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Applying and Interpreting Assessment, Inventory, and Monitoring (AIM) Data at the Field Office Level: An Example

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Applying and Interpreting Assessment, Inventory, and Monitoring (AIM) Data at the Field Office Level: An Example

Technical Note 455

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Abstract

The mission of the Bureau of Land Management (BLM) is to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations. The BLM manages approximately 245 million acres of public land for multiple uses, including livestock grazing, energy development, wildlife habitat, and outdoor recreation. Data collected through the BLM Assessment, Inventory, and Monitoring (AIM) Program represent one of the largest available datasets to inform resource management decisions on public lands. This technical note serves as a companion to BLM Technical Note 453, "Guide to Using AIM and LMF Data in Land Health Evaluations and Authorizations of Permitted Uses," by providing an example of using AIM data, along with other available data, to answer management questions at the field office level. The Grand Junction Field Office in Colorado began this process in 2015 to inform a land health evaluation and livestock grazing permit renewal as required by BLM policy (43 CFR 4180). The detailed example presented in this technical note is intended to help (1) provide consistency in the BLM's application of AIM data to field office-level decisions; (2) demonstrate the process of selecting AIM core indicators that crosswalk to a specific set of land health standards and interpreting those data within the context of land health standard achievement; (3) increase the ability of field office staff to use AIM data to address field office-level management questions and decisions; and (4) increase efficiency in the use of AIM data at the field office level by providing a process that can be replicated.

1. Introduction

The mission of the Bureau of Land Management (BLM) is to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations. The BLM is responsible for the management of more land than any other federal agency, approximately 245 million acres of public lands, predominantly in western states, including Alaska. Throughout the nation, the BLM also administers approximately 710 million acres of subsurface mineral estate. The BLM manages public lands for a variety of uses while conserving natural, cultural, and historic resources. The BLM has managed public lands under a multiple-use mandate since 1976, following passage of the Federal Land Policy and Management Act.

The "Assessment, Inventory, and Monitoring Strategy: For Integrated Renewable Resources Management" (AIM strategy) was developed in 2011 (Toevs et al. 2011) to provide a standardized approach for measuring natural resource condition and trend on BLM-managed public lands. Quantitative data collected using the standardized methods of the AIM strategy are used to identify the status and trend of terrestrial and lotic indicators, which informs the status and trend of resources and supports management decisions at multiple spatial scales (Toevs et al. 2011; Kachergis et al. 2020).

At the field office level, AIM data can be used to answer the question: What is the status and trend of priority renewable resources (both terrestrial and lotic) within the field office? More specifically, AIM data can be used to evaluate whether land health standards are being achieved and address compliance with the National Environmental Policy Act (NEPA) (Toevs et al. 2011). Further, AIM data can be used to determine if management decisions and adjustments are leading to resource management objectives being met.

AIM data are collected following a structured implementation process and stored in the centralized Terrestrial AIM Database (TerrADat) and Aquatic AIM Database (AquADat), where they can be accessed by BLM staff. As of May 2021, AIM data had been collected at more than 35,000 terrestrial sites and nearly 2,800 lotic sites (Figure 1). These data provide a means for natural resource managers to understand public lands and the natural resources they manage and provide a basis for management decisions.

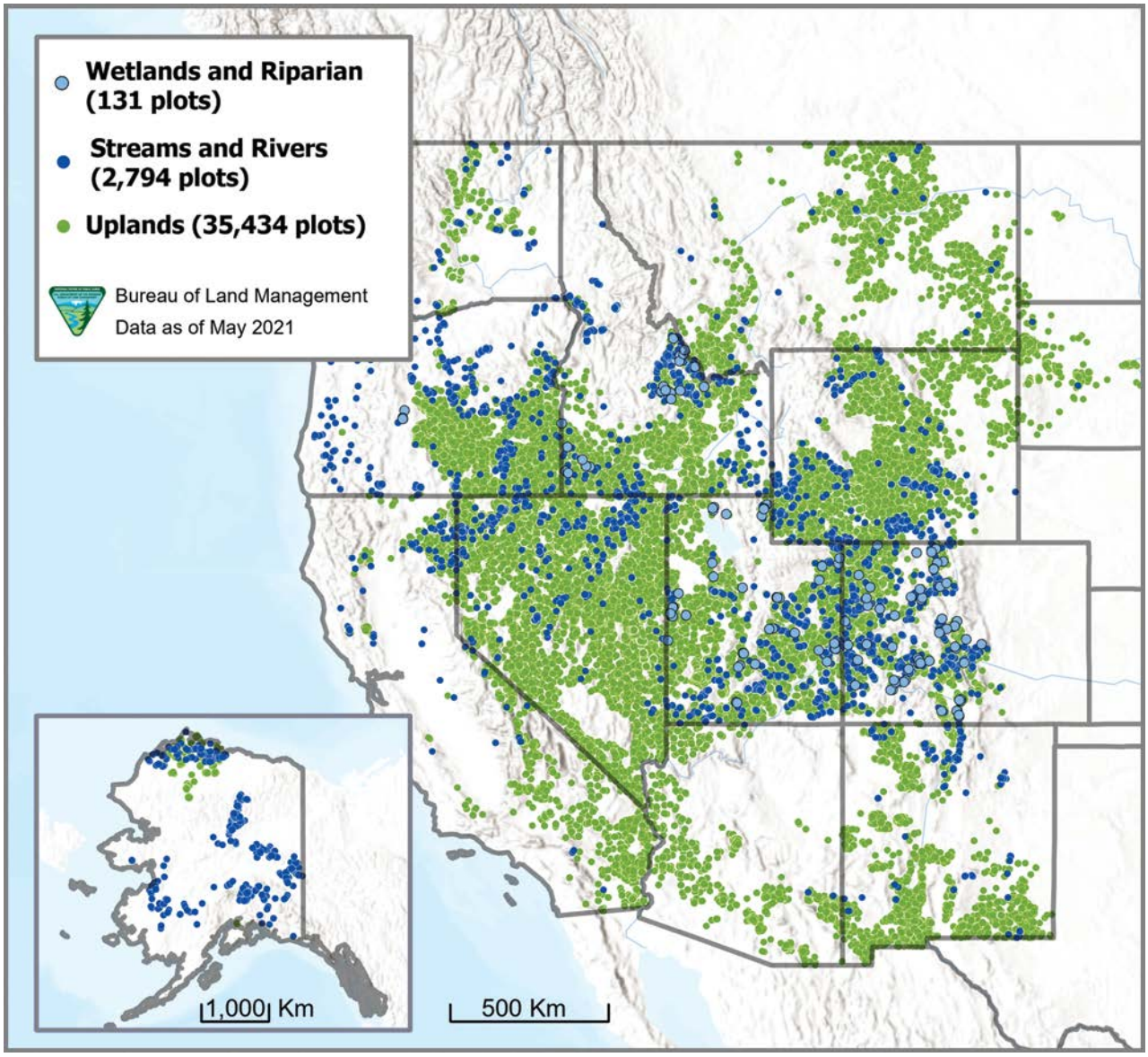


Figure 1. AIM terrestrial (green), lotic (dark blue), and lentic (light blue) data collection locations in the Western United States and Alaska as of May 2021.

This technical note serves as a companion to Technical Note 453, titled "Guide to Using AIM and LMF Data in Land Health Evaluations and Authorizations of Permitted Uses" (subsequently referred to as TN 453), by providing an example of applying and interpreting AIM data at the field office level and can help:

1. Provide consistency in the BLM's application of AIM data to field office-level decisions.
2. Demonstrate the process of selecting AIM core indicators that crosswalk to a specific set of land health standards and interpreting those data within the context of land health standard achievement.
3. Increase the ability of field office staff to use AIM data to address field office-level management questions and decisions.
4. Increase efficiency in the use of AIM data at the field office level by providing a process that can be replicated.

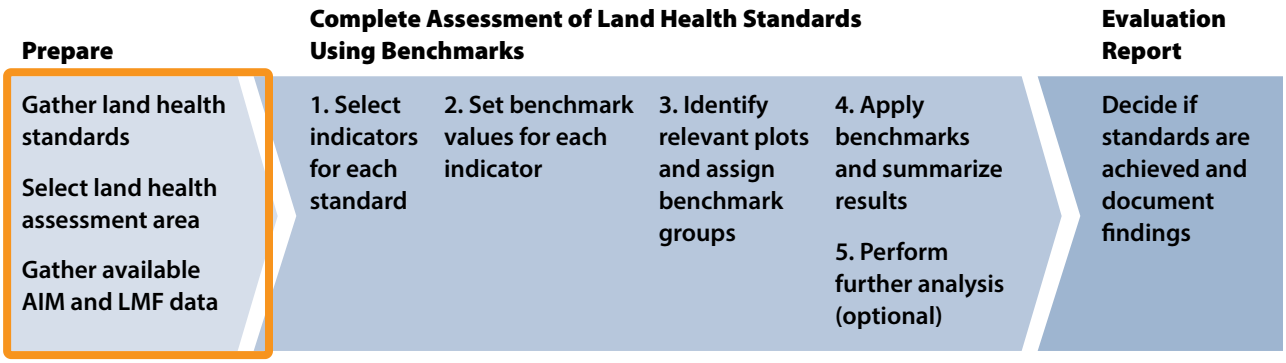
2. Background

In 2015, the BLM Grand Junction Field Office in Colorado began the process of evaluating land health as part of a livestock grazing permit renewal as required by BLM policy (43 CFR 4180) in an area where terrestrial AIM data had been collected. This technical note documents the process followed by the field office to incorporate AIM data in the evaluation of land health standards and subsequent NEPA process for a grazing permit renewal. The scenario presented in this technical note uses data that are adapted from real AIM data. The process and workflow for accessing and using these data for field office decisions is described more fully in TN 453.

This technical note is not meant to replace previous policy or guidance but, rather, is meant to serve as a companion to TN 453 and provide an example that field offices may find useful. The reader is referred to TN 453 for additional details and background prior to undertaking any AIM data analysis process for land health assessment or management decisions. Note that this example reflects the Colorado land health standards (43 CFR 4180.2) and the land health evaluation process used by the BLM in Colorado. There may be differences in some aspects of the land health evaluation process and use of AIM data among BLM offices based on differences in land health standards, planning documents, data availability, and local policies and procedures.

3. Land Health Assessment and Evaluation

To assist the reader in cross-referencing between this document and TN 453, the workflow process found on page 11 (Figure 3A) of TN 453 is duplicated at the beginning of each section, highlighting the workflow step that is described.



3.1 Select the Assessment Area

The Grand Junction Field Office interdisciplinary team (ID team) began the land health assessment and evaluation process to inform a livestock grazing permit renewal. The assessment area in this example is an approximately 100,000-acre grazing allotment (Figure 2) located in the Colorado Plateau, EPA level III ecoregion. The allotment contains 10 pastures and five vegetation types (mixed salt desert scrub, saltbush/shadscale, Wyoming big sagebrush, pinyon-juniper, and cottonwood). The dominant vegetation types are mixed salt desert scrub, saltbush/shadscale, Wyoming big sagebrush, and pinyon-juniper. The allotment includes a 10,000-acre area of critical environmental concern (ACEC), which provides habitat for threatened animal species A. The allotment has minimal riparian habitat; therefore, associated aquatic AIM data and aquatic resources are not discussed in detail.

