INTERPRETING INDICATORS OF RANGELAND HEALTH

—VERSION 3—

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Intended Applications

Qualitative assessments of rangeland health provide land managers and technical assistance specialists with a good communication tool for use with the public. Many of these tools have been used successfully for this purpose over the past 100 years. This technique, in association with quantitative monitoring and inventory information, can be used to provide early warnings of resource problems on upland rangelands. Rangelands are defined as "land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangelands include natural grasslands, savannas, shrublands, many deserts, tundra, alpine communities, marshes, and wet meadows" (Society for Range Management 1999). Included in this definition are oak and pinyon-juniper woodlands.

*The approach described in this technical reference **IS** designed to:*

- Be used only by knowledgeable, experienced people.
- Provide a preliminary evaluation of soil/site stability, hydrologic function, and integrity of the biotic community (at the ecological site level).
- Help land managers identify areas that are potentially at risk of degradation.
- Provide early warnings of potential problems and opportunities.
- Be used to communicate fundamental ecological concepts to a wide variety of audiences in the field.
- Improve communication among interest groups by focusing discussion on critical ecosystem properties and processes.
- Select monitoring sites in the development of monitoring programs.
- Help understand and communicate rangeland health issues.

*The approach is **NOT** to be used to:*

- Identify the cause(s) of resource problems.
- Make grazing and other management decisions.
- Monitor land or determine trend.
- Independently generate national or regional assessments of rangeland health.

This procedure has been developed for use by experienced, knowledgeable land managers. It is not intended that this assessment procedure be used by individuals who do not have experience or knowledge of the rangeland ecological sites they are evaluating. This approach requires a good understanding of ecological processes, vegetation, and soils for each of the sites to which it is applied. Furthermore, as comprehensive ecological site descriptions (which are used for reference) are not available for most sites, the user is frequently required to generate reference information based on their knowledge of the range of spatial and temporal variability apparent in a particular ecological site. This will frequently require two or more individuals (e.g., ecologist and soil scientist) to work together to make the evaluation.

Introduction

The science of assessing rangelands is changing as concepts and protocols continue to evolve. Recently the concept of rangeland health was advanced by a panel assembled by the National Research Council as an alternative to range condition. The ecological status concept is currently used by most range professionals as the basis for inventory and assessment. Although the term "health" has been controversial when used in association with natural systems (Smith 1999, Wicklum and Davies 1995, Lackey 1998 and Rapport et al. 1998), the current document follows the lead provided by the National Academy of Science (National Research Council 1994).

The National Research Council (1994) publication, *Rangeland Health, New Methods to Classify, Inventory, and Monitor Rangelands* defined rangeland health as:

> "*the degree to which the integrity of the soil and ecological processes of rangeland ecosystems are maintained.*"

In a parallel effort, the Society for Range Management's committee on Unity in Concepts and Terminology recommended that rangeland assessments should focus on the maintenance of soil at the site (Task Group on Unity in Concepts and Terminology 1995). A federal interagency ad hoc committee was established to integrate the concepts of these two groups into the various agencies' rangeland inventories and assessments. This committee refined the previous definition to read:

> *The degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem, are balanced and sustained.*

They defined integrity to mean: Maintenance of the functional attributes characteristic of a locale, including normal variability.

The challenge to scientists and managers is to translate this concept involving complex ecological processes and components into terms that the public can comprehend and that resource specialists can use to assist in identifying rangeland sites where ecological processes are or are not functioning properly. This document describes a process to educate the public and agency personnel on using observable indicators to interpret and assess rangeland health. This process relies on the use of a qualitative (i.e., non-measurement) procedure to assess the functional status of each indicator. The use of qualitative assessments is suggested as a fast survey technique to rate site protection indicators, including both plant and soil components (Morgan 1986).

The use of qualitative information (e.g., observations) to determine range and soil conditions has a long history of use in land management inventory and monitoring. Early procedures that made use of indicator ratings (i.e., a scorecard approach) included the Interagency Range Survey of 1937, Deming Two-Phase, and Parker Three-Step Method that determined, among other things, site-soil stability and usefulness of forage for livestock grazing (Wagner 1989). The Bureau of Land Management (BLM) also used soil surface factors to determine the erosional status of public lands in the 1970s (USDI 1973). Interagency Technical Reference 1737-9, Riparian Area Management: Process for Assessing Proper Functioning Condition (USDI 1993), included a qualitative checklist to assess the proper functioning condition of riparian areas.

This interagency technical reference incorporates concepts and materials from previous inventory and monitoring procedures, as well as from the National Research Council's book on Rangeland Health (NRC 1994) and the Society for Range Management's Task Group on Unity in Concepts and Terminology (1995).

Earlier versions of the current procedure were developed concurrently. An interagency technical team led by the BLM developed Version 1a (Pellant 1996). The Natural Resources Conservation Service (NRCS) developed Version 1b, as published in the National Range and Pasture Handbook (USDA 1997). Another interagency team melded these concepts and protocols with the results from numerous field tests of Version 1a (Rasmussen, Pellant, and Pyke 1999) and Version 1b into Version 2. Version 2 received peer review and numerous other comments to arrive at the process described herein, which is Version 3.

