



Rangeland Health Assessment of Grazing Allotments in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area

Natural Resource Report NPS/NRSS/BRD/NRR—2022/2440



ON THE COVER

View of the landscape around an assessment site in the south of Curecanti National Recreation Area.
Photo by J Courkamp

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Abstract

We assessed rangeland health at 28 locations distributed across nine grazing allotments in Black Canyon of the Gunnison National Park (BLCA; five allotments) and Curecanti National Recreation Area (CURE; four allotments). Assessments were conducted using Interpreting Indicators of Rangeland Health (IIRH), a qualitative protocol designed to assess departures from reference condition for three rangeland attributes: soil/site stability, hydrologic function, and biotic integrity. Nine locations in three allotments at BLCA were assessed in 2019, and the rest of the locations were assessed in 2021. Assessment sites are reviewed on an allotment-by-allotment basis, and sites with at least one IIRH attribute rated as a moderate or greater departure from reference were considered “ecologically compromised” for the purpose of this report. Rangeland health varied, with conditions in some allotments more concerning than others. All locations in the Red Rock Canyon Allotment at BLCA (three) were ecologically compromised due to annual weed dominance, and all locations in the Stevens Creek allotment (three) were ecologically compromised due to widespread evidence of erosion and a near complete lack of herbaceous vegetation. Across all allotments, many locations were characterized by a lack of perennial bunchgrasses, which were identified as a dominant or sub-dominant component of the reference plant community in most cases. The authors of this report were not fully informed of the criteria used to select the assessment locations; thus, managers should seek out other pertinent information (e.g., management history) to contextualize the findings of this report before changing management.

1. Introduction and Summary

The ecological condition of the rangelands of the western United States has been, and continues to be, the subject of significant controversy (Sayre, 2017). Some stakeholders argue that western rangelands are in better condition than at any time since the mid-19th century, the start of a long period of generally-agreed-upon degradation. Others argue that rangelands continue to be degraded, with increasing stakeholder demands, including energy development, livestock grazing, and recreational use, counteracting improved management and increased research.

Part of the reason for these opposed perspectives is that the assessment of ecological condition on rangelands—for a single location or, especially, across an entire region—is incredibly complex. Fortunately, range scientists have been grappling with this challenge for decades. The most widely adopted assessment approach that has emerged from this work is “Interpreting Indicators of Rangeland Health” (IIRH; Pellant et al., 2018; Pyke et al., 2002).

A US government interagency committee has defined rangeland health as “the degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem are balanced and sustained” (NRCS, 2003, p. 4–23). The committee went on to define integrity as the “maintenance of the functional attributes of a locale, including normal variability”.

Assessment refers to a point-in-time evaluation of ecosystem function relative to its potential (Herrick et al., 2005). On the other hand, monitoring, which is frequently confused with assessment, refers to measurements (usually quantitative) conducted over time to determine trends in targeted key indicators or variables. One way to think of this distinction is that assessment is intended as a management-independent evaluation of standardized indicators, in the way that a baseball umpire might call balls and strikes. Monitoring often incorporates the lessons learned from assessment to identify key indicators that are relevant to management concerns so that adaptation can occur, as a baseball manager might use player statistics to decide whom to play to have the best chance to succeed.

IIRH is a qualitative assessment protocol aimed at evaluating three fundamental attributes of rangeland health, which relate to core ecological processes in rangelands. These attributes are Soil and Site Stability, Hydrologic Function, and Biotic Integrity. They are defined as:

“Soil/site stability: the capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and/or water, and to recover this capacity when a reduction does occur.

Hydrologic function: the capacity of an area to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity when a reduction does occur.

Biotic integrity: the capacity of the biotic community to support ecological processes within the natural range of variability expected for the site, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic community includes

plants (vascular and nonvascular), animals, insects, and microorganisms occurring both above and below ground” (Pellant et al., 2018, pp. 14–15).

A total of 17 indicators are used to assess the above fundamental attributes. These indicators are briefly described in Table 1. Each is rated according to a five-class ordinal system, with the degree of departure from a benchmark condition characterized as none to slight (NS), slight to moderate (SM), moderate (M), moderate to extreme (ME), or extreme to total (E-T).

The benchmark condition for a given location is known as the reference condition and is contained within the Ecological Site Description (ESD). An ecological site is a:

“conceptual division of the landscape that is defined as a distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances” (Caudle, 2013, p. 12).

ESDs are created by the Natural Resource Conservation Service (NRCS) and maintained within a central repository. Within many, but not all, ESDs is a reference sheet that contains the description of the benchmark conditions for each of the 17 indicators. These reference sheets are developed by NRCS staff familiar with the given ecological site.

This report describes the use of IIRH to assess rangeland health at 28 locations in nine grazing allotments within the boundaries of Black Canyon of the Gunnison National Park (BLCA; 13 locations) and the Curecanti National Recreation Area (CURE; 15 locations), in southwest Colorado. Locations were assessed in two different years, with 9 locations sampled in BLCA in 2019 and the remaining locations sampled in 2021. These assessments can be used to identify potential focus areas for management, guide future monitoring, inform future resource adaptive management plans, and inform resource protection strategies.

Table 1. Indicators used in IIRH.

Indicator and brief description	Attributes ¹			Quantitative data
	S	H	B	–
1. Rills – frequency and spatial distribution of linear erosion rivulets	X	X	–	–
2. Water-flow patterns – amount and distribution of overland flow paths that are identified by litter distribution and visual evidence of soil and gravel movement	X	X	–	–
3. Pedestals and/or terracettes – frequency and distribution of rocks or plants where soil has been eroded from their base (pedestals), and/or occurrence of erosional terracettes	X	X	–	–

¹ S= Soil/site stability, H= Hydrologic function, B= Biotic integrity; “X” indicates that indicator contributes to final attribute rating.

Table 1 (continued). Indicators used in IIRH.

Indicator and brief description	Attributes ¹			Quantitative data
	S	H	B	–
4. Bare ground – size and connectivity among areas of soil not protected by vegetation, biological soil crusts, litter, standing dead vegetation, or rocks	X	X	–	% bare ground
5. Gullies – amount of channels cut into the soil and the amount and distribution of vegetation in the channel	X	X	–	–
6. Wind-scoured areas and/or depositional areas – frequency of areas where soil is removed from under or around vegetation OR frequency of accumulation areas of soil associated with large structural objects	X	–	–	–
7. Litter movement – frequency and size of litter displaced by wind and overland flow of water	X	–	–	–
8. Soil surface resistance to erosion – ability of soils to resist erosion through the incorporation of organic material into soil aggregates	X	X	X	Soil aggregate stability
9. Soil surface loss or degradation – frequency and size of areas missing all or portions of the upper soil horizons	X	X	X	–
10. Plant community composition and distribution relative to infiltration and runoff – the community composition or distribution of species that restrict the infiltration of water on the site	–	X	–	% composition by F/S group
11. Compaction layer – thickness and distribution of the structure of the soil near the soil surface (≤ 15 cm)	X	X	X	–
12. Functional / structural (F/S) groups – relative dominance of groups, number of groups not expected, total number of groups, and changes in relative dominance of species within groups	–	–	X	Plant foliar and basal cover by F/S group or species
13. Dead or dying plants or plant parts – frequency of dead or moribund (dying) plants or plant parts	–	–	X	–
14. Litter cover and depth – deviation in the amount of litter	–	X	X	% litter cover
15. Annual production – amount of aboveground plant production relative to the potential for that year based upon recent climatic conditions	–	–	X	Plant production by F/S group
16. Invasive plants – abundance and distribution of invasive plants based on a plant's potential to dominate a site to which it is not native, regardless of the plant's status as a noxious weed or exotic species	–	–	X	Invasive plant cover
17. Vigor with an emphasis on reproductive capability of perennial plants – evidence of inflorescences or of vegetative tiller production relative to the potential for that year based upon recent climatic conditions	–	–	X	–

¹ S= Soil/site stability, H= Hydrologic function, B= Biotic integrity; “X” indicates that indicator contributes to final attribute rating.

2. Methods

2.1. Study Area

Black Canyon of the Gunnison National Park (BLCA) and Curecanti National Recreation Area (CURE) are National Park Service Units in southwestern Colorado, straddling approximate 150 km of the Gunnison River. For about 55 km through CURE, the river is impounded, from east to west, as Blue Mesa Reservoir, Morrow Point Reservoir, and Crystal Reservoir. BLCA encompasses 12,440 ha with an elevation range from 1,640 m to 2,524 m, including a maximum canyon depth of 830 m. CURE encompasses 17,440 ha with an elevation range of approximately 1,987 m to 2,653 m. Mean annual temperature (1981–2010) ranges from 5.1°C to 9.4°C while mean annual precipitation (1981–2010) ranges from 317 mm to 406 mm (U.S. Geological Survey, 2010; U.S. Geological Survey/PRISM, 2010).

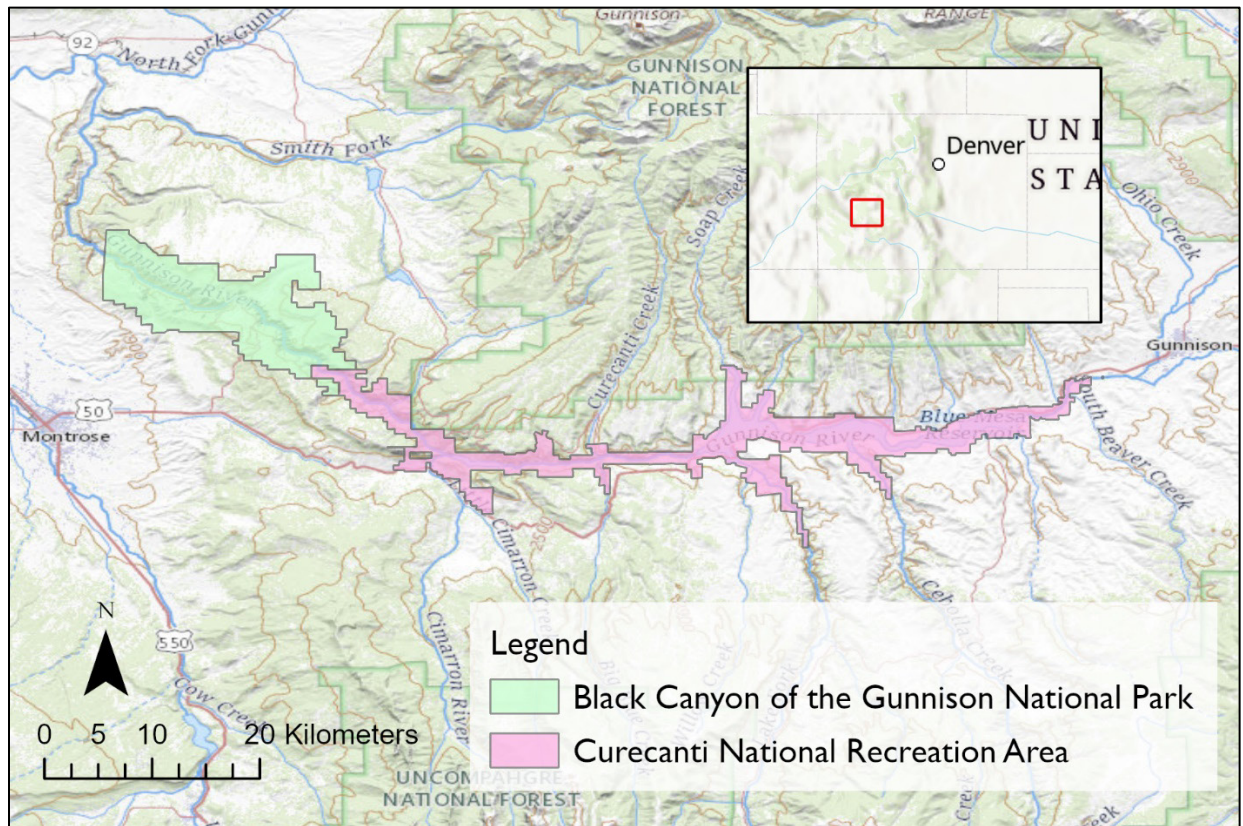


Figure 1. Location of Black Canyon of the Gunnison National Park and Curecanti National Recreation Area.

Because IIRH requires careful consideration of context, including recent growing conditions, it is important to note that the BLCA and CURE area was classified as D2- Severe Drought at the time of sampling in 2021 (National Drought Mitigation Center, University of Nebraska-Lincoln, 2021). When judgement of recent growing conditions was required, the crew therefore assessed the 2021

growing season as moderately poor. In 2019, there was no drought in the area and the growing season was considered slightly above average.

Vegetation communities across the two units are diverse and variable with changes in elevation, aspect, and soils. Tree communities include Douglas fir (*Pseudotsuga menziesii* (Mirbel) Franco), Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), quaking aspen (*Populus tremuloides* Michx.), and Gambel oak (*Quercus gambelii* Nutt.), while shrub communities are typically dominated by big sagebrush (*Artemisia tridentata* Nutt.), fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.) and yellow rabbitbrush (*Chrysothamnus viccidiflorus* (Hook) Nutt.). Grasslands are less common, though an understory of bunchgrasses such as Indian ricegrass (*Achnatherum hymenoides* (Roem. & Schult.) Barkworth) and muttongrass (*Poa fendleriana* (Steud.) Vasey) along with other grasses such as western wheatgrass (*Pascopyrum smithii* (Rydb.) A. Love) and blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths) is common across all vegetation communities.

The nine grazing allotments that we surveyed total 5,826 ha, roughly 20% of the units. Note that there are additional grazing allotments that were not surveyed, and that most of the allotments are contiguous with grazing areas outside of the units, with livestock able to move freely across boundaries. Additionally, management arrangements differ among the different allotments. Total size within the units for each of the allotments is shown in Table 2.

Table 2. Characteristics of allotments assessed in Black Canyon of the Gunnison National Park (BLCA) and the Curecanti National Recreation Area (CURE) in 2019 and 2021.

Allotment name	Location	Year Assessed	Hectares	Number of Locations	Sites per km ²
East Portal (EP)	BLCA	2019	192	3	1.56
Green Mountain (GM)	BLCA	2021	890	1	0.11
Grizzly Gulch (GG)	BLCA	2021	581	2	0.34
Iola	CURE	2021	1,313	6	0.46
Vernal Mesa (VM)	BLCA	2019	711	3	0.42
Red Rock Canyon (RR)	BLCA	2019	110	3	2.73
Sapinero Mesa (SM)	CURE	2021	1,451	6	0.41
Spring Gulch (SG)	CURE	2021	417	1	0.24
Stevens Creek (SC)	CURE	2021	161	3	1.86

2.2. Sampling

Sampling sites were restricted to three allotments in 2019 and seven allotments in 2021 across both BLCA and CURE. Site locations were determined by NPS staff to 1) capture the variability across each allotment, and 2) strategically assess allotment-specific management objectives. Attributes taken into consideration during site selection included: 1) allotment boundaries; 2) permitted use; 3) ecological sites; 4) potential Gunnison sage-grouse (*Centrocercus minimus*); 5) soils; 6) elevation; 7) topography; 8) vegetation; and 9) distance from existing long-term monitoring locations. All sampling locations were surveyed and analyzed for potential impacts to natural and cultural resources through the National Park Service National Environmental Protection Act (NEPA) and National Historic Preservation Act (NHPA) compliance process, which includes Section 7 and Section 106 consultation. Note that points were selected without input from Colorado State University to preserve the integrity of the IIRH assessment, and assessors were not informed of the full set of sample stratification criteria. A total of 31 sites were identified; however, 2 sites in 2019 and 1 site in 2021 were not visited due to time and access constraints, leaving only 28 locations visited for the assessment.

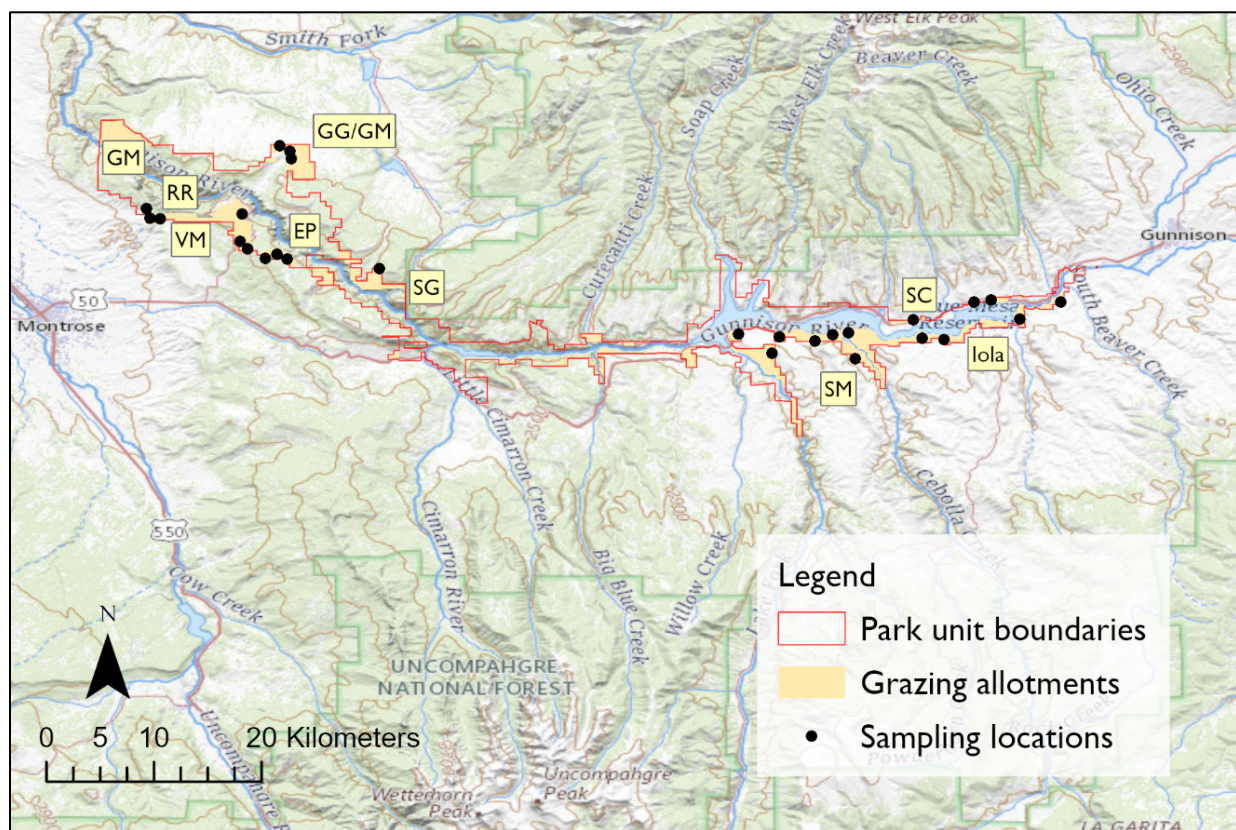


Figure 2. Grazing allotments and sampling locations at BLCA and CURE. See Table 2 for grazing allotment abbreviations.

2.3. Interpreting Indicators of Rangeland Health

After selection of the evaluation area, the first step in applying the IIRH protocol is to determine the ecological site using soil data, topographic position, and climate. Prior to entering the field, we incorporated existing NPS data and expert consultation from NRCS to identify one to three potential ecological sites for each sample location. In the field, the IIRH crew then dug a soil pit and otherwise collected site verification data to confirm the ecological site. They could then use the associated IIRH reference sheet attached to the Ecological Site Description (ESD). All ESDs used in the work are listed in Section 3.3 (Table 8).

With the ESD and associated reference sheet in hand, the crew could then follow the IIRH protocol as described in Interpreting Indicators of Rangeland Health (Pellant et al., 2018). The crew in 2019 used IIRH version 5, while the crew in 2021 used IIRH version 4. The COVID-19 pandemic prevented the 2021 crew from attending training for IIRH version 5, but prior training allowed for the use of IIRH version 4 during field data collection in 2021. We believe that the use of both protocols is acceptable due to minimal differences between versions 4 and 5 as well as consistency in assessment version use within allotments (i.e., each individual allotment was assessed using only one protocol).

Both IIRH version 4 and IIRH version 5 are described in extensive technical references created by numerous ecologists, soil scientists, and other specialists, and published by the Bureau of Land Management National Operations Center. Terminology used in this report is consistent with the IIRH version 5 technical reference (Pellant et al., 2018), and may differ slightly from definitions found elsewhere. For example, some invasive plants as specified in IIRH may not be considered invasive according to other definitions. All indicator ratings were determined by coauthors and/or crew members with prior training in IIRH (IIRH version 4: JC; IIRH version 5: KJ, MF, JL, and JW).

In some cases, a sampling location may not be identifiable as an extant ecological site, the ESD for the site may not yet be written, or the ESD may exist but not contain an IIRH reference sheet. In all these cases the field crew applied the protocol for Describing Indicators of Rangeland Health (DIRH), a descriptive protocol for detailing the status of the 17 indicators in the absence of an ESD or reference sheet.

2.4. Summary of Field Procedures

The crew used a handheld Global Positioning System (GPS) unit to navigate to each location. Once the GPS indicated the location had been reached, a suitable location was chosen to dig a soil pit. In some cases, locations were adjusted slightly to choose areas that the crew felt would be more representative of the overall site. Once the location was selected, the crew dug a soil pit to verify the soil matched that described in the ESD, a new GPS point was recorded in the field at the location of the final soil pit, and the pit was filled back in. Metadata were then collected for each location. These included slope, elevation, aspect and directional photos from the approximate soil pit location (north, south, east, west). Potential offsite influences (e.g., nearby roads or power transmission lines) were also noted while collecting metadata.

The quantitative data required for assessment were then collected using methods identified in the IIRH technical reference (both versions). After randomly selecting an azimuth, the crew would extend a tape measure along this azimuth from a location near the soil pit to establish a 25 m transect. The line-point intercept (LPI) method was used to measure the vegetation canopy and soil surface cover at 25 locations along this transect (Elzinga et al., 1998). These data were used to estimate the cover of bare ground (Indicator 4), the relative dominance of functional/structural groups (Indicator 12) and the cover of litter (Indicator 14). It is important to note that both a qualitative assessment of relative plant community dominance and the cover estimates resulting from LPI sampling were used to assess the composition of functional/structural groups (Indicator 12).

Soil surface resistance to erosion (Indicator 8) was measured using the soil stability test outlined in Herrick et al. (2005). Soil surface peds were collected from representative areas in plant interspaces and under perennial plant canopies, and the integrity of these soil peds was assessed repeatedly during a specific sequence of submersion and dipping in distilled water to generate ratings for comparison with the IIRH reference sheet.