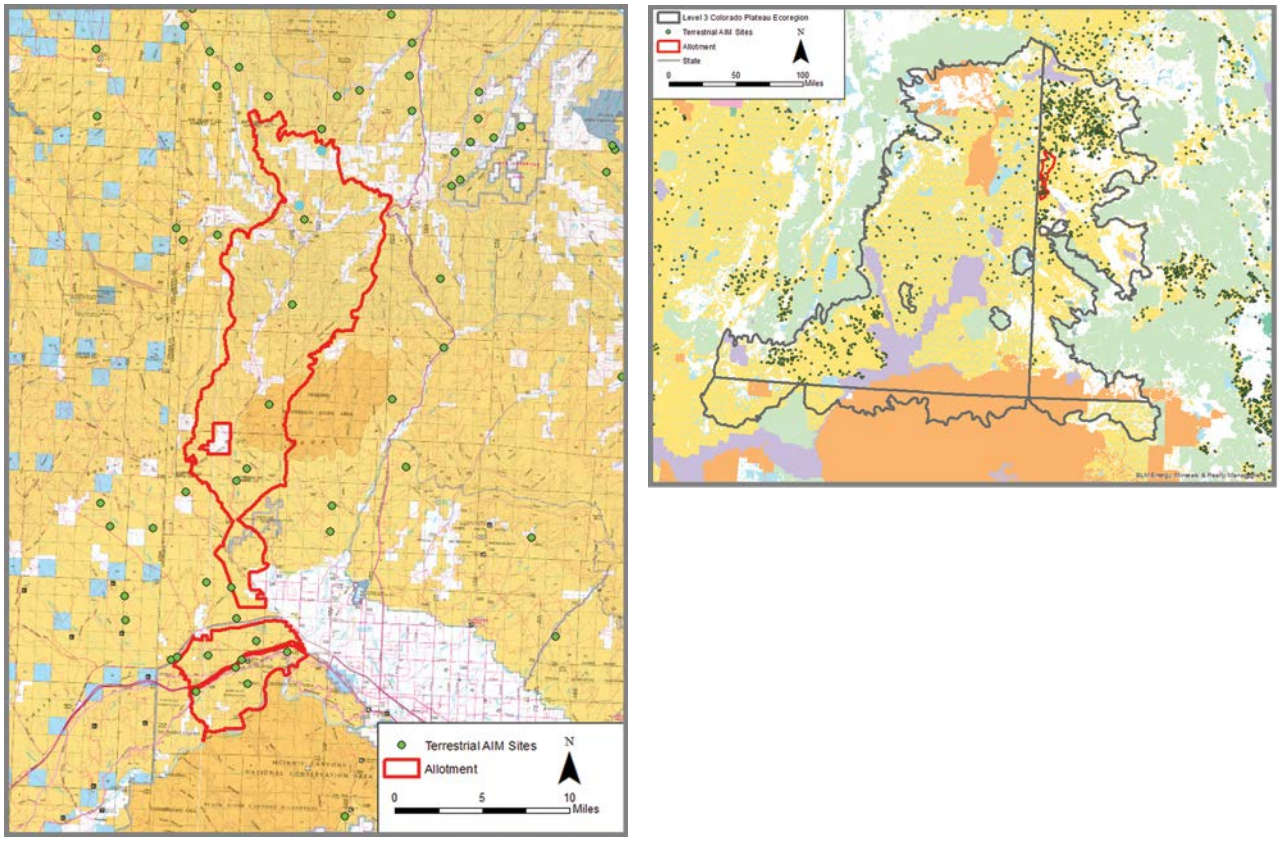


Figure 2. (Left) Map of the assessment area (grazing allotment). (Right) Map of the grazing allotment within the Colorado Plateau, EPA level III ecoregion. Data from the Colorado Plateau ecoregion was used, along with other data, to establish benchmarks.

3.2 Identify Land Health Standards

The BLM-managed public lands in this allotment are managed in accordance with the "Grand Junction Field Office Approved Resource Management Plan" and subject to the Colorado land health standards (Table 1). There are five Colorado land health standards; achievement of each of the five standards is evaluated based on a list of primarily qualitative indicators. Many of these qualitative indicators can be informed by quantitative indicators derived from AIM data. The process outlined in this technical note focuses on use of terrestrial AIM data to support evaluation of Colorado standards 1 (upland soils), 3 (native and other desirable species), and 4 (special status, threatened and endangered, and other species) (Table 1). The ID team's review of data use for standards 2 and 5 are mentioned but are not discussed in detail due to minimal riparian and water resources in the grazing allotment.

Table 1. Land health standards for Colorado (43 CFR 4180.2) with associated AIM indicators, which can be used to evaluate if the land health standard is being achieved. The 19 sets of land health standards for each BLM administrative state or Resource Advisory Council area can be found in Appendix 1 of BLM Technical Note 453 (Kachergis et al. 2020).

COLORADO	
Indicators Associated with Land Health Standard	**AIM Indicators Associated with Land Health Standard**
STANDARD #1—Upland soils: Upland soils exhibit infiltration and permeability rates that are appropriate to soil type, climate, landform, and geologic processes. Adequate soil infiltration and permeability allows for the accumulation of soil moisture necessary for optimal plant growth and vigor, and minimizes surface runoff.	
• Expression of rills and soil pedestals is minimal. • Evidence of actively eroding gullies (incised channels) is minimal. • Canopy and ground cover are appropriate. • There is litter accumulating in place and is not sorted by normal overland water flow. • There is appropriate organic matter in soil. • There is diversity of plant species with a variety of root depths. • Upland swales have vegetation cover or density greater than that of adjacent uplands. • There are vigorous, desirable plants.	• Bare ground • Proportion of large gaps between plant canopies • Soil aggregate stability • Vegetation composition
STANDARD #2—Riparian systems: Riparian systems associated with both running and standing water function properly and have the ability to recover from major disturbance such as fire, severe grazing, or 100-year floods. Riparian vegetation captures sediment, and provides forage, habitat, and biodiversity. Water quality is improved or maintained. Stable soils store and release water slowly.	
• Vegetation is dominated by an appropriate mix of native or desirable introduced species. • Vigorous, desirable plants are present. • There is vegetation with diverse age class structure, appropriate vertical structure, and adequate composition, cover, and density. • Streambank vegetation is present and is comprised of species and communities that have root systems capable of withstanding high streamflow events. • Plant species present indicate maintenance of riparian moisture characteristics. • Stream is in balance with the water and sediment being supplied by the watershed (e.g., no headcutting, no excessive erosion or deposition). • Vegetation and free water indicate high water tables. • Vegetation colonizes point bars with a range of age classes and successional stages. • An active floodplain is present. • Residual floodplain vegetation is available to capture and retain sediment and dissipate flood energies. • Stream channels have appropriate size and meander patterns, for the stream's position in the landscape, and parent materials. • Woody debris contributes to the character of the stream channel morphology.	• Floodplain connectivity • Large wood • Greenline vegetation composition • Bank stability and cover • Streambed particle sizes • Pool tail fines • Thalweg depth profile

COLORADO	
Indicators Associated with Land Health Standard	**AIM Indicators Associated with Land Health Standard**
STANDARD #3—Native and other desirable species: Healthy, productive plant and animal communities of native and other desirable species are maintained at viable population levels commensurate with the species and habitat's potential. Plants and animals at both the community and population level are productive, resilient, diverse, vigorous, and able to reproduce and sustain natural fluctuations and ecological processes.	
• Noxious weeds and undesirable species are minimal in the overall plant community. • Native plant and animal communities are spatially distributed across the landscape with a density, composition, and frequency of species suitable to ensure reproductive capability and sustainability. • Plants and animals are present in mixed age classes sufficient to sustain recruitment and mortality fluctuations. • Landscapes exhibit connectivity of habitat or presence of corridors to prevent habitat fragmentation. • Photosynthetic activity is evident throughout the growing season. • Diversity and density of plant and animal species are in balance with habitat/landscape potential and exhibit resilience to human activities. • Appropriate plant litter accumulates and is evenly distributed across the landscape. • Landscapes are composed of several plant communities that may be in a variety of successional stages and patterns.	• Nonnative invasive species • Plant species of management concern • Vegetation composition • Vegetation height
STANDARD #4—Special status, threatened and endangered, and other species: Special status, threatened and endangered species (federal and state), and other plants and animals officially designated by the BLM, and their habitats are maintained or enhanced by sustaining healthy, native plant and animal communities.	
• All the indicators associated with the plant and animal communities standard apply. • There are stable and increasing populations of endemic and protected species in suitable habitat. • Suitable habitat is available for recovery of endemic and protected species.	• Nonnative invasive species • Plant species of management concern • Vegetation composition
STANDARD #5—Water quality: The water quality of all water bodies, including groundwater where applicable, located on or influenced by BLM lands will achieve or exceed the water quality standards established by the State of Colorado. Water quality standards for surface and groundwaters include the designated beneficial uses, numeric criteria, narrative criteria, and antidegradation requirements set forth under state law as found in (5 CCR 1002-8), as required by Section 303(c) of the Clean Water Act.	
• Appropriate populations of macroinvertebrates, vertebrates, and algae are present. • Surface and groundwaters only contain substances (e.g., sediment, scum, floating debris, odor, heavy metal precipitates on channel substrate) attributable to humans within the amounts, concentrations, or combinations as directed by the water quality standards established by the State of Colorado (5 CCR 1002-8).	• pH • Specific conductance • Temperature • Total nitrogen and total phosphorous • Turbidity • Benthic macroinvertebrates • Streambed particle sizes

3.3 Gather Data

After selecting the assessment area and identifying relevant land health standards, the ID team gathered existing AIM data and local data and reviewed this information to decide if it would be sufficient for evaluating the land health standards or whether additional data would be needed. The ID team determined which data and AIM indicators to use to evaluate each land health standard. The ID team identified the most relevant AIM data and other available data to compile for the assessment report and to use for evaluation of each of the five Colorado land health standards.

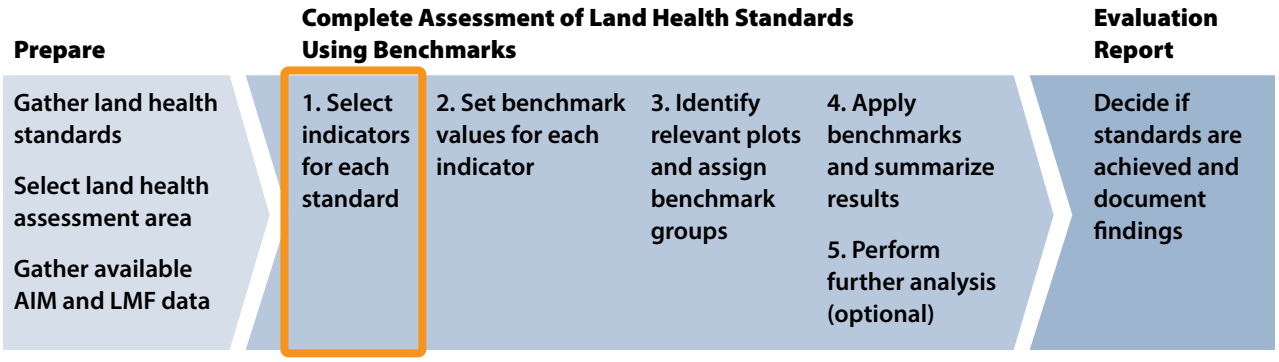
A TerrADat query showed 24 AIM and Landscape Monitoring Framework (LMF) plots with available data in the allotment. At least one AIM or LMF plot occurred in all but two of the 10 allotment pastures. AIM data points were distributed across all of the dominant vegetation types as determined by the ID team, including Wyoming big sagebrush, mixed salt desert scrub, saltbush/shadscale, and pinyon-juniper. Other data (e.g., Interpreting Indicators of Rangeland Health (IIRH), range frequency plot for trend (Elzinga et al. 1998)) were available for the two pastures that did not have available AIM or LMF data. The ID team determined that this data would be relevant and informative to the land health evaluation process, in combination with other data used for each standard, and that available data were sufficient.

