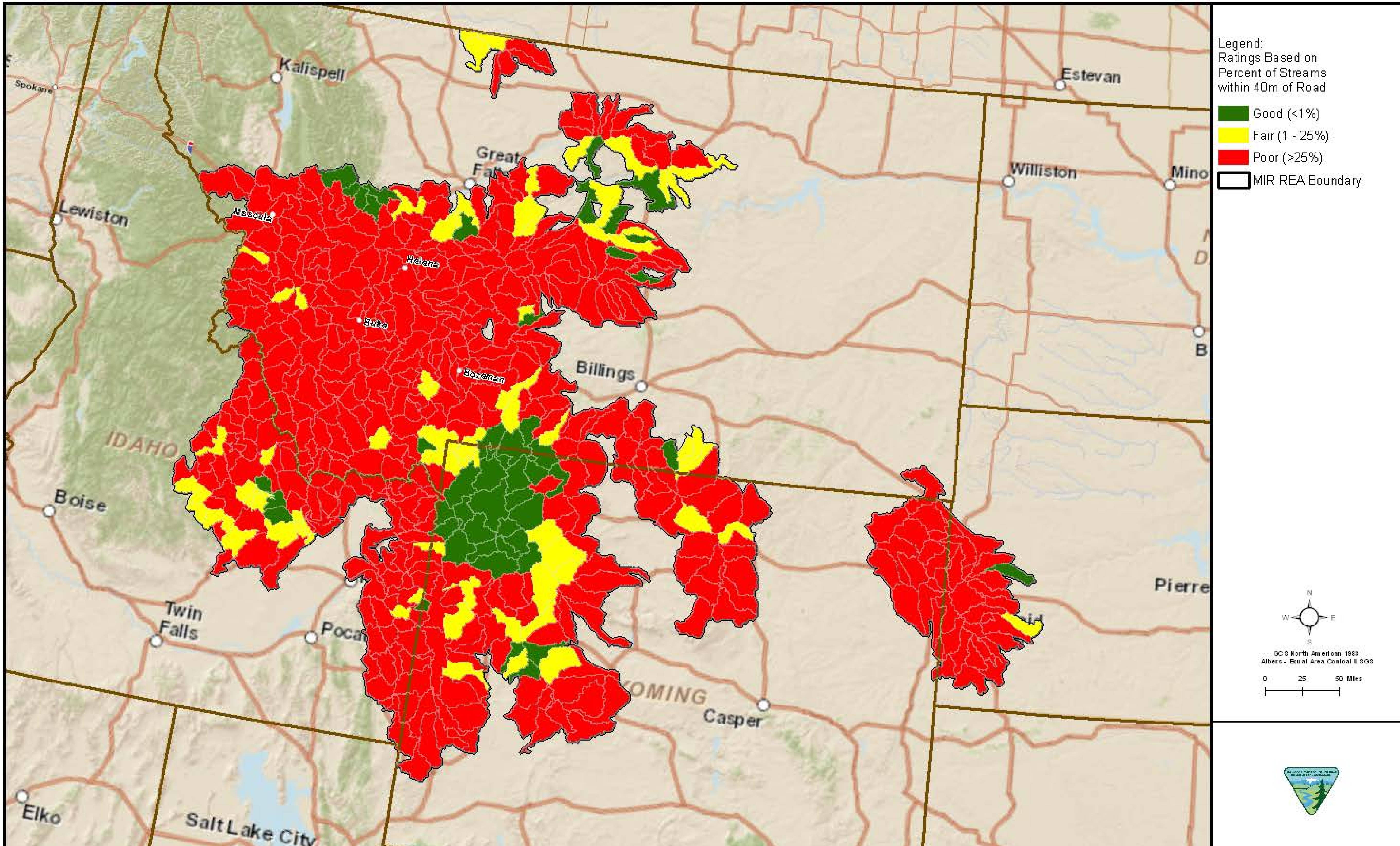

Figure G-15. Aquatic Ecological Intactness Percent of Streams within 40m of Road

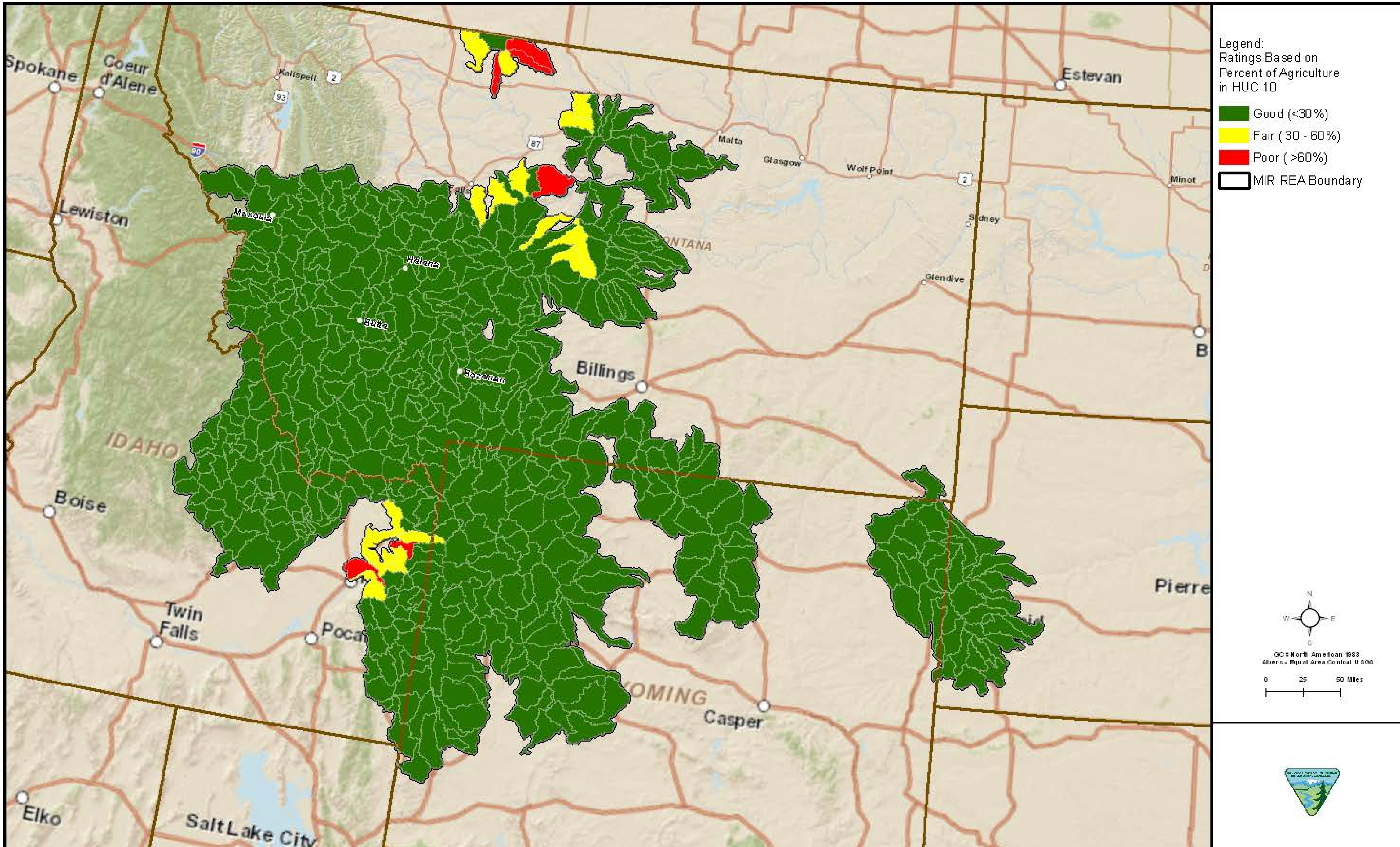