Annual production (Indicator 15) was estimated using the double sampling method (NRCS, 2003). A small scale was used to measure the mass of field identified “units” of biomass for each plant functional group in a single sampling quadrat (approx. 0.5 m²), and then units were estimated in four additional quadrats at each site. Quadrats were haphazardly located in the field by tossing the sampling quadrat and recording data where it landed. Sampled biomass units and the dry matter conversions from the IIRH version 5 technical reference were then used to estimate annual production at each location. Accurately and quickly estimating annual production in the field is extremely difficult, and, in many cases, annual production was omitted from the final site assessment because of the perceived inaccuracy of production estimates.

After collecting the necessary quantitative data, the remaining indicators were rated based on a qualitative assessment of the area. In general, the crew considered the area within a 50 m radius extending from the soil pit location (approx. 0.8 ha) when assessing qualitative indicators. This was adjusted slightly in some cases when there was an obvious transition (e.g., change in slope or a grove of trees) within 50 m of the soil pit. After a period of observation (variable from site to site, approximately 45–60 minutes), the crew would consult with one another and assign final ratings to each of the 17 IIRH indicators. The assessment matrix provided in the IIRH technical reference (both

versions), along with continued discussion among crew members, was then used to assign final ratings for each of the IIRH attributes and complete the assessment.

2.5. Geographic Data

We incorporated all relevant geographic data into a Geographic Information System (GIS) using ArcGIS Pro 2.4 (ESRI, 2019). This included existing NPS data, such as allotment locations, unit boundaries, and water source locations. We also integrated other relevant data sources, such as elevation, river locations, and soils, both for field preparation and analysis.

2.6. Data Summarization

Due to concerns about the appropriateness of converting qualitative IIRH ratings to quantitative data, we did not conduct any statistical analysis. However, we converted ratings to numbers for the purpose of summary. To do so, we converted departure from reference condition ratings to an ordinal scale, where none to slight equals one and extreme to total equals five.

3. Results

3.1. Overview

Of the 28 locations visited, 27 were conclusively associated with ecological sites with existing ESDs and IIRH reference sheets. Describing Indicators of Rangeland Health (DIRH) was applied to one location in the Iola allotment (CURE) that was associated with an ecological site without an existing ESD or IIRH reference sheet. Because DIRH consists of only qualitative descriptions and no indicator or attribute ratings, all summaries of indicators and attributes will include only the 27 locations for which an ESD and IIRH reference sheet were available. Information about the locations assessed using DIRH can be found in the subsection devoted to the Iola allotment (3.2.4).

Throughout this section, and unless otherwise indicated, numbers in parentheses following an indicator name or description refer to the indicator numbers found in Table 1 and Table 4.

Distributions of attribute and indicator ratings for all 27 locations are shown in Table 3 and Table 4, respectively. Some indicators were generally consistent with reference conditions. These included rills (1), gullies (5), wind-scours, blowouts, and deposition areas (6), and dead or dying plants (13), all of which were rated as none to slight departures at 25 or more of the 27 total locations. Other indicators were distributed across multiple departure categories, but for nearly all indicators none to slight was the most common rating. The exception was composition of functional/structural groups (12), which was most often rated as a moderate departure from reference conditions. Annual production (15) was omitted from consideration at 15 locations due to the difficulty of field estimation, and soil surface loss or degradation (9) was omitted at one location because the crew was unable to dig a soil pit.

It is important to note that attribute ratings are qualitative, and, while they are guided by consideration of each relevant indicator, they are also influenced by context and the general impression that the crew has of each site. This can make it difficult to assign departures from reference condition for the attributes to specific indicators, but, nonetheless, patterns do emerge from the data. For example, composition of functional/structural groups (12) is used to rate each site's Biotic Integrity and it was rated as at least a moderate departure from reference at 25 of the 27 total locations. This is reflected in the ratings for Biotic Integrity, which was rated as at least a slight to moderate departure from reference at 24 locations, and a moderate or greater departure more than one-third of the time. A relative lack of established bunchgrasses was a commonly noted issue at many of the locations assessed.

Water-flow patterns (2) and pedestals and/or terracettes (3) were key drivers of departure from reference condition at locations where Soil and Site Stability was rated as at least a slight to moderate departure from reference. This pattern also largely held true for Hydrologic Function, where water-flow patterns (2) and pedestals and/or terracettes (3) again drove departures from reference, along with departures in plant community composition and distribution relative to infiltration and runoff (10). Limited evidence of erosion and runoff was commonly observed during the assessment, but some allotments were worse than others. This will be highlighted in the following sections.

Maps of ratings for the 17 indicators and three attributes are included in Appendix A. Summary data, including ratings for each indicator and attribute at each location, are included in Appendix C.

Table 3. Distributions of ratings for the three attributes for all 27 IIRH locations.

Attribute	Departure from reference condition ¹				
	N-S	S-M	M	M-E	E-T
Soil and Site Stability (S)	15	6	6	0	0
Hydrologic Function (H)	11	7	9	0	0
Biotic Integrity (B)	3	14	7	2	1

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

Table 4. Distribution of ratings for the 17 indicators for all 27 IIRH locations.

Indicator	Associated attributes ¹	Departure from reference condition ²				
		N-S	S-M	M	M-E	E-T
1. Rills	S, H	27	0	0	0	0
2. Water-flow patterns	S, H	11	4	4	6	2
3. Pedestals and/or terracettes	S, H	12	6	3	3	3
4. Bare ground	S, H	18	6	2	1	0
5. Gullies	S, H	25	2	0	0	0
6. Wind-scoured areas, blowouts, and/or deposition areas	S	27	0	0	0	0
7. Litter movement	S	21	5	1	0	0
8. Soil surface resistance to erosion	S, H, B	21	5	1	0	0
9. Soil surface loss or degradation ³	S, H, B	17	8	1	0	0
10. Plant community composition and distribution relative to infiltration and runoff	H	13	3	5	5	1
11. Compaction layer	S, H, B	23	2	2	0	0
12. Functional/structural groups	B	1	1	12	7	6
13. Dead or dying plants or plant parts	B	26	0	0	1	0
14. Litter cover and depth	H, B	17	7	3	0	0
15. Annual production ⁴	B	6	1	0	4	1
16. Invasive plants	B	19	3	1	0	4
17. Vigor with an emphasis on reproductive capability of perennial plants	B	22	3	2	0	0

¹ Attributes: S = Soil and site stability, H = Hydrologic function, B = Biotic integrity.

² Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

³ Soil surface loss or degradation was omitted at one location because crew did not dig a soil pit.

⁴ Annual production was omitted at 15 locations due to inaccurate estimation.

3.2. By Grazing Allotment

Mean ratings for attributes are shown in Table 5. Other than the Stevens Creek allotment, Soil and Site Stability was generally quite close to reference condition, with slightly greater departures in Hydrologic Function and Biotic Integrity observed in most allotments. The Stevens Creek allotment stands out due to the relatively greater mean departures from reference observed for all three attributes, while Red Rock Canyon stands out due to the particularly large mean departure observed for Biotic Integrity. Mean indicator ratings for each allotment are shown in Table 6, and each grazing allotment is addressed in greater detail in the next section.

Table 5. Mean attribute ratings for each of the grazing allotments included in the assessment. Qualitative ratings are converted to an ordinal scale, where none to slight equals one and extreme-to total equals 5.

Allotment name ¹	Locations (#)	Attribute ²		
		S	H	B
East Portal (BLCA)	3	1.33	1.67	2.33
Green Mountain (BLCA)	1	2.00	2.00	2.00
Grizzly Gulch (BLCA)	2	1.50	1.50	1.50
Iola (CURE)	6	2.00	2.60	2.20
Vernal Mesa (BLCA)	3	1.00	1.00	2.33
Red Rock Canyon (BLCA)	3	1.00	2.00	4.33
Sapinero Mesa (CURE)	6	1.67	1.67	2.00
Spring Gulch (CURE)	1	1.00	1.00	1.00
Stevens Creek (CURE)	3	3.00	3.00	3.00

¹ BLCA = Black Canyon of the Gunnison National Park; CURE = Curecanti National Recreation Area.

² Attributes: S = Soil and Site Stability; H = Hydrologic Function; B = Biotic Integrity.

Table 6. Mean values for indicator ratings among grazing allotments. Qualitative ratings are converted to an ordinal scale, where none to slight equals one and extreme to total equals five.

Allotment name ¹	Indicator																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
East Portal (BLCA)	1.0	2.0	1.7	1.3	1.0	1.0	1.0	1.7	1.3	1.7	1.0	3.0	1.0	1.3	2.5	3.3	1.0
Green Mountain (BLCA)	1.0	1.0	2.0	2.0	1.0	1.0	1.0	3.0	1.0	1.0	1.0	3.0	1.0	1.0	NR	1.0	1.0
Grizzly Gulch (BLCA)	1.0	2.0	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.5	1.0	3.0	1.0	1.5	2.0	1.5	1.0
Iola (CURE)	1.0	3.8	3.4	1.4	1.0	1.0	1.8	1.0	2.0	3.0	1.0	3.6	1.0	1.2	NR	1.0	1.2
Vernal Mesa (BLCA)	1.0	2.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.3	3.3	2.0	1.3	4.0	1.3	1.7
Red Rock Canyon (BLCA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.0	3.0	2.7	5.0	1.0	1.7	2.3	5.0	1.0
Sapinero Mesa (CURE)	1.0	2.2	2.2	1.7	1.2	1.0	1.3	1.2	1.2	2.0	1.0	3.5	1.0	2.0	1.0	1.2	1.7
Spring Gulch (CURE)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	NR	1.0	1.0
Stevens Creek (CURE)	1.0	4.0	4.0	2.3	1.3	1.0	1.3	1.0	2.0	3.3	1.0	4.7	1.0	1.3	NR	1.0	2.0

¹ BLCA = Black Canyon of the Gunnison National Park; CURE = Curecanti National Recreation Area.

3.2.1. East Portal (BLCA)

Three locations were assessed in the East Portal allotment in 2019 (IIRH version 5). Soil and Site Stability was rated as a slight to moderate departure from reference at one location and a none to slight departure at two locations. Hydrologic Function and Biotic Integrity were rated as moderate departures from reference at one location each and no attribute ratings exceeded moderate departures from reference conditions. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 3.

Evidence of erosion in the form of water-flow patterns (2) and pedestals/terraces (3), along with altered plant community composition and distribution relative to infiltration (10), drove departures from reference for Hydrologic Function. Departures from reference condition for Biotic Integrity were driven by the presence of invasive plants (16) and altered composition of functional/structural groups (12). The location that received a moderate rating for Biotic Integrity was dominated by trees, which was not expected based on the reference plant community described in the ESD.

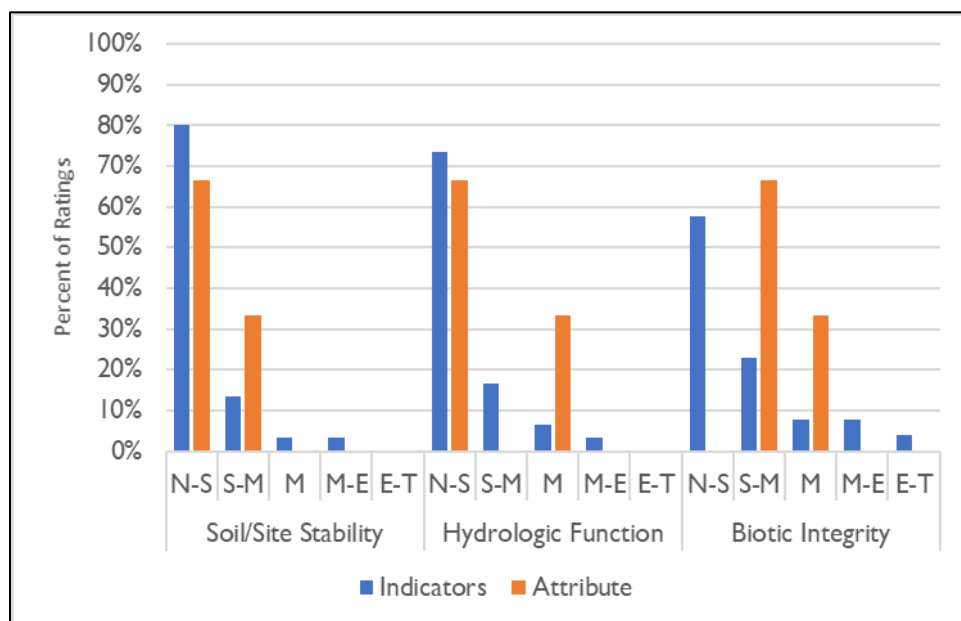


Figure 3. Distribution of indicator and final attribute ratings for the three locations assessed in the East Portal allotment in 2019 (BLCA).

3.2.2. Green Mountain (BLCA)

One location was assessed in the Green Mountain allotment in 2021 (IIRH version 4). All three attributes were rated as slight to moderate departures from reference condition at this location. Departures were driven by soil surface resistance to erosion (8), which was lower than expected based on the conditions described in the ESD. Much of the soil surface at this location appeared to be disturbed by livestock/wildlife hooves. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 4.

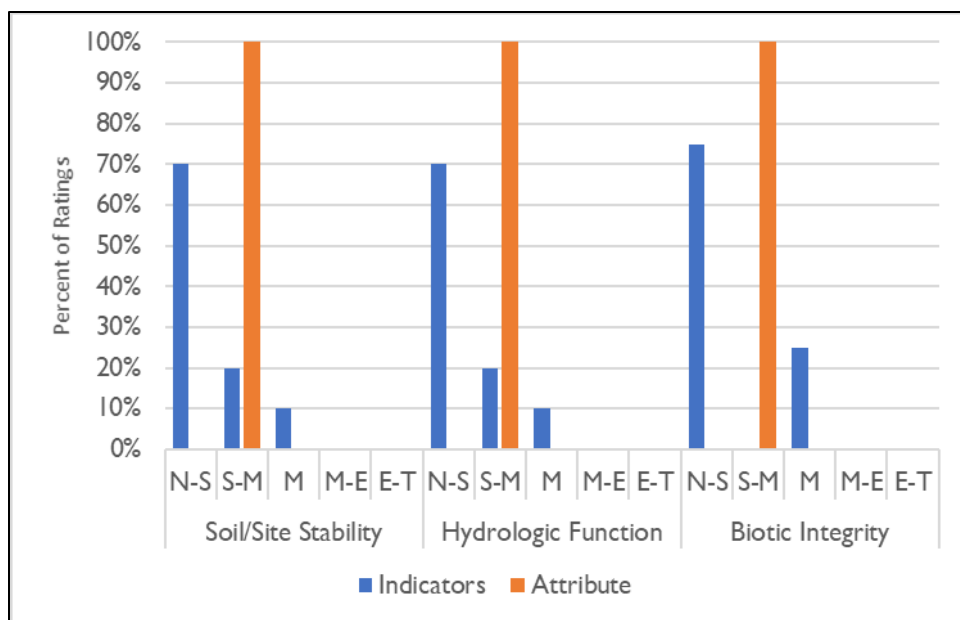


Figure 4. Distribution of indicator and final attribute ratings for the one location assessed in the Green Mountain allotment in 2021 (BLCA).

3.2.3. Grizzly Gulch (BLCA)

Two locations were assessed in the Grizzly Gulch allotment in 2021 (IIRH version 4). For each attribute, one location was rated as a none to slight and one was rated as a slight to moderate departure from reference condition. Departures were driven by evidence of erosion in the form of water-flow patterns (2) and pedestals/terraces (3), increased bare ground (4), and altered composition of functional/structural groups (12). Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 5.

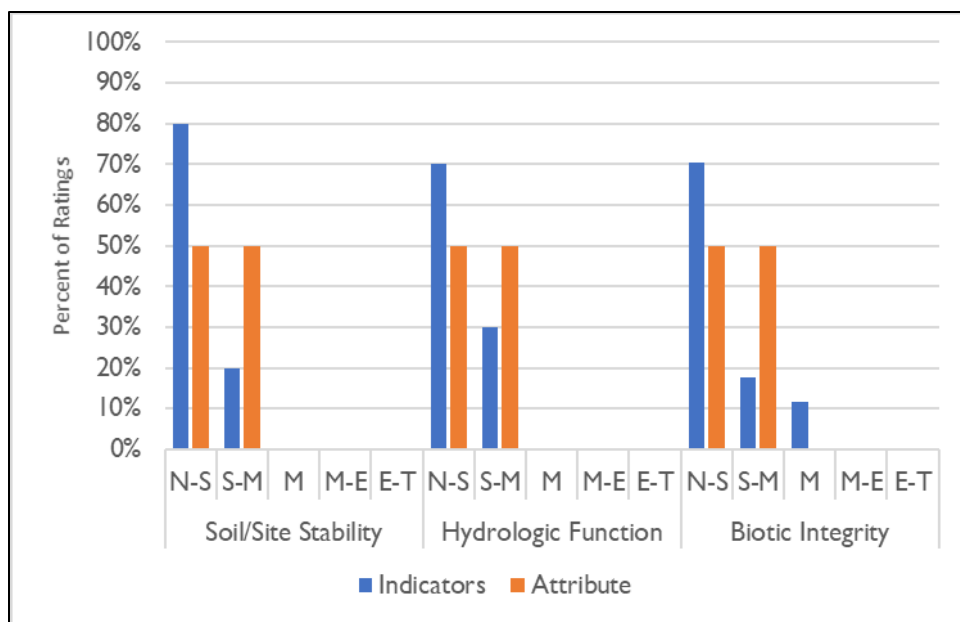


Figure 5. Distribution of indicator and final attribute ratings for the two locations assessed in the Grizzly Gulch allotment in 2021 (BLCA).

3.2.4. Iola (CURE)

Six locations were assessed in the Iola allotment in 2021 (IIRH version 4; DIRH). For the five locations assessed using IIRH, Soil and Site Stability and Biotic Integrity were rated as a moderate departure from reference at one location and Hydrologic Function was rated as a moderate departure from reference at three locations. No attribute ratings exceeded moderate departures from reference. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 6.

Widespread evidence of erosion in the form of water-flow patterns (2) and pedestals/terraces (3), as well as altered community composition and distribution relative to infiltration (10) drove deviations from reference condition for Hydrologic Function across the three sites rated as moderate departures from reference for this attribute. This same evidence of erosion (2; 3), along with litter movement (7) and soil surface loss (9), drove departures from reference for Soil and Site Stability. Departures from reference for Biotic Integrity were also driven by soil surface loss (9), along with altered composition of functional/structural groups (12).

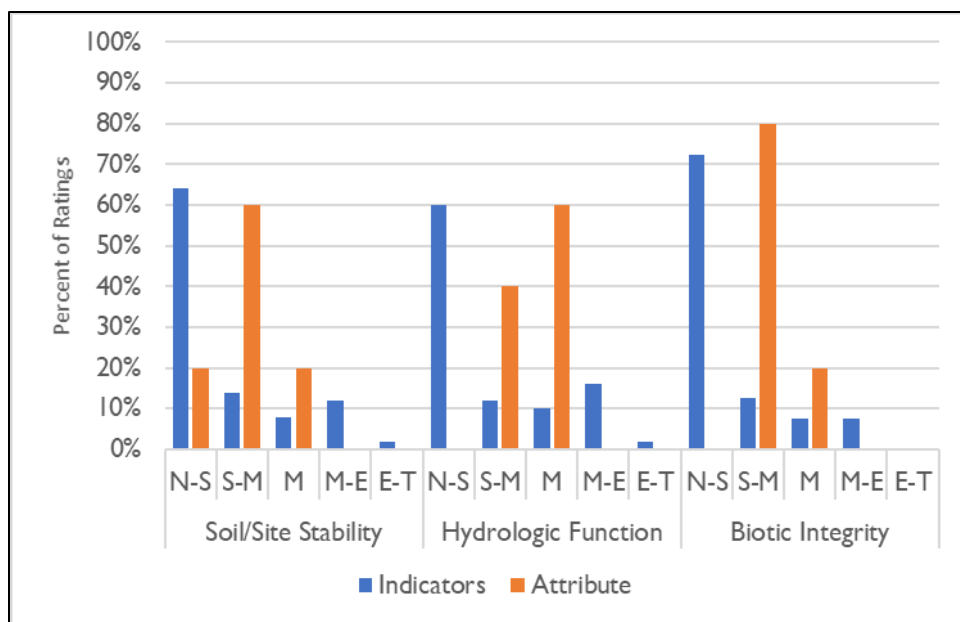


Figure 6. Distribution of indicator and final attribute ratings for the six locations assessed in the Iola allotment in 2021 (CURE).

The site described using DIRH was identified as a *Stony Rock Land* ecological site, but this ecological site does not have an ESD or IIRH reference sheet. Connected water flow patterns (2) and an overall lack of herbaceous plants (12), particularly in shrub interspaces (10), were the main concerns identified during DIRH. The results of the DIRH assessment of this site generally reflected patterns similar to other locations in the Iola allotment assessed using IIRH.

3.2.5. Vernal Mesa (BLCA)

Three locations were assessed in the Vernal Mesa allotment in 2019 (IIRH version 5). Soil and Site Stability and Hydrologic Function were rated as none to slight departures from reference at all three locations, while Biotic Integrity was rated as a moderate departure at one location and slight to moderate at the other two locations. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 7.

Altered composition of functional/structural groups (12) drove departures from reference for Biotic Integrity across all three locations. Dead or dying plants (13) and low reproductive vigor (17) also contributed to the rating for Biotic Integrity at the location rated as moderate for this attribute.

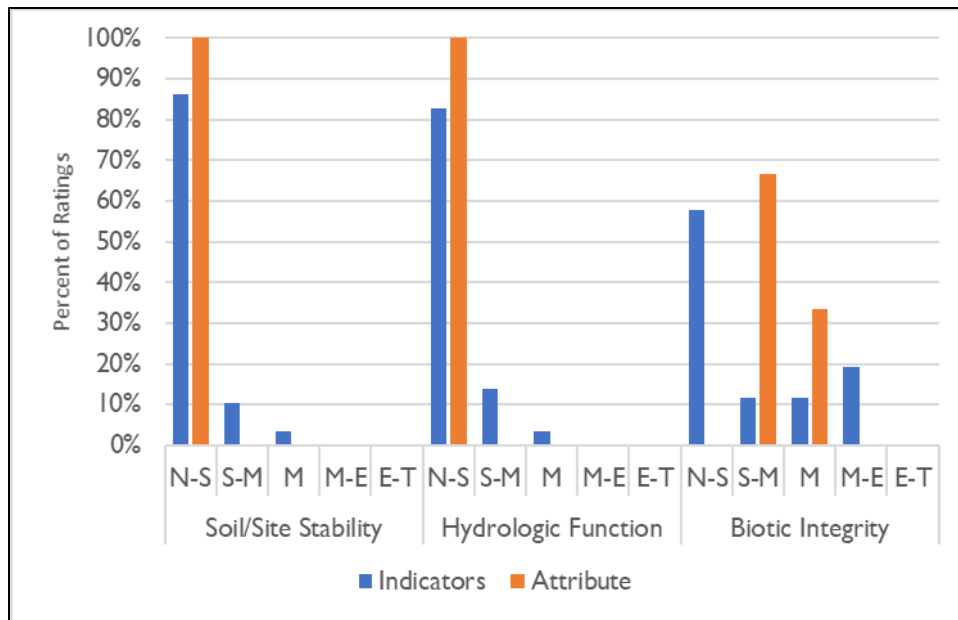


Figure 7. Distribution of indicator and final attribute ratings for the three locations assessed in the Vernal Mesa allotment in 2019 (BLCA).