Along the way, this procedure has been termed "rapid assessment," "qualitative assessment of rangeland health," and "visualization of rangeland health." This document refers to the procedure as *Interpreting Indicators of Rangeland Health*, *Version 3*. This version will be revised in the future as science and experience provides additional information on indicators of rangeland health and their assessment.

Relationship to Similarity Index and Trend Studies

Similarity index (range condition) and trend studies have long been used to assess the conditions of rangeland. The similarity index is an index of where the current plant community is in relation to the historic climax plant community, or to a desired plant community, that is one of the site's potential vegetation states. Trend is a determination of the direction of change in the current plant community and associated soils in relation to the historic climax plant community or some other desired plant community.

This rangeland health assessment is an attempt to look at how the ecological processes on a site are functioning. These three assessment tools (similarity index, trend, and rangeland health assessment) evaluate the rangeland site from different perspectives and are not necessarily correlated.

Attributes of Rangeland Health

Ecological processes include the **water cycle** (the capture, storage, and redistribution of precipitation), **energy flow** (conversion of sunlight to plant and animal matter), and **nutrient cycle** (the cycle of nutrients such as nitrogen and phosphorus through the physical and biotic components of the environment).

Ecological processes functioning within a normal range of variation will support specific plant and animal communities. Direct measures of site integrity and status of ecological processes are difficult or expensive to measure due to the complexity of the processes and their interrelationships. Therefore, biological and physical attributes are often used as indicators of the functional status of ecological processes and site integrity.

The product of this qualitative assessment is not a single rating of rangeland health, but an assessment of three components called attributes (Table 1).

Definitions of these three closely interrelated attributes are:

Soil/Site Stability

The capacity of the site to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.

Hydrologic Function

The capacity of the site to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity following degradation.

Integrity of the Biotic Community

The capacity of the site to support characteristic functional and structural communities in the context of normal variability, to resist loss of this function and structure due to disturbance, and to recover following disturbance.

Based upon a preponderance of evidence approach for the applicable indicators, each of these three attributes of rangeland health are summarized in Part 3 of the Rangeland Health Evaluation Summary Worksheet (Appendix 1). This assessment is preliminary and may be modified with the interpretation of applicable quantitative monitoring and inventory data. Both the original rating and any modification of it require a written explanation.

To reiterate, the process described here will not produce just one rating of rangeland health, but three attributes departure from the ecological site description/ecological reference area(s).

Table 1. Attributes of rangeland health and the rating categories.

Soil/Site Stability	Hydrologic Function	Integrity of the Biotic Community		
Attribute ratings are based upon "departure from ecological site description/ ecological reference area(s)" in these categories.				
Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight

Concepts

A discussion of two concepts essential to understanding and properly using this assessment procedure follow.

Transitions, Thresholds, and States

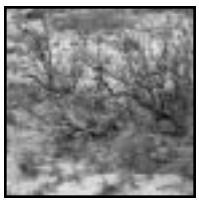
Transitions are shifts in plant composition that result in relatively stable states, as reflected in composition and structure. These shifts can occur by natural forces or as a result of human actions. Disturbances are natural and necessary parts of all ecosystems. Healthy ecosystems are both resistant to external disturbance and resilient or able to recover if external disturbances occur (Pimm 1984), thereby allowing various combinations of plant species to fluctuate over time.

A threshold is a transition boundary that an ecosystem crosses resulting in a new stable state that is not easily reversed without significant inputs of resources (NRC 1994). Once an ecosystem crosses a threshold, it may be very difficult to restore the original plant community and ecological processes by changes in management alone. Expensive restoration measures (e.g., weed control, seeding, soil modifications or additions) may be necessary to restore these degraded ecosystems.

Indicators

Unfortunately, ecological processes are difficult to observe or measure in the field due to the complexity of most rangeland ecosystems. Indicators are components of a system whose characteristics (e.g., presence or absence, quantity, distribution) are used as an index of an attribute (e.g., rangeland health) that is too difficult, inconvenient, or expensive to measure. Just as the Dow Jones Index is used to gauge the strength of the stock market, so different combinations of the 17 indicators (Appendix 6) are used to gauge soil/site stability, hydrologic function, and the integrity of the biotic community of selected rangeland ecological sites. Each of the indicators is followed by five descriptors with a narrative that the evaluator(s) reviews prior to agreeing on an appropriate category for each indicator.

Indicators have historically been used in rangeland monitoring and resource inventories by land management and technical assistance agencies. These indicators focused on vegetation (e.g., production, composition, density) or soil stability as indicators of rangeland condition or livestock carrying capacity. Such single indicator assessments are inadequate to determine rangeland health because they do not reflect nor assess the complexity of the ecological processes. There is no one indicator of ecosystem health; instead, a suite of key indicators should be used for an assessment (Karr 1992).