Figure G-16. Aquatic Ecological Intactness Percent of HUC in Agricultural Use

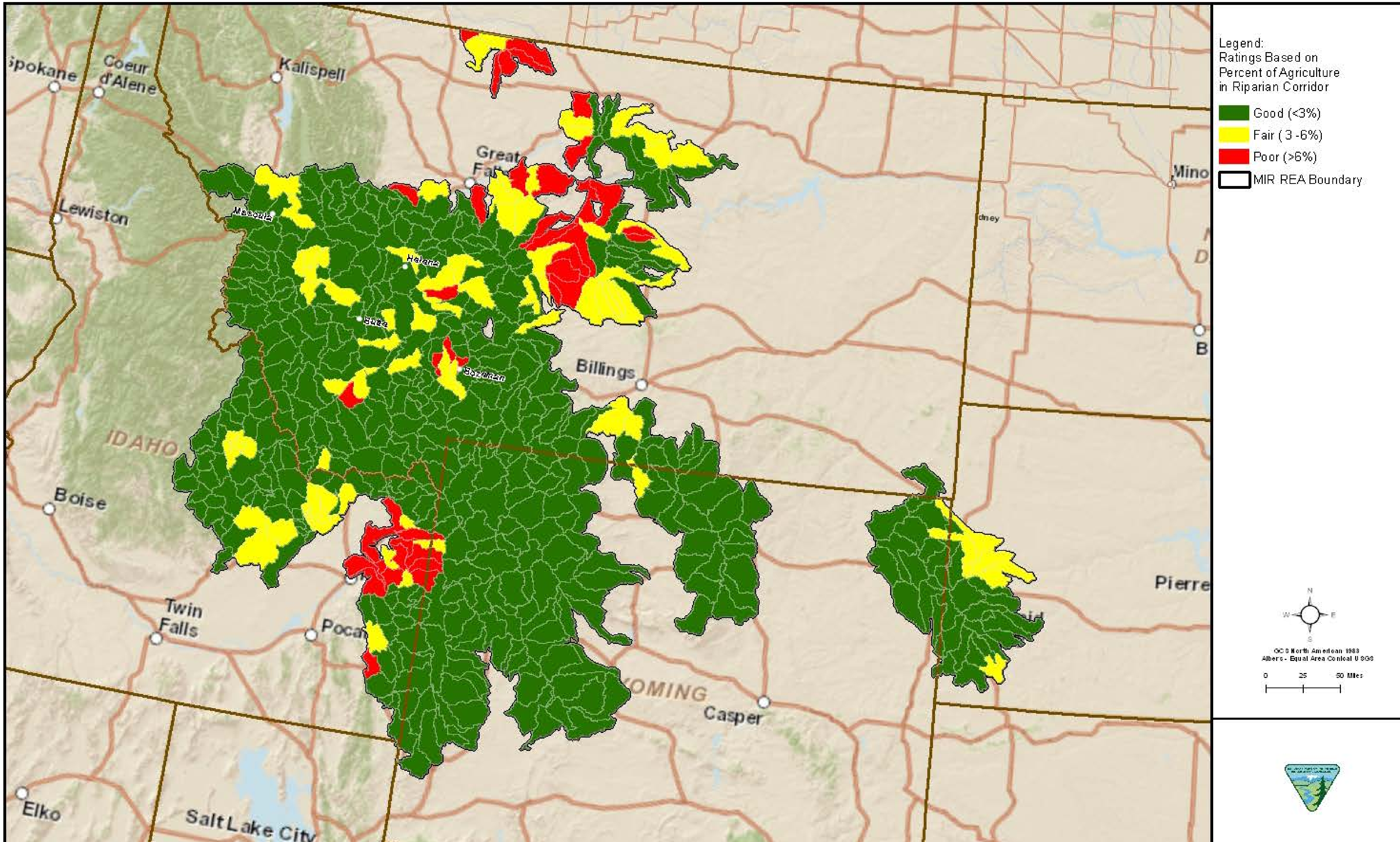

Figure G-17. Aquatic Ecological Intactness Percent of HUC Riparian Corridor in Agricultural Use