Available AIM data were collected from 2015 to 2018. The ID team evaluated each dataset for completeness, relevance, and confidence in data quality. No AIM or LMF points were excluded from analyses. However, if a decision is made by an ID team to exclude data points from analyses, exclusions should be agreed upon by the ID team and justified.

3.4 Identify Monitoring Questions

The ID team defined management questions based on relevant policy (e.g., BLM Manual 4180, "Land Health Standards") and planning documents. Each state or area with BLM-managed public lands that are managed for livestock grazing (with some exceptions) has a set of land health standards and indicators in accordance with 43 CFR 4180.2. The Grand Junction Field Office's primary management question to be addressed through the land health standards evaluation was stated as: Are BLM-managed lands achieving Colorado's land health standards in the livestock grazing allotment of interest? As outlined in Table 1, the five Colorado land health standards are each evaluated through the consideration of a suite of qualitative and quantitative indicators, many of which can be connected to AIM core indicators. More specific management questions could be defined for each land health standard. For example, for Colorado standard 1 (upland soils), a management question could be posed as: Are upland soil infiltration and permeability rates adequate for accumulation of soil moisture for optimal plant growth and minimizing surface runoff?

3.5 Select Indicators for Each Applicable Land Health Standard to be Evaluated



Next, the ID team listed the AIM indicators related to each land health standard and other available data that would be considered in evaluating each standard. This assisted in organizing the available data and identifying the appropriate AIM indicators for each standard. Potential data for each standard may include general indicators (e.g., vegetation composition). These may be further defined by more specific AIM indicators identified by the ID team, for example foliar cover by functional/structural group (noninvasive perennial native forb, noninvasive annual grass, invasive annual grass, etc.). The process for selecting specific indicators and other data sources based on each land health standard follows.

LAND HEALTH STANDARD #1—Upland soils: Upland soils exhibit infiltration and permeability rates that are appropriate to soil type, climate, landform, and geologic processes. Adequate soil infiltration and permeability allows for the accumulation of soil moisture necessary for optimal plant growth and vigor, and minimizes surface runoff.

Potential indicators for land health standard 1 (Table 1): Bare ground, proportion of large gaps between plant canopies, soil aggregate stability, and vegetation composition

For land health standard 1, the ID team decided to use the following data sources and indicators for evaluation.

- Terrestrial AIM indicators
  - Soil aggregate stability
  - Vegetation composition
    - Total foliar cover
    - Foliar cover by functional/structural group
    - Deep-rooted perennial grass species
  - Bare ground
  - Litter cover
- Key area plot frequency for trend (Elzinga et al. 1998)
  - Functional/structural groups (frequency)
  - Deep-rooted perennial plant species

LAND HEALTH STANDARD #2—Riparian systems: Riparian systems associated with both running and standing water function properly and have the ability to recover from major disturbance such as fire, severe grazing, or 100-year floods. Riparian vegetation captures sediment, and provides forage, habitat, and biodiversity. Water quality is improved or maintained. Stable soils store and release water slowly.

Potential indicators for land health standard 2 (Table 1): Floodplain connectivity, large wood, greenline vegetation composition, bank stability and cover, streambed particle sizes, pool tail fines, and thalweg depth profile

For land health standard 2, the ID team decided to use the following data sources and indicators for evaluation. (However, this land health standard was not evaluated for this allotment due to the minimal presence of riparian areas.)

- Proper functioning condition (PFC)
- Lotic AIM data

LAND HEALTH STANDARD #3—Native and other desirable species: **Healthy, productive plant and animal communities of native and other desirable species are maintained at viable population levels commensurate with the species and habitat's potential. Plants and animals at both the community and population level are productive, resilient, diverse, vigorous, and able to reproduce and sustain natural fluctuations and ecological processes.**

Potential indicators for land health standard 3 (Table 1): **Nonnative invasive species, plant species of management concern, vegetation composition, and vegetation height**

For land health standard 3, the ID team decided to use the following data sources and indicators for evaluation.

- AIM indicators
  - Nonnative invasive species
    - Foliar cover
    - Plot species list
  - Vegetation composition
    - Foliar cover by functional/structural group (e.g., native perennial grasses, native annual forbs, invasive plant species)
      - Noninvasive perennial forb foliar cover
      - Noninvasive perennial grass foliar cover
      - Noninvasive perennial shrub foliar cover
    - Species richness
    - Diversity
    - Plot species list (full plot search from AIM data)
- Key area plot frequency for trend (species trend) (Elzinga et al. 1998)
- Animal data
  - Important bird area monitoring data
    - Bird point count data
  - Colorado Parks and Wildlife data
    - Game counts
    - Game population objectives

LAND HEALTH STANDARD #4—Special status, threatened and endangered, and other species: **Special status, threatened and endangered species (federal and state), and other plants and animals officially designated by the BLM, and their habitats are maintained or enhanced by sustaining healthy, native plant and animal communities.**

Potential indicators for land health standard 4 (Table 1): **Nonnative invasive species, plant species of management concern, and vegetation composition**

The allotment contains a 10,000-acre ACEC. The ACEC represents 20% of the overall range available for animal species A, which is unique to the Grand Junction Field Office and listed as threatened. The ACEC is present within all pastures. AIM points within the designated habitat were used to evaluate land health standard 4. There are no other known special status, threatened, or endangered plants or animals known to occur, or potentially occur, within the allotment, and animal species A habitat does not occur outside the ACEC in this allotment. No aquatic threatened or endangered species are present due to lack of riparian areas.

For land health standard 4, the ID team decided to use the following data sources and indicators for evaluation.

- AIM indicators
  - Vegetation composition
    - Noninvasive perennial grass cover
    - Noninvasive perennial shrub cover
- Other data
  - Key area plot frequency for trend (Elzinga et al. 1998)
  - Game counts
  - Game population objectives

LAND HEALTH STANDARD #5—Water quality: **The water quality of all water bodies, including groundwater where applicable, located on or influenced by BLM lands will achieve or exceed the water quality standards established by the State of Colorado. Water quality standards for surface and groundwaters include the designated beneficial uses, numeric criteria, narrative criteria, and antidegradation requirements set forth under state law as found in (5 CCR 1002-8), as required by Section 303(c) of the Clean Water Act.**

Potential indicators for land health standard 5 (Table 1): **pH, specific conductance, temperature, total nitrogen and total phosphorous, turbidity, benthic macroinvertebrates, and streambed particle sizes**

For land health standard 5, the ID team decided to use the following data sources and indicators for evaluation. (However, this land health standard was not evaluated for this allotment due to the minimal presence of riparian areas.)

- State water quality data
- Lotic AIM data

Additional Data Included in the Assessment Report

Additionally, livestock management data (actual use reports and utilization rates) and recreation data (visitor use) were included where applicable in the land health assessment report. Management data are used to determine the significant causal factor(s) when a land health standard is not achieved or is not making significant progress towards achievement. See section 7.

3.6 Draft Monitoring Objectives

After identifying and compiling data related to each standard, the ID team identified monitoring objectives and quantitative benchmarks for indicators relating to each land health standard to address the overall management question of: Are BLM-managed lands achieving Colorado's land health standards in the livestock grazing allotment of interest? While indicators from other datasets identified in the previous section were considered in the land health evaluation as multiple lines of evidence, the following discussion is focused on the process of selecting terrestrial AIM indicators and setting related monitoring objectives and benchmarks.

Monitoring objectives describe the desired resource conditions that support management objectives. Benchmarks are indicator values or ranges of values that establish goals for resource conditions and are a key part of monitoring objectives. Benchmark values are compared to observed indicator values of AIM points in the allotment as part of the evaluation of achievement of land health standards or other management objectives.

The ID team used terrestrial AIM indicator data from TerrADat to inform the draft monitoring objectives for land health standards 1 and 3. Based on the data, the draft monitoring objectives for the mixed salt desert scrub vegetation type include:

Standard 1 (Upland soils)

- Soil aggregate stability is adequate to stabilize soils and minimize runoff.
- Bare ground does not exceed appropriate amounts.
- Plant foliar cover is adequate to protect soils.

Standard 3 (Native and other desirable species)

- The following plant functional/structural groups are contributing to appropriate plant community composition:
  - Noninvasive perennial forbs
  - Noninvasive perennial grasses
  - Noninvasive perennial shrubs

Once the ID team determined draft monitoring objectives, the team reviewed AIM indicators in TerrADat (e.g., noninvasive perennial grass cover, noninvasive perennial shrub cover) for the allotment and selected indicators that best addressed the draft monitoring objectives.

Identifying indicators in TerrADat can be done by a project lead or an ID team. The ID team should consist of staff and specialists familiar with the assessment area and who represent resources considered in management questions and

monitoring objectives. If this is done by a project lead, it should be reviewed by an appropriate ID team. If the team had determined that precalculated indicators did not appropriately address the defined monitoring objectives, the next step would have been to work with the National Operations Center AIM staff to determine if custom indicator calculations could be derived from available AIM data.

TerrADat provides a long list of precalculated indicators, but in most cases a subset of these indicators most relevant to the stated monitoring objectives should be selected. Some calculated indicators in TerrADat, such as soil aggregate stability, correlate directly to the AIM indicators listed in Table 1 for each standard. Other calculated indicators comprise one aspect or portion of the quantitative indicators listed in Table 1. For example, vegetation composition for Colorado land health standard 3 is not expressed by a single indicator value but, rather, multiple indicators, such as foliar cover for shrubs, grasses, and forbs.

The ID team focused on selecting precalculated indicators that were most directly related to the identified monitoring objectives and benchmarks. If an indicator does not relate to the defined monitoring objectives, it should not be incorporated in the benchmark analysis process. In this example, cover of invasive trees was not relevant, since, in general, invasive trees are only found in riparian areas in the Grand Junction Field Office, and the allotment does not include significant riparian areas. Reviewing the calculated indicator values for AIM points in the allotment may reveal anomalies. For example, if invasive tree cover was reported in a terrestrial AIM plot in the allotment, the ID team should more closely analyze the data to determine if there is an emerging resource issue. Some precalculated indicators overlapped, such as noninvasive annual forb cover, noninvasive annual grass cover, and noninvasive annual forb and grass cover combined. In most cases, either forb and grass cover could be used separately, or the combined indicator could be used.

Indicator data should be organized in a meaningful way that facilitates later interpretation of the multiple lines of evidence during the evaluation process. For example, information about invasive species, including cover of invasive species and number of invasive species, could be presented together. Indicator data are organized based on how the indicators relate to each land health standard for each vegetation type. For standards 1 and 3, the draft monitoring objectives and the associated indicators selected for benchmark analysis are shown in Table 2.