Instructions for Use

A rangeland health assessment provides information on the functioning of the ecological site. This assessment provides information that is not available with other methods of evaluation. It gives an indication of the status of the three attributes chosen to represent the health of the "area of interest" (i.e., the area where the evaluation of the rangeland health attributes takes place). This interest may be due to concern about current condition, lack of information on condition, or public perceptions on the condition of the area of interest.

The following instructions are intended to provide a step-by-step guide for the user. The steps are identified along with the worksheet(s) required to complete each step. The action or concept for that step is then explained.

Step 1. Identify the Evaluation Area, Verify Soil and Ecological Site Identification

Complete the Rangeland Health Evaluation Summary Worksheet, Part 1 (Appendix 1).

Describe the area of interest (area where evaluation is conducted)

Part 1 of the Rangeland Health Evaluation Summary Worksheet is used to record information on site location for the evaluation of an area of interest and basic site characteristic information (Appendix 1). Parts 2 and 3 of this worksheet are completed during Steps 5 and 6. Critical items that **must be** completed on this form are shown in **bold** print.

The evaluation area (area of interest) should be large enough to include the natural variability associated with each ecological site being assessed. Upon arrival at the location, the evaluator(s) should identify the boundaries of the area of interest and walk 1 to 2 acres of each ecological site (if more than one ecological site is present in the area of interest). This enables the evaluator(s) to become familiar with the plant species, soil surface features, and the variability of the area of interest.

Surrounding features which may affect ecological processes within the area of interest should also be noted. The topographic position of the area of interest, adjacent roads, trails, watering points, gullies, timber harvests, and other disturbances can all affect onsite processes. The topographic position should be carefully described with documentation of offsite influences on the area of interest. There is significant variability in the potential of different sites associated with relatively minor differences in landscape position and soils (e.g., differences in aspect, or location at the top vs. bottom of a slope). Landscape position and surrounding features are documented in Part 1 of the Rangeland Health Evaluation Summary Worksheet (Appendix 1).

Photographs, slides, or digital images should be taken and included as an attachment to this worksheet. Two general view photographs taken in different directions (include some skyline for future point of reference) should be taken along with photographs that illustrate important indicator values or anomalies.

Verify the soil and ecological site

Each ecological site within the area of interest should be verified by matching the site to the appropriate ecological site description and soils. The best way to confirm the soil classification,

and thus the ecological site, is for a soil scientist to dig one or more shallow pits to verify that the soil classification matches the soils at the area of interest. The evaluator(s) should review the ecological site description for consistency with the soils and vegetation found on the area of interest.

All soil map units have inclusions of soils other than those in the map unit name; location of a site on an inclusion is not recommended. If the area of interest falls on an inclusion, special care must be taken in comparing the sites with the appropriate ecological reference area(s) (ERAs) (see Step 2) and the ecological site description. If the soil map unit is a soil association or soil complex (i.e., includes more than one soil series), the soil series that occurs within the area of interest should be identified and recorded.

The rangeland ecological site description contains information in the soils sections to aid in the verification of the site. Those soil features that are important to the soil/plant/air/water relationships are the items of interest. Soil texture for each horizon, and soil depth, or depth to horizons which may restrict water movement or root growth (e.g., calcic or sodic) or hold more water (e.g., argillic) and other soil features which are important to soil/plant/air/water relationships need to be verified. Each rangeland ecological site will have its own set of important soil features that are identified in the site description and will need to be considered in the correlation process. The information needed in the Rangeland Health Evaluation Summary Worksheet, Part 1 (Appendix 1), and in the Ecological Reference Area Worksheet for the Soil/Site Verification Section (Appendix 2) can be found in the soils section of the rangeland ecological site description.

Actions to take if soil and/or ecological site information is not available

Comparisons between the ecological reference area (see Step 2) and one or more areas of interest are difficult in areas where a soil survey has not been completed and/or ecological site descriptions have not been developed or are not adequate. Identification of ERAs is hindered and correlation between ERAs and area(s) of interest is difficult. Soil information in the ecological site description and soil survey or soil series descriptions are good sources of information to piece together the potential for erosion on the site. Soil information, together with information on the climate, including storm types, intensities, and duration provides information necessary to conduct the assessment. Vegetation information may be available in other sources such as habitat type descriptions, long-term monitoring studies, and other inventory data. If possible, obtain the assistance of a qualified soil scientist to assist the evaluator(s) in making the initial soil/site correlations.

The process used to conduct the evaluation without the required soils and ecological site information should be clearly documented by the team on the Ecological Reference Area Worksheet (Appendix 2).

Step 2. Visit an Ecological Reference Area

Complete the Cover Worksheet (Appendix 3), Species Dominance Worksheet (Appendix 4), Functional/Structural Groups Worksheet (Appendix 5), and Ecological Reference Area Worksheet (Appendix 2), in that order.

An ecological reference area (ERA) is a landscape unit in which ecological processes are functioning within a normal range of variability and the plant community has adequate resistance to and resilience from most disturbances. An ERA is the visual representation of the characteristics and variability of the components found in the ecological site description. These areas do not need to be pristine, historically unused lands (e.g., climax plant communities or relict areas). This concept is similar to that proposed by the Western Regional

Coordinating Committee-40 on Rangeland Research of using well-managed rangelands and appropriate relict areas as benchmarks for assessments (West et al.1994). The concept of ERAs is an integral component in the development of ecological site descriptions. Information obtained from the Cover, Species Dominance, and Functional/Structural Groups Worksheets provides useful information in completing the Ecological Reference Area Worksheet. The influences of wildland fire on the ERA should also be documented on the Ecological Reference Area Worksheet.