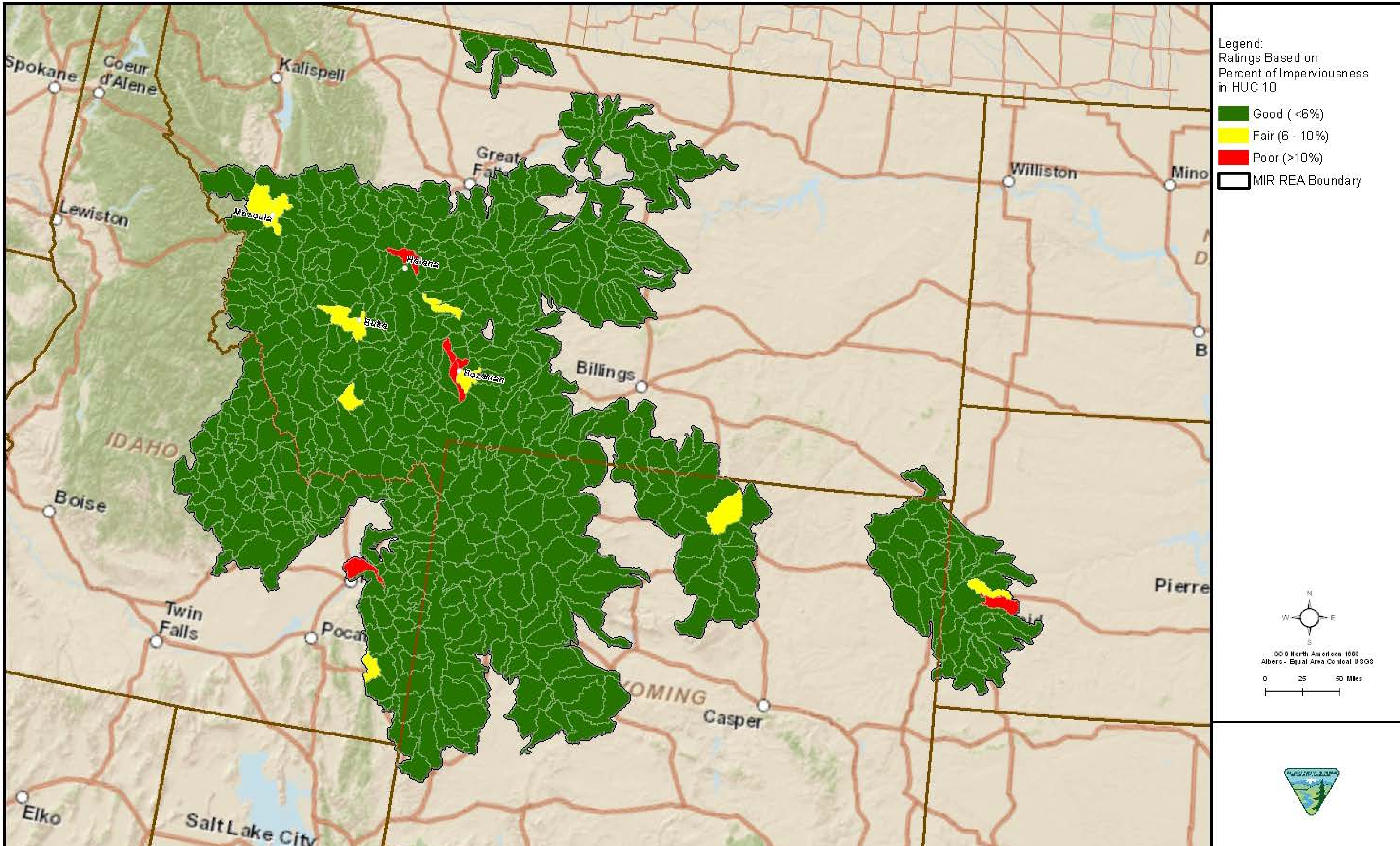

Figure G-18. Aquatic Ecological Intactness Percent Impervious

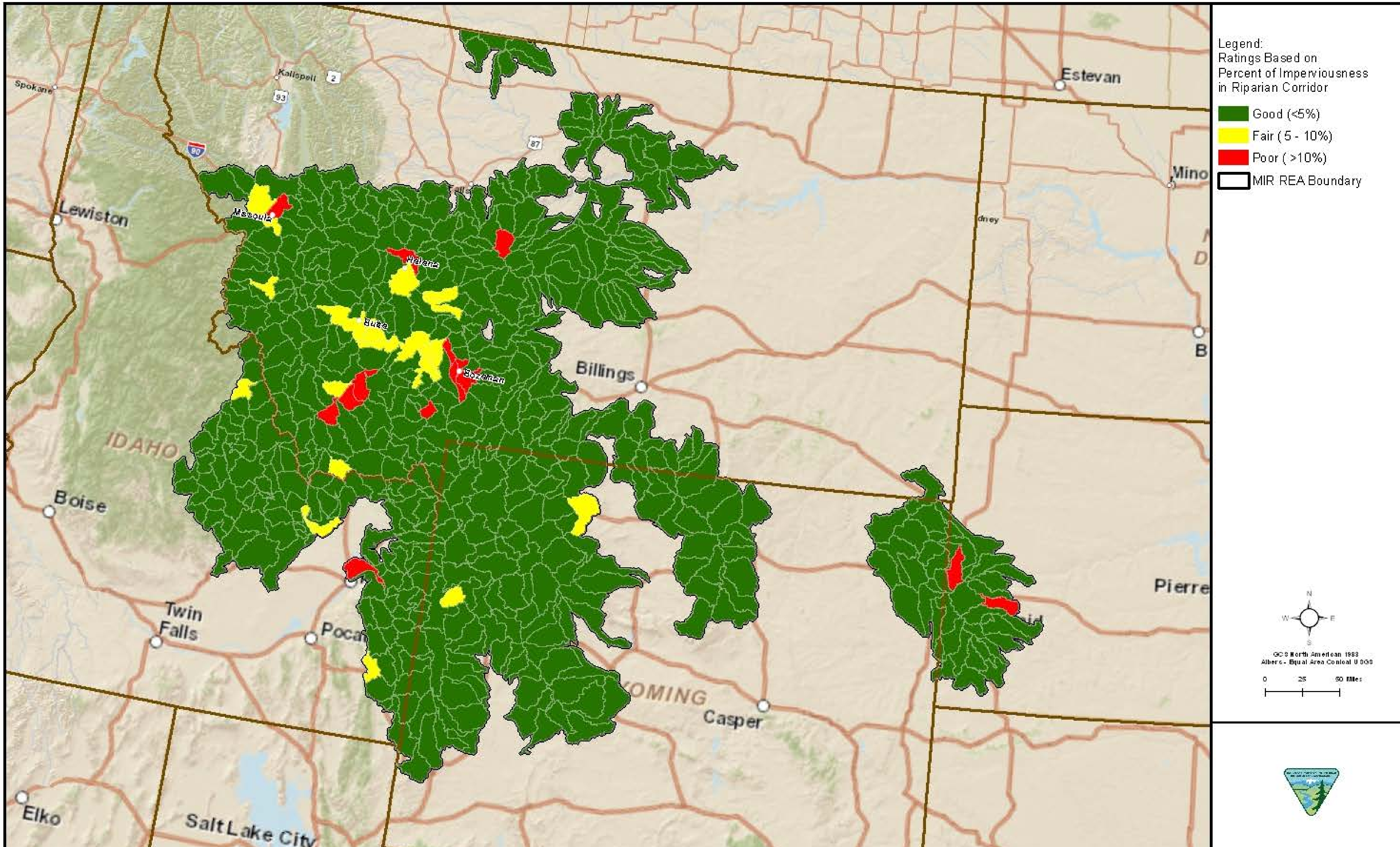

Figure G-19. Aquatic Ecological Intactness Percent of Riparian Corridor in Impervious