Site-Specific Application of Indicators

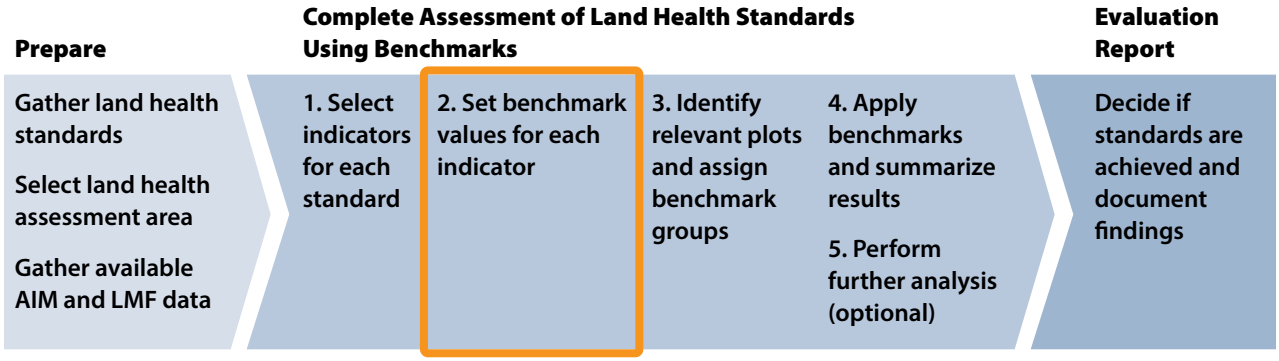
Unique resources and varying site potential or reference conditions within an area of interest can influence how and where the selected indicators are applied. In this example, initial monitoring objectives included sagebrush indicators in all shrub vegetation types. However, upon further review and incorporation of local knowledge, it was determined that sagebrush did not occur in the mixed salt desert scrub vegetation type. Sagebrush can be rare in mixed salt desert scrub communities, and AIM data confirmed that other shrubs (e.g., *Atriplex* spp.) were found within this vegetation type. Therefore, it was not appropriate to apply sagebrush benchmarks to this vegetation type. See page 14 of TN 453 for additional details about benchmark groups.

Table 2. Draft monitoring objectives and the calculated AIM indicators selected from TerrADat for each objective.

	Draft Monitoring Objective	Selected AIM Indicator
Standard 1: Upland Soils	**Soil aggregate stability is adequate to stabilize soils and minimize runoff.**	**Soil aggregate stability**
	Bare ground does not exceed appropriate amounts.	**Bare ground percent**
	Plant foliar cover is adequate to protect soils.	**Total foliar cover percent**
Standard 3: Native and Other Desirable Species	**Perennial forbs are contributing to appropriate plant community composition.**	**Foliar cover percent of noninvasive perennial forbs**
	Perennial grasses are contributing to appropriate plant community composition.	**Foliar cover percent of noninvasive perennial grasses**
	Perennial shrubs are contributing to appropriate plant community composition.	**Foliar cover percent of noninvasive shrubs**

At this point in the process, AIM data can be used to support specific management needs. Different AIM indicators will address different monitoring objectives—in other words, not every indicator will address every objective. For example, a hydrology objective may be addressed by soil stability and canopy gaps; a wildlife objective may be addressed by shrub height and cover; a rangeland management objective may be addressed by cover and height of perennial grasses; and an ecological objective may be addressed by cover of forbs, shrubs, grasses, and invasive species.

4. Set Benchmark Values for AIM Indicators



Once the quantifiable monitoring objectives and relevant AIM indicators were defined, the ID team established benchmark values for each indicator. Benchmark values define success or failure (attainment/nonattainment) of benchmarks. For example, considering the management question (Are BLM-managed lands achieving Colorado's land health standards in the livestock grazing allotment of interest?), the ID team selected several AIM indicators from TerrADat. However, the following discussion of setting benchmarks focuses on the indicators of soil aggregate stability and noninvasive perennial plant cover.

Benchmark values should be set by an ID team using relevant available data. This process will vary from site to site and team to team. Quantitative benchmarks may be available from sources such as ecological site descriptions, sage grouse habitat guidelines, reference areas, or scientific references. However, when these sources of benchmark values are not available or sufficient, an alternate process of benchmark analysis can be conducted. The Grand Junction Field Office ID team reviewed the range and distribution of values for a given calculated indicator across locations within an area that is ecologically similar (same potential vegetation type in the same ecological region) to the allotment (see Kachergis et al. 2020). See Appendix A for a more detailed description of how the ID team used data from the Colorado Plateau, EPA level III ecoregion, to inform benchmarks.

It may be necessary to set different benchmark values for a given indicator in areas with different site potential. For example, appropriate composition of shrubs, grasses, and forbs will vary based on soils, precipitation, and other factors. Similarly, greater amounts of bare ground may be expected in arid environments, as compared to mesic environments (Pellant et al. 2020). For example, more bare ground may be expected in mixed salt desert scrub than in pinyon-juniper vegetation types.

The ID team summarized indicator values (e.g., soil aggregate stability, noninvasive perennial plant cover) for the Colorado Plateau ecoregion (Figure 3) and used this information to inform benchmark values for the selected indicators (Table 3). Where available, the ID team also used expected values (e.g., soil stability) from ecological site descriptions to support the benchmark values. Table 3 lists the benchmark values and quantitative monitoring objectives for selected indicators related to land health standards 1 and 3 in the mixed salt desert scrub vegetation type.

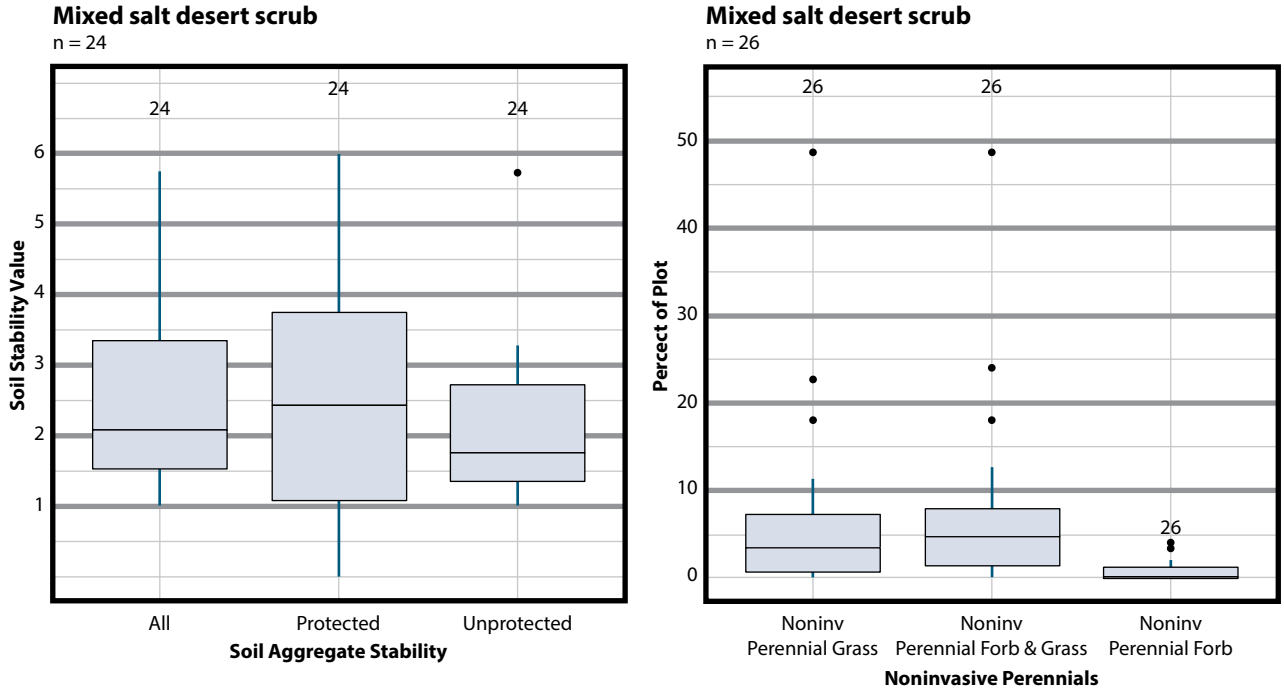
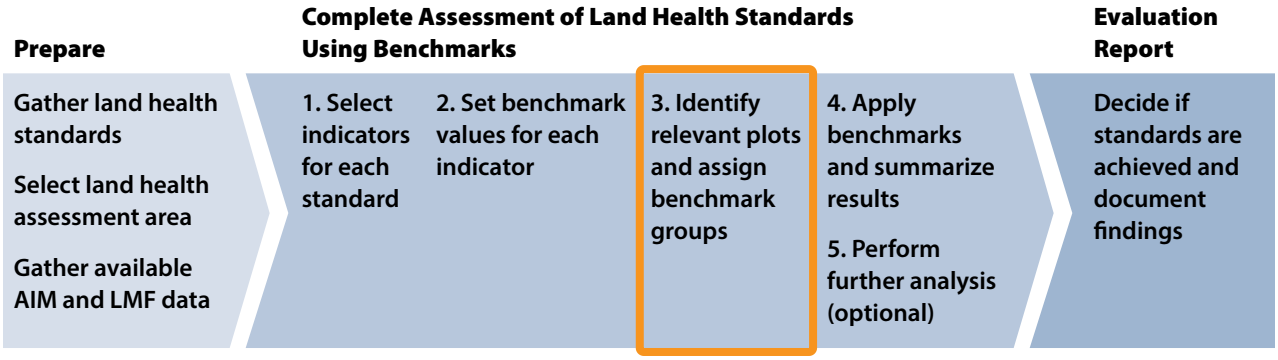


Figure 3. Box plots for soil aggregate stability (protected and unprotected) and noninvasive perennial plant cover in the mixed salt desert scrub vegetation type within the Colorado Plateau ecoregion. Shown are the median, 25% and 75% quantiles within the box, upper and lower whiskers, maximum, and minimum. These are regional values that were used to help determine benchmark values. Box plots courtesy of the Agricultural Research Service, Jornada Experimental Range.

Table 3. Benchmark values and quantitative monitoring objectives for selected indicators for AIM points in the mixed salt desert scrub vegetation type.

	Indicator Benchmark Value	Quantitative Monitoring Objective
Standard 1: Upland Soils	Maximum bare ground of 18%	For the mixed salt desert scrub vegetation type, bare ground should not exceed 18% (the value of the 25th quantile from the Colorado Plateau ecoregion benchmark analysis) (Appendix A).
	Soil stability between 3 and 6	For the mixed salt desert scrub vegetation type, soil stability should be between 3 (the value of the 75th quantile from the Colorado Plateau ecoregion benchmark analysis) and 6 (the maximum possible value) (Appendix A).
	Total foliar cover between 55% and 88%	For the mixed salt desert scrub vegetation type, foliar cover should be between 55% (the value of the 75th quantile from the Colorado Plateau ecoregion benchmark analysis) and 88% (the value of the 95th quantile from the Colorado Plateau ecoregion benchmark analysis) (Appendix A).
Standard 3: Native and Other Desirable Species	Noninvasive perennial forb cover between 2% and 6%	Noninvasive perennial forb cover should be between 2% (the value of the 75th quantile from the Colorado Plateau ecoregion benchmark analysis) and 6% (the value of the 95th quantile from the Colorado Plateau ecoregion benchmark analysis) (Appendix A).
	Noninvasive perennial grass cover between 36% and 63%	Noninvasive perennial grass cover should be more than 36% (the value of the 75th quantile from the Colorado Plateau ecoregion benchmark analysis) but no greater than 63% (the value of the 95th quantile from the Colorado Plateau ecoregion benchmark analysis) (Appendix A).
	Noninvasive shrub cover between 18% and 35%	Noninvasive shrub cover should be more than 18% (the value of the 75th quantile from the Colorado Plateau ecoregion benchmark analysis) but no greater than 35% (the value of the 95th quantile from the Colorado Plateau ecoregion benchmark analysis) (Appendix A).

4.1 Assign AIM Points to Benchmark Groups



After setting benchmarks, the ID team assigned AIM points from the allotment to benchmark groups based on potential vegetation types (e.g., mixed salt desert scrub) (Table 4) and performed benchmark analysis by using the benchmark tool provided by the NOC AIM team (Kachergis et al. 2020). The ID team identified the proportion of the AIM points within the allotment that should attain benchmarks. To determine if existing livestock grazing management is allowing achievement of Colorado's land health standards in the allotment, the ID team determined that benchmarks must be attained in at least 80% of AIM points sampled within the allotment. For example, 80% of the sampled points must attain the benchmark for percent bare ground. If only 60% of points attain the benchmark, then the land health standard may not be achieved. Note that the number of AIM points does not necessarily represent a proportion of the area. For example, 3 out of 10 points in the allotment does not necessarily translate to 30% of the allotment. To get proportions of areas (acres, hectares), a weighted analysis needs to be done. The NOC AIM team can support field offices interested in a weighted analysis.