Completing the Cover Worksheet (Appendix 3)

The Cover Worksheet is divided into two sections: The Life Forms section, where canopy cover is estimated for important life forms (e.g., grass, forb, shrub, tree, succulents, and biological crusts) and the Ground Cover section, where the amount (cover) of bare ground, litter, standing dead vegetation, rock/gravel, biological crust, and plants are estimated.

Canopy cover is the percentage of the ground covered by plant foliage. When estimating canopy cover, small openings (less than 2 inches in diameter) within the canopy are included as cover. Canopy cover of plants removed by grazing is **not** reconstructed to pregrazing canopy for this estimate. Estimate only the canopy cover present at the time the evaluation is conducted. This ensures an accurate picture of the actual site protection from raindrop impacts at the time that the assessment is conducted.

The cover in the **Life Forms** section includes cover estimates of the overlapping canopies of different life forms. For example, the cover of both a grass beneath a shrub canopy and the canopy cover of the shrub are estimated and recorded on the worksheet in the appropriate categories. The subdivisions of life forms for each life form class (e.g., annuals, native perennial, exotic perennial under the Grass category) may be deleted and other categories added to better represent local vegetation. The cover ranges may also be changed to better fit natural or ecologically relevant breaks in cover for different areas.

The **Ground Cover** section represents the proportion of the soil that is protected from being hit directly by a raindrop. Ground cover is the percentage of material (e.g., litter, standing dead vegetation, gravel/rocks, vascular plants, and biological crust), covering the land surface. In contrast with the Life Forms section, overlapping cover classes are not estimated.

Ground cover is estimated by recording cover estimates of the first contact (i.e., highest contact above soil surface) with live vascular plants, standing dead vegetation, litter, biological crust, rock/gravel, and bare ground. The sum of these six cover categories should roughly total 100 percent, given the use of ranges of cover instead of discrete cover values on the form. If cover measurements are taken, they may be inserted into the Cover Worksheet in lieu of a checkmark for the appropriate cover category.

The total cover of the vegetation Life Forms will not necessarily equal the Vascular Plants cover value in the Ground Cover section since the former contains cover estimates for overlapping canopies while the latter does not.

The litter category in the Ground Cover section includes both persistent and non-persistent litter. Litter includes all dead organic matter in contact with the soil surface.

Standing dead vegetation includes all plants that have been dead more than one growing season that are not in direct contact with the soil surface. Standing dead vegetation is important in protecting the site from raindrop contact, while litter provides the same site protection and is an important source of organic matter via decomposition in many areas.

The rock/gravel category includes all material with a diameter **greater than 0.2 inch**. Any gravel less than this diameter is recorded as bare ground.

Biological crust includes lichens, mosses, cyanobacteria, and algae that grow on the soil surface. It is sometimes difficult to differentiate biological crust from bare soil or dead organic matter during the dry portion of summer. Spraying questionable areas with water and waiting a minute will often give live lichens or mosses a greenish tinge indicating live tissue. Conversely, cyanobacteria crusts are often very difficult to identify, especially when weakly developed, without a careful examination of the internal structure of the crust. Cyanobacteria crusts are generally not included when estimating cover.

Training is required to estimate cover in the classes shown on the form. A quick procedure to train inexperienced personnel in estimating cover or to collect quantitative data is the Step-Point Method described in the Interagency Technical Reference, *Sampling Vegetation Attributes* (NARSC 1996). The information on the Cover Worksheet is useful in verifying consistency with cover information in the ecological site description.

Completing the Species Dominance Worksheet (Appendix 4)

The Species Dominance Worksheet is used to identify the dominant species based upon either production or cover. State or federally listed noxious weeds and invasive plants are also recorded. The evaluator(s) should be trained in the identification of all state or federally listed noxious weeds prior to conducting any evaluations. New noxious weed locations should be reported immediately to the appropriate person or office.

Part 1 is required, while Part 2 (Dominant Species by Life Form) is recommended but not required. Do not reconstruct canopy cover or production when determining species dominance if utilization of plants has occurred. It is not necessary to fill each blank in the list with a plant name if additional dominant species in that life form are not present or are rare.

Completing the Functional/Structural Groups Worksheet (Appendix 5)

This worksheet is used to group species into life form/functional/structural categories to aid in the rating of Indicator 12, Functional/Structural Groups. It is important for the evaluator(s) to have a good understanding of plant function, including but not limited to, nitrogen fixers, deep versus shallow rooted plants, warm versus cool season plants, and native versus invasive plants. Examples of functional/structural groups and more information on the determination of these groups may be found in the narrative for Indicator 12 (Functional/Structural Groups) in Step 5.