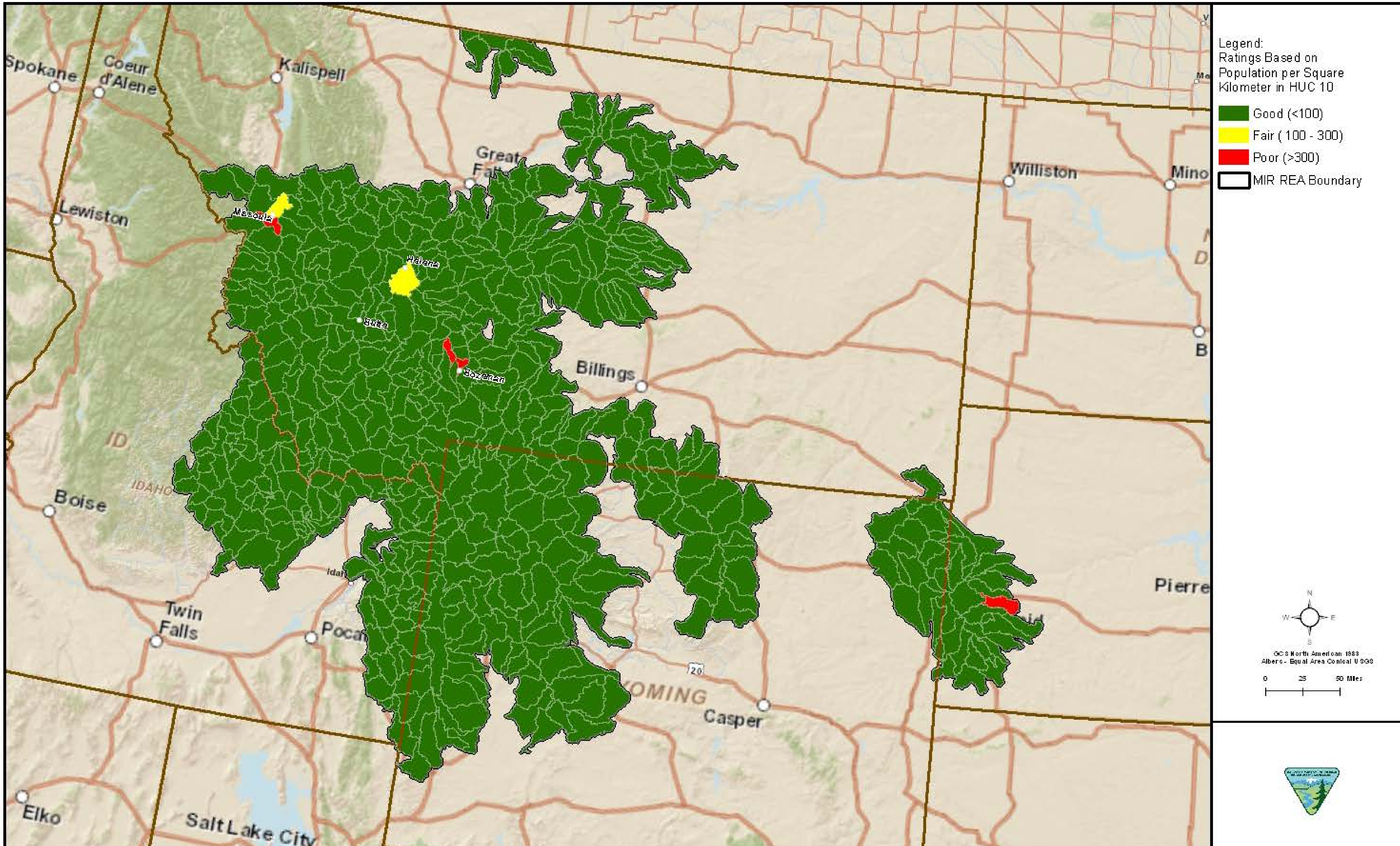

Figure G-20. Aquatic Ecological Intactness Population per Square km

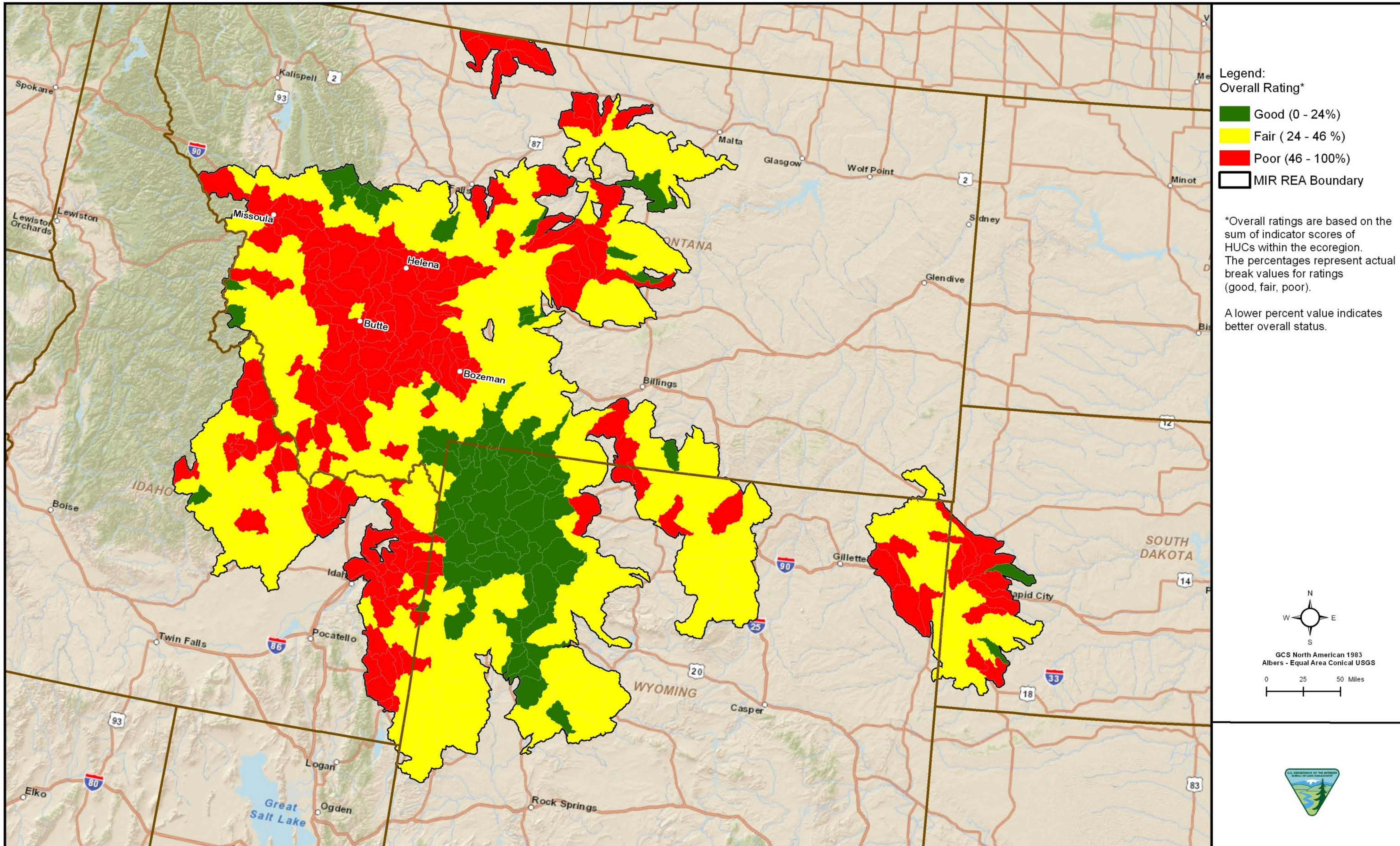

Figure G-21. Aquatic Ecological Intactness Overall Score