Table 4. Benchmark group assignments based on vegetation type and ecological site for AIM points within the allotment. Sites within a given benchmark group all have the same expected minimum soil aggregate stability benchmark values.

	AIM Vegetation Category	Ecological Site Description (ESD)	Expected ESD Value	Benchmark Value
Benchmark Group 1	Mixed Salt Desert Scrub	34BY212UT Semi Desert Loam	5	3-6
Benchmark Group 2	Saltbush/Shadscale	34BY106UT Desert Loam	4	4-6
	Saltbush/Shadscale	36XY114CO Mtn Pinyon	3-6	4-6
	Saltbush/Shadscale	None	NA	4-6
Benchmark Group 3	Wyoming Big Sagebrush	34BY106UT Desert Loam 34BY109UT Desert Loamy Clay	4 3 - 4	5-6
	Wyoming Big Sagebrush	34XY401CO Loamy Salt Desert DRAFT	NA	5-6
	Wyoming Big Sagebrush	None	None	5-6
Benchmark Group 4	Pinyon-Juniper	None	None	5-6
	Pinyon-Juniper	None	None	5-6
Benchmark Group 5	Cottonwood	34BY106UT Desert Loam Shadscale	4	4-6

5. Data Analysis

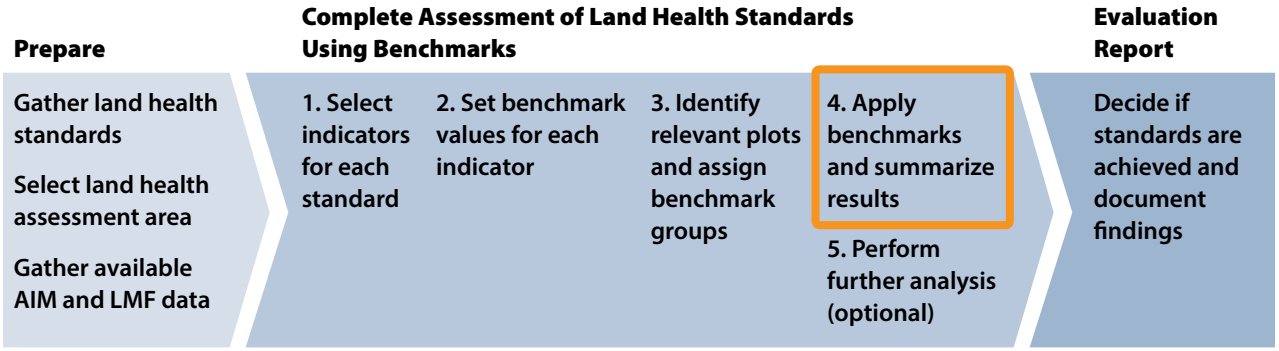


Figure 4 shows the workflow process for addressing management questions with the use of AIM data. Steps 1 through 3 are rather straightforward. However, Step 4, Data Analysis (Figure 4), may be an adaptive and iterative process. An ID team must determine which indicators need to be evaluated against benchmarks based on management questions and monitoring objectives for the proposed management action.

For this example, the following are the components for the bare ground indicator in the mixed salt desert scrub vegetation type.

Management action: Livestock grazing permit renewal

Management question: Are BLM-managed lands achieving Colorado's land health standards in the livestock grazing allotment of interest?

Indicator: Bare ground

Monitoring objective: For the mixed salt desert scrub vegetation type, bare ground should not exceed 18% (Appendix A).

Benchmark value: maximum bare ground of 18%

So far, this technical note has shown the process for determining these components. These components will vary for each management action and will be determined differently by each ID team leading up to data analysis.

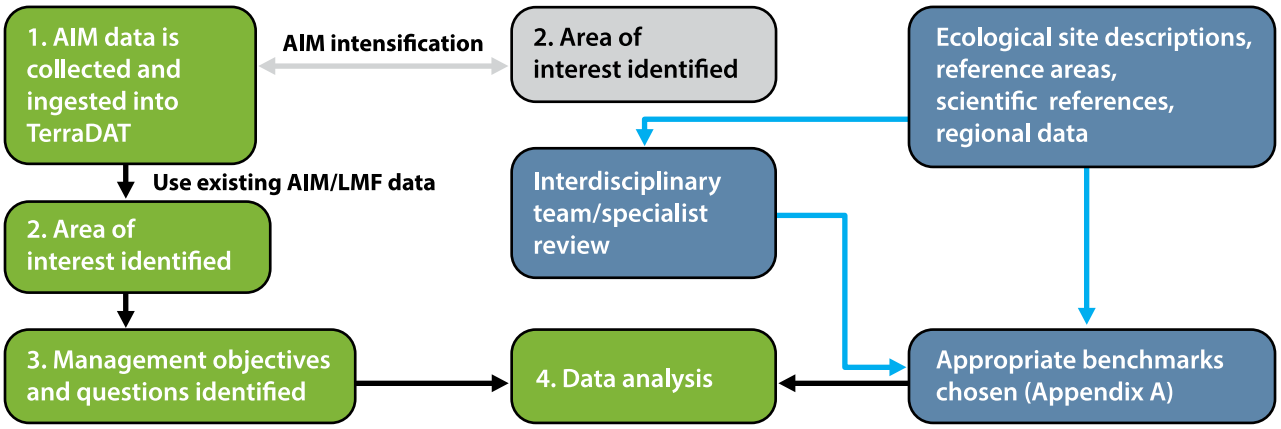


Figure 4. Process for addressing management questions with the use of AIM data.

5.1 Organize the Data

The ID team visually organized data to determine whether AIM points are meeting quantitative monitoring objectives by comparing the indicator values at each point to the applicable benchmarks. Data can be displayed in many ways, including box plots (see Figure 3), graphs, tables (see Table 5), or histograms. The following figures and tables are examples of some of the ways data can be organized.

Figures 5, 6, 7, and 8 show AIM points that were sampled in the mixed salt desert scrub vegetation type in the allotment and where specific points fall compared to set benchmarks and maximum and minimum values. This can be helpful in data interpretation and NEPA analysis.

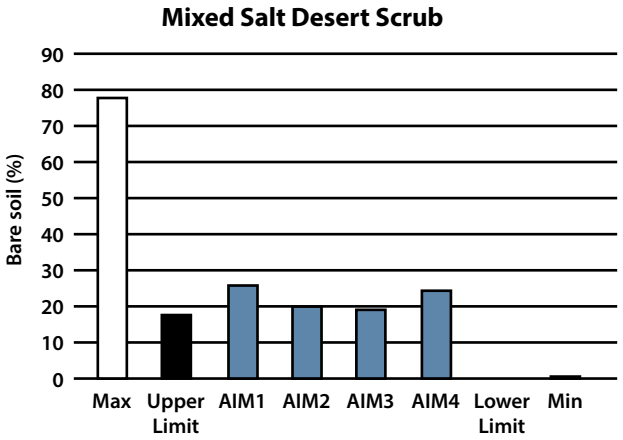


Figure 5. Graph showing a summary of the percentages of bare soil from AIM data points in the mixed salt desert scrub vegetation type within the Colorado Plateau ecoregion. The max and min are the highest and lowest percentages of bare soil from AIM data points across the Colorado Plateau ecoregion. The upper limit and lower limit are the upper and lower benchmark values determined by the interdisciplinary team. AIM1, AIM2, AIM3, and AIM4 are percentages of bare soil from AIM data points in mixed salt desert scrub in the assessment area (grazing allotment).

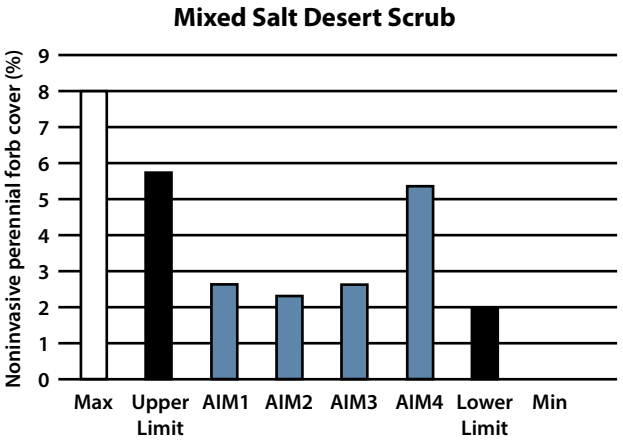


Figure 6. Graph showing a summary of the percentages of noninvasive perennial forb cover from AIM data points in mixed salt desert scrub vegetation type within the Colorado Plateau ecoregion. The max and min are the highest and lowest percentages of noninvasive perennial forb cover from AIM data points within the Colorado Plateau ecoregion. The upper limit and lower limit are the upper and lower benchmark values determined by the interdisciplinary team. AIM1, AIM2, AIM3, and AIM4 are percentages of noninvasive perennial forb cover from AIM data points in mixed salt desert scrub in the assessment area (grazing allotment).

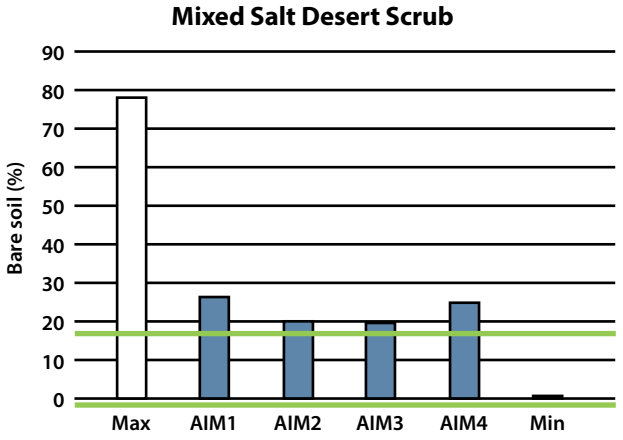


Figure 7. Graph showing the same information as Figure 5, presented in a slightly different way. The green lines represent the upper and lower benchmark values. This representation makes it easier to see which AIM points meet the benchmarks, which are the points that fall within the green lines. The bare soil indicator did not attain the benchmark at AIM1, AIM2, AIM3, and AIM4 points.

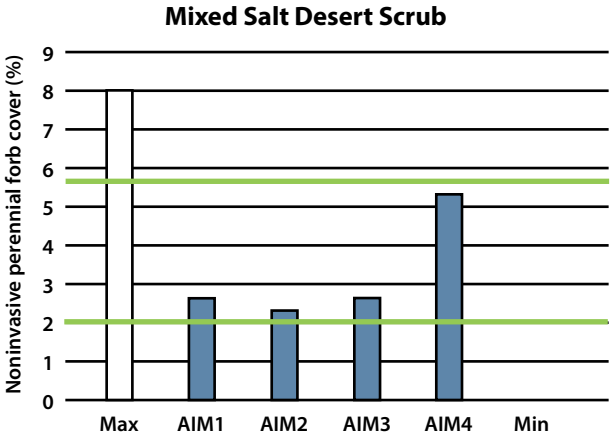


Figure 8. Graph showing the same information as Figure 6, presented in a slightly different way. The green lines represent the upper and lower benchmark values. This representation makes it easier to see which AIM points meet the benchmarks, which are the points that fall within the green lines. The noninvasive perennial forb cover indicator attained the benchmark at AIM1, AIM2, AIM3, and AIM4 points.