Completing the Ecological Reference Area Worksheet (Appendix 2)

Once the rangeland ecological site description and potential ERAs are identified, the evaluator(s) should visit the potential ERAs and determine (using the Ecological Reference Area Worksheet) if the ERAs are functioning at least as well as described in the ecological site description with respect to soil and site stability, hydrologic function, and biotic integrity. A number of different plant communities have the potential to meet these criteria. Species composition does not have to match the ecological site description; however, the functional and structural groups must closely match the potential depicted in the ecological site description.

Before assessing the health of an area of interest, some understanding of the structure, function, and dynamics of the local landscape is required. The evaluator needs to develop a benchmark. This is a combination of the ecological site description and an ERA, to which

the area of interest will be compared. Evaluators must identify the soils (see Steps 1 and 2 for instructions on the soil/site verification process) and climate, while considering the geomorphology and the geographic location of the area of interest. Ecological site descriptions and soil surveys provide much of this needed information, but many past ecological site descriptions only describe a single plant community, the historic climax. It is also important to remember that healthy rangelands are variable and that a number of stable states representing a suite of species and compositions (stable vegetation communities e.g., Westoby et al. 1989) may exist for each ecological site.

Care must be taken in using the ecological site description or ERA as the benchmark when disturbances have occurred. For example, if a fire occurred 5 years ago in the area of interest, the ERA should reflect the effects of a recent burn. To obtain this understanding, the evaluator(s) reviews appropriate rangeland ecological site (range site) descriptions and selects and uses appropriate ERAs for training and evaluation.

Sources to assist in the selection of potential ERAs include:

- Ecological site descriptions
- Soil surveys
- Topographic maps
- Vegetation inventories
- Research Natural Areas, Wilderness Study Areas, or other protected (large exclosures)/ special management areas
- Historical records and photographs
- Well-managed rangelands (grazing use is appropriate to maintain ecological processes and the plant community in a proper functioning state); grazing use pattern maps are helpful in identifying these areas.

Evaluators need to examine ERAs in the same year and season as the area of interest since weather during that year may affect the rating of indicators. However, ERAs may be located in different watersheds within the geographic region. At each ERA, the evaluator(s) should take photographs and record baseline information on indicator status by completing the Ecological Reference Area Worksheet and conducting quantitative cover studies.

There are instances when ERAs are not available for selected ecological sites due to past disturbance. In these cases, rangeland ecological site descriptions should be used along with the best available field sites to reconstruct the ERA on the Ecological Reference Area Worksheet. Historical journals, photographs, similar ecological sites, and scientific literature along with knowledge of the area (including the interdisciplinary team and users of the land) are other useful tools in the reconstruction process. Document the reconstruction process and rationale on the Ecological Reference Area Worksheet or on an attachment to it.

Step 3. Review/Modify Descriptors of Indicators at the Ecological Reference Area

Complete the Rangeland Health Indicator Evaluation Matrix Worksheet (Appendix 6).

Ideally, each ecological site would have a unique set of descriptors (i.e., narrative under the five categories) for each indicator. In lieu of this, a set of standard or generic descriptors (called default descriptors) have been developed for each indicator and are listed in the Rangeland Health Indicator Evaluation Matrix (Appendix 6). These descriptors are used in the evaluation of areas of interest if they "fit" the observations on the indicators found on the ecological reference area. If the default descriptor does not fit an indicator, the evaluator(s) should modify the descriptor in the "revised descriptor" space found below the "default descriptor."

This Rangeland Health Indicator Evaluation Matrix, with the revised descriptors, should be used on subsequent evaluations on that **same ecological site**. Therefore, it is important to fill out the site documentation information at the top of this Matrix if any of the descriptors are revised. These modifications in the descriptors will aid in the ongoing development of ecological site specific indicators and descriptors. Copies of the Rangeland Health Indicator Evaluation Matrix with the modified descriptors should be forwarded to the person responsible for maintaining ecological site descriptions in the state (usually the NRCS State Rangeland Management Specialist).

Badlands site where descriptors on the Rangeland Health Indicator Evaluation Matrix (Appendix 6) should be modified in the "revised descriptor" space to reflect naturally high erosion.

Indicators of soil/site stability are more likely to require these changes due to the inherently higher erosion potential on certain ecological sites. An example follows (Table 2) of possible changes in the descriptor narrative for the bare ground indicator for a badlands site (Appendix 6). Similar changes could be made for other indicators.

Table 2. Example of a revised descriptor for the bare ground indicatior.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
4. Bare Ground (Default Descriptor)	Much higher than expected for the site. Bare areas are large and generally connected.	Moderate to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas nearly to totally matches that expected for the site.
4. Bare Ground (Revised Descriptor)	Much higher than expected for the site. Bare areas are extensive with little ground cover.	Moderately higher than expected for the site. Bare areas are very large and usually connected.	Moderately to slightly higher than expected for the site. Bare areas are large and usually connected.	Slightly higher than expected for the site. Bare areas are of moderate size and usually connected.	Same as default descriptor.