3.2.6. Red Rock Canyon (BLCA)

Three locations were assessed in the Red Rock Canyon allotment in 2019 (IIRH version 5). Soil and Site Stability was rated as a none to slight departure from reference and Hydrologic Function was rated as a slight to moderate departure from reference at all three locations, but Biotic Integrity was rated as a moderate to extreme departure from reference at two locations and an extreme to total departure at one location. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 8.

Altered composition of functional/structural groups (12) and invasive plants (16) drove departures from reference condition for Biotic Integrity across all three locations. The expected dominant and sub-dominant functional/structural groups were absent and the plant community was dominated by invasive plants at all three locations assessed in the allotment. Annual grasses and forbs including downy brome (*Bromus tectorum* L.) and tumble mustard (*Sisymbrium altissimum* L.) were the most common noted invaders at these locations.

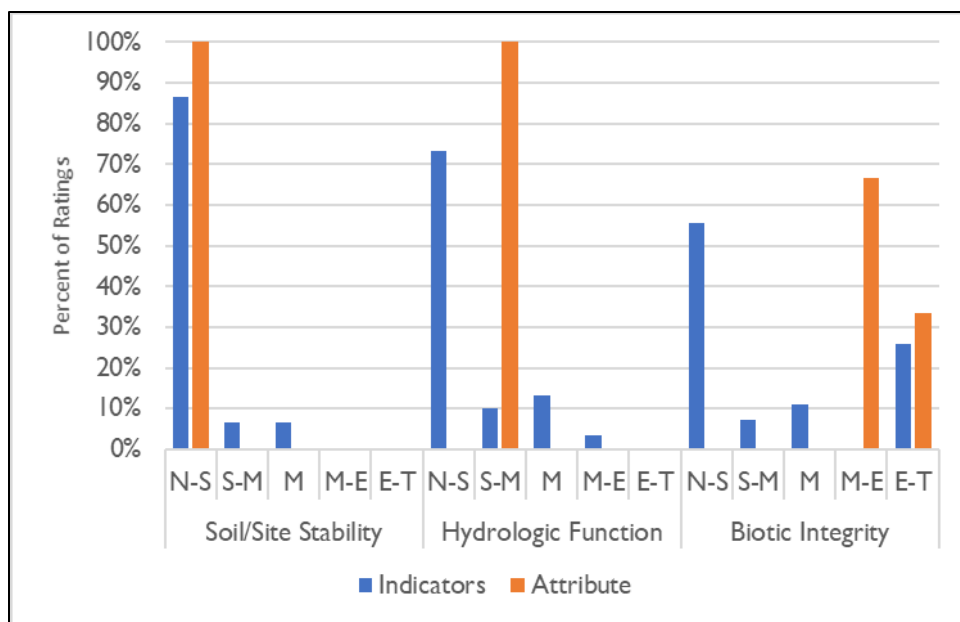


Figure 8. Distribution of indicator and final attribute ratings for the three locations assessed in the Red Rock Canyon allotment in 2019 (BLCA).

3.2.7. *Sapinero Mesa (CURE)*

Six locations were assessed in the Sapinero Mesa allotment in 2021 (IIRH version 4). Soil and Site Stability and Hydrologic Function were rated as moderate departures from reference conditions at two locations each and Biotic Integrity was rated as moderate at one location. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 9.

Evidence of erosion in the form of water-flow patterns (2) and pedestals/terraces (3), along with increased bare ground (4) and altered plant community composition and distribution relative to infiltration (10), drove departures from reference for Soil and Site Stability and Hydrologic Function. Departures from reference for Biotic Integrity were driven by altered composition of functional/structural groups (12) and several of the locations featured large patches of Gambel oak, that were not included in the reference plant community described in the ESD.

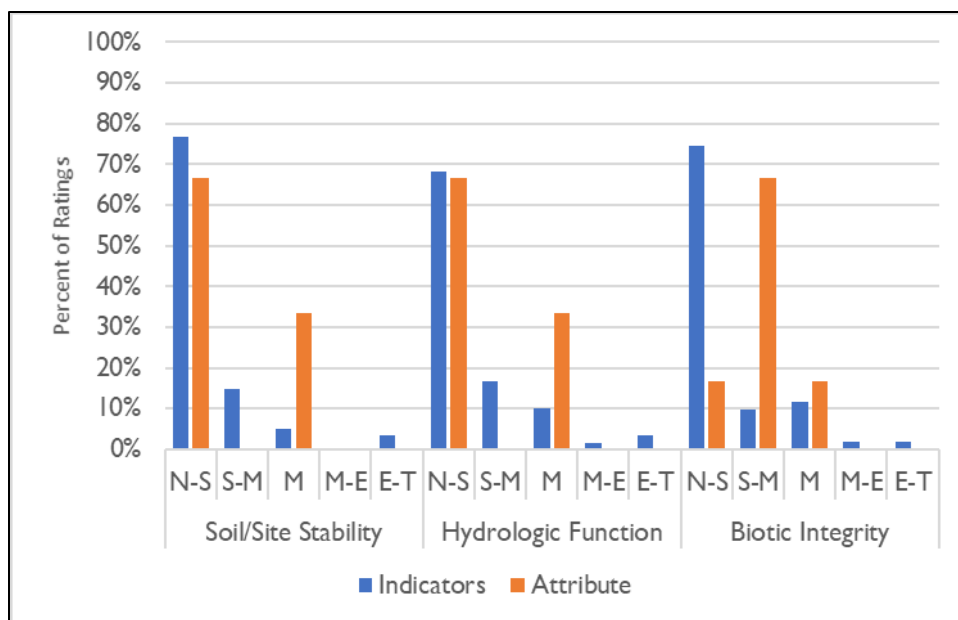


Figure 9. Distribution of indicator and final attribute ratings for the six locations assessed in the Sapinero Mesa allotment in 2021 (CURE).

3.2.8. Spring Gulch (CURE)

One location was assessed in the Spring Gulch allotment in 2021 (IIRH version 4). All attributes were rated as none to slight departures from reference conditions at this location. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 10.

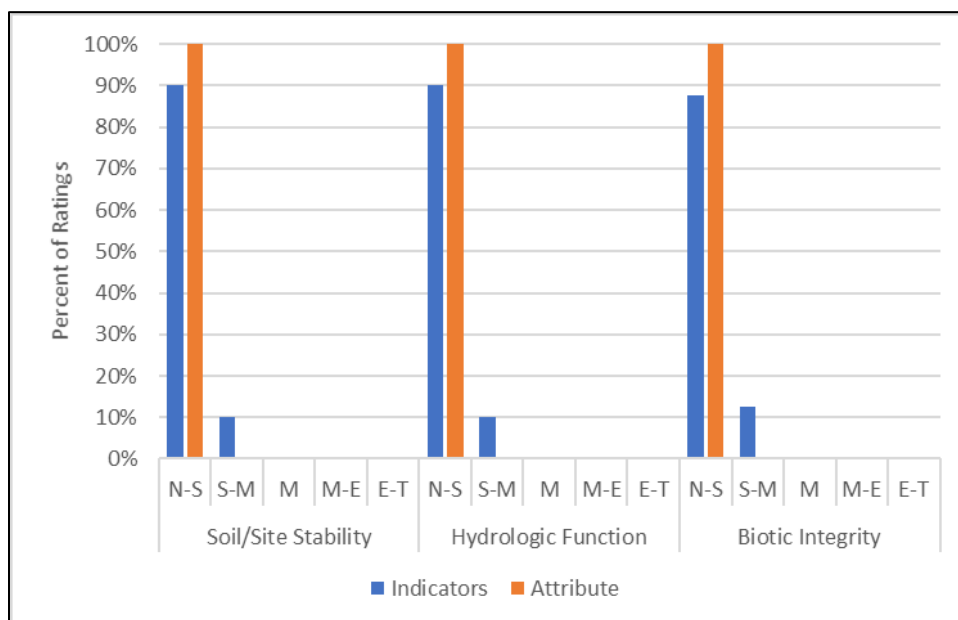


Figure 10. Distribution of indicator and final attribute ratings for the one location assessed in the Spring Gulch allotment in 2021 (CURE).

3.2.9. Stevens Creek (CURE)

Three locations were assessed in the Stevens Creek allotment in 2021 (IIRH version 4). All attributes were rated as moderate departures from reference condition at all three sites. Final attribute ratings and the distribution of indicator ratings that contributed to them are shown in Figure 11.

Widespread and extensive evidence of erosion in the form of water-flow patterns (2) and pedestals/terraces (3), along with altered plant community composition and distribution relative to infiltration (10), drove departures from reference condition for Soil and Site Stability and Hydrologic Function. At all three locations almost no herbaceous plants were found outside of existing shrub canopies. Departures from reference for Biotic Integrity were driven by altered composition of functional/structural groups (12) and low reproductive vigor (17).

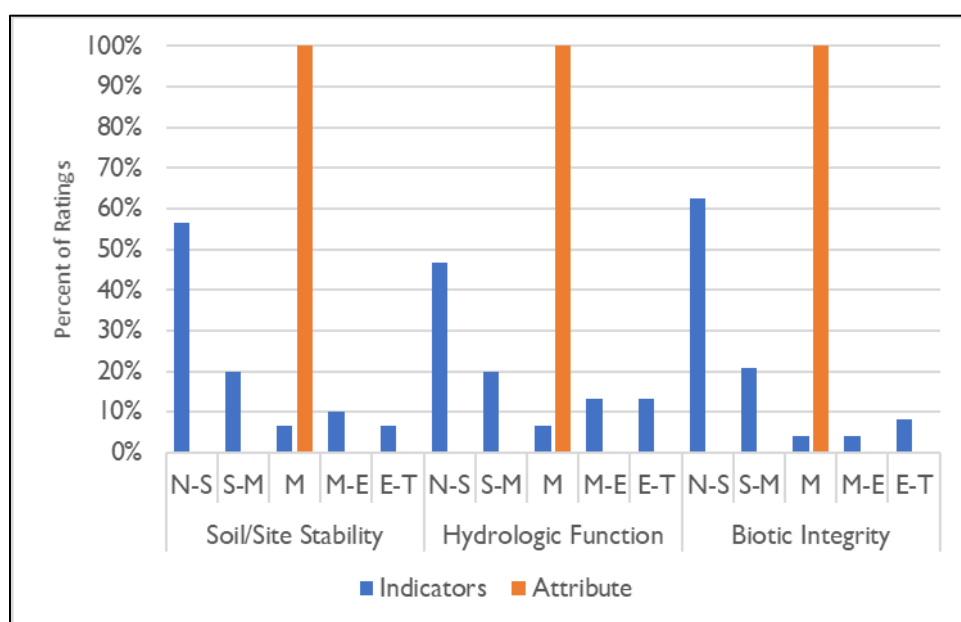


Figure 11. Distribution of indicator and final attribute ratings for the three locations assessed in the Stevens Creek allotment in 2021 (CURE).

3.3. By Ecological Site Description

Seven total Ecological Site Descriptions were used among the 27 IIRH assessment sites. These ESDs and the number of locations to which they were applied are shown in Table 7. Table 8 shows the number of locations to which each ESD was applied within each specific grazing allotment.

Average IIRH attribute ratings for each ESD are shown in Table 9, and the patterns observed across all locations were generally conserved within the individual ESDs. Average departure from reference was generally greatest for Biotic Integrity, while average ratings for Soil and Site Stability and Hydrologic Function were generally close to reference conditions. Depending on the objectives, future monitoring and management may benefit from considering each ESD independently, as is detailed in the Discussion.

Table 7. List of Ecological Site Descriptions (ESD) used in the IIRH assessments, along with the number of IIRH locations that corresponded to each ESD.

ESD Code	ESD Name	Number of Locations
R034BY306UT	Upland Loam (Wyoming Big Sagebrush)	3
R036XY284CO	Loamy Foothills	1
R036XY287CO	Stony Foothills	1
R036XY289CO	Clayey foothills	1
R048AY231CO	Dry Mountain Loam Gunnison Basin LRU	14
R048AY238CO	Brushy Loam	4
R048AY247CO	Deep Clay Loam	3

Table 8. The number of locations corresponding to each ecological site across the grazing allotments included in the assessment.

ESD Code	Allotment ¹								
	EP	GM	GG	IO	VM	RR	SM	SG	SC
R034BY306UT	–	1	2	–	–	–	–	–	–
R036XY284CO	–	–	–	–	–	1	–	–	–
R036XY287CO	–	–	–	–	–	1	–	–	–
R036XY289CO	–	–	–	–	–	1	–	–	–
R048AY231CO	–	–	–	5	–	–	6	–	3
R048AY238CO	2	–	–	–	1	–	–	1	–
R048AY247CO	1	–	–	–	2	–	–	–	–

¹ Allotments: EP = East Portal (BLCA); GM = Green Mountain (BLCA); GG = Grizzly Gulch (BLCA); IO = Iola (CURE); VM = Vernal Mesa (BLCA); RR = Red Rock Canyon (BLCA); SM = Sapinero Mesa (CURE); SG = Spring Gulch (CURE); SC = Stevens Creek (CURE).

Table 9. Mean attribute ratings for each ecological site encountered during assessment. Qualitative ratings are converted to an ordinal scale, where none to slight equals one and extreme to total equals five.

ESD Code	Locations (#)	Attribute ¹		
		S	H	B
R034BY306UT	3	1.67	1.67	1.67
R036XY284CO	1	1.00	2.00	5.00
R036XY287CO	1	1.00	2.00	4.00
R036XY289CO	1	1.00	2.00	4.00
R048AY231CO	14	2.07	2.29	2.29
R048AY238CO	4	1.25	1.50	2.00
R048AY247CO	3	1.00	1.00	2.33

¹ Attributes: S = Soil and Site Stability; H = Hydrologic Function; B = Biotic Integrity.

3.4. Compromised Sites

In this section we will review, on an allotment-by-allotment basis, all assessment sites that may require further consideration, integrating ESD-relevant information. For this, we will consider “ecologically compromised” all locations where at least one of the three IIRH attributes was rated as a moderate or greater departure from reference condition. Note that this term is not used to suggest anything other than its IIRH rating. Figure 12 shows all such locations for Black Canyon of the Gunnison National Park and the Curecanti National Recreation Area, and Table 10 summarizes ecologically compromised sites by allotment. Note that none of the locations in the Green Mountain, Grizzly Gulch, or Spring Gulch allotments were compromised, and that, because the assessment took place at two different times (2019 and 2021), there is overlap between some of the Site ID numbers used to identify individual locations. For the purposes of identification, the year of the assessment is noted in parentheses next to each compromised site. A complete list of Site ID numbers can be found in Appendix C, and the photos referenced in this section can be found in Appendix D.

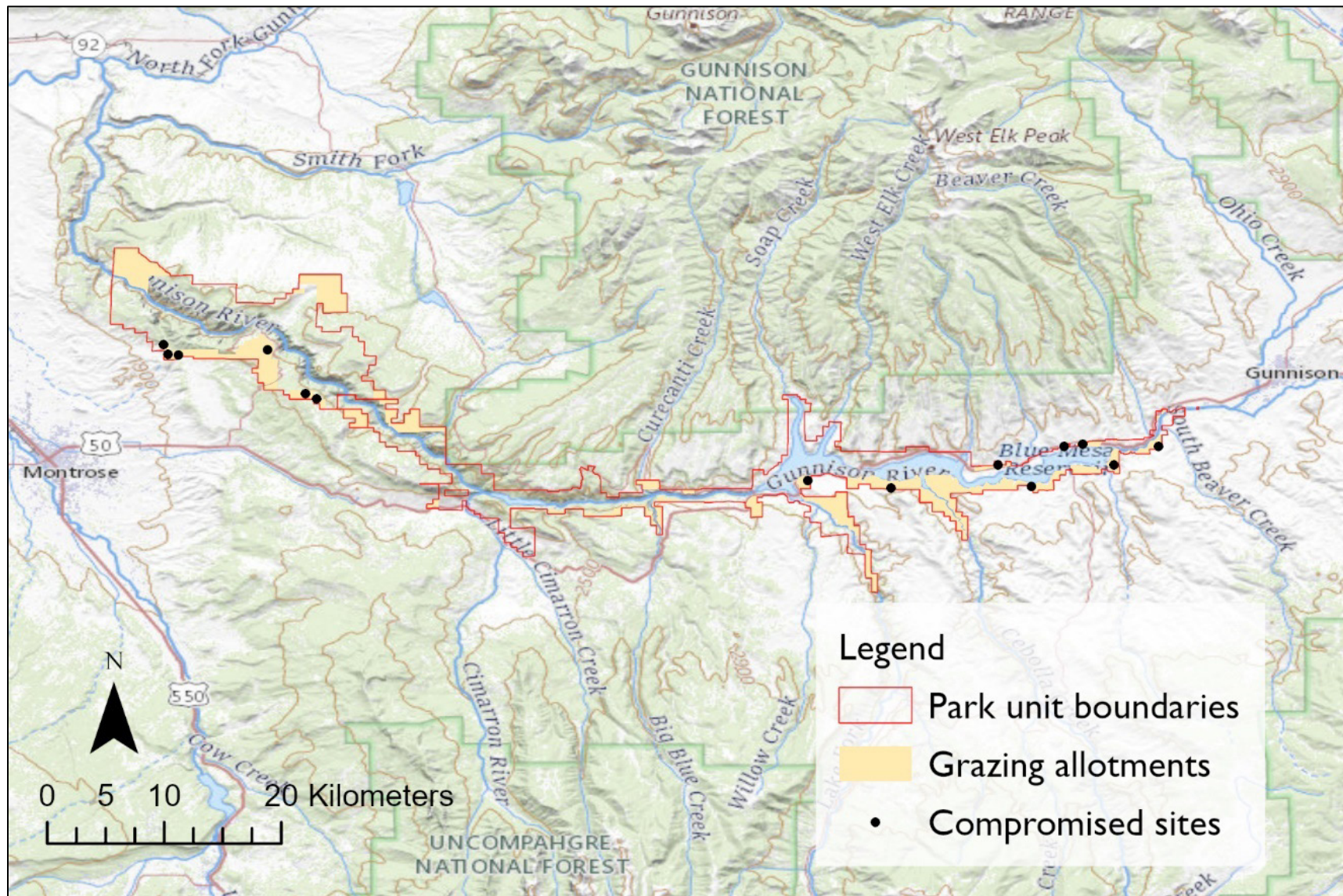


Figure 12. Location of ecologically compromised sites at BLCA and CURE.

Table 10. Distribution of locations with a moderate or greater departure from reference condition (compromised sites) for at least one IIRH attribute.

Allotment name¹	Hectares	Total Locations (#)	Compromised Sites (#)	Percent Compromised
East Portal (BLCA)	192	3	2	66%
Green Mountain (BLCA)	890	1	0	0%
Grizzly Gulch (BLCA)	581	2	0	0%
Iola (CURE)	1,313	5	3	60%
Vernal Mesa (BLCA)	711	3	1	33%
Red Rock Canyon (BLCA)	110	3	3	100%
Sapinero Mesa (CURE)	1,451	6	3	50%
Spring Gulch (CURE)	417	1	0	0%
Stevens Creek (CURE)	161	3	3	100%

¹ BLCA = Black Canyon National Park; CURE = Curecanti National Recreation Area.

3.4.1. East Portal (BLCA)

Two of the three locations assessed in the East Portal allotment were classified as compromised sites. One of these locations was rated as a moderate departure from reference for Biotic Integrity, and one was rated as a moderate departure for Hydrologic Function. Table 11 and Table 12 show the indicator ratings that contributed to the departures from reference for these attributes, and no other attribute ratings exceeded a slight to moderate departure from reference condition.

Site 10 (2019) was associated with a *Brushy Loam* ecological site and was located on a north-facing slope at an elevation of 2,548 m. The reference plant community for this site is shrub-dominated with sub-dominant cool-season bunchgrasses. While all of the expected plant groups were present at the site, the IIRH assessment determined that trees, mostly aspen, comprised both dominant and sub-dominant components of the plant community, resulting in a moderate to extreme departure from reference condition for functional/structural groups (12). In addition, non-native dandelions (*Taraxacum officinale* F.H. Wigg) dominated the herbaceous community, resulting in a moderate to extreme departure from reference condition for invasive plants (16). These departures from reference contributed to the moderate rating for Biotic Integrity. Photo 1 shows the tree-dominated plant community (12) observed at this location.

Table 11. Indicator ratings that contributed to the Biotic Integrity rating for Site 10 (2019) in the East Portal allotment (BLCA).

Site ID	ESD Code	Attributes and Indicators									
		Biotic Integrity ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹	12. F/S groups ¹	13. Dead or dying plants ¹	14. Litter cover ¹	15. Ann. prod. ¹	16. Inv. plants ¹	17. Vigor ¹
10	R048AY238CO	M	S-M	N-S	N-S	M-E	N-S	N-S	–	E-T	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 11 (2019) was associated with a *Brushy Loam* Ecological Site and was located on a shallow east facing slope at an elevation of 2,517 m. Evidence of erosion and runoff was commonly observed at this location. This included wide and connected water-flow patterns (2) and pedestals/terraces (3). The crew noted that 5–10 percent of plants were located on slight pedestals (3) and that the plant community was not distributed evenly relative to infiltration and runoff (10). These departures from reference, along with evidence of runoff and raindrop erosion, contributed to the moderate rating for Hydrologic Function.

Table 12. Indicator ratings that contributed to the Hydrologic Function rating for Site 11 (2019) in the East Portal allotment (BLCA).

Site ID	ESD Code	Attributes and Indicators										
		Hydr. Function ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	10. Infiltration ¹	11. Comp. layer ¹	14. Litter cover ¹
11	R048AY238CO	M	N-S	M-E	M	S-M	N-S	N-S	N-S	M	N-S	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

3.4.2. Iola (CURE)

Three of the five locations assessed in the Iola allotment were classified as compromised sites. All three of these locations were rated as a moderate departure from reference condition for Hydrologic Function, and one these three locations was also rated as a moderate departure for both Soil and Site Stability and Biotic Integrity. Tables 13–15 show the indicator ratings that contributed to the departures from reference for these attributes, and no other attribute ratings exceeded a slight to moderate departure from reference condition.