Figures 5, 6, 7, and 8 show whether AIM points attained or did not attain benchmarks. It may be helpful to see which indicators are attaining benchmarks versus which indicators are not attaining benchmarks. Indicators that did not attain benchmarks at any AIM points are resources of concern. For example, bare soil (bare ground) did not attain benchmarks at any of the AIM data points. Therefore, the amount of bare soil is of concern in the allotment (Figures 5 and 7). Indicators that attain benchmarks at all AIM points are likely not of concern. For example, noninvasive perennial forb cover attained the benchmark at all of the AIM data points. Therefore, there is little concern about noninvasive perennial forbs (Figures 6 and 8). Indicators that attained benchmarks at some points and not others will require further interpretation (e.g., other monitoring data with rationale). Table 5 shows a summary of AIM soil aggregate stability values from the allotment and whether they attained or did not attain benchmarks.

Table 5. Summary table for soil aggregate stability from AIM points by pasture within the allotment. Comparisons of benchmarks and provisional ecological site descriptions are provided if available.

Pasture	Site (AIM)	AIM Vegetation Category	Ecological Site Description (ESD)	Expected Value (ESD)	Observed Value	Benchmark Value	Benchmark Attained (Y/N)
Pasture 1	AIM 1	Mixed Salt Desert Scrub	34BY106UT Desert Loam Shadscale	4	4	4-6	Y
Pasture 1	AIM 2	Mixed Salt Desert Scrub	34BY106UT Desert Loam Shadscale	4	4	4-6	Y
Pasture 1	AIM 3	Mixed Salt Desert Scrub	34BY106UT Desert Loam Shadscale	4	2	4-6	N
Pasture 1	AIM 4	Mixed Salt Desert Scrub	36XY114CO Mtn Pinyon	3-6	4	4-6	Y
Pasture 1	AIM 5	Cottonwood	None	NA	5	4-6	Y
Pasture 2	AIM 6	Mixed Salt Desert Scrub	34BY212UT Semi Desert Loam	5	2	3-6	N
Pasture 2	AIM 7	Wyoming Big Sagebrush	34BY106UT Desert Loam	4	3	5-6	N
Pasture 3	AIM 8	Saltbush/ Shadscale	34BY106UT Desert Loam	4	4	4-6	Y
Pasture 3	AIM 9	Wyoming Big Sagebrush	34XY401CO Loamy Salt Desert - DRAFT	NA	5	5-6	Y
Pasture 4	AIM 10	Pinyon-Juniper	None	None	4	5-6	N
Pasture 5	AIM 11	Pinyon-Juniper	None	None	3	5-6	N
Pasture 5	AIM 12	Wyoming Big Sagebrush	None	None	2	5-6	N

5.2 Document Attainment/ Nonattainment of Benchmark Values

Once data are organized, specialists should check benchmarks and understand the data. For example, check specific points that did or did not attain benchmarks, and consider whether the assumptions made in applying the benchmarks are valid. Look for site-specific conditions, anomalies, and limitations of benchmarks. Are there certain points that should be eliminated or moved to a different benchmark group? Be sure to provide the rationale behind any changes.

This is a check on defensible benchmark values. If benchmark values are altered, a logical and well-supported explanation for that change needs to be clearly stated. Changes to established benchmark values should be rare and should be reviewed and agreed upon by the ID team. These analyses are only as confident as resource specialists and managers are confident in the benchmarks themselves. Therefore, it is important to document how benchmarks were chosen and known limitations of benchmarks. It is also important to avoid circular reasoning, in which the indicator values within the assessment area are also relied upon to set benchmark values. Documentation of rationale may be required for some decision-making processes.

5.3 Evaluate Achievement/ Nonachievement of Land Health Standards

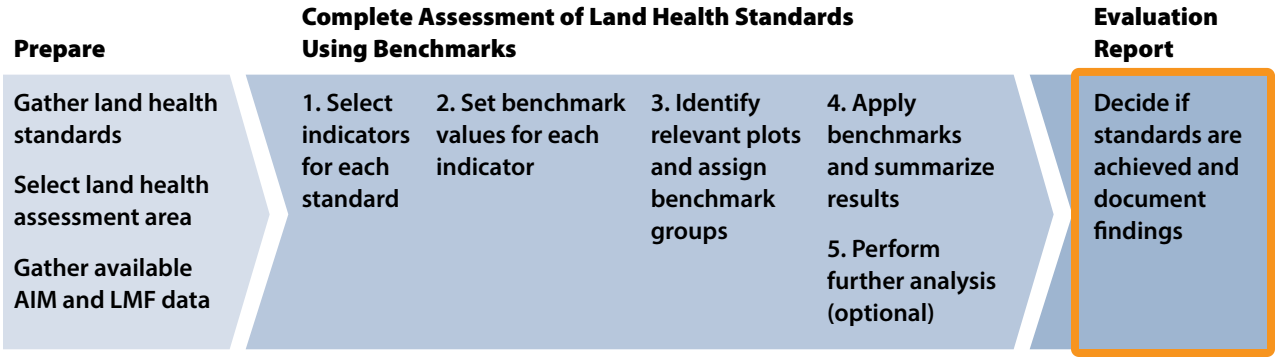
If an indicator does not meet a benchmark, the first questions to ask are Why? and What does this mean? Not meeting a particular benchmark for a particular indicator may not mean that a management objective (e.g., land health standard) has not been met. The ID team needs to use AIM data, along with other data, as multiple lines of evidence (preponderance of evidence) to determine if a management objective has or has not been met. Then the ID team must use evidence from all management objectives to evaluate management questions. For example, in an area recently treated, bare ground may exceed benchmarks. However, if monitoring data show that desirable species are increasing, higher than expected bare ground may not be cause for the area to be deemed not meeting management objectives for land health standard 1. When an indicator does not meet a benchmark at a point, it may be useful to consider it in the context of the other indicators at the point, and the overall ecological condition.

This will likely take an extended or several extended meetings, depending on the amount of data available and the area to be evaluated. During these meetings, the ID team evaluated achievement of land health standards, through multiple lines of evidence including attainment or nonattainment of benchmark values. A designated notetaker documented rationale during the evaluation.

Example data summary which can be included in the assessment/evaluation report:
The Grand Junction Field Office sampled five AIM points between 2015 and 2017 in pasture 1. Four of the five points were found in mixed salt desert scrub communities, and one was found in the cottonwood community, based on LANDFIRE biophysical settings and the AIM project design. These sites were compared with other similar sites on BLM-managed lands across the Colorado Plateau ecoregion. Comparisons were made by an ID team based on benchmarks, which were defined by the available data and references. Compared with similar points across the Colorado Plateau ecoregion, all sites sampled in pasture 1 had less cover of noninvasive plants (grasses and shrubs). All sites had greater bare ground, less soil stability, greater cover of invasive annual grasses, and a greater number of invasive species compared with similar points across the Colorado Plateau ecoregion. All points attained benchmarks for cover of invasive annual and perennial forbs.

Concerns consistently identified through AIM monitoring for pasture 1 include less cover of noninvasive perennial grasses and shrubs, greater bare ground, and less soil stability than expected.

6. Evaluation Report



The process for assessing land health is defined in BLM Manual 4180, "Land Health." This section shows how the Grand Junction Field Office used AIM and other data, and the previously detailed process to inform the land health assessment and evaluation report following the workflow in Figure 9.

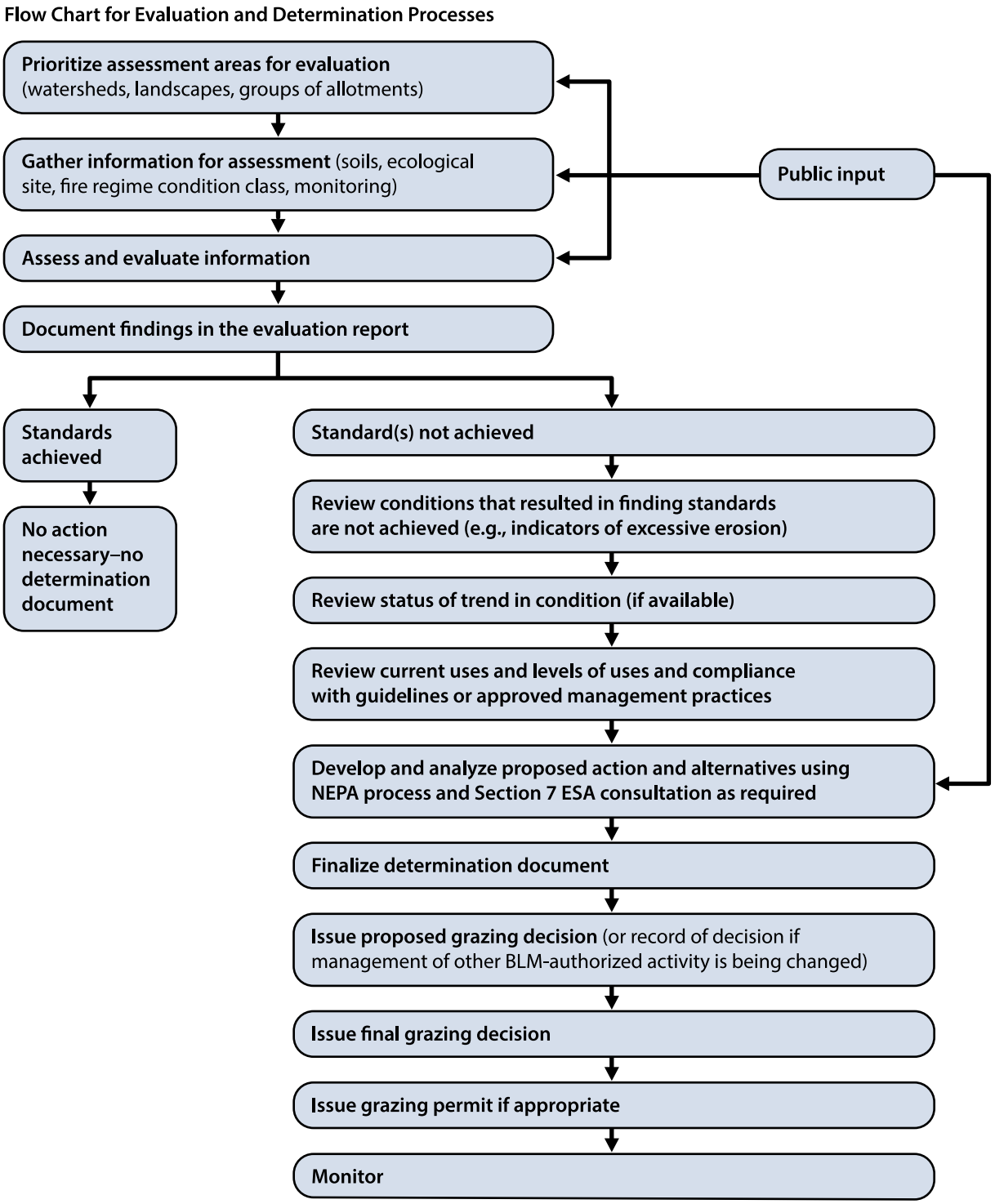


Figure 9. Workflow for incorporating land health evaluation and determination into processing of grazing permits and leases (BLM 2008).

AIM data may be used to provide multiple lines of evidence toward evaluations of land health standards. If conditions are not clear from reviewing the data, or if AIM and other available data conflict, an ID team may want to revisit AIM points for added insight or context. After evaluating data and benchmarks, the ID team considered multiple lines of evidence to conclude whether each applicable standard was met at the pasture level and document the rationale for conclusions.