Step 4. Return to the Area of Interest and Complete the Site Characterization Worksheets (Repeat Step 2, Numbers 1-3)

Complete the Cover Worksheet (Appendix 3), Species Dominance Worksheet (Appendix 4), and Functional/Structural Groups Worksheet–the "Actual" column (Appendix 5).

Refer to Step 2, Numbers 1-3, for instructions on completing the Cover, Species Dominance, and Functional/Structural Groups Worksheets. These three worksheets provide background information that is used in Step 5 to rate the individual indicators.

Step 5. Rate the 17 Indicators on the Area of Interest

Complete the Rangeland Health Evaluation Summary Worksheet, Part 2 (Appendix 1), using the Rangeland Health Indicator Evaluation Matrix (Appendix 6).

The evaluator(s) selects the category descriptor (i.e., narrative) that most closely describes the site for each indicator on the Rangeland Health Indicator Evaluation Matrix (Appendix 6) and records it on the Rangeland Health Evaluation Summary Worksheet, Part 2. The rating for each indicator in the area of interest is based on that indicator's degree of departure from the ecological site description and/or ecological reference area(s) (ERAs). Comparisons of cover (Cover Worksheet), species dominance (Species Dominance Worksheet), and functional/ structural plant groups (Functional/ Structural Groups Worksheet) on the area of interest relative to their proper functioning condition on the ERA and/or as described in the ecological site description are valuable sources of information when evaluating indicators.

For each area of interest that is assessed, the appropriate Ecological Reference Area Worksheet (if an ERA is used or if the site potential is reconstructed from an ecological site description) should be reviewed and used in conducting field evaluations on areas of interest.

Narrative descriptors in the Rangeland Health Indicator Evaluation Matrix are intended to aid in the determination of the degree of departure. The narrative descriptors for each indicator form a relative scale from "Extreme" to "None to Slight." Not all indicator descriptors will match what is observed requiring a "best fit" approach in making the ratings. The rating for each indicator should be supported by comments in the space provided under each indicator rating. In some instances there may be no evidence of the indicator on the area of interest. However, it is still rated "None to Slight."

The "revised descriptors for an indicator is used to rate indicators if the "default descriptor" on the Rangeland Health Indicator Evaluation Matrix did not adequately represent the range and status of an indicator found in the ecological site description and/or at the ERA. Revised descriptors for indicators are developed and recorded in Step 3.

When making an assessment, the history of disturbances (e.g., drought, fire) should be considered. For example, if a fire occurred 5 years ago in the area being assessed, reduced shrub (e.g., sagebrush) cover is not an indication of lack of biotic integrity if the natural successional process for shrub reestablishment is occurring. Comments on wildfire return intervals (expected and current) may also be documented in the comments section on this worksheet.

Descriptions of each indicator are provided in the following sections. Photographs of the indicators are located in Appendix 7.

1. Rills

Rills are small erosional rivulets that are generally linear and do not necessarily follow the microtopography as flow patterns do. They are formed through complex interactions between raindrops, overland flow, and the characteristics of the soil surface (Bryan 1987). The potential for rills increases as the degree of disturbance (loss of cover) and slope increases. Some soils have a greater potential for rill formation than others (Bryan 1987, Quansah 1985). Therefore, it is important to establish the degree of natural versus accelerated rill formation by interpretations made from the soil survey, rangeland ecological site description, and the ecological reference area. Generally, concentrated flow erosional processes are accelerated when the distance between rills decreases and the depth and width of rills increase (Morgan 1986, Bryan 1987).

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
1. Rills	Rill formation is severe and well defined throughout most of the area.	Rill formation is moderately active and well defined throughout most of the area.	Active rill formation is slight at infrequent intervals, mostly in exposed areas.	No recent formation of rills; old rills have blunted or muted features.	Current or past formation of rills as expected for the site.

2. Water Flow Patterns

Flow patterns are the path that water takes (i.e., accumulates) as it moves across the soil surface during overland flow. Overland flow will occur during rainstorms or snowmelt when a surface crust impedes water infiltration, or the infiltration capacity is exceeded. These patterns are generally evidenced by litter, soil or gravel redistribution, or pedestalling of vegetation or stones that break the flow of water (Morgan 1986). Interrill erosion caused by overland flow has been identified as the dominant sediment transport mechanism on rangelands (Tiscareño-Lopez et al., 1993). Water flow patterns are controlled in length and coverage by the number and kinds of obstructions to water flow provided by basal intercepts of living or dead plants, biological crust, persistent litter, or rocks. They are rarely continuous, and appear and disappear as the slope and microtopography of the slope changes.

Generally, as slope increases and ground cover decreases, flow patterns increase (Morgan 1986). Soils with inherently low infiltration capacity may have a large number of natural flow patterns.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
2. Water Flow Patterns	Extensive and numerous; unstable with active erosion; usually connected.	More numerous than expected; deposition and cut areas common; occasionally connected.	Nearly matches what is expected for the site; erosion is minor with some instability and deposition.	Matches what is expected for the site; some evidence of minor erosion. Flow patterns are stable and short.	Matches what is expected for the site; minimal evidence of past or current soil deposition or erosion.