Table 13. Indicator ratings that contributed to the Hydrologic Function ratings for Sites 7, 8 and 9 (all 2021) in the Iola allotment (CURE).

Site ID	ESD Code	Attributes and Indicators										
		Hydr. Function ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	10. Infiltration ¹	11. Comp. layer ¹	14. Litter cover ¹
7	R048AY231CO	M	N-S	M-E	E-T	N-S	N-S	N-S	M	M	N-S	N-S
8	R048AY231CO	M	N-S	M-E	M-E	N-S	N-S	N-S	S-M	M	N-S	S-M
9	R048AY231CO	M	N-S	M-E	M-E	S-M	N-S	N-S	S-M	M-E	N-S	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 7 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a flat bench at an elevation of 2,397 m. Evidence of erosion and runoff was commonly observed at this location, including long and connected water-flow patterns (2), extensive pedestaling of perennial plants (3), movement of small woody litter (7), and soil surface loss (9). Further, almost no herbaceous plants were established outside of existing shrub canopies, resulting in a moderate rating for plant community composition and distribution relative to infiltration (10). These departures from reference contributed to the moderate ratings for both Soil and Site Stability and Hydrologic Function. Altered composition of functional/structural groups (12) and soil surface loss (9) contributed to the moderate rating for Biotic Integrity. While the reference plant community is dominated by cool-season bunchgrasses, the plant community was dominated by shrubs at the time of the assessment with very few herbaceous plants. However, the crew noted that many small bunchgrasses were present and the site may be in the process of recovery. Examples of pedestals (3) and litter movement (7) observed at this location are shown in Photo 2 and Photo 3, respectively.

Table 14. Indicator ratings that contributed to the Hydrologic Function rating for Site 7 (2021) in the Iola allotment (CURE).

Site ID	ESD Code	Attributes and Indicators										
		Soil and Site Stability ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	6. Wind scour/dep. areas ¹	7. Litter mvmt. ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹
7	R048AY231CO	M	N-S	M-E	E-T	N-S	N-S	N-S	M	N-S	M	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Table 15. Indicator ratings that contributed to the Biotic Integrity rating for Site 7 (2021) in the Iola allotment (CURE).

Site ID	ESD Code	Attributes and Indicators									
		Biotic Integrity ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹	12. F/S groups ¹	13. Dead or dying plants ¹	14. Litter cover ¹	15. Ann. prod. ¹	16. Inv. plants ¹	17. Vigor ¹
7	R048AY231CO	M	N-S	M	N-S	M-E	N-S	N-S	–	N-S	S-M

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 8 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a shallow, northwest-facing slope at an elevation of 2,324 m. Evidence of erosion and runoff was commonly observed at this location. Long, connected water-flow patterns (2) were commonly observed, and nearly all plants were located on slight pedestals (3). The crew also noted that, while there were small patches where bunchgrasses were abundant, there were few bunchgrasses outside of established shrub canopies across most of the site (10). These departures from reference contributed to the moderate rating for Hydrologic Function. An example of a water-flow pattern (2) observed at this location is shown in Photo 4.

Site 9 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a flat bench at an elevation of 2,353 m. This location was similar to Site 8, with evidence of erosion and runoff commonly observed in the form of water-flow patterns (2) and pedestals (3), and a lack of bunchgrasses outside of established shrub canopies (10). These departures from reference contributed to the moderate rating for Hydrologic Function.

3.4.3. Vernal Mesa (BLCA)

Site 8 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a shallow, northwest-facing slope at an elevation of 2,324 m. Evidence of erosion and runoff was commonly observed at this location. Long, connected water-flow patterns (2) were commonly observed, and nearly all plants were located on slight pedestals (3). The crew also noted that, while there were small patches where bunchgrasses were abundant, there were few bunchgrasses outside of established shrub canopies across most of the site (10). These departures from reference contributed to the moderate rating for Hydrologic Function. An example of a water-flow pattern (2) observed at this location is shown in Photo 4.

Site 9 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a flat bench at an elevation of 2,353 m. This location was similar to Site 8, with evidence of erosion and runoff commonly observed in the form of water-flow patterns (2) and pedestals (3), and a lack of bunchgrasses outside of established shrub canopies (10). These departures from reference contributed to the moderate rating for Hydrologic Function.

Table 16. Indicator ratings that contributed to the Biotic Integrity rating for Site 4 (2019) in the Vernal Mesa allotment (BLCA).

Site ID	ESD Code	Attributes and Indicators									
		Biotic Integrity ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹	12. F/S groups ¹	13. Dead or dying plants ¹	14. Litter cover ¹	15. Ann. prod. ¹	16. Inv. plants ¹	17. Vigor ¹
4	R048AY247CO	M	N-S	N-S	S-M	M-E	M-E	N-S	M	N-S	M

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

3.4.4. Red Rock Canyon (BLCA)

All three of the locations assessed in the Red Rock Canyon allotment were classified as compromised sites. Two of these three locations were rated as moderate to extreme departures and one was rated as an extreme to total departure from reference condition for Biotic Integrity. Table 17 shows the indicator ratings that contributed to the departures from reference for Biotic Integrity and no other attribute ratings exceeded a slight to moderate departure from reference condition.

Table 17. Indicator ratings that contributed to the Biotic Integrity ratings for Sites 6, 7 and 8 (all 2019) in the Red Rock Canyon allotment (BLCA).

Site ID	ESD Code	Attributes and Indicators									
		Biotic Integrity ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹	12. F/S groups ¹	13. Dead or dying plants ¹	14. Litter cover ¹	15. Ann. prod. ¹	16. Inv. plants ¹	17. Vigor ¹
6	R036XY287CO	M-E	N-S	N-S	M	E-T	N-S	N-S	N-S	E-T	N-S
7	R036XY289CO	M-E	S-M	N-S	S-M	E-T	N-S	M	N-S	E-T	N-S
8	R036XY284CO	E-T	N-S	N-S	M	E-T	N-S	N-S	E-T	E-T	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 6 (2019) was associated with a *Stony Foothills* ecological site and was located on a west-facing slope at an elevation of 2,088 m. The plant community at this location was tree-dominated as expected, but invasive plants (16), including cheatgrass (downy brome) and non-native forbs (mustards), were the subdominant component of the plant community. The crew also noted that many of the expected functional/structural groups (12) and plant species were missing from the community, likely as a result of invasion. These departures from reference, along with consistent soil compaction (11), contributed to the moderate to extreme rating for Biotic Integrity. Photo 5 shows the invaded plant community (16) observed at this location.

Site 7 (2019) was associated with a *Clayey Foothills* ecological site and was located on a shallow, north-facing slope at an elevation of 2,014 m. Similar to Site 6, the plant community at this location was also invaded by annual weeds, resulting in extreme to total departures from reference for functional/structural groups (12) and invasive plants (16). Cheatgrass (downy brome), mustard (*Sisymbrium* spp.), and field bindweed (*Convolvulus arvensis* L.) were noted by the crew as particularly abundant. The crew also noted that litter cover (14) was much higher than expected, perhaps as a result of invasion by annual weeds. These departures from reference contributed to the moderate to extreme rating for Biotic Integrity. Photo 6 shows the invaded plant community (16) observed at this location.

Site 8 (2019) was associated with a *Loamy Foothills* ecological site and was located in a relatively flat meadow at an elevation of 2,056 m. Similar to the other sites in the Red Rock Canyon allotment, the plant community at this location was dominated by invasive plants (16) and many of the expected functional/structural groups (12) were missing. The crew noted that the site was dominated by mustards (*Sisymbrium* spp.), but that several other invasive plants were also present. Further, nearly all of the annual production (15) at the site resulted from the growth of annual weeds, and the soil seemed compacted (11), though the crew notes that they did not dig a pit to assess root penetration. These departures from reference contributed to the extreme to total rating for Biotic Integrity.

3.4.5. Sapinero Mesa (CURE)

Two of the six locations assessed in the Sapinero Mesa allotment were classified as compromised sites. Both of these locations were rated as moderate departures from reference condition for Soil and Site Stability and Hydrologic Function, and one of these was also classified as a moderate departure for Biotic Integrity. Tables 18–20 show the indicator ratings that contributed to the departures from reference for these attributes, and no other attribute ratings exceeded a slight to moderate departure from reference condition.

Table 18. Indicator ratings that contributed to the Soil and Site Stability ratings for Sites 14 and 16 (both 2021) in the Sapinero Mesa allotment (CURE).

Site ID	ESD Code	Attributes and Indicators										
		Soil and Site Stability ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	6. Wind scour/ dep. areas ¹	7. Litter mvmt. ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹
14	R048AY231CO	M	N-S	M	E-T	N-S	N-S	N-S	S-M	S-M	S-M	N-S
16	R048AY231CO	M	N-S	E-T	S-M	M	S-M	N-S	N-S	N-S	N-S	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Table 19. Indicator ratings that contributed to the Hydrologic Function ratings for Sites 14 and 16 (both 2021) in the Sapinero Mesa allotment (CURE).

Site ID	ESD Code	Attributes and Indicators										
		Hydr. Function ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	10. Infiltration ¹	11. Comp. layer ¹	14. Litter cover ¹
14	R048AY231CO	M	N-S	M	E-T	N-S	N-S	S-M	S-M	M	N-S	S-M
16	R048AY231CO	M	N-S	E-T	S-M	M	S-M	N-S	N-S	M-E	N-S	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 14 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a flat bench at an elevation of 2,367 m. Evidence of erosion and runoff was commonly observed at this location. Nearly all perennial plants were located on slight pedestals (3), and long, connected water-flow patterns (2) were common throughout the site. Further, there were very few bunchgrasses outside of existing shrub canopies, resulting in a moderate rating for plant community composition and distribution relative to infiltration (10). These departures from reference contributed to the moderate ratings for both Soil and Site Stability and Hydrologic Function. Photo 7 shows an example of pedestals (3) observed at this location.

Table 20. Indicator ratings that contributed to the Biotic Integrity rating for Site 16 (2019) in the Vernal Mesa allotment (BLCA).

Site ID	ESD Code	Attributes and Indicators									
		Biotic Integrity ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹	12. F/S groups ¹	13. Dead or dying plants ¹	14. Litter cover ¹	15. Ann. prod. ¹	16. Inv. plants ¹	17. Vigor ¹
16	R048AY231CO	M	N-S	N-S	N-S	E-T	N-S	N-S	–	N-S	S-M

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 16 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a shallow, north-facing slope at an elevation 2,398 m. Evidence of erosion and runoff was commonly observed at this location. Long, connected water-flow patterns (2) were common throughout this site and the crew noted that some of these may be approaching gullies (5). These departures from reference, along with large patches of bare ground (4) and an almost complete lack of herbaceous plants outside of existing shrub canopies (10), contributed to the moderate ratings for Soil and Site Stability and Hydrologic Function. Altered composition of functional/structural groups (12) drove the moderate rating for Biotic Integrity. The crew noted an almost complete lack of herbaceous plants despite bunchgrasses being the dominant component of the reference plant community. Photo 8 shows an example of water-flow patterns (2) observed at this location.

3.4.6. Stevens Creek (CURE)

All three locations assessed in the Stevens Creek allotment were classified as compromised sites and all of these locations were rated as moderate departures from reference for all three IIRH attributes. Tables 21–23 show the indicator ratings that contributed to the departures from reference for these attributes.

Table 21. Indicator ratings that contributed to the Soil and Site Stability ratings for Sites 18, 19 and 20 (all 2021) in the Stevens Creek allotment (CURE).

Site ID	ESD Code	Attributes and Indicators										
		Soil and Site Stability ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	6. Wind scour/ dep. areas ¹	7. Litter mvmt. ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹
18	R048AY231CO	M	N-S	E-T	M	S-M	S-M	N-S	S-M	N-S	S-M	N-S
19	R048AY231CO	M	N-S	M	M-E	N-S	N-S	N-S	N-S	N-S	S-M	N-S
20	R048AY231CO	M	N-S	M-E	E-T	M-E	N-S	N-S	N-S	N-S	S-M	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Table 22. Indicator ratings that contributed to the Hydrologic Function ratings for Sites 18, 19 and 20 (all 2021) in the Stevens Creek allotment (CURE).

Site ID	ESD Code	Attributes and Indicators										
		Hydr. Function ¹	1. Rills ¹	2. Water-flow patterns ¹	3. Peds. and/or terr. ¹	4. Bare grnd. ¹	5. Gullies ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	10. Infiltration ¹	11. Comp. layer ¹	14. Litter cover ¹
18	R048AY231CO	M	N-S	E-T	M	S-M	S-M	N-S	S-M	E-T	N-S	S-M
19	R048AY231CO	M	N-S	M	M-E	N-S	N-S	N-S	S-M	E-T	N-S	N-S
20	R048AY231CO	M	N-S	M-E	E-T	M-E	N-S	N-S	S-M	M-E	N-S	N-S

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Table 23. Indicator ratings that contributed to the Hydrologic Function ratings for Sites 18, 19 and 20 (all 2021) in the Stevens Creek allotment (CURE).

Site ID	ESD Code	Attributes and Indicators									
		Biotic Integrity ¹	8. Soil surf. res. erosion ¹	9. Soil loss or degr. ¹	11. Comp. layer ¹	12. F/S groups ¹	13. Dead or dying plants ¹	14. Litter cover ¹	15. Ann. prod. ¹	16. Inv. plants ¹	17. Vigor ¹
18	R048AY231CO	M	N-S	S-M	N-S	M-E	N-S	S-M	–	N-S	N-S
19	R048AY231CO	M	N-S	S-M	N-S	E-T	N-S	N-S	–	N-S	S-M
20	R048AY231CO	M	N-S	S-M	N-S	E-T	N-S	N-S	–	N-S	M

¹ Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate (shaded gray); M-E = Moderate to extreme (shaded gray); E-T = Extreme to total (shaded gray).

Site 18 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a shallow, south-facing slope at an elevation of 2,306 m. Evidence of erosion and runoff was commonly observed at this location. Water-flow patterns (2) and pedestals (3) were extreme in patches and extensive throughout the site, and the crew noted that some water-flow patterns may be approaching gullies (5). Along with an almost complete lack of herbaceous plants outside of existing shrub canopies (10), these departures from reference contributed to the moderate ratings for Soil and Site Stability and Hydrologic Function. Altered composition of functional/structural groups (12) drove the moderate rating for Biotic Integrity. While the reference plant community is dominated by cool-season bunchgrasses, herbaceous plants were much less abundant than expected and the plant community was clearly shrub-dominated at the time of the assessment. Photo 9 shows an example of water-flow patterns (2) observed at this location.

Site 19 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a flat bench at an elevation of 2,306 m. Evidence of erosion and runoff was commonly observed at this location. Nearly all plants were located on slight pedestals (3) and water-flow patterns (2), while generally short, were common throughout the site. Along with an almost complete lack of herbaceous plants outside of existing shrub canopies (10), these departures from reference contributed to the moderate ratings for Soil and Site Stability and Hydrologic Function. Altered composition of functional/structural groups (12) drove the moderate rating for Biotic Integrity. While the reference plant community is dominated by cool-season bunchgrasses, herbaceous plants were nearly absent and the plant community was clearly shrub-dominated at the time of the assessment. Photo 10 shows the almost complete lack of herbaceous plants observed in the plant community (12) at this location.

Site 20 (2021) was associated with a *Dry Mountain Loam Gunnison Basin LRU* ecological site and was located on a flat bench at an elevation of 2,306 m. Evidence of erosion and runoff was commonly observed at this location. Extensive water-flow patterns (2) and pedestals (3) were observed throughout the site, and large patches of bare ground (4) were also common. The crew noted that some of these water flow patterns may be related to abandoned irrigation ditches. Along with the lack of herbaceous plants outside of existing shrub canopies (10), these indicators contributed to the moderate ratings for Soil and Site Stability and Hydrologic Function. Altered composition of functional/structural groups (12) and a relative lack of reproductive vigor among perennial plants (17) drove the moderate rating for Biotic Integrity. While the reference plant community is dominated by cool-season bunchgrasses, herbaceous plants were much less abundant than expected and the plant community was clearly shrub-dominated at the time of the assessment. The crew also noted that most shrubs lacked reproductive structures and may not be reproducing. Photo 11 shows an example of water-flow patterns (2) observed at this location.

4. Summary and Recommendations

4.1. Summary

Overall, rangeland health varied across the locations assessed, and the conditions in some allotments were more concerning than others. While many of the concerns we identified are specific to individual locations, there are some broad patterns that are worth considering in greater depth. For example, the Biotic Integrity of locations assessed in the Red Rock Canyon allotment is especially compromised. The herbaceous plant community at all the sites visited in this allotment was nearly entirely dominated by annual weeds, resulting in large departures from reference condition for this attribute (see Section 3.4.4). In addition, conditions at the locations assessed in the Stevens Creek allotment were also concerning, as demonstrated by the moderate average ratings for all three IIRH attributes among the sites visited in this allotment (Table 5). The sites in the Stevens Creek allotment were all characterized by an overall lack of perennial herbaceous plants, particularly in interspaces between established shrubs, and widespread evidence of erosion and runoff. While this phenomenon was consistent in this allotment, it also was found, to different degrees, across most assessment sites. The reference plant community identified in the Ecological Site Descriptions in most cases contained a significant perennial bunchgrasses layer, yet at only a handful of locations did the abundance of these important rangeland plants mirror that expectation. Outside of these issues, rangeland health was quite good in most cases, with the majority of attributes rated as none to slight or slight to moderate departures from reference (Table 3).

The overall lack of invasive species concerns outside of a few sites was striking and suggests that the rangelands assessed are somewhat less degraded than the cheatgrass-invaded rangelands that characterize much of the Intermountain West (Bradley et al., 2018). However, cheatgrass was present at low levels at or very near many locations, suggesting that it could become problematic in the future if the right conditions arise. This was particularly the case in the Sapinero Mesa allotment, where the crew noted that cheatgrass was abundant in patches on the slopes adjacent to Blue Mesa Reservoir but diminished further from the lake where the assessment sites were located. Colder, higher elevation areas like those included in this assessment are thought to be relatively more resistant to cheatgrass invasion (Chambers et al., 2014), but climate warming may lead to invasion at higher altitudes in the future and this has already been observed in several cases (Smith et al., 2021; Meador et al., 2012). In addition, some of the increased resistance to cheatgrass invasion at higher elevations is related to the greater abundance of perennial grasses these areas tend to support (Applestein and Germino, 2021; Davies and Johnson, 2017). Given that many sites had reduced bunchgrass abundance relative to reference condition, continuing to closely track the presence and spread of invasive annual grasses should be a monitoring priority. Efforts to restore or otherwise support perennial bunchgrasses could also reduce the likelihood of more significant invasion.

In the following sections, we discuss each of the broad concerns (plant communities dominated by annual invaders and a lack of perennial herbaceous plants along with evidence of erosion) in greater detail and offer recommendations for where and how to focus management and monitoring efforts. It is important to note, however, that these findings should be interpreted in the context of each individual assessment location and integrate a firm understanding of the specifics of the appropriate

ecological site. Ecological Site Descriptions are written to be valid across relatively wide regions but are often based on a handful of sampled reference locations. Thus, for example, the dominance of a species at a site where the ESD indicates it should be a relatively minor component of the plant community is not always indicative of compromised Biotic Integrity but may instead be simply a bioregional quirk. These quirks are ultimately rare among the assessed sites, and the qualitative nature of IIRH allows them to be accounted for in final attribute ratings, but care should nonetheless be taken in drawing management conclusions.

We want to reiterate that NPS chose the IIRH assessment locations, and the authors of this report were not fully informed of the selection criteria. These criteria may limit how the assessment applies to a broader area, so the discussion to follow is pertinent only to the sites assessed. Extrapolation to larger areas (if appropriate) can only be carried out by the individuals who know the criteria used to select the sites. Lacking a full understanding of current and historical management also limits our ability to make specific management and monitoring recommendations. If managers decide to pursue opportunities to change management in response to the findings of this assessment, information from other sources should first be sought, and we recommend that any available monitoring, inventory, and assessment data, along with information pertinent to the areas of interest (e.g., management history), be compiled and used to guide management decisions.

4.2. Sites with Plant Communities Dominated by Exotic Annuals

Three IIRH assessment locations were identified as sites with herbaceous plant communities dominated by exotic annual plants. All of these locations were located in the Red Rock Canyon allotment (Sites 6–8), and the exotic annuals included cheatgrass (*B. tectorum*) and non-native mustards (*Sisymbrium* spp.). Three different ecological sites were represented among these locations (Table 8), with the reference plant community comprised of pinyon-juniper woodland at one location (Site 6) and perennial shrubland/grassland at the other two (Sites 7 and 8).

The expected dominant and sub-dominant functional/structural groups were greatly reduced or missing at all of the sites in this group and, while we can only speculate due to our lack of historical information, site characteristics suggested that the condition of these locations may be related to management history. At these sites, flatter areas tended to be composed of near complete monocultures of invasive annuals, while areas with greater slope tended to support communities with more abundant native perennial plants. The assessments considered only the flatter areas to avoid including obvious community transitions in the assessment area, but relatively less-invaded slopes can be seen nearby in the directional photos taken at Sites 7 and 8. Photo 12 (Appendix D) shows a relatively uninvaded sagebrush-dominated plant community on a slope near the heavily invaded and flatter area assessed at Site 8. Soil compaction was also identified as a concern at Sites 6 and 8, which further suggests that rangeland health may be impacted by current or historical agricultural land-use that requires equipment that can uniformly compact soil.

The near complete lack of the expected vegetation community at these locations suggests that it may be extremely difficult to improve conditions at these sites. It is likely that some combination of both invasive plant control and revegetation would be necessary to begin recovering a desirable plant community. Several herbicides are commonly used to control invasive annual grasses and forbs, with

varying degrees of success (e.g., James et al., 2015; Kessler et al., 2015; McIver et al., 2014; Munson et al., 2015; Pyke et al., 2014). The relatively new herbicide indaziflam (Rejuvra®, Bayer) has shown promise for controlling invasive annuals for several years with a single application (Courkamp and Meiman, 2020; Sebastian et al., 2017; Sebastian et al., 2016) and was recently labeled for use in rangelands grazed by livestock (EPA, 2020). However, managers should use caution if considering indaziflam treatment in conjunction with other restoration efforts because indaziflam may impact desirable native plants seeded into treated areas if the appropriate plant back interval is not observed. It may be possible to increase the pace of restoration by protecting desirable seeds from herbicide using seed coatings (Terry et al., 2021; Holfus et al., 2021), but large scale applications of this technology have not yet been evaluated in rangeland ecosystems. Regardless of specifics, active restoration is likely necessary to shift plant communities towards more abundant desirable plants, but a restoration plan is beyond the scope of this assessment.