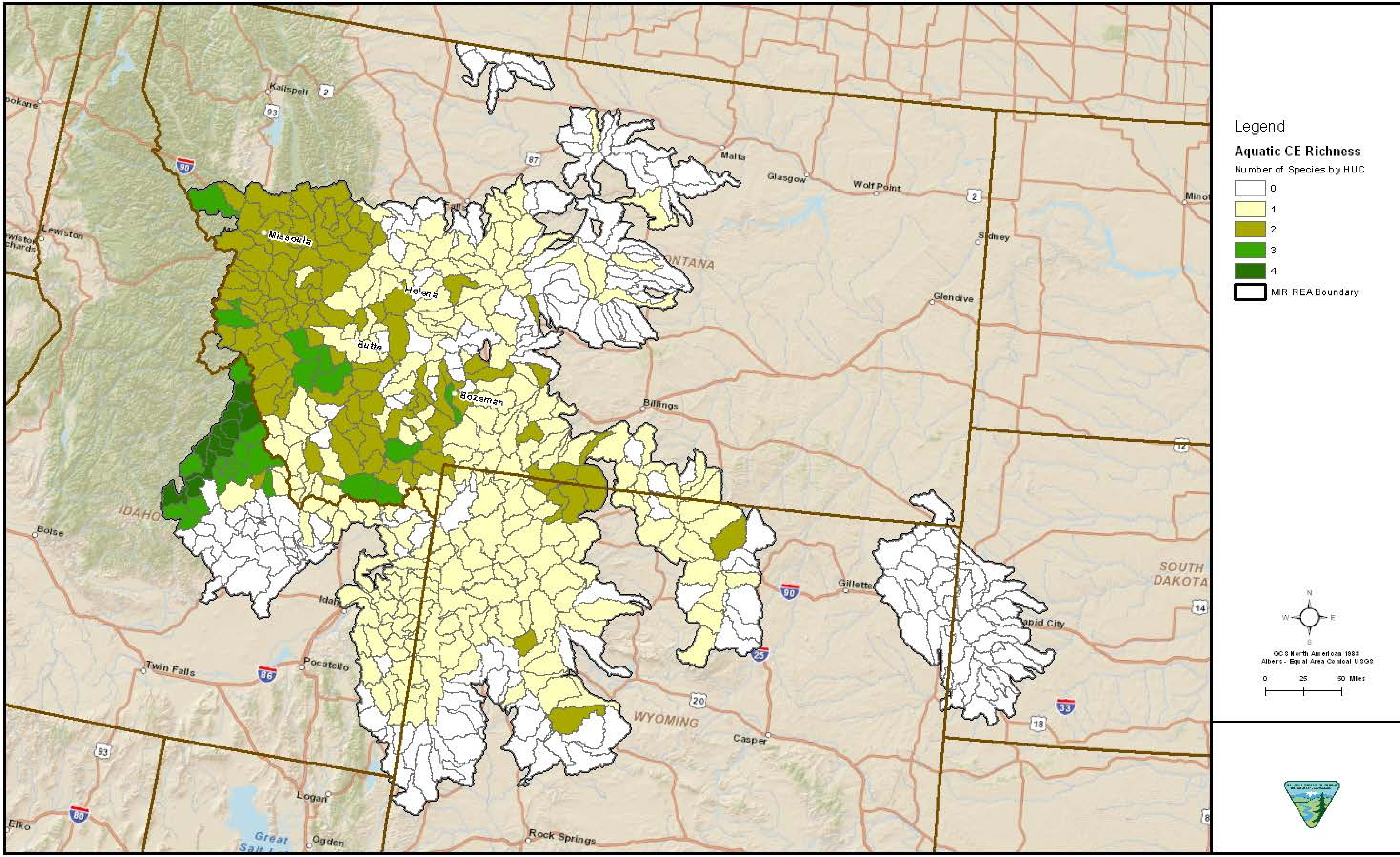

Figure G-22. Aquatic Ecological Intactness CE Species Richness

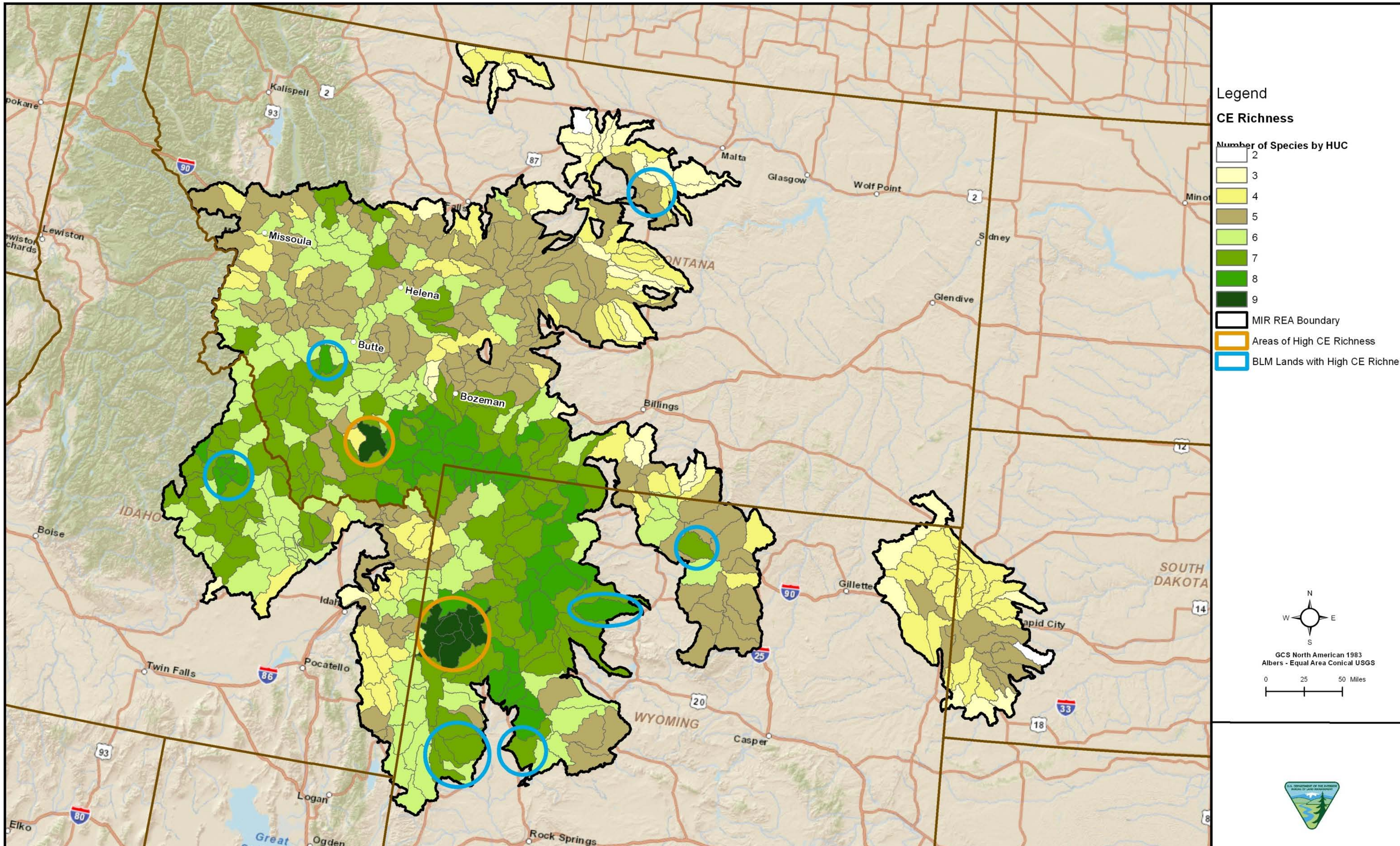

Figure G-23. Terrestrial Ecological Intactness CE Richness Concentration Analysis by HUC