If an ID team concludes that a standard is not met, any available trend information should be used to investigate whether significant progress towards achieving the standard is being made. AIM data may be used for this purpose when plots have been sampled more than once. In this example, the AIM plots had only been sampled once and could not be used to infer trend. However, long-term key area frequency trend data were available and provided some information about trends over time.

The following are some examples of summaries of evaluation findings of land health standard 3 (native and other desirable species) in the allotment.

Evaluation findings of Colorado land health standard 3 (native and other desirable species) for all pastures within the grazing allotment.

Evaluation Finding for Colorado Land Health Standard 3 for the Allotment

☒ Meeting the Standard
Pastures: Pasture 4

☒ Not meeting the Standard
Pastures: Pasture 1, Pasture 2, and Pasture 3

☐ Not meeting the Standard, but making progress toward meeting the Standard
Pastures:

☐ Standard does not apply
Pastures:

Allotment is not meeting Land Health Standard 3.

Summary of the conditions and rationale for evaluation findings of Colorado land health standard 3 for all pastures within the grazing allotment:

Pasture 1: **The pasture is not meeting land health standard 3. Based on AIM data, there are less native perennial grasses, perennial and annual forbs, and shrubs than expected. There are more invasive plant species than expected. Nested frequency data from key areas show that the trend for key native perennial species, in general, is stable to downward. Interpreting indicators of rangeland health (IIRH) data identify issues of low vegetation production, little presence of perennial grasses, and decreasing shrubs.**

Pasture 2: **The pasture is not meeting land health standard 3. Based on AIM data, there is less foliar cover and more cover of invasive plants than expected. Nested frequency data from key areas show that the trend for key native perennial species, in general, is stable to downward. IIRH data identify issues of low vegetation production, little presence of perennial grasses, and decreasing shrubs.**

Pasture 3: **The pasture is not meeting land health standard 3. Based on AIM data, there is less native perennial vegetation, more bare ground, and more invasive plants than expected. Nested frequency data from key areas show that the trend for key native perennial species, in general, is stable to downward. IIRH data identify issues of low vegetation production, little presence of perennial grasses, and decreasing shrubs.**

Pasture 4: **The pasture is meeting land health standard 3 based on AIM and IIRH data.**

7. Next Steps: Determination of Causal Factor(s) and NEPA Analysis

If through the evaluation process, an ID team concludes that one or more standards is not achieved, and there is not evidence that significant progress is being made towards achievement, the next step is to identify causal factors and complete a determination (see BLM Handbook H-4180-1, "Rangeland Health Standards"). AIM data do not directly address causal factors, as the data do not assign causes to conditions. AIM data provide one line of evidence regarding resource conditions and can help identify potential resource concerns. However, causal factors can be well informed with a multiple lines of evidence approach. AIM, as well as other data, including land health data, interpreting indicators of rangeland health (IIRH) data (Pellant et al. 2020), targeted studies (e.g., utilization studies, route inventories), actual use records, fire and land treatment records, climate analysis, scientific references, or other sources, can help inform conclusions regarding causal factors. Compiling multiple data sources and drawing conclusions based on a preponderance of evidence approach will limit reliance on "professional judgement" and reduce ambiguity. This results in a well-informed and logical conclusion regarding causal factor determinations.

The following are example excerpts of a determination of causal factors and an affected environment for an environmental assessment. Note that the example causal factors excerpt shows the rationale for one pasture, but the determination document would include rationale for all of the pastures within the allotment. The final determination for the entire allotment would be made based on all pastures discussed.

Example Excerpt of Determination of Causal Factors for Pasture 1:
Pasture 1 is not achieving land health standards 3 and 4. Standards 3 and 4 are interrelated and therefore have similar rationale for not being achieved. Causal factors for the findings include current and historic livestock grazing, fire regime, drought, introduction of invasive species, and increased recreation.

Actual use reporting of current livestock grazing over the last 15 years has fluctuated according to livestock use data in the 2019 rangeland health assessment (RHA). [Note: The RHA referenced here is a data summary, assessment, and evaluation report and is not included as a reference in this technical note]. In general, this pasture has been used from winter into spring (December to March) with livestock either starting or ending in Pasture 1, depending on year and rotation.

Both BLM and permittee IIRH data identify issues of low vegetation production, little presence of perennial grasses, and decreasing shrubs (RHA 2019). Based on AIM data, cover of native perennial grasses, perennial and annual forbs, and shrubs were less than expected (RHA 2019), and cover of invasive plants was greater than expected.

Another concern within the pasture is documented heavy livestock grazing on rabbitbrush (*Chrysothamnus* spp.), which is a native perennial shrub. In general, rabbitbrush is considered to have poor forage value to livestock and is therefore considered an important browse species on depleted rangelands (USU 2017). The observation that undesirable vegetation is being grazed by livestock may indicate the lack of available quality forage plants.

Example Excerpt of Determination of Causal Factors for Pasture 1: continued

Excessive utilization levels have been documented in some years on dormant plants (RHA 2019) with insufficient residual vegetation. Utilization levels have exceeded 50% on key species, which is above the suggested guidelines within the Grand Junction Field Office Approved Resource Management Plan (2015). Removing dead leaves and stems during dormancy has minimal direct effect on the plant. However, there may be negative impacts if grazing is heavy, and mechanical injury to crowns can occur. Proper utilization allows stubble for root and crown protection, litter accumulation for organic matter contribution to the soil, cover and habitat for wildlife, and forage availability for grazing animals utilizing the area. Further, stubble breaks raindrop impact, reduces splash erosion, cools the soil with shade, and conserves moisture in the soil.

Drought was documented with less than half of the average recorded precipitation in 2004 and 2008 (WRCC 2017) and had negative effects on perennial plants, contributing to decreases in perennial plant frequency in years after drought. The 4 Road Fire burned 25% of the acres in Pasture 1, and rehabilitation efforts were largely unsuccessful with little documented establishment of perennial plants after reseeding efforts in 2006. Increased recreation has contributed to increased cover of invasive plant species along trails within the pasture.

It has been determined that the significant causal factors for nonachievement of standard 3 within the allotment include current and historic grazing, fire regime, drought, introduction of invasive species, and increased recreation. Impact from natural gas development is a localized causal factor in a small portion of the allotment.

Example Excerpt of Affected Environment for Environmental Assessment:

The allotment contains a 10,000-acre area of critical environmental concern (ACEC). The ACEC represents 20% of the overall range available for animal species A, which is unique to the Grand Junction Field Office and listed as threatened. AIM data collected within the allotment and within the ACEC show that benchmarks were not attained, with less than expected cover for noninvasive perennial grasses and noninvasive shrubs, which provide forage for animal species A. Thus, this allotment is not achieving Colorado land health standard 4, which states: "Special status, threatened and endangered species (federal and state), and other plants and animals officially designated by the BLM, and their habitats are maintained or enhanced by sustaining healthy, native plant and animal communities."

An evaluation of land health standard 4 found that pastures 1, 2, 3, and 4 do not meet land health standard 4 with current livestock grazing as a causal factor (RHA 2019). Actual use reporting showed livestock in the pastures during the critical growing period. Utilization data showed that livestock have exceeded resource management plan proposed utilization rates for perennial grasses. Animal species A and livestock overlap in use of perennial grasses for forage.

8. Summary

Data collected through the BLM AIM Program represent one of the largest available datasets to inform resource management decisions on public lands. This technical note provides an example of using AIM data, along with other available data, to answer management questions at the field office level. This is an example only, and specific processes may differ. The detailed example presented in this technical note is a companion to TN 453, "Guide to Using AIM and LMF Data in Land Health Evaluations and Authorizations of Permitted Uses," and is intended to help field offices use AIM data to make field office-level decisions.

Appendix A: Indicators and the Justification for Upper and Lower Limits of Benchmarks