4.3. Sites with Few Native Perennial Bunchgrasses and Evidence of Erosion and Runoff

To varying degrees, most of the locations included in this assessment featured a plant community relatively more shrub-dominated and less perennial grass-dominated than expected based on the reference community. In the most extreme cases, when perennial herbaceous plants were nearly absent despite being identified as the dominant component of the reference plant community, this lack of perennial grasses was often accompanied by substantial evidence of erosion. Among the compromised sites, the three locations assessed in the Stevens Creek allotment (Sites 18–20), Site 7 in the Iola allotment, and Site 16 in the Sapinero Mesa allotment represented the most compromised locations in this group. All of these sites were characterized by a single ecological site (R048AY231CO; *Dry Mountain Loam*), with a reference plant community dominated by perennial bunchgrasses.

At these locations, perennial herbaceous plants were particularly lacking in interspaces between established perennial shrubs, which is likely to promote erosion and runoff from these areas during precipitation events. Further, this may indicate that heavy utilization has favored plants with the added protection from herbivory provided by the structure of woody shrubs because in many cases there were at least some grasses growing within established shrub canopies. We caution against assuming that contemporary grazing management is directly to blame. It is often difficult to disentangle the effects of historical grazing intensity, which typically was extreme (Borman, 2005), from those of contemporary use, and moderate grazing does not appear to hinder the long-term recovery of herbaceous plants in degraded sagebrush communities (Copeland et al., 2021; Morris and Leger, 2016).

Given that herbivory, both by livestock and wildlife, has complex effects on plant communities that depend on the timing, intensity, and frequency of defoliation (Davies and Boyd, 2020), we are unable to make further recommendations without understanding how these impacted sites have been managed in the past. For areas grazed by domestic livestock, managers (both NPS and permittees) familiar with the current and historic livestock grazing management may be able to identify opportunities to promote the recruitment and growth of perennial grasses by altering livestock

grazing management. If so, livestock grazing management should ensure that perennial grasses have an opportunity to grow or regrow in the absence of herbivory at some point during the growing season. Monitoring efforts then must be able to quantify changes in species composition and capture information about annual grazing management and other factors that influence plant growth. If herbivores other than domestic livestock are important at particular sites, monitoring should be conducted in a way that allows managers to estimate the impacts of various groups of herbivores.

Beyond alterations to grazing management, it will likely be difficult to improve the conditions of the plant community and reduce or halt erosion at these locations without active restoration. In all cases, plant communities continued to support abundant mature shrubs that may provide valuable habitat for sensitive wildlife species (e.g., Gunnison sage-grouse). Maintaining these shrubs presents challenges to the more active types of restoration with the potential to restore the abundant perennial grasses that dominate the reference plant community (e.g., drill seeding). However, managers may consider actively adding perennial grass seeds to the worst of the sites in this group in a manner that does not disturb established plants (e.g., hand or aerial seeding), and there may be potential to opportunistically restore areas where wildfires, or other disturbances, reduce the abundance of mature shrubs.

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Appendix A. Indicator Result Maps

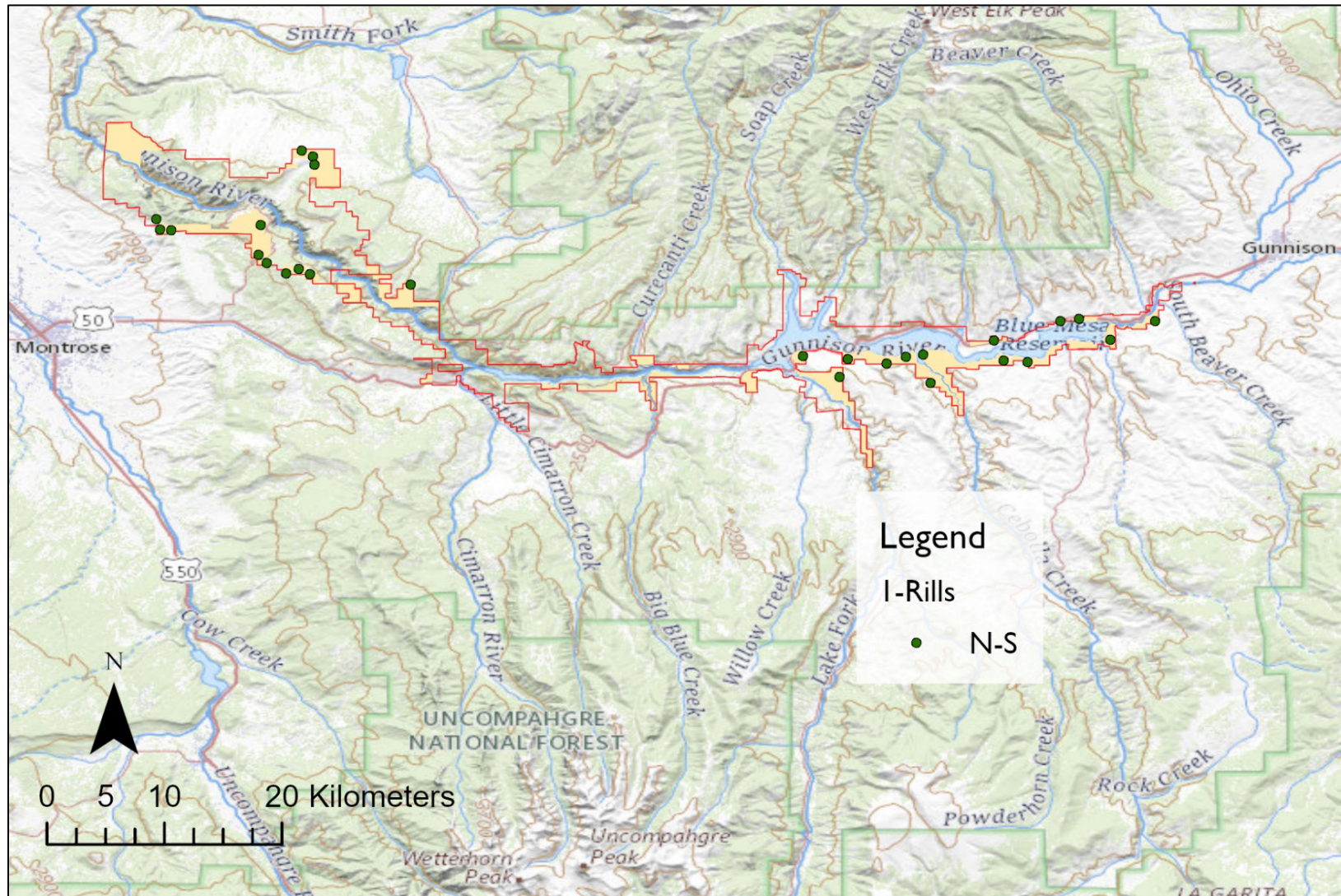


Figure A1. IIRH assessment ratings for indicator #1, rills. Rating: N-S = None to slight.

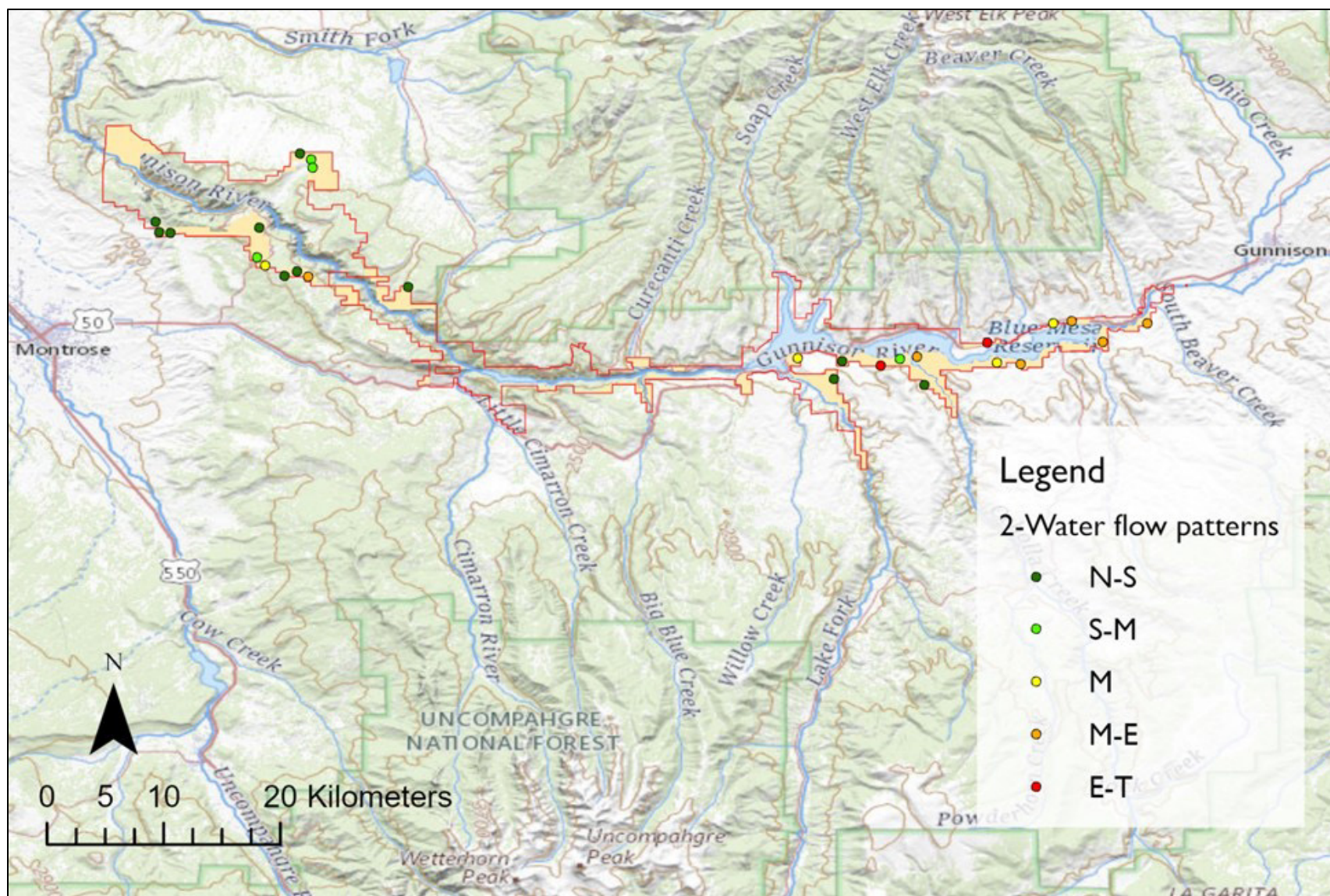


Figure A2. IIRH assessment ratings for indicator # 2, water flow patterns. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

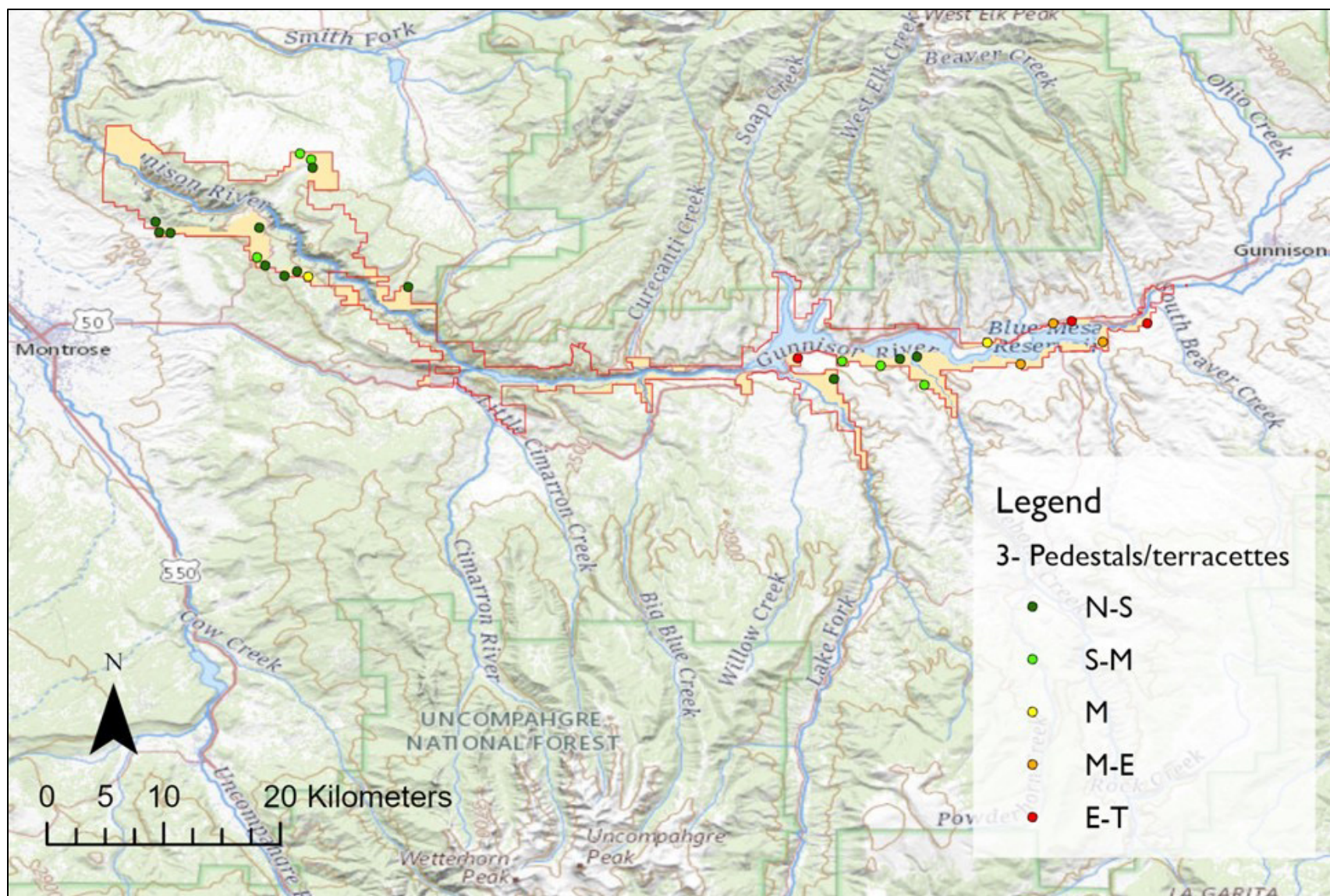


Figure A3. IIRH assessment ratings for indicator #3, pedestals and/or terraces. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

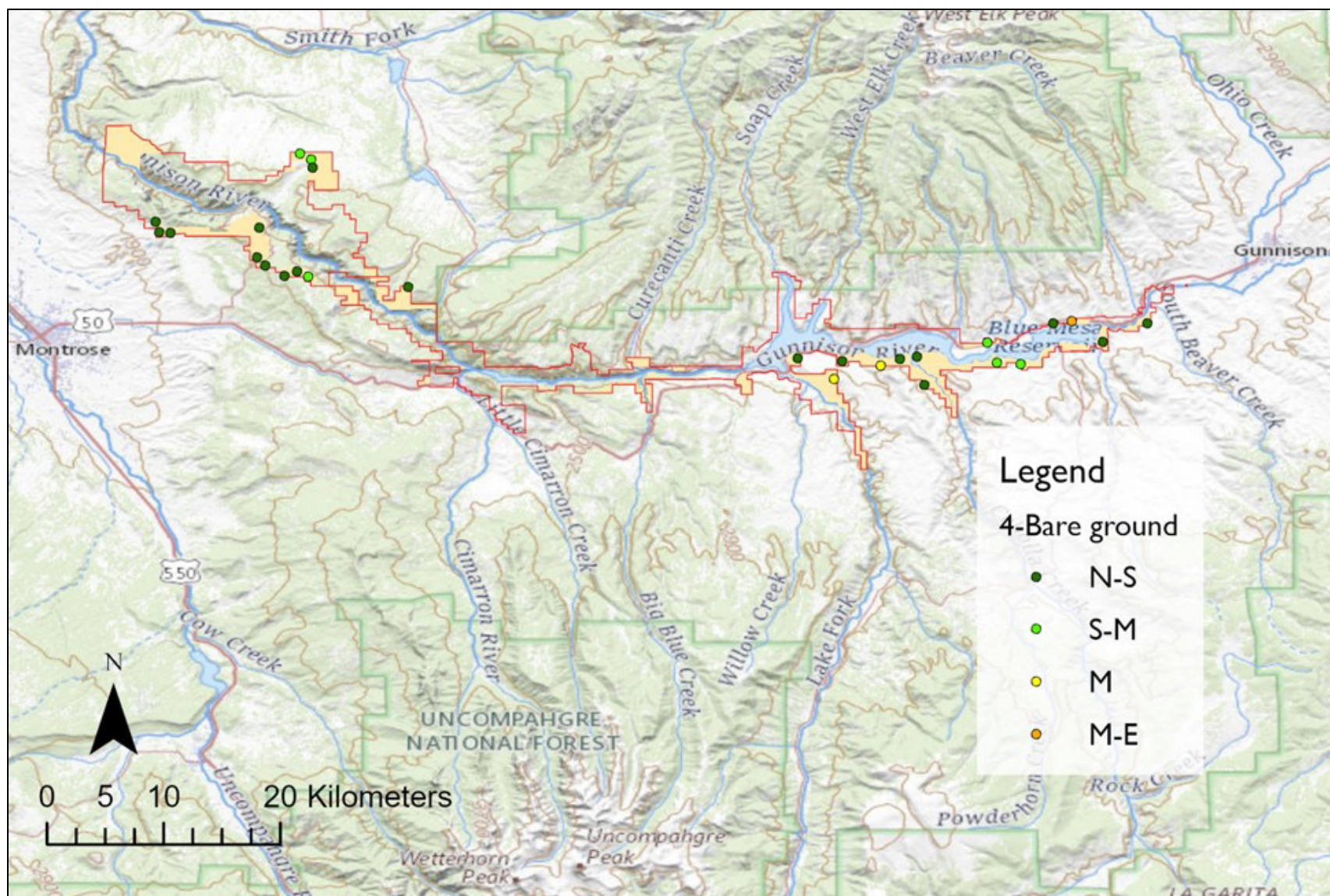


Figure A4. IIRH assessment ratings for indicator #4, bare ground. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme.

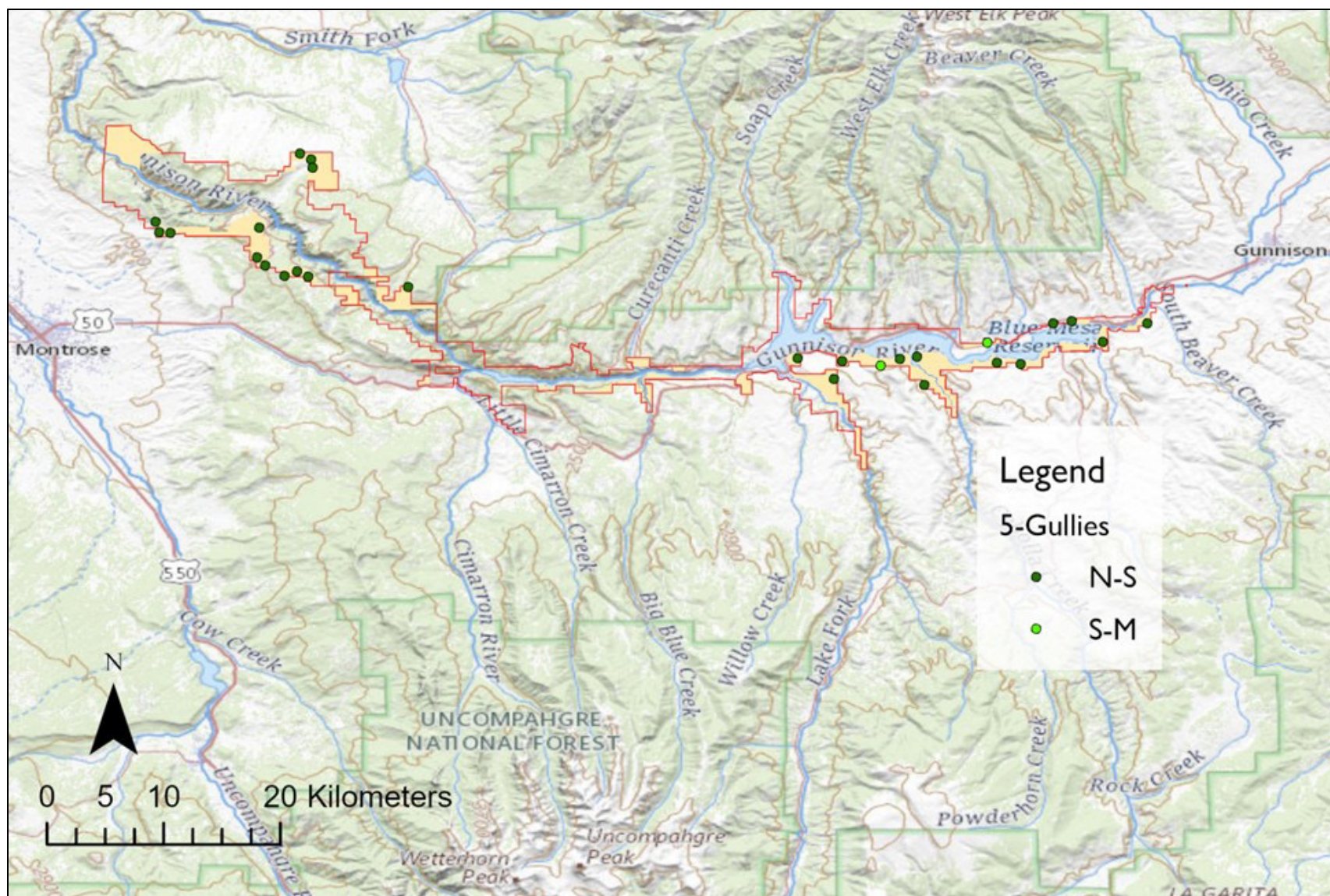


Figure A5. IIRH assessment ratings for indicator #5, gullies. Rating: N-S = None to slight; S-M = Slight to moderate.