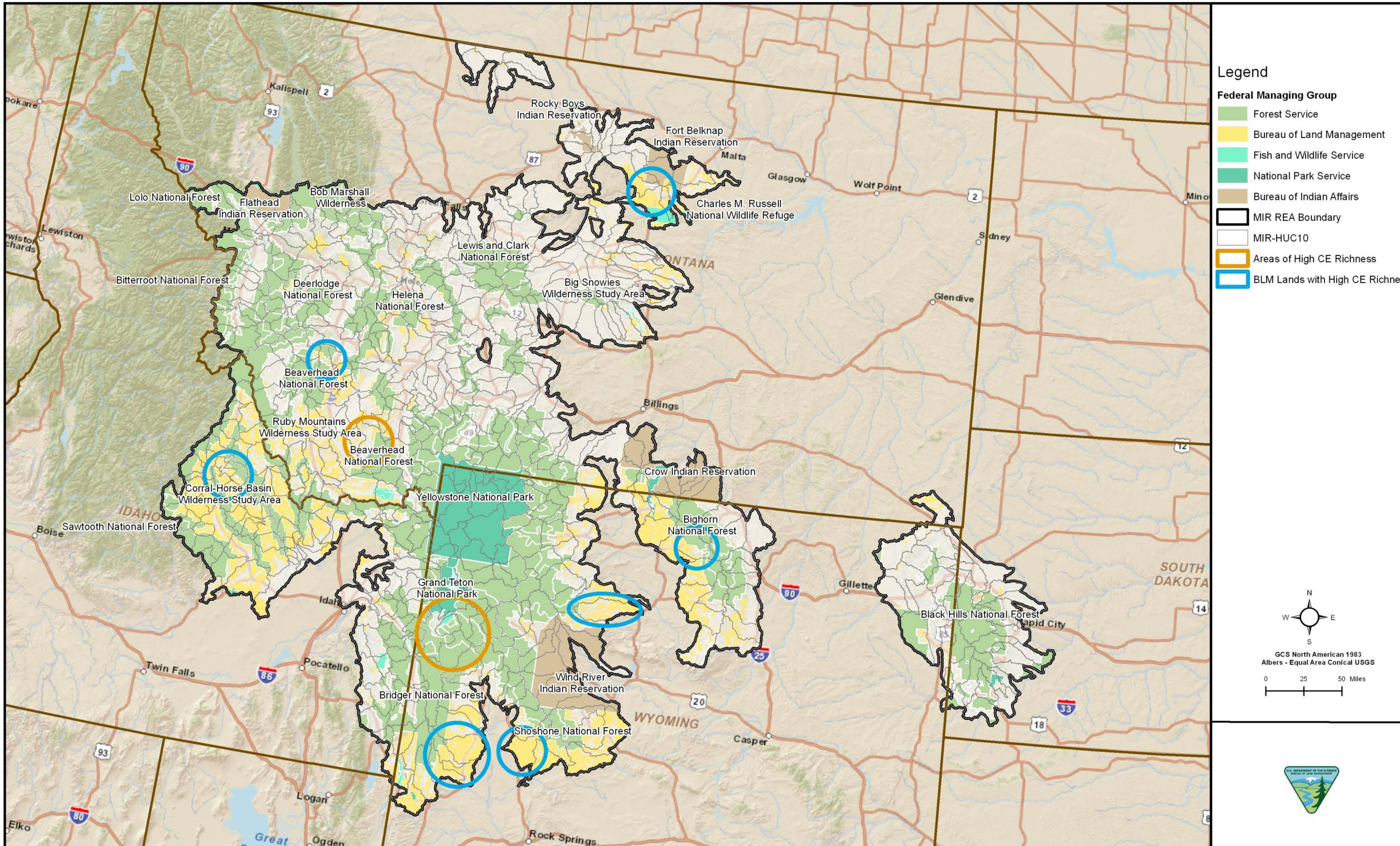

Figure G-24. Terrestrial Ecological Intactness CE Richness Concentration Analysis with Federally Managed Lands