This appendix presents the justification for upper and lower limits of benchmarks using quantiles (Q) from an analysis of all Assessment, Inventory, and Monitoring (AIM) data points within the Colorado Plateau (EPA level III ecoregion) and other scientific data (e.g., EPA 2000) as determined by the Grand Junction Field Office interdisciplinary team. The use of quantiles allows additional data to be used to inform benchmarks as it becomes available. Another approach is to use set values (e.g., from ecological site descriptions). Whichever method is used, benchmarks should be periodically reviewed by an appropriate interdisciplinary team. In this analysis, benchmarks were developed from AIM points within a vegetation type within the Colorado Plateau ecoregion. Vegetation categories from LANDFIRE were combined into more general categories. Approved ecological site descriptions were not available for the assessment area. However, provisional major land resource area (MLRA) ecological site descriptions were compared with benchmarks and AIM data as another line of evidence to support evaluations about on-the-ground conditions, where possible. Shaded cells indicate interdisciplinary team reasoning and discussion.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Bare Soil Cover	Q25	0	In this vegetation type, less bare ground is considered to indicate a more intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have no bare ground up to as much bare ground as 25% of points in the Colorado Plateau with the least amount of bare ground.
Cottonwood	Gap (25-50 cm) Proportion of Line			In this vegetation type, smaller gaps do not necessarily indicate a more intact system. This system may be healthy with some small gaps or no small gaps. Since the interdisciplinary team could not come up with a meaningful benchmark, this indicator is not considered in this analysis.
Cottonwood	Gap (> 25 cm) Proportion of Line			This indicator encompasses all other indicators and was not meaningful in this example. More specific gap indicators were used.
Cottonwood	Gap (51-100 cm) Proportion of Line	Q25	0	In this vegetation type, gaps from 51 to 100 cm are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have no gaps from 51 to 100 cm to as many 51 to 100 cm gaps as 25% of points in the Colorado Plateau with the least cover of gaps from 51 to 100 cm.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Gap (101-200 cm) Proportion of Line	Q25	0	In this vegetation type, gaps from 101 to 200 cm are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have no gaps from 101 to 200 cm to as many 101 to 200 cm gaps as 25% of points in the Colorado Plateau with the least cover of gaps from 101 to 200 cm.
Cottonwood	Gap (> 200 cm) Proportion of Line	Q25	0	In this vegetation type, gaps greater than 200 cm are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have no gaps over 200 cm to as many gaps over 200 cm as 25% of points in the Colorado Plateau with the least cover of gaps over 200 cm.
Cottonwood	Average Herbaceous Height	Max	Q75	In this vegetation type, taller herbaceous vegetation is considered to indicate a more intact system. Additionally, there is no upper limit (e.g., very tall herbaceous vegetation is not considered to indicate a concern in this system). Therefore, the upper limit of the benchmark is the maximum height found in the Colorado Plateau, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have herbaceous vegetation at least as tall as 25% of points in the Colorado Plateau with the tallest herbaceous vegetation.
Cottonwood	Invasive Annual Forb Cover	Q25	0	Invasive annual forb species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive annual forb species than 25% of points in the Colorado Plateau with the least cover of invasive annual forb species. No cover of invasive annual forb species (0) is the lower limit.
Cottonwood	Invasive Annual Forb and Grass Cover	Q25	0	Invasive annual forb and annual grass species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive annual forb and annual grass species than 25% of points in the Colorado Plateau with the least cover of invasive annual forb and annual grass species. No cover of invasive annual forb and annual grass species (0) is the lower limit.
Cottonwood	Invasive Annual Grass Cover	Q25	0	Invasive annual grass species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive annual grass species than 25% of points in the Colorado Plateau with the least cover of invasive annual grass species. No cover of invasive annual grass species (0) is the lower limit.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Invasive Perennial Forb Cover	Q25	0	Invasive perennial forb species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive perennial forb species than 25% of points in the Colorado Plateau with the least cover of invasive perennial forb species. No cover of invasive perennial forb species (0) is the lower limit.
Cottonwood	Invasive Perennial Forb and Grass Cover	Q25	0	Invasive perennial forb and perennial grass species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive perennial forb and perennial grass species than 25% of points in the Colorado Plateau with the least cover of invasive perennial forb and perennial grass species. No cover of invasive perennial forb and perennial grass species (0) is the lower limit.
Cottonwood	Invasive Perennial Grass Cover	Q25	0	Invasive perennial grass species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive perennial grass species than 25% of points in the Colorado Plateau with the least cover of invasive perennial grass species. No cover of invasive perennial grass species (0) is the lower limit.
Cottonwood	Average Invasive Perennial Grass Height	Q25	0	Invasive perennial grass species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to be shorter (less height) invasive perennial grass species than 25% of points in the Colorado Plateau with the shortest invasive perennial grass species. No height (none present) of invasive perennial grass species (0) is the lower limit.
Cottonwood	Invasive Plants (Number of Species)	Q25	0	Invasive species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have fewer species of invasive plants than 25% of points in the Colorado Plateau with the fewest invasive species. No invasive species (0) is the lower limit.
Cottonwood	Invasive Shrub Cover			Invasive shrubs are not a concern in the study area in this vegetation type.
Cottonwood	Invasive Subshrub Cover			Invasive subshrubs are not a concern in the study area in this vegetation type.
Cottonwood	Invasive Tree Cover	Q25	0	For this vegetation type, this indicator is relevant, because there are invasive trees such as tamarisk, Russian olive, and Siberian elm often present in this vegetation type. Invasive tree species are considered to indicate a less intact system. Therefore, the upper limit of the benchmark is the 25th quantile, while the lower limit is 0. This indicates that for a point to attain the benchmark it needs to have less cover of invasive tree species than 25% of points in the Colorado Plateau with the least cover of invasive tree species. No cover of invasive tree species (0) is the lower limit.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Noninvasive Annual Forb Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive annual forbs is considered to indicate a more intact system. However, very high cover may indicate a system with a component out of balance. For example, 100% cover of native grass in a vegetation type where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive annual forbs as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Noninvasive Annual Forb and Grass Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive annual forbs and annual grass is considered to indicate a more intact system. However, very high cover may indicate a vegetation type with a component out of balance. For example, 100% cover of native grass in a vegetation type where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive annual forbs and annual grass as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Noninvasive Annual Grass Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive annual grass is considered to indicate a more intact system. However, very high cover may indicate a vegetation type with a component out of balance. For example, 100% cover of native grass in a vegetation type where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive annual grass as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Noninvasive Perennial Forb Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive perennial forbs is considered to indicate a more intact system. However, very high cover may indicate a vegetation type with a component out of balance. For example, 100% cover of native grass in a vegetation type where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive perennial forbs as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Noninvasive Perennial Forb and Grass Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive perennial forbs and perennial grass is considered to indicate a more intact system. However, very high cover may indicate a vegetation type with a component out of balance. For example, 100% cover of native grass in a system where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive perennial forbs and perennial grass as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Noninvasive Perennial Grass Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive perennial grass is considered to indicate a more intact system. However, very high cover may indicate a vegetation type with a component out of balance. For example, 100% cover of native grass in a system where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive perennial grass as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Average Noninvasive Perennial Grass Height	Max	Q75	In this vegetation type, taller noninvasive perennial grass vegetation is considered to indicate a more intact system. Additionally, there is no upper limit (e.g., very tall noninvasive perennial grass vegetation is not considered to indicate a concern in this system). Therefore, the upper limit of the benchmark is the maximum height found in the Colorado Plateau, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have noninvasive perennial grass vegetation at least as tall as 25% of points in the Colorado Plateau with the tallest noninvasive perennial grass.
Cottonwood	Noninvasive Plants (Number of Species)	Max	Q75	In this vegetation type, more species of noninvasive plants is considered to indicate a more intact system. Additionally, there is no upper limit to the number of species. Therefore, the upper limit of the benchmark is the maximum number of noninvasive species found in the Colorado Plateau, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as many noninvasive species as 25% of points in the Colorado Plateau with the most noninvasive species.
Cottonwood	Noninvasive Shrub Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive shrubs is considered to indicate a more intact system. However, very high cover may indicate a system with a component out of balance. For example, 100% cover of native grass in a system where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive shrubs as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Noninvasive Subshrub Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive subshrubs is considered to indicate a more intact system. However, very high cover may indicate a system with a component out of balance. For example, 100% cover of native grass in a system where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive subshrubs as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Noninvasive Tree Cover	Q95	Q75	In this vegetation type, higher cover of noninvasive trees is considered to indicate a more intact system. However, very high cover may indicate a system with a component out of balance. For example, 100% cover of native grass in a system where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much cover of noninvasive trees as the top 25% of points in the Colorado Plateau, but less cover than the top 5% of points.
Cottonwood	Average Other Shrub Height	Max	Q75	In this vegetation type, taller shrub (nonsagebrush shrubs) vegetation is considered to indicate a more intact system. Additionally, there is no upper limit (e.g., very tall shrub vegetation is not considered to indicate a concern in this system). Therefore, the upper limit of the benchmark is the maximum height found in the Colorado Plateau, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have shrub (nonsagebrush shrub) vegetation at least as tall as 25% of points in the Colorado Plateau with the tallest shrubs.
Cottonwood	Sagebrush Cover			The management question and monitoring objectives are not driven by greater or Gunnison sage-grouse in this assessment area. Therefore, this indicator was not relevant to the management question for this vegetation type.
Cottonwood	Average Sagebrush Height			The management question and monitoring objectives are not driven by greater or Gunnison sage-grouse in this assessment area. Therefore, this indicator was not relevant to the management question for this vegetation type.
Cottonwood	Soil Stability (All)	6	Q75	More stable soils are considered to indicate a more intact system. Additionally, there is no upper limit above which soil stability is considered to indicate a concern in this vegetation type. The scale of soil stability reaches 6; therefore, the upper limit of the benchmark is 6, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have soil stability at least as stable as the top 25% of points in the Colorado Plateau.
Cottonwood	Soil Stability (Protected)	6	Q75	More stable soils are considered to indicate a more intact system. Additionally, there is no upper limit above which soil stability is considered to indicate a concern in this vegetation type. The scale of soil stability reaches 6; therefore, the upper limit of the benchmark is 6, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have soil stability at least as stable as the top 25% of points in the Colorado Plateau.
Cottonwood	Soil Stability (Unprotected)	6	Q75	More stable soils are considered to indicate a more intact system. Additionally, there is no upper limit above which soil stability is considered to indicate a concern in this vegetation type. The scale of soil stability reaches 6; therefore, the upper limit of the benchmark is 6, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have soil stability at least as stable as the top 25% of points in the Colorado Plateau.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Cottonwood	Total Foliar Cover	Max	Q75	In this vegetation type, higher foliar cover is considered to indicate a more intact system. There is not generally an upper limit above which foliar cover is considered to indicate a concern in this vegetation type. Therefore, the upper limit of the benchmark is the maximum (highest foliar cover found), while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much foliar cover as the top 25% of points in the Colorado Plateau.
Cottonwood	Average Woody Height	Max	Q75	In this vegetation type, taller woody species vegetation is considered to indicate a more intact system. Additionally, there is no upper limit (e.g., very tall woody vegetation is not considered to indicate a concern in this vegetation type). Therefore, the upper limit of the benchmark is the maximum height found in the Colorado Plateau, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have woody vegetation at least as tall as 25% of points in the Colorado Plateau with the tallest trees.
Mixed Salt Desert Scrub	Bare Soil Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Gap (25-50 cm) Proportion of Line			Based on previous data, no reasonable benchmarks for gap could be found for this vegetation type. Specialists reviewed gap data from previous land health evaluations in the area and compared means and ranges (max and min) for areas achieving and not achieving land health standards. No discernable patterns were seen in the data.
Mixed Salt Desert Scrub	Gap (> 25 cm) Proportion of Line			Encompasses all other categories.
Mixed Salt Desert Scrub	Gap (51-100 cm) Proportion of Line			Based on previous data, no reasonable benchmarks for gap could be found for this vegetation type. Specialists reviewed gap data from previous land health evaluations in the area and compared means and ranges (max and min) for areas achieving and not achieving land health standards. No discernable patterns were seen in the data.
Mixed Salt Desert Scrub	Gap (101-200 cm Proportion of line			Based on previous data, no reasonable benchmarks for gap could be found for this vegetation type. Specialists reviewed gap data from previous land health evaluations in the area and compared means and ranges (max and min) for areas achieving and not achieving land health standards. No discernable patterns were seen in the data.
Mixed Salt Desert Scrub	Gap (> 200 cm) Proportion of Line			Based on previous data, no reasonable benchmarks for gap could be found for this vegetation type. Specialists reviewed gap data from previous land health evaluations in the area and compared means and ranges (max and min) for areas achieving and not achieving land health standards. No discernable patterns were seen in the data.
Mixed Salt Desert Scrub	Average Herbaceous Height	Max	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Annual Forb Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Annual Forb and Grass Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Mixed Salt Desert Scrub	Invasive Annual Grass Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Perennial Forb Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Perennial Forb and Grass Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Perennial Grass Cover	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Average Invasive Perennial Grass Height	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Plants (Number of Species)	Q25	0	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Shrub Cover			Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Subshrub Cover			Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Invasive Tree Cover			Not relevant to this vegetation type.
Mixed Salt Desert Scrub	Noninvasive Annual Forb Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Annual Forb and Grass Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Annual Grass Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Perennial Forb Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Perennial Forb and Grass Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Perennial Grass Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Average Noninvasive Perennial Grass Height	Max	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Plants (Number of Species)	Max	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Shrub Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Noninvasive Subshrub Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.

Vegetation Type	Indicator	Upper Limit	Lower Limit	Benchmark Justification
Mixed Salt Desert Scrub	Noninvasive Tree Cover	Q95	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Average Other Shrub Height	Max	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Sagebrush Cover	Q95	Q75	Sagebrush can be a component of the shrub community in this vegetation type. In this vegetation type, higher shrub cover is considered to indicate a more intact system. However, very high cover may indicate a system with a component out of balance. For example, 100% cover of native grass in a vegetation type where shrubs are expected may indicate a concern. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much sagebrush cover as the top 25% of points in the Colorado Plateau, but less sagebrush cover than the top 5% of points.
Mixed Salt Desert Scrub	Average Sagebrush Height	Max	Q75	Sagebrush can be a component of the shrub community in this vegetation type. In this vegetation type, taller shrubs can indicate high vigor and are considered to indicate a more intact system. There is no meaningful limit to the height of a shrub. Therefore, the upper limit of the benchmark is the maximum, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark sagebrush height needs to be at least as high as the top 25% of points in the Colorado Plateau.
Mixed Salt Desert Scrub	Soil Stability (All)	6	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Soil Stability (Protected)	6	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Soil Stability (Unprotected)	6	Q75	Same justification as this indicator in the cottonwood vegetation type.
Mixed Salt Desert Scrub	Total Foliar Cover	Q95	Q75	In this vegetation type, some gaps in foliar vegetation are expected. Therefore, very high foliar cover may not indicate a system in balance. Nonnative and invasive plant species present in this vegetation type can cause high foliar cover. Therefore, the upper limit of the benchmark is the 95th quantile, while the lower limit is the 75th quantile. This indicates that for a point to attain the benchmark it needs to have at least as much foliar cover as the top 25% of points in the Colorado Plateau, but less foliar cover than the top 5% of points.
Mixed Salt Desert Scrub	Average Woody Height	Max	Q75	Same justification as this indicator in the cottonwood vegetation type.

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