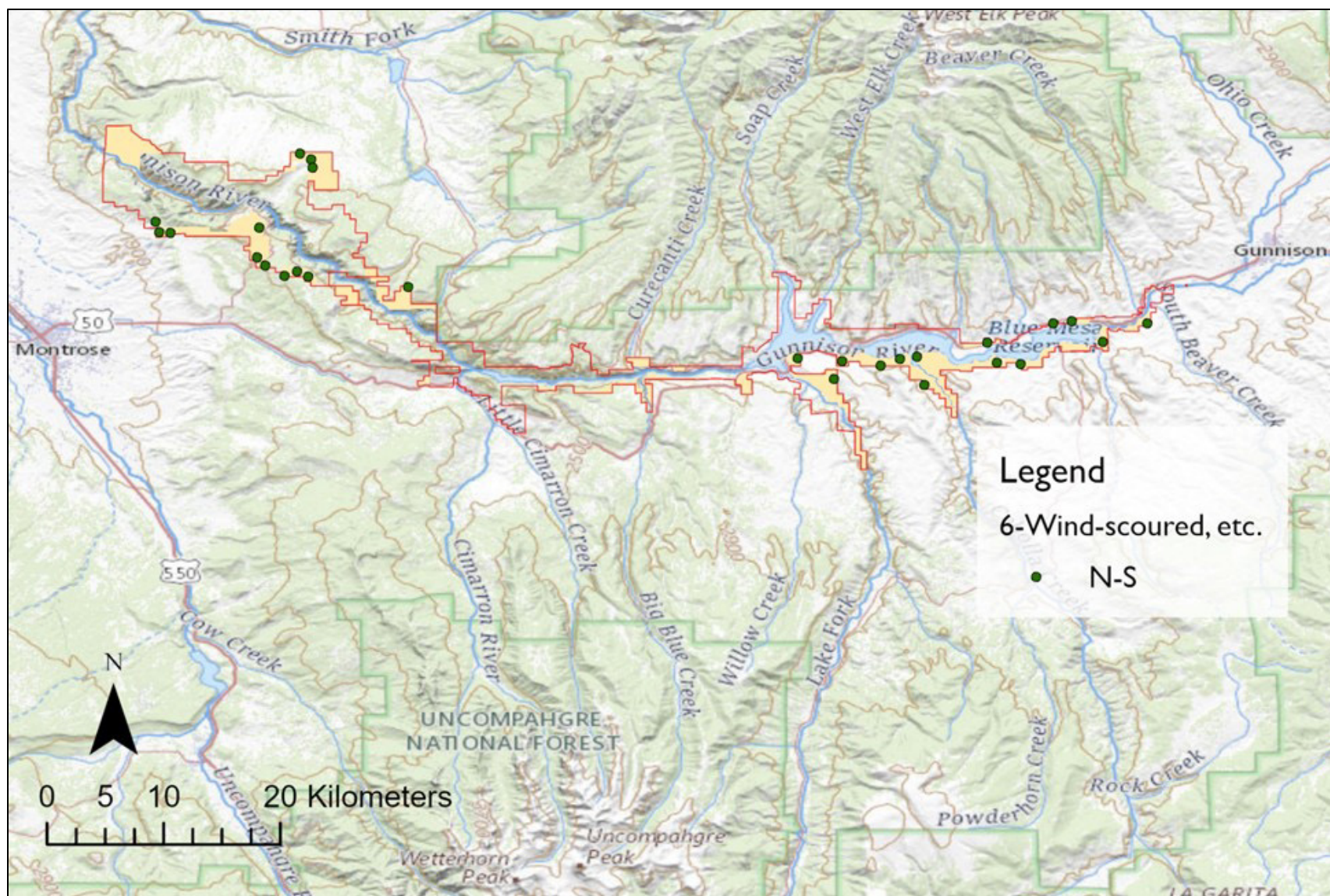


Figure A6. IIRH assessment ratings for indicator #6, wind-scoured areas, blowouts, and/or deposition areas. Rating: N-S = None to slight.

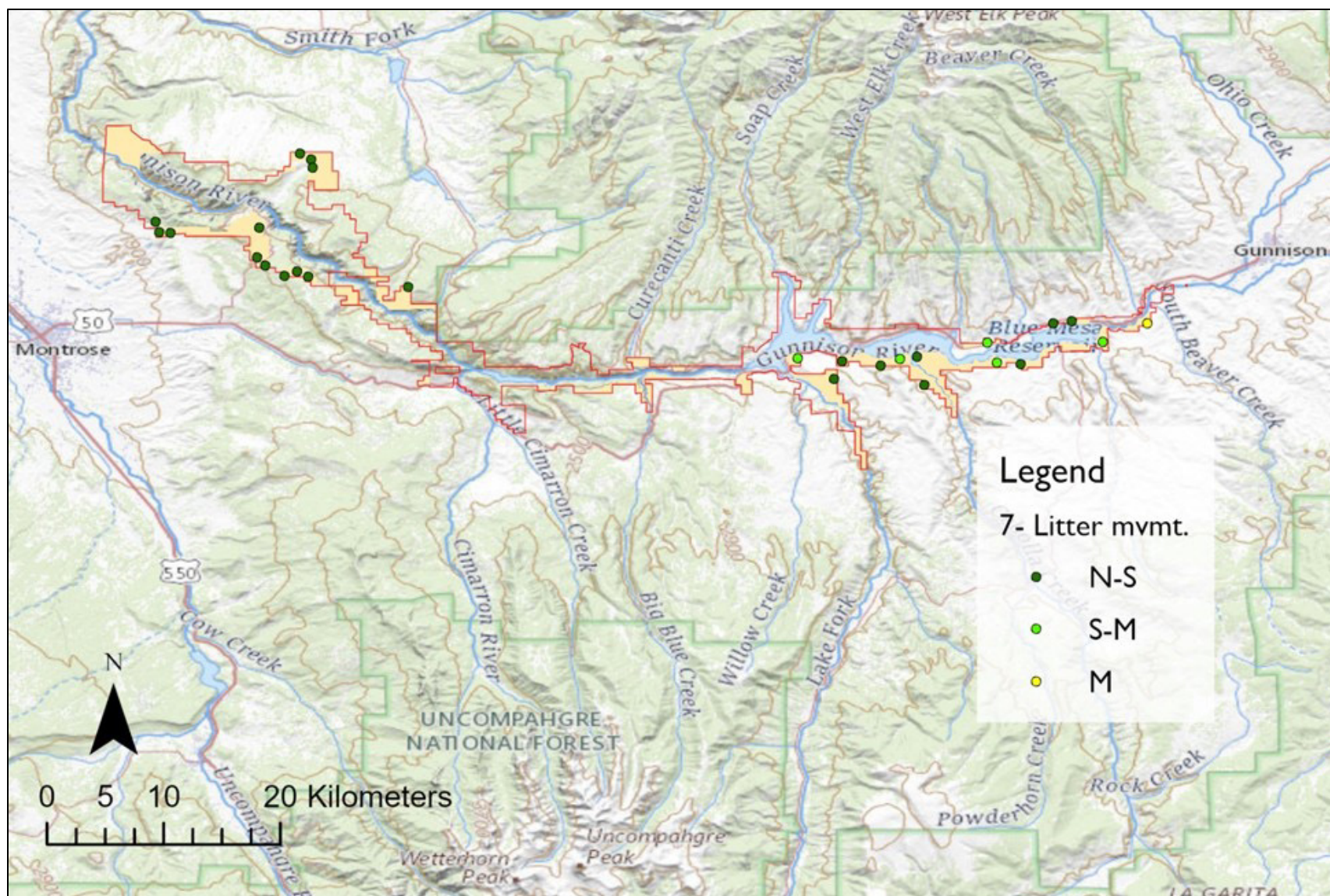


Figure A7. IIRH assessment ratings for indicator #7, litter movement. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

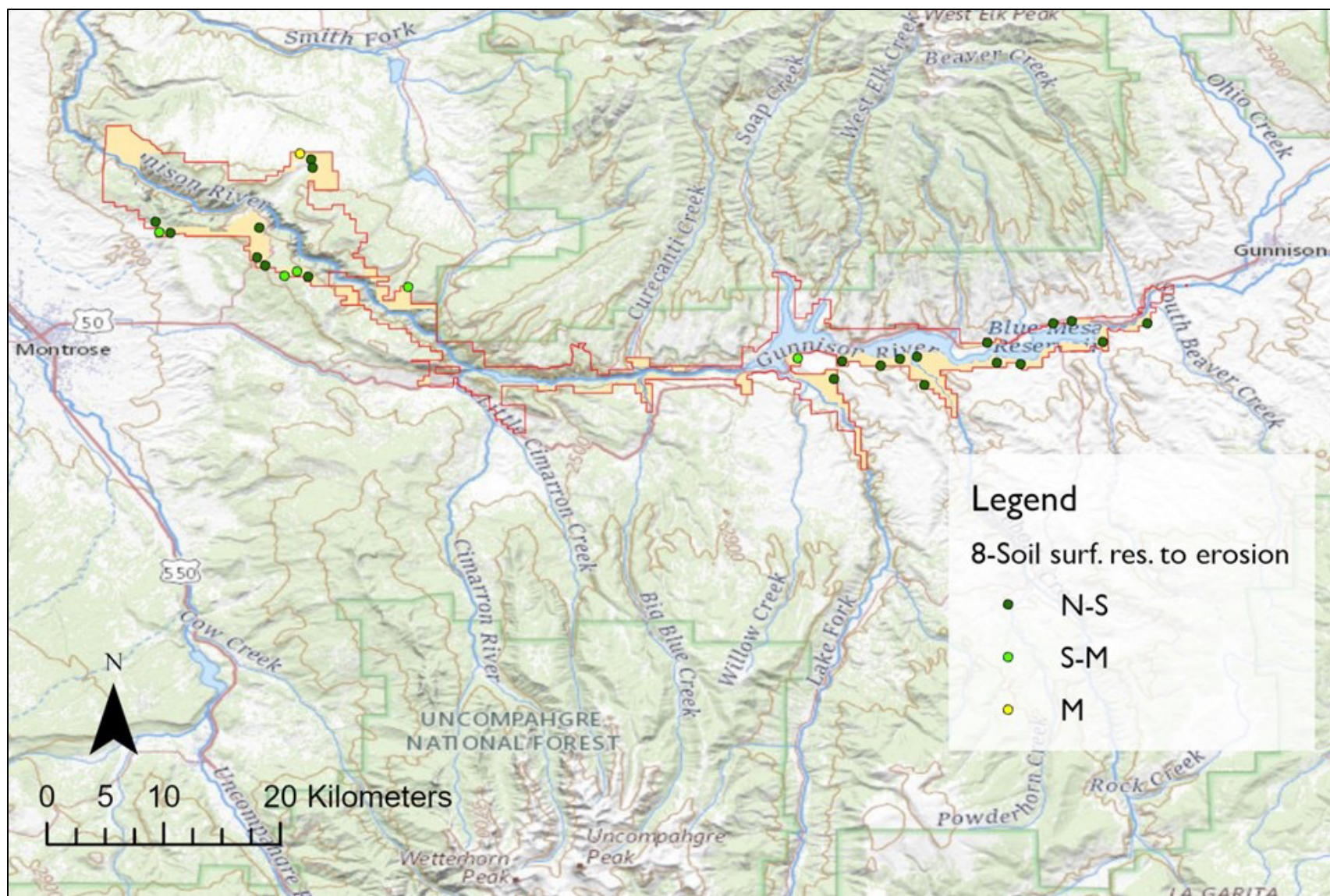


Figure A8. IIRH assessment ratings for indicator #8, soil surface resistance to erosion. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

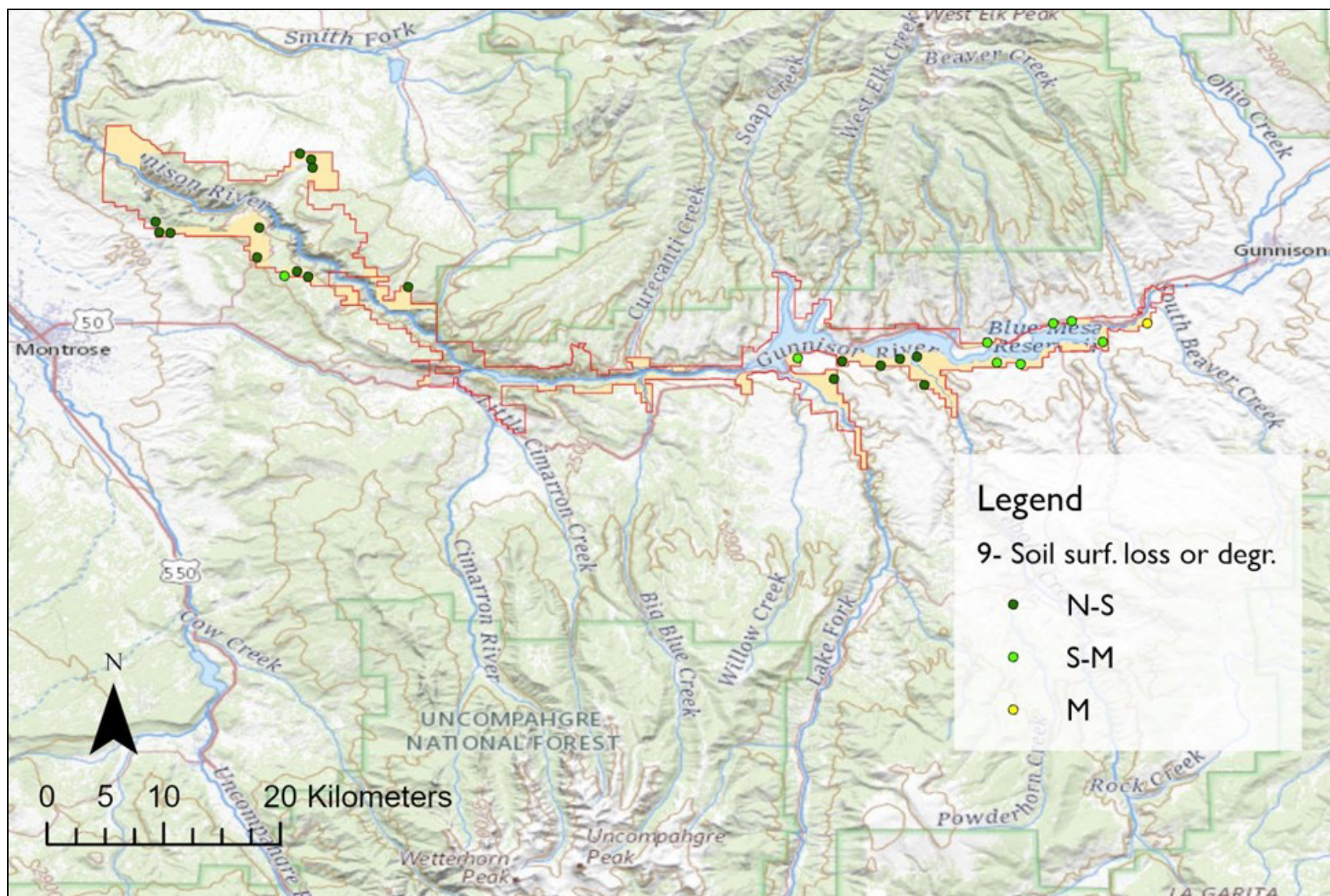


Figure A9. IIRH assessment ratings for indicator #9, soil surface loss or degradation. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

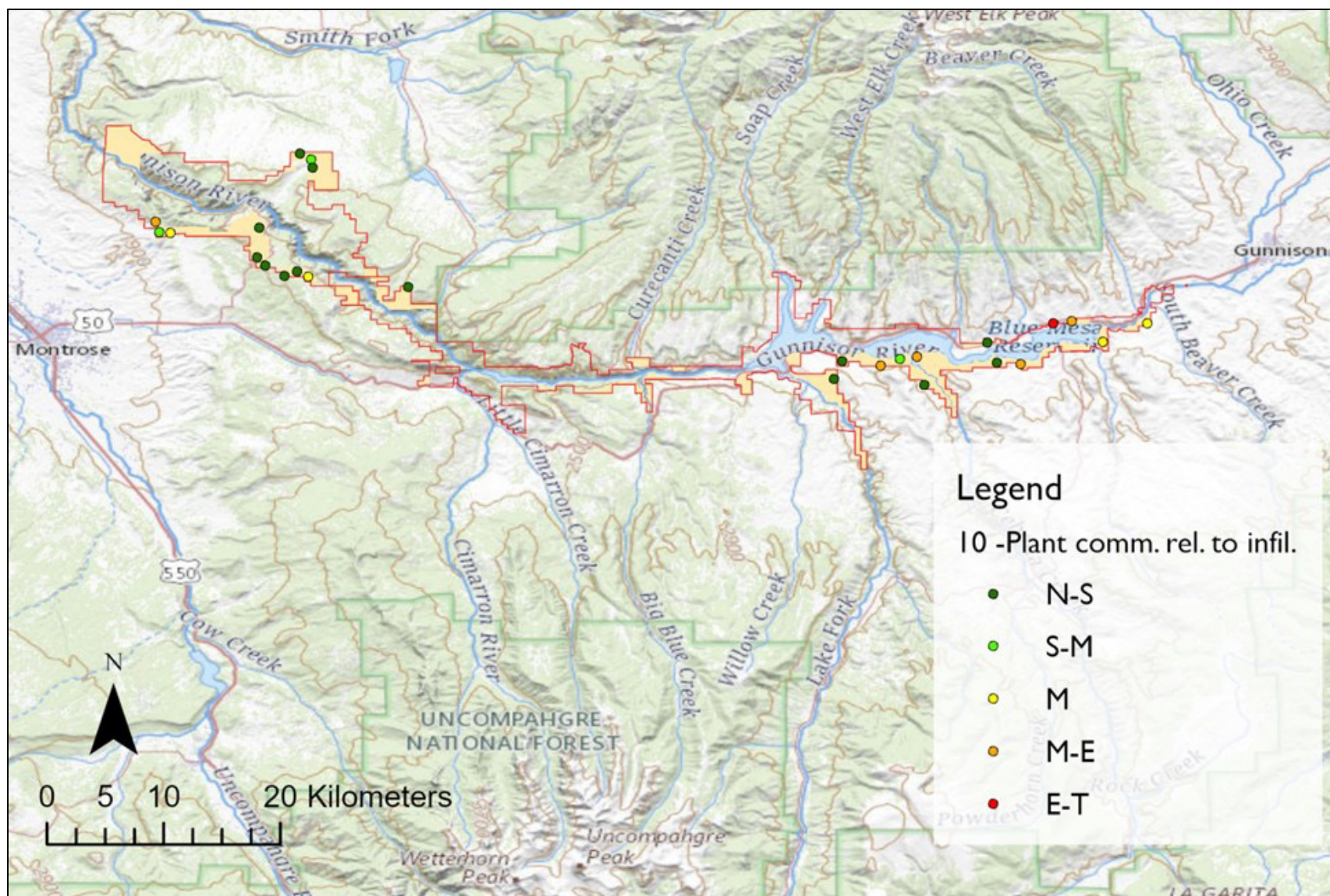


Figure A10. IIRH assessment ratings for indicator #10, plant community composition and distribution relative to infiltration and runoff. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

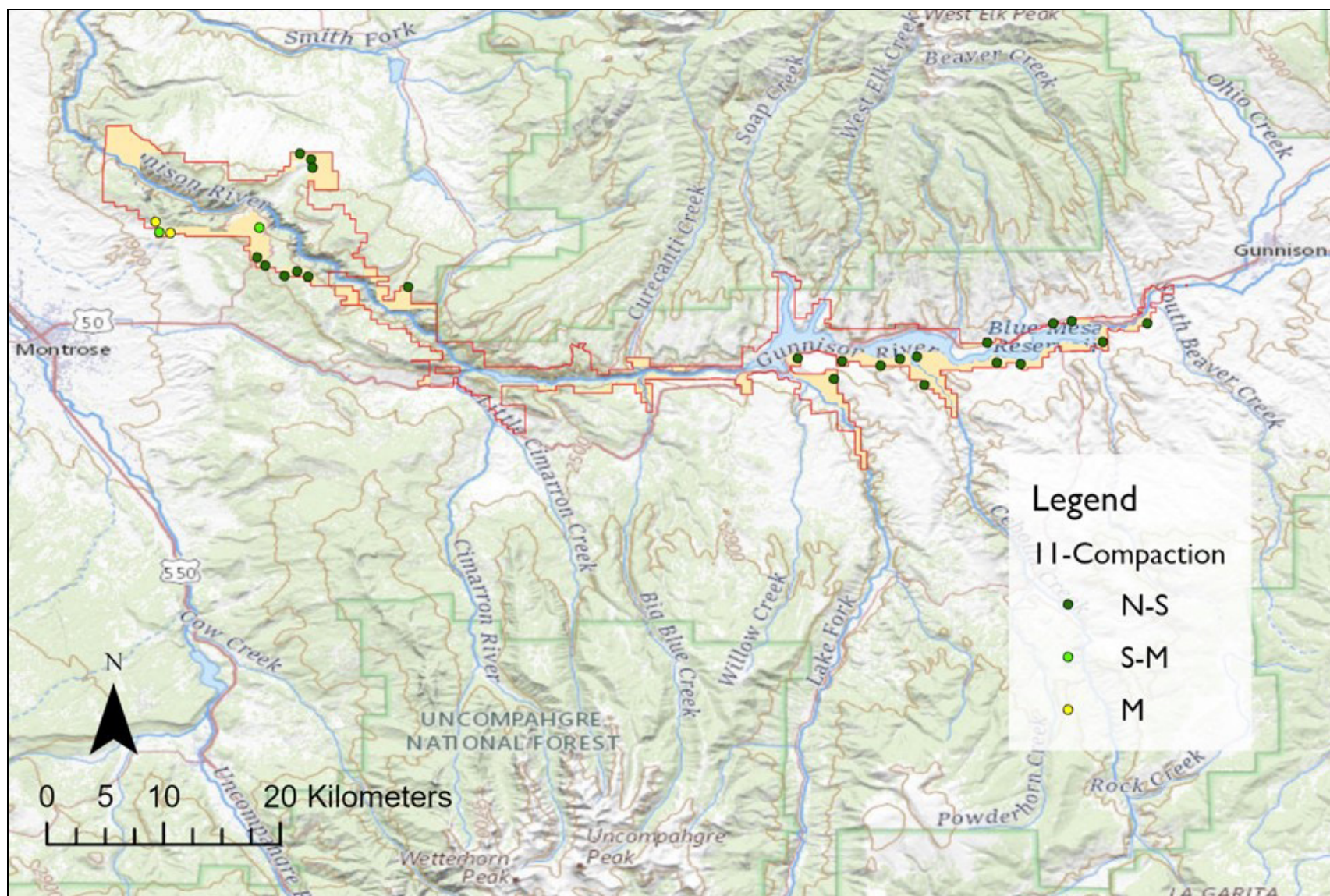


Figure A11. IIRH assessment ratings for indicator #11, compaction. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