3. Pedestals and/or Terracettes

Pedestals and terracettes are important indicators of the movement of soil by water and/or by wind (Anderson 1974, Morgan 1986, Satterlund and Adams 1992, Hudson 1993). Pedestals are rocks or plants that appear elevated as a result of soil loss by wind or water erosion. Pedestals can also be caused by non-erosional processes such as frost heaving or through soil or litter deposition on and around plants (Hudson 1993), thus it is important to distinguish and not include this type of pedestalling as an indication of erosional processes.

Terracettes are benches of soil deposition behind obstacles caused by water movement (not wind). As the degree of soil movement by water increases, terracettes become higher and more numerous and the area of soil deposition becomes larger. Terracettes caused by livestock or wildlife movements on hillsides are not considered erosional terracettes, thus they are not assessed in this process. However, these terracettes can increase erosion by concentrating water flow and/or reducing infiltration. These effects are recorded with the appropriate indicators (e.g., water flow patterns, compaction layer, and soil surface loss and degradation).

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
3. Pedestals and/or Terracettes	Abundant active pedestalling and numerous terracettes. Many rocks and plants are pedestalled; exposed plant roots are common.	Moderate active pedestalling; terracettes common. Some rocks and plants are pedestalled with occasional exposed roots.	Slight active pedestalling; most pedestals are in flow paths and interspaces and/or on exposed slopes. Occasional terracettes present.	Active pedestalling or terracette formation is rare; some evidence of past pedestal formation, especially in water flow patterns and/or on exposed slopes.	Current or past evidence of pedestalled plants or rocks as expected for the site. Terracettes absent or uncommon.

4. Bare Ground

Bare ground is exposed mineral or organic soil that is susceptible to raindrop splash erosion, the initial form of most water-related erosion (Morgan 1986). It is the opposite of ground cover, which is the percentage of ground surface covered by vegetation, litter, standing dead vegetation, gravel/rock, and visible biological crust (e.g., lichen, mosses, algae), meaning everything except bare ground (Weltz et al. 1998).

The amount and distribution of bare ground is one of the most important contributors to site stability relative to the site potential; therefore, it is a direct indication of site susceptibility to accelerated wind or water erosion (Smith and Wischmeier 1962, Morgan 1986, Benkobi et al. 1993, Blackburn et al. 1994, Pierson et al. 1994, Gutierrez and Hernandez 1996, Cerda 1999). In general, a site with bare soil present in a few large patches will be less stable than a site with the same ground cover percentage in which the bare soil is distributed in many small patches, especially if these patches are unconnected (Gould 1982, Spaeth et al. 1994, Puigdefabregas and Sanchez 1996).

The determination of adequacy of ground cover at the area of interest is made in a comparison with the ground cover information in the rangeland ecological site description (if it contains ground cover information) and/or at the ecological reference area(s) (ERAs). The Cover Worksheet (Appendix 3) is a good source of information to compare bare ground amounts between the site potential via the ERA and the site being assessed.

The amount of bare ground can vary seasonally depending on impacts on vegetation canopy cover (e.g., herbivore utilization), and litter amount (e.g., trampling loss), and annually relative to weather (e.g., drought, above average precipitation) (Gutierrez and Hernandez 1996, Anderson 1974). Current and past climate must be considered in determining the adequacy of current cover in protecting the site against the potential for accelerated erosion.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
4. Bare Ground	Much higher than expected for the site. Bare areas are large and generally connected.	Moderately to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas nearly to totally match that expected for the site.

5. Gullies

A gully is a channel that has been cut into the soil by moving water. Gullies generally follow the natural drainages and are caused by accelerated water flow and the resulting downcutting of soil. Gullies are a natural feature of some landscapes, while on others management actions (e.g., excessive grazing, recreation vehicles, or road drainages) may cause gullies to form or expand (Morgan 1986). Water flow is concentrated but intermittent, with gully depth $^1/_2$ meter or more in depth. Gullies can be caused by resource problems offsite (document this on the Rangeland Health Evaluation Worksheet), but still affect the site function on the area of interest.

Gullies may be assessed by observing the numbers of gullies in an area and/or assessing the severity of erosion on individual gullies. General signs of active erosion, (e.g., incised sides along a gully) are indicative of a current erosional problem, while a healing gully is characterized by rounded banks, vegetation growing in the bottom and on the sides (Anderson 1974), and a reduction in gully depth (Martin and Morton 1993). Active headcuts may be a sign of accelerated erosion in a gully even if the rest of the gully is showing signs of healing (Morgan 1986).

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
5. Gullies	Common with indications of active erosion and down-cutting; vegetation is infrequent on slopes and/or bed. Nickpoints and headcuts are numerous and active.	Moderate to common with indications of active erosion; vegetation is intermittent on slopes and/or bed. Headcuts are active; downcutting is not apparent.	Moderate in number with indications of active erosion; vegetation is intermittent on slopes and/or bed. Occasional headcuts may be present.	Uncommon with vegetation stabilizing the bed and slopes; no signs of active headcuts, nickpoints, or bed erosion.	Drainages are represented as natural stable channels; no signs of erosion with vegetation common.