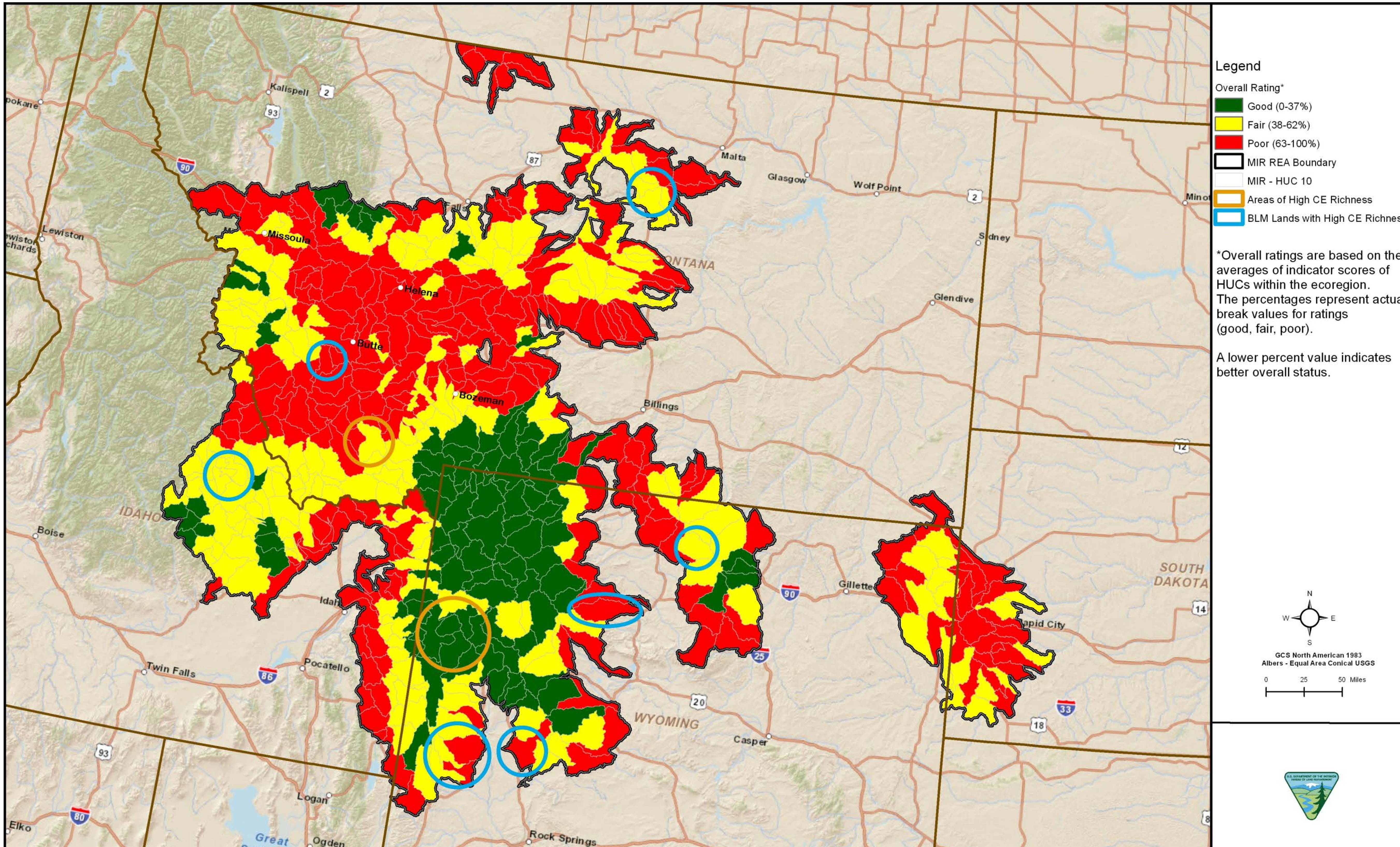

Figure G-25. Terrestrial Ecological Intactness CE Richness with Overall EI Score

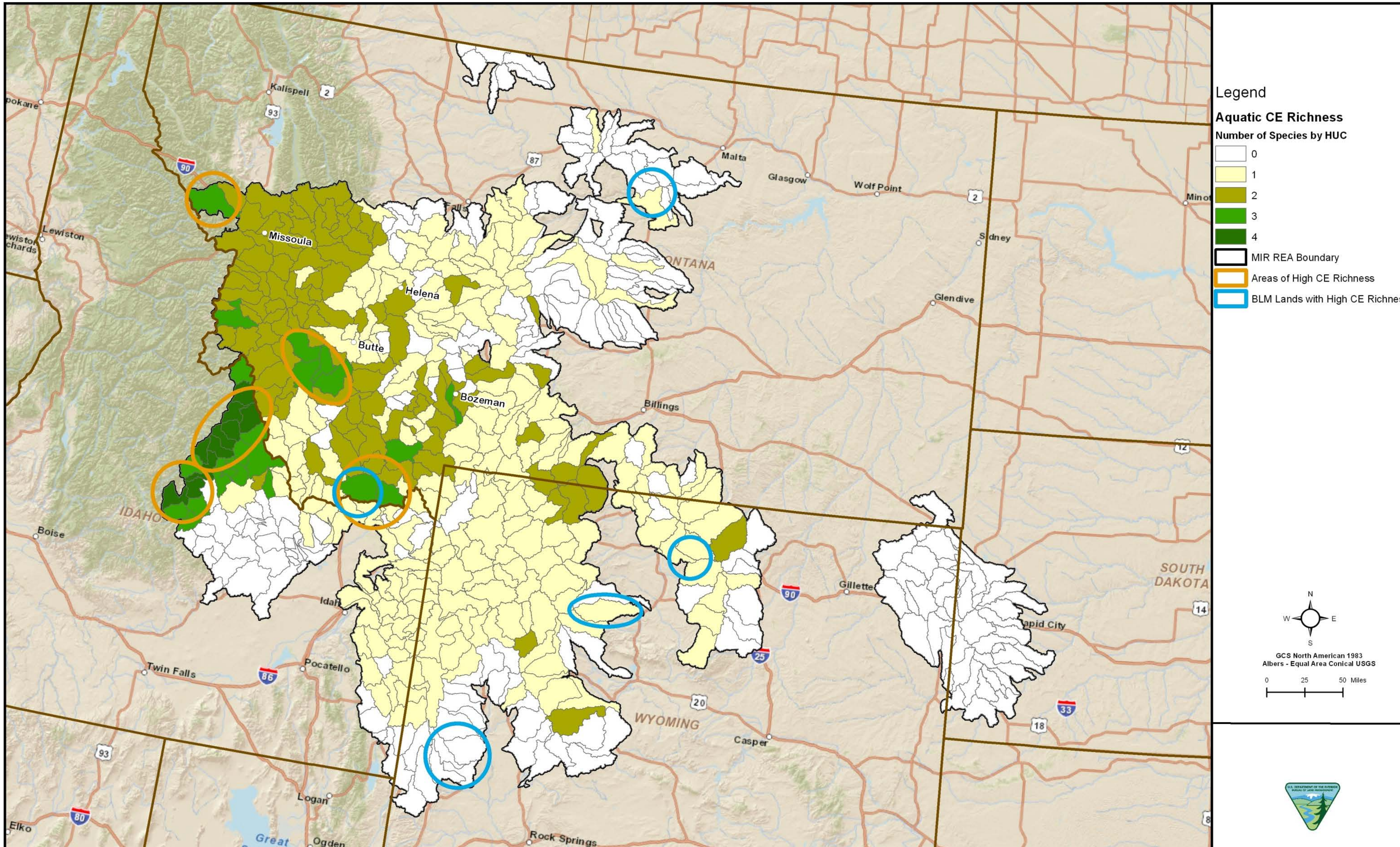

Figure G-26. Aquatic Ecological Intactness CE Richness Concentration Analysis by HUC