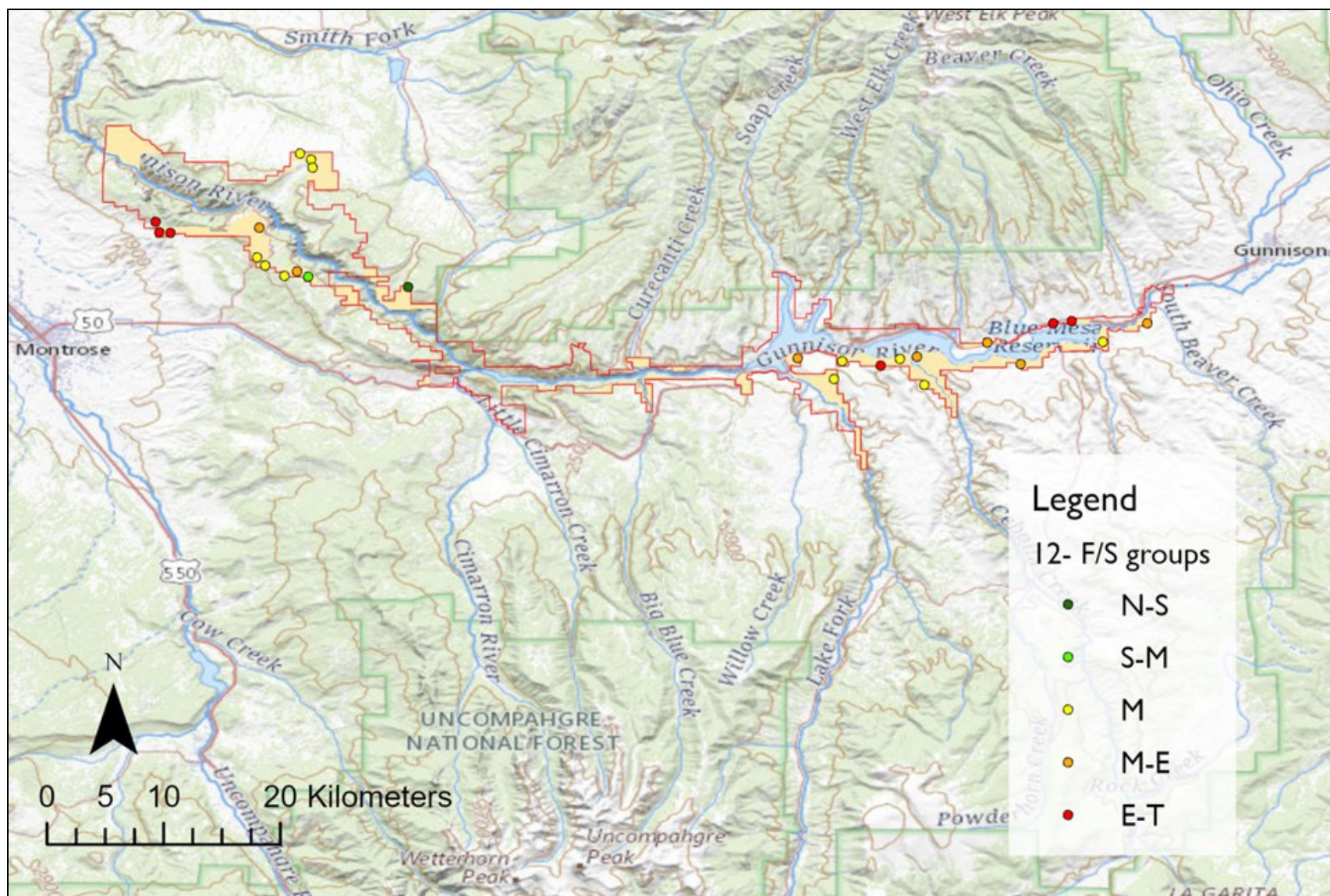


Figure A12. IIRH assessment ratings for indicator #12, functional/structural groups. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

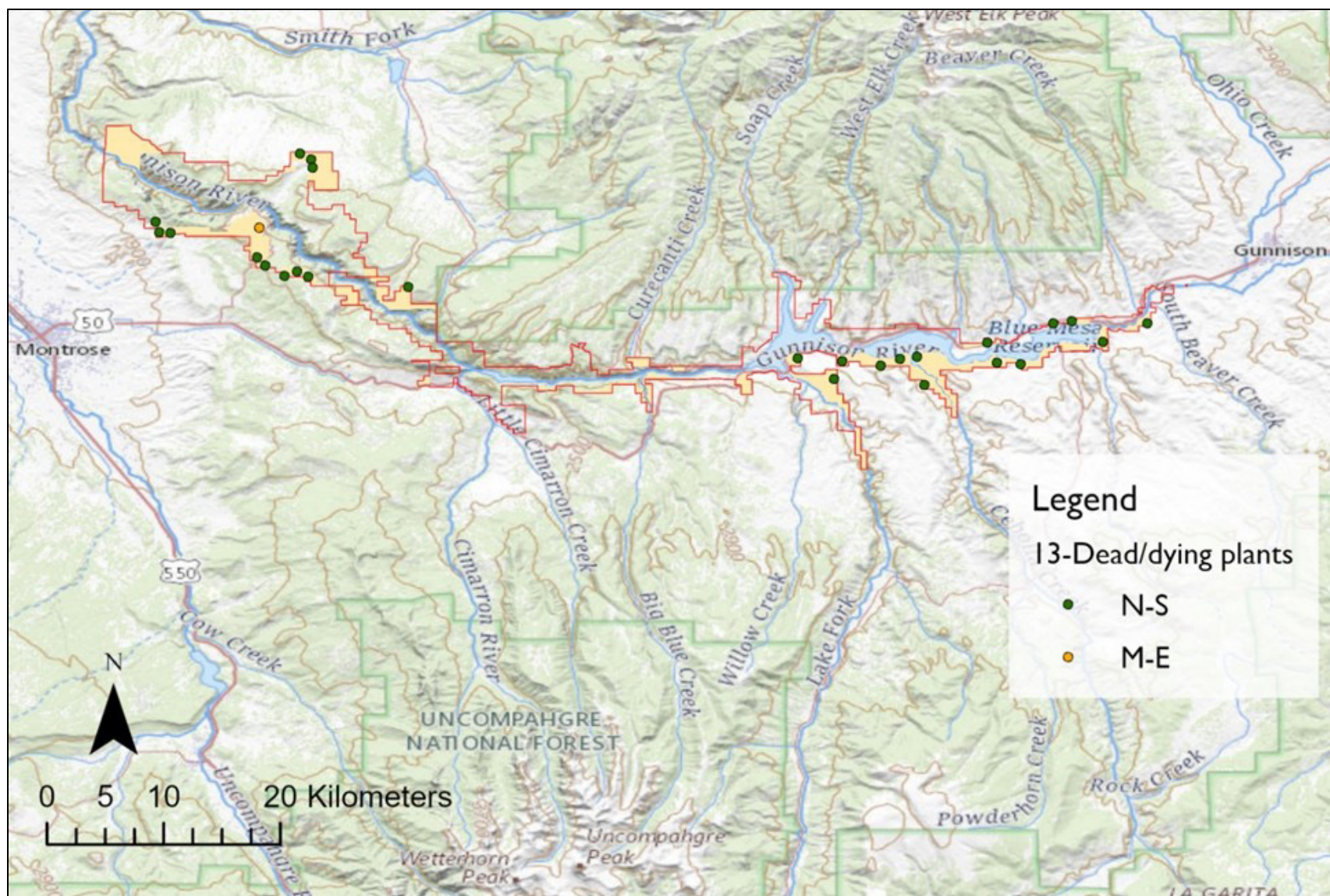


Figure A13. IIRH assessment ratings for indicator #13, dead or dying plants or plant parts. Rating: N-S = None to slight; M-E = Moderate to extreme.

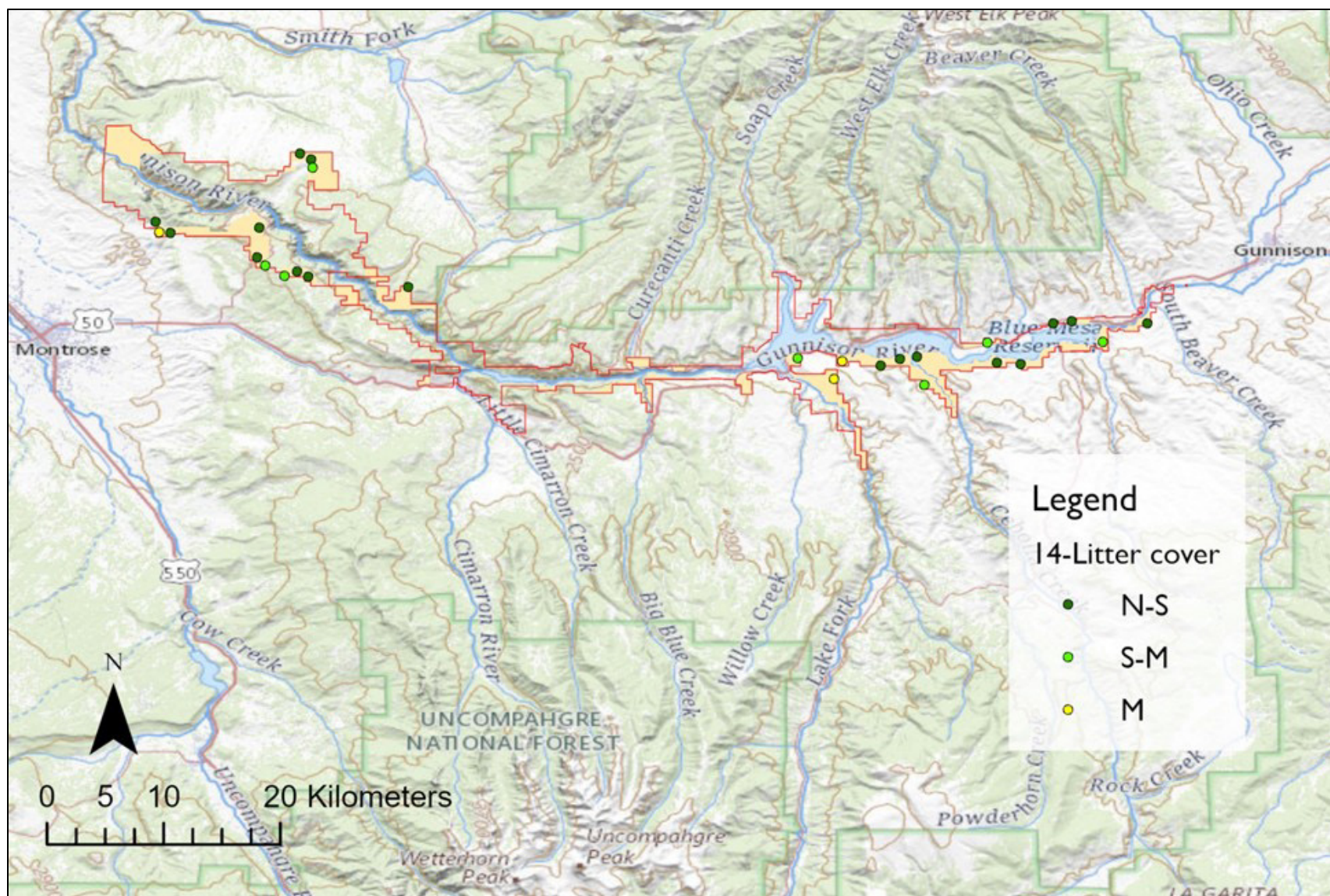


Figure A14. IIRH assessment ratings for indicator #14- litter cover and depth. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

Note that Figure A15, representing annual production, is absent for reasons noted in the main text.

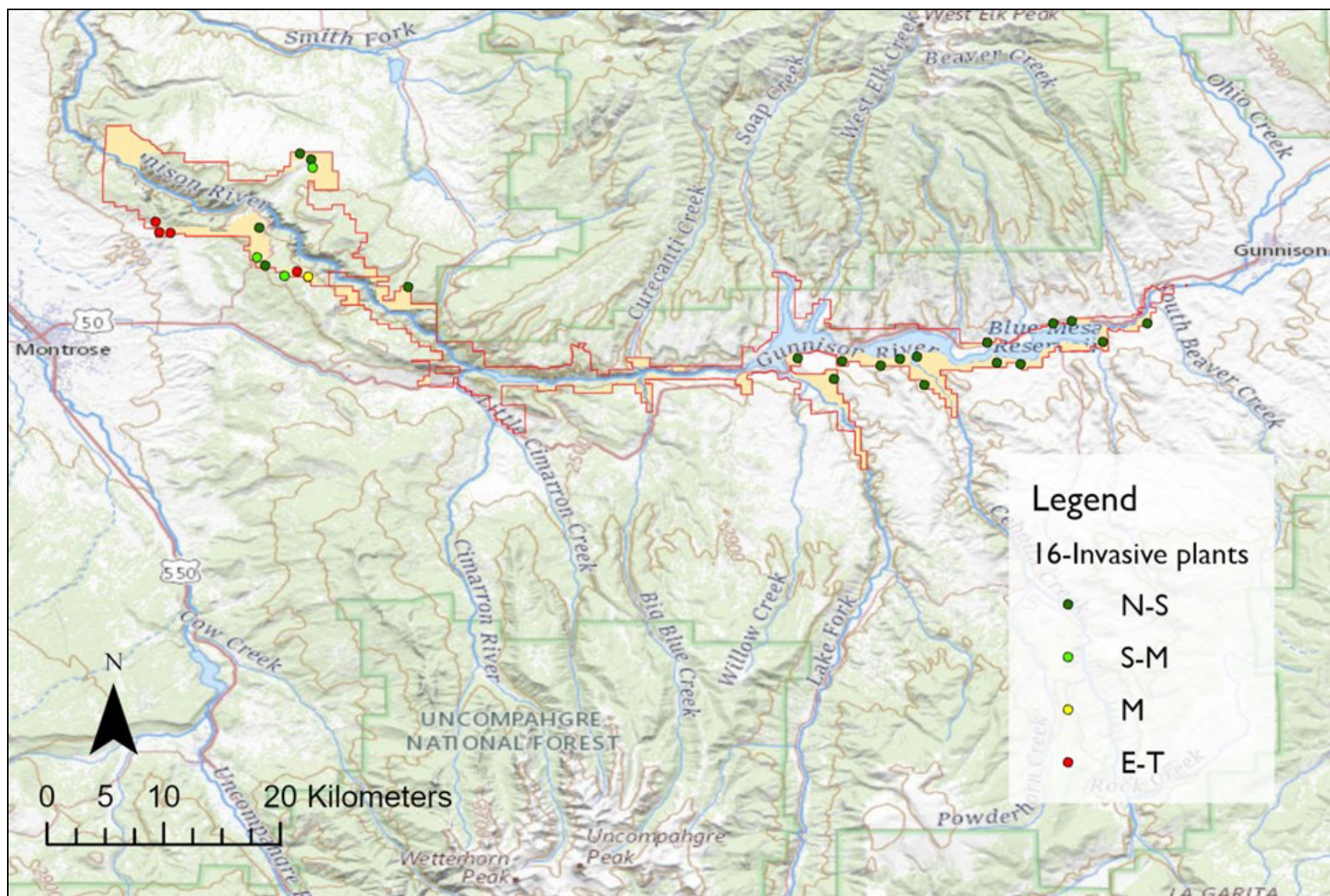


Figure A16. IIRH assessment ratings for indicator #16, invasive plants. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; E-T = Extreme to total.

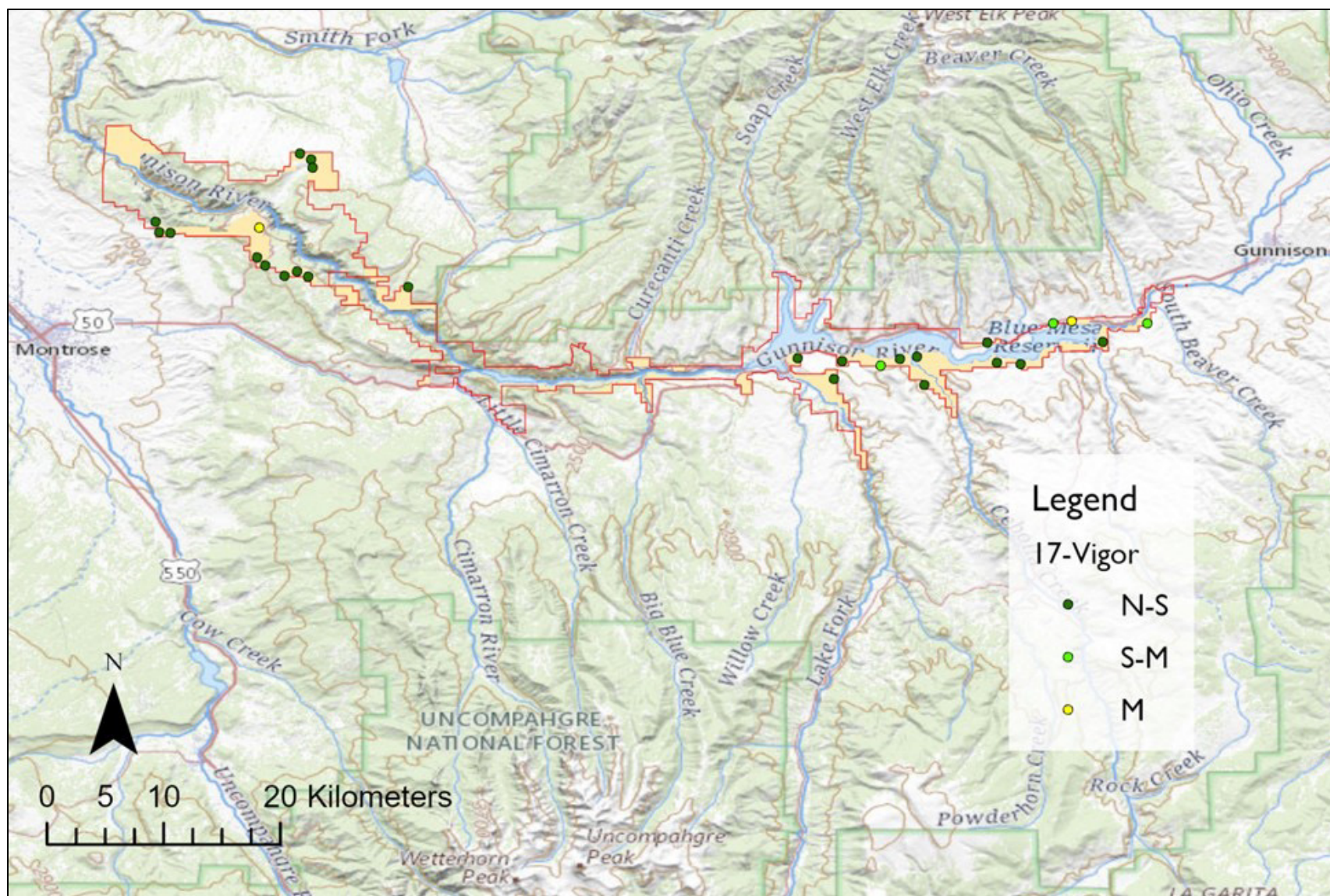


Figure A17. IIRH assessment ratings for indicator #17, vigor with an emphasis on reproductive capability of perennial plants. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

Appendix B. Attribute Result Maps

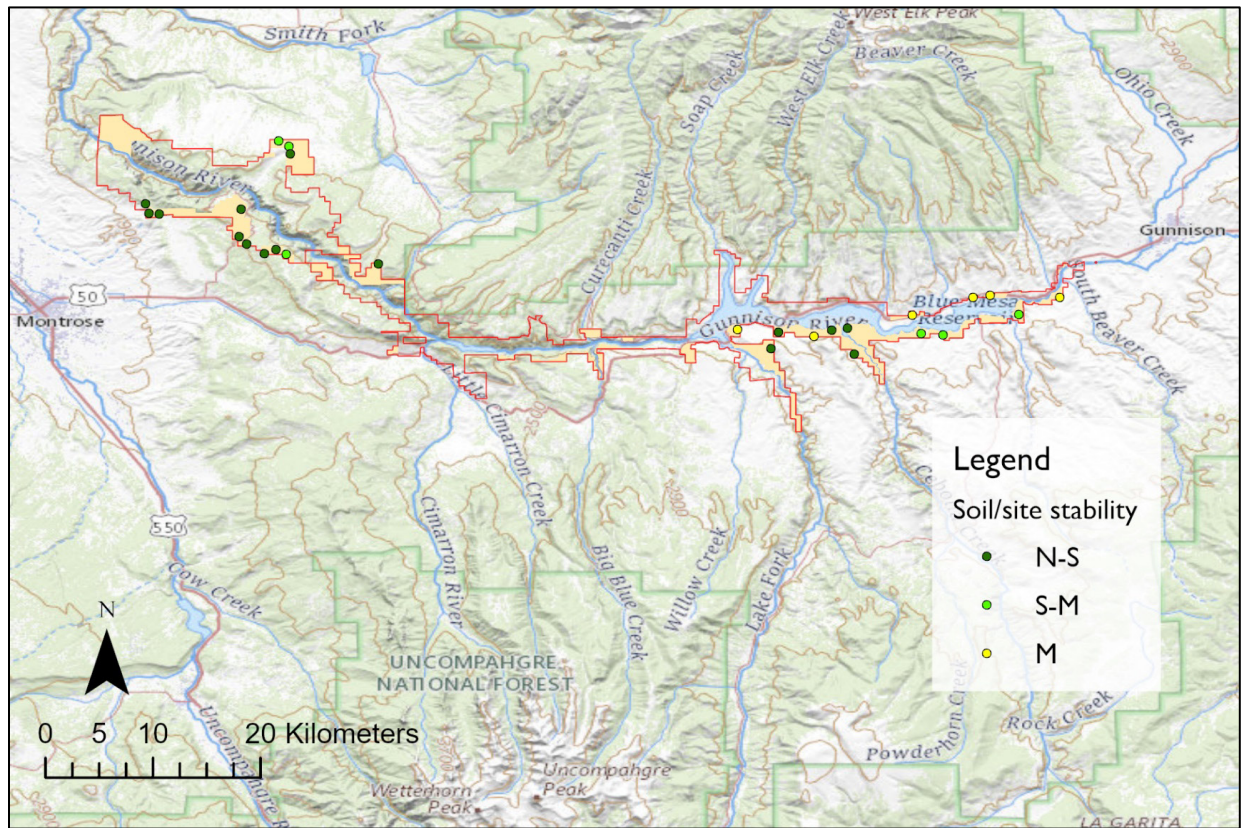


Figure A18. IIRH assessment ratings for the attribute Soil and Site Stability. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

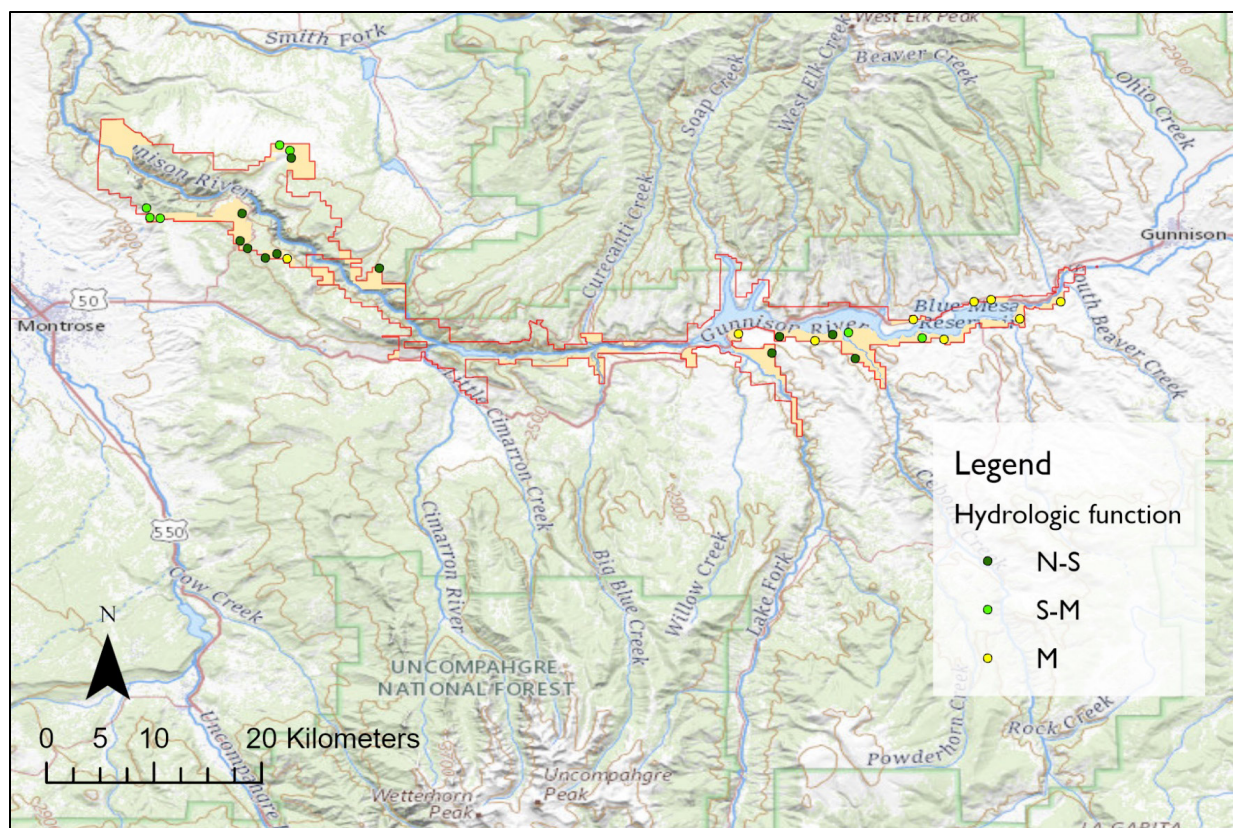


Figure A19. IIRH assessment ratings for the attribute Hydrologic Function. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate.

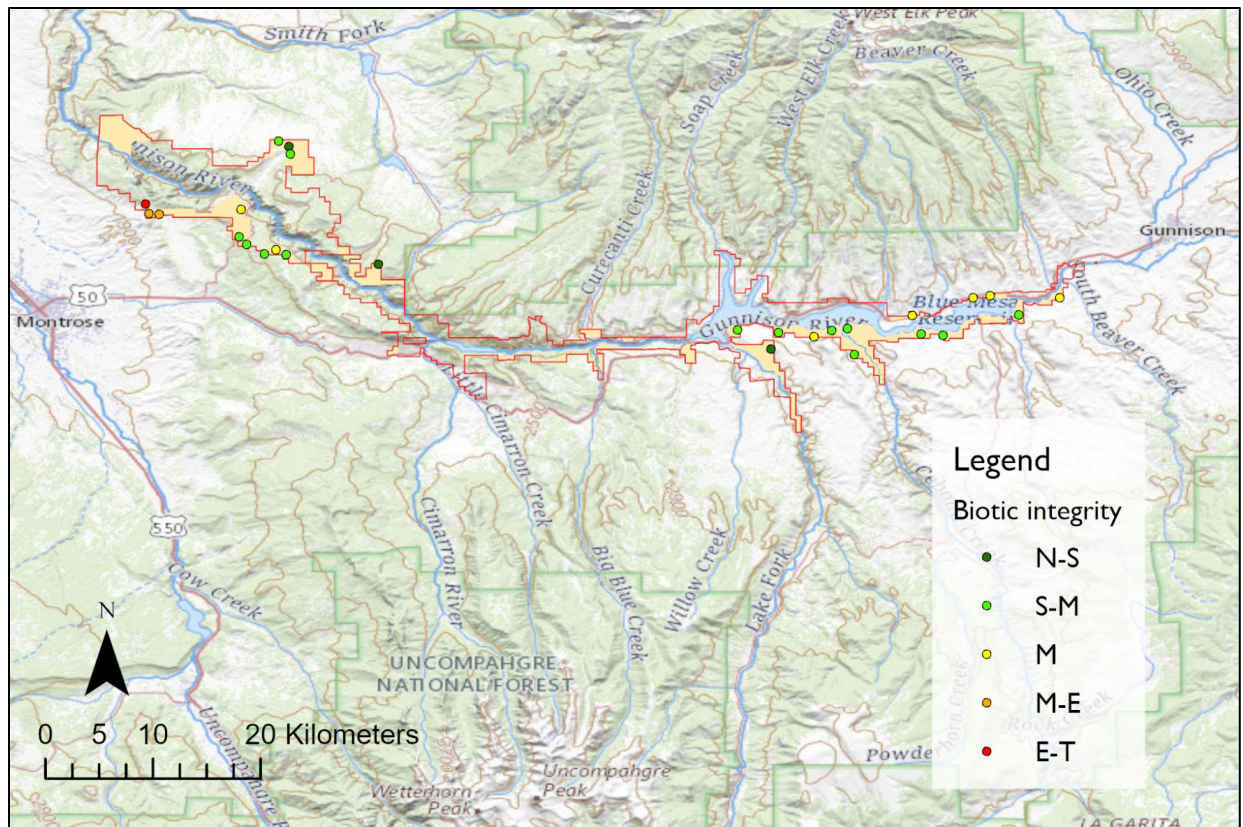


Figure A20. IIRH assessment ratings for the attribute Biotic Integrity. Rating: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total.

Appendix C. Summary Data

Table C1. Metadata for assessment sites.

Assessment	Site ID	Date	UTM ¹ (easting)	UTM ¹ (northing)	Elevation (m)	Allotment	ESD code	Method
2021 Assessment (IIRH v. 4)	1	7/9/2021	266902	4277962	2398	Green Mountain	R034BY306UT	IIRH
	2	7/9/2021	267604	4277437	2412	Grizzly Gulch	R034BY306UT	IIRH
	3	7/9/2021	267699	4276713	2369	Grizzly Gulch	R034BY306UT	IIRH
	4	7/8/2021	273821	4266380	2580	Spring Gulch	R048AY238CO	IIRH
	6	7/10/2021	309775	4259136	7644	Iola	–	DIRH
	7	7/11/2021	323386	4262005	2397	Iola	R048AY231CO	IIRH
	8	7/11/2021	320350	4260464	2324	Iola	R048AY231CO	IIRH
	9	7/6/2021	314787	4258737	2353	Iola	R048AY231CO	IIRH
	10	7/10/2021	307848	4259544	2323	Iola	R048AY231CO	IIRH
	11	7/6/2021	313214	4258856	2353	Iola	R048AY231CO	IIRH
	12	7/7/2021	306692	4259379	2323	Sapinero Mesa	R048AY231CO	IIRH
	13	7/5/2021	302805	4259236	2376	Sapinero Mesa	R048AY231CO	IIRH
	14	7/8/2021	299820	4259618	2367	Sapinero Mesa	R048AY231CO	IIRH
	15	7/11/2021	308279	4257093	2395	Sapinero Mesa	R048AY231CO	IIRH
	16	7/7/2021	305402	4258843	2398	Sapinero Mesa	R048AY231CO	IIRH
	17	7/11/2021	302242	4257759	2657	Sapinero Mesa	R048AY231CO	IIRH
	18	7/12/2021	312604	4260633	2306	Stevens Creek	R048AY231CO	IIRH
	19	7/11/2021	317073	4262142	2306	Stevens Creek	R048AY231CO	IIRH
	20	7/11/2021	318334	4262294	2306	Stevens Creek	R048AY231CO	IIRH

¹ All coordinates UTM Zone 13 S.

Table C1 (continued). Metadata for assessment sites.

Assessment	Site ID	Date	UTM ¹ (easting)	UTM ¹ (northing)	Elevation (m)	Allotment	ESD code	Method
2019 Assessment (IIRH v. 5)	1	7/2/2019	264298	4268497	2486	Vernal Mesa	R048AY247CO	IIRH
	2	7/2/2019	0263767	4269178	2460	Vernal Mesa	R048AY238CO	IIRH
	4	7/1/2019	263979	4271728	2846	Vernal Mesa	R048AY247CO	IIRH
	6	7/3/2019	0257976	4231472	2088	Red Rock Canyon	R036XY287CO	IIRH
	7	7/3/2019	0257273	4271559	2014	Red Rock Canyon	R036XY289CO	IIRH
	8	7/3/2019	0257042	4272405	2056	Red Rock Canyon	R036XY284CO	IIRH
	9	7/5/2019	0265568	4267575	2606	East Portal	R048AY247CO	IIRH
	10	7/4/2019	0266398	4267918	2548	East Portal	R048AY238CO	IIRH
	11	7/4/2019	0267125	4267461	2517	East Portal	R048AY238CO	IIRH

¹ All coordinates UTM Zone 13 S.

Table C2. Attribute ratings for sites assessed using IIRH.

Assessment	Site ID	Attribute ^{1,2}		
		S	H	B
2021 Assessment (IIRH v. 4)	1	S-M	S-M	S-M
	2	S-M	S-M	N-S
	3	N-S	N-S	S-M
	4	N-S	N-S	N-S
	7	M	M	M
	8	S-M	M	S-M
	9	S-M	M	S-M
	10	N-S	S-M	S-M
	11	S-M	S-M	S-M
	12	N-S	N-S	S-M
	13	N-S	N-S	S-M
	14	M	M	S-M
	15	N-S	N-S	S-M
	16	M	M	M
	17	N-S	N-S	N-S
	18	M	M	M
	19	M	M	M
	20	M	M	M
2019 Assessment (IIRH v. 5)	1	N-S	N-S	S-M
	2	N-S	N-S	S-M
	4	N-S	N-S	M
	6	N-S	S-M	M-E
	7	N-S	S-M	M-E
	8	N-S	S-M	E-T
	9	N-S	N-S	S-M
	10	N-S	N-S	M
	11	S-M	M	S-M

¹ Attributes: S = Soil and Site Stability; H = Hydrologic Function; B = Biotic Integrity.

² Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total. .

Table C3. IIRH indicator (#1–9) ratings for assessment sites.

Assessment	Site ID	Indicator ^{1,2}								
		1	2	3	4	5	6	7	8	9
2021 Assessment (IIRH v. 4)	1	N-S	N-S	S-M	S-M	N-S	N-S	N-S	M	N-S
	2	N-S	S-M	S-M	S-M	N-S	N-S	N-S	N-S	N-S
	3	N-S	S-M	N-S	N-S	N-S	N-S	N-S	N-S	N-S
	4	N-S	N-S	N-S	N-S	N-S	N-S	N-S	S-M	N-S
	7	N-S	M-E	E-T	N-S	N-S	N-S	M	N-S	M
	8	N-S	M-E	M-E	N-S	N-S	N-S	S-M	N-S	S-M
	9	N-S	M-E	M-E	S-M	N-S	N-S	N-S	N-S	S-M
	10	N-S	M-E	N-S	N-S	N-S	N-S	N-S	N-S	N-S
	11	N-S	M	M	S-M	N-S	N-S	S-M	N-S	S-M
	12	N-S	S-M	N-S	N-S	N-S	N-S	S-M	N-S	N-S
	13	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S	N-S
	14	N-S	M	E-T	N-S	N-S	N-S	S-M	S-M	S-M
	15	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S	N-S
	16	N-S	E-T	S-M	M	S-M	N-S	N-S	N-S	N-S
	17	N-S	N-S	N-S	M	N-S	N-S	N-S	N-S	N-S
	18	N-S	E-T	M	S-M	S-M	N-S	S-M	N-S	S-M
	19	N-S	M	M-E	N-S	N-S	N-S	N-S	N-S	S-M
	20	N-S	M-E	E-T	M-E	N-S	N-S	N-S	N-S	S-M
2019 Assessment (IIRH v. 5)	1	N-S	M	N-S	N-S	N-S	N-S	N-S	N-S	–
	2	N-S	S-M	S-M	N-S	N-S	N-S	N-S	N-S	N-S
	4	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
	6	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
	7	N-S	N-S	N-S	N-S	N-S	N-S	N-S	S-M	N-S
	8	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
	9	N-S	N-S	N-S	N-S	N-S	N-S	N-S	S-M	S-M
	10	N-S	N-S	N-S	N-S	N-S	N-S	N-S	S-M	N-S
	11	N-S	M-E	M	S-M	N-S	N-S	N-S	N-S	N-S

¹ See Table 1 for indicator references.

² Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total; dashes represent locations where indicator was omitted from consideration when determining attribute ratings.

Table C4. IIRH indicator (#10–17) ratings for sites.

Assessment	Site ID	Indicator ^{1,2}							
		10	11	12	13	14	15	16	17
2021 Assessment (IIRH v. 4)	1	N-S	N-S	M	N-S	N-S	–	N-S	N-S
	2	S-M	N-S	M	N-S	N-S	–	N-S	N-S
	3	N-S	N-S	M	N-S	S-M	S-M	S-M	N-S
	4	N-S	N-S	N-S	N-S	N-S	–	N-S	N-S
	7	M	N-S	M-E	N-S	N-S	–	N-S	S-M
	8	M	N-S	M	N-S	S-M	–	N-S	N-S
	9	M-E	N-S	M-E	N-S	N-S	–	N-S	N-S
	10	M-E	N-S	M-E	N-S	N-S	–	N-S	N-S
	11	N-S	N-S	M	N-S	N-S	–	N-S	N-S
	12	S-M	N-S	M	N-S	N-S	–	N-S	N-S
	13	N-S	N-S	M	N-S	M	N-S	N-S	N-S
	14	M	N-S	M-E	N-S	S-M	N-S	N-S	N-S
	15	N-S	N-S	M	N-S	S-M	–	N-S	N-S
	16	M-E	N-S	E-T	N-S	N-S	–	N-S	S-M
	17	N-S	N-S	M	N-S	M	N-S	N-S	N-S
	18	E-T	N-S	M-E	N-S	S-M	–	N-S	N-S
	19	E-T	N-S	E-T	N-S	N-S	–	N-S	S-M
	20	M-E	N-S	E-T	N-S	N-S	–	N-S	M
2019 Assessment (IIRH v. 5)	1	N-S	N-S	M	N-S	S-M	M-E	N-S	N-S
	2	N-S	N-S	M	N-S	N-S	M-E	S-M	N-S
	4	N-S	S-M	M-E	M-E	N-S	M-E	N-S	M
	6	M	M	E-T	N-S	N-S	N-S	E-T	N-S
	7	S-M	S-M	E-T	N-S	M	N-S	E-T	N-S
	8	M-E	M	E-T	N-S	N-S	E-T	E-T	N-S
	9	N-S	N-S	M	N-S	S-M	N-S	S-M	N-S
	10	N-S	N-S	M-E	N-S	N-S	–	E-T	N-S
	11	M	N-S	S-M	N-S	N-S	M-E	M	N-S

¹ See Table 1 for indicator references.

² Ratings: N-S = None to slight; S-M = Slight to moderate; M = Moderate; M-E = Moderate to extreme; E-T = Extreme to total; dashes represent locations where indicator was omitted from consideration when determining attribute ratings.

Appendix D. Photos of Ecologically Compromised Sites



Photo 1. Tree-dominated plant community at Site 10 (2019) in the East Portal allotment (BLCA).

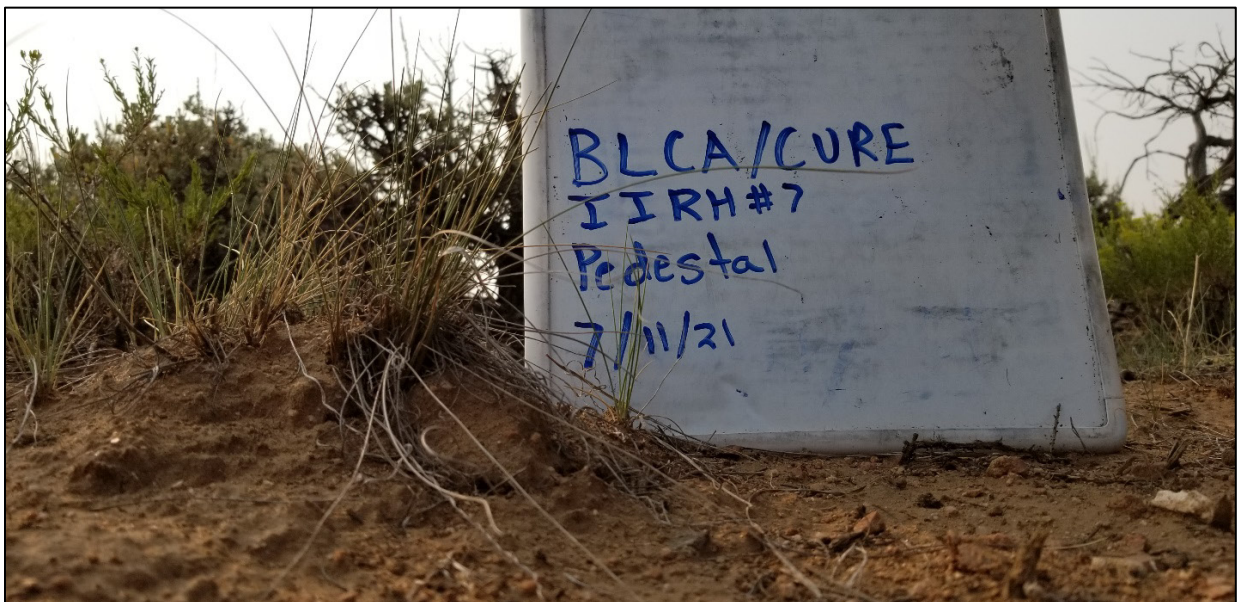


Photo 2. Pedestal observed at Site 7 (2021) in the Iola allotment (CURE).



Photo 3. Litter movement observed at Site 7(2021) in the Iola allotment (CURE).



Photo 4. Water-flow pattern observed at Site 8 (2021) in the Iola allotment (CURE).



Photo 5. Invaded plant community observed at Site 6 (2019) in the Red Rock Canyon allotment (BLCA).



Photo 6. Invaded plant community observed at Site 7 (2019) in the Red Rock Canyon allotment (BLCA)

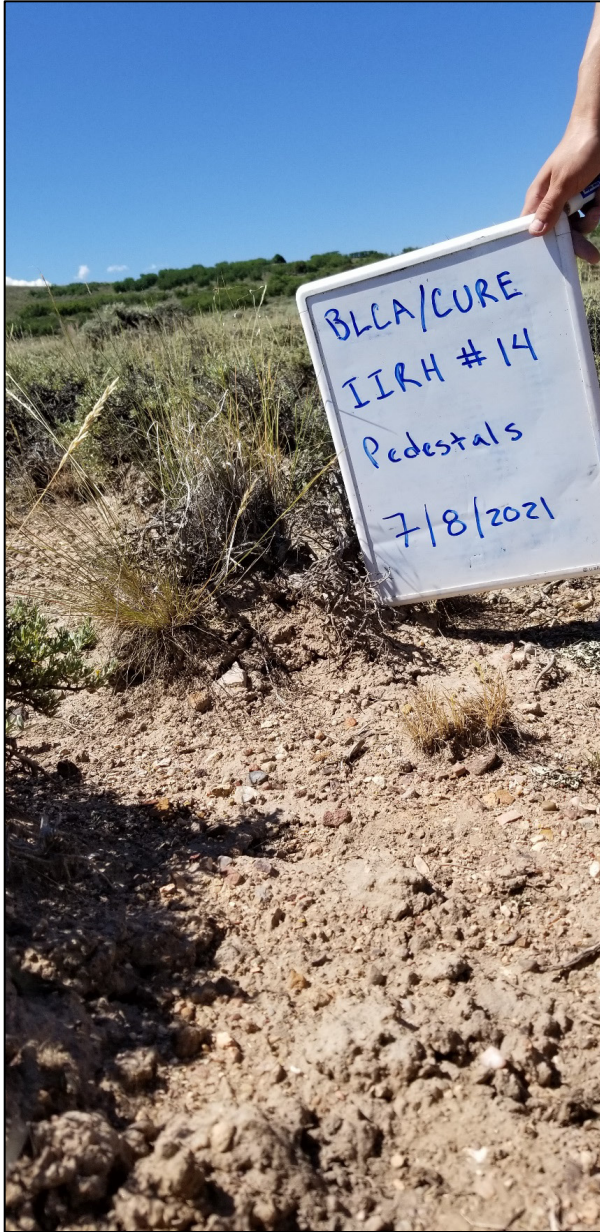


Photo 7. Pedestal observed at Site 14 (2021) in the Sapinero Mesa allotment (CURE).



Photo 8. Water-flow pattern observed at Site 16 (2021) in the Iola allotment (CURE). The crew noted that some water-flow patterns observed at this site were approaching gullies.



Photo 9. Water-flow pattern observed at Site 18 (2021) in the Stevens Creek allotment (CURE). The crew noted that some water-flow patterns at this site were approaching gullies.



Photo 10. Plant community almost completely lacking herbaceous plants observed at Site 19 (2021) in the Stevens Creek allotment (CURE).



Photo 11. Water-flow pattern observed at Site 20 (2021) in the Stevens Creek allotment (CURE). The crew noted that some water-flow patterns observed at this site may be abandoned irrigation ditches.



Photo 12. Relatively uninvaded sagebrush plant community near Site 8 (2019) in the Red Rock Canyon (BLCA) allotment. Note the clear transition with increasing slope.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior



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