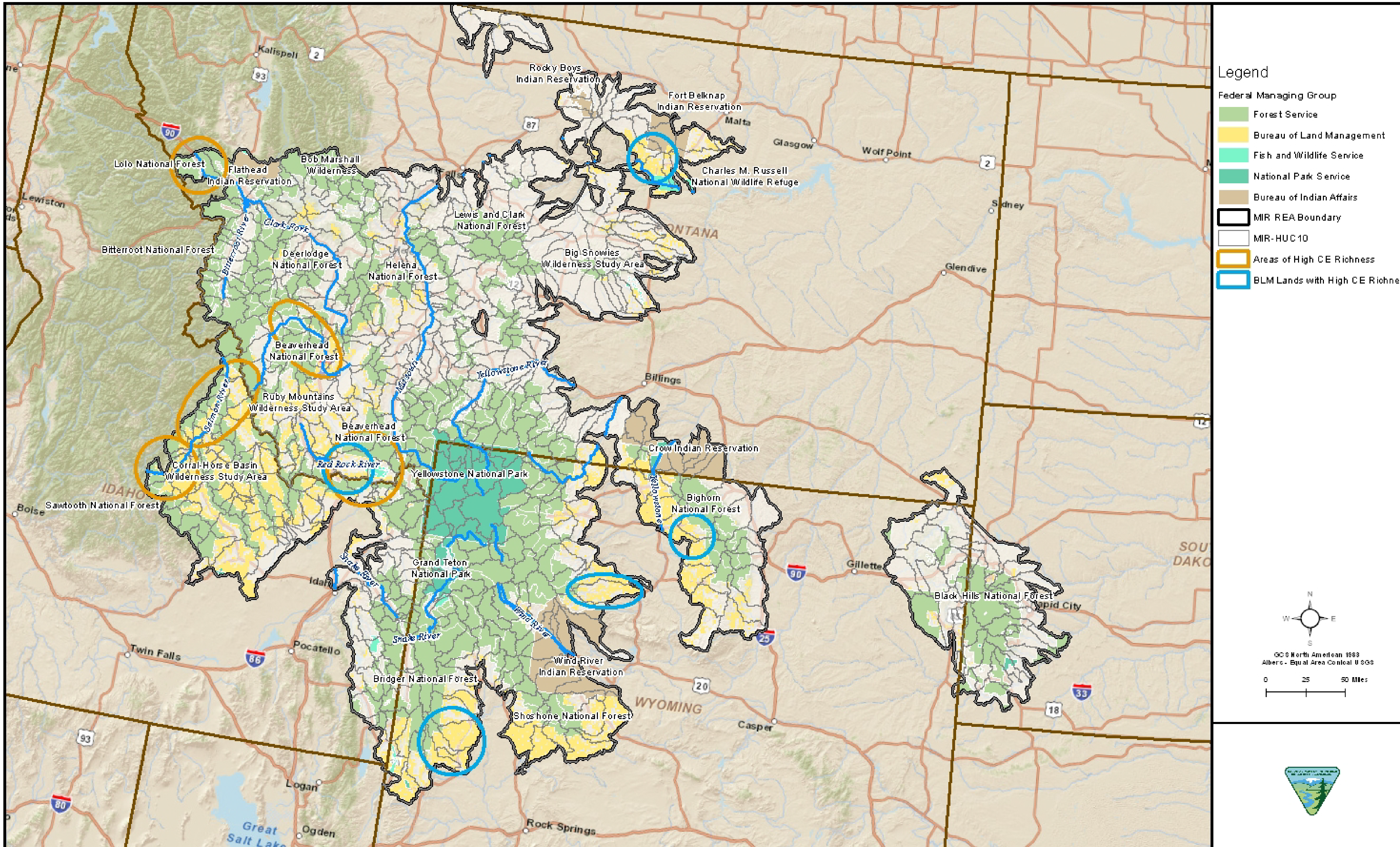

Figure G-27. Aquatic Ecological Intactness CE Richness Concentration Analysis with Federally Managed Lands

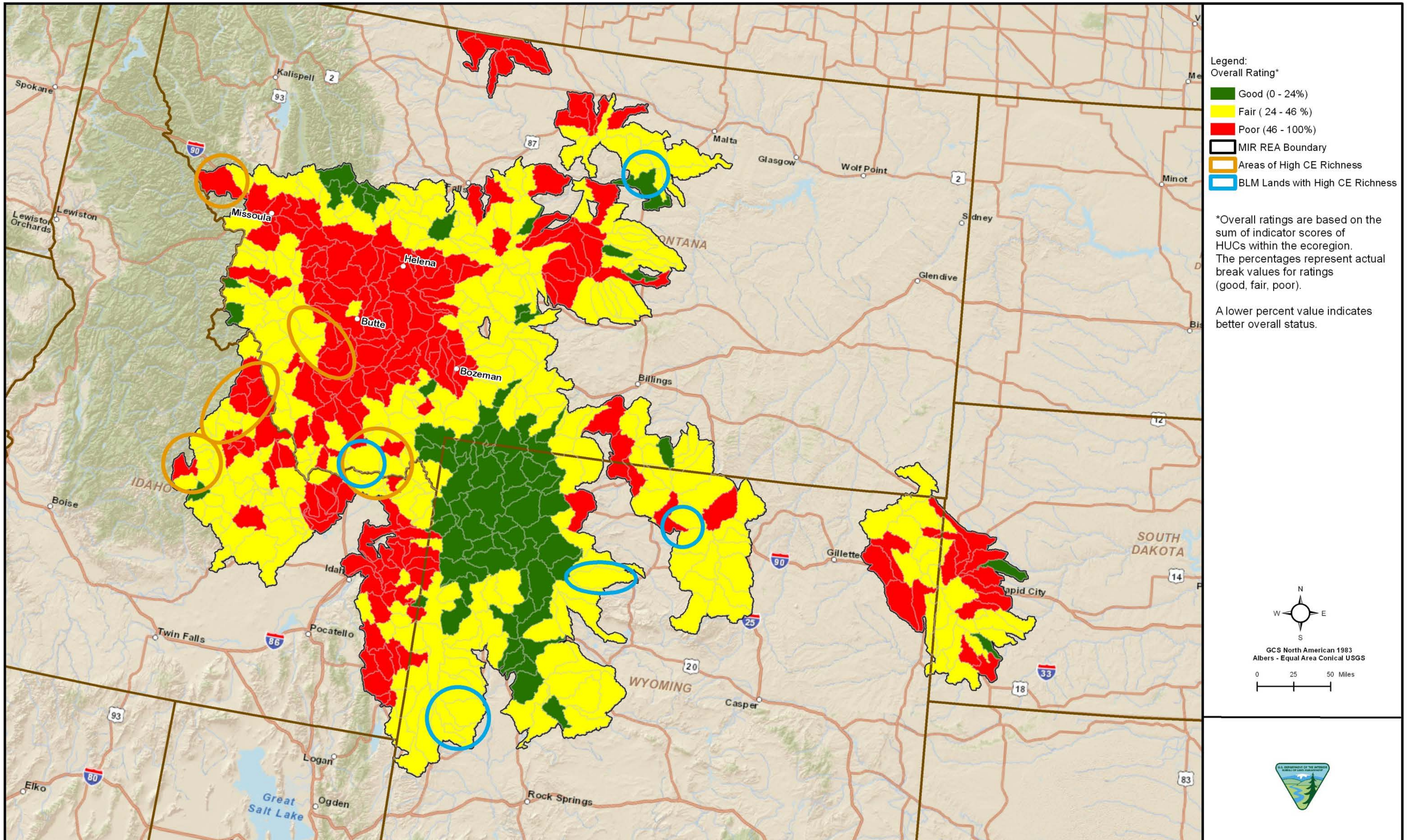

Figure G-28. Aquatic Ecological Intactness CE Richness with Overall EI Score

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

Data Request Method

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

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

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

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

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

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