6. Wind-Scoured, Blowouts, and/or Deposition Areas

Accelerated wind erosion on an otherwise stable soil increases as the surface crust (i.e., either physical, chemical, or biological crust) is worn by disturbance or abrasion. Physical crusts are extremely important on many rangelands with low canopy cover in protecting the soil surface from wind erosion. The exposed soil beneath these surface crusts are often weakly consolidated and vulnerable to movement via wind (Chepil and Woodruff 1963). As wind velocity increases, soil particles begin bouncing against each other in the saltation process. This abrasion leads to suspension of fine particles into the wind stream where they may be transported off the site (Chepil 1945, Gillette, Blifford and Fenster 1972, Gillette, Blifford and Fryrear 1974, Gillette and Walker 1977, Hagen 1984).

Areas of wind erosion within a vegetation community are represented by wind-scoured or blowout areas where the finer particles of the topsoil have blown away, sometimes leaving residual gravel, rock, or exposed roots on the soil surface (Anderson 1974). They are generally found in interspace areas, with a close correlation between soil cover/bare patch size, soil texture, and degree of accelerated erosion (Morgan 1986).

Deposition of suspended soil particles is often associated with vegetation that provides roughness to slow the wind velocity and allow soil particles to settle from the wind stream. The taller the vegetation, the greater the deposition rate (Pye 1987); thus, shrubs and trees in rangeland ecosystems are likely sinks for deposition (e.g., mesquite dunes, Gibbens et al. 1983, Hennessy 1983). The soil removed from wind-scoured depressions is redistributed to accumulation areas (e.g., eolian deposits) which increase in size and area of coverage as the degree of wind erosion increases (Anderson 1974).

Like water erosion, wind deposited soil particles can originate from offsite, but affect the function of the site by modifying soil surface texture (Hennessey et al. 1986, Morin and Van Winkel 1996). The changes in texture will influence the site's hydrologic function. Even when soil particles originate from offsite, they can have detrimental effects on plants at the deposition site.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
6. Wind-Scoured, Blowouts and/or Deposition Areas	Extensive.	Common.	Occasionally present.	Infrequent and few.	Matches what is expected for the site.

7. Litter Movement

The degree and amount of litter (i.e., dead plant material that is in contact with the soil surface) movement (e.g., redistribution) is an indicator of the degree of wind and/or water erosion. The redistribution of litter within a small area on a site is indicative of less erosion, whereas the movement of litter offsite due to wind or water is indicative of more severe erosion. In a study in the Edwards Plateau in Texas, litter accumulation was shown to be the variable most closely correlated with interrill erosion. The same study showed that litter of bunchgrasses represented significant obstructions to runoff, thereby causing sediment transport capacity to be reduced and a portion of the sediment to be deposited (Thurow et al. 1988a).

The inherent capacity for litter movement on a soil is a function of its slope and geomorphic stability. For example, alluvial fans and floodplains are active surfaces over which water and sediments are moved in response to major storm events. The amount of litter movement varies from large to small depending on the amount of bare space typical of the plant community and the intensity of the storm.

The size of litter moved by wind or water is also an indicator of degree of litter redistribution. In general, the greater distance that litter is moved from its point of origin and the larger the size and/or amount of litter moved, the more the site is being influenced by erosional processes.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
7. Litter Movement (wind or water)	Extreme; concentrated around obstructions. Most size classes of litter have been displaced.	Moderate to extreme; loosely concentrated near obstructions. Moderate to small size classes of litter have been displaced.	Moderate movement of smaller size classes in scattered concentrations around obstructions and in depressions.	Slightly to moderately more than expected for the site with only small size classes of litter being displaced.	Matches that expected for the site with a fairly uniform distribution of litter.

8. Soil Surface Resistance to Erosion

This indicator assesses the resistance of the surface of the soil to erosion. Resistance depends on soil stability, microtopography, and on the spatial variability in soil stability relative to vegetation and microtopographic features. The stability of the soil surface is key to this indicator (Morgan 1986). Soil surfaces may be stabilized by soil organic matter which has been fully incorporated into aggregates at the soil surface, adhesion of decomposing organic matter to the soil surface, and biological crusts. The presence of one or more of these factors is a good indicator of soil surface resistance to erosion (Blackburn et al. 1992; Pierson et al. 1994).

Where soil surface resistance is high, soil erosion may be minimal even under rainfall intensities of over 5 inches/hour, generating high runoff rates on plots from which all cover has been removed (Goff et al. 1993). Conversely, the presence of highly erodible materials at the soil surface can dramatically increase soil erosion by water even when there is high vegetative cover (Morgan et al. 1997) and by wind when vegetative cover is removed (Fryrear et al. 1994, Belnap and Gillette 1998).

In areas with low vegetative cover, the stability of soil in the plant interspaces is more important than stability under plants. Similarly, where pedestals have formed along flow paths, the soil at the edge of the pedestal will be subjected to more intense forces during overland flow than soil which is topographically above the flow path.

Another good indicator is the resistance of soil surface fragments to breakdown when placed in water. For a simple test, use the tip of a knife to remove several small (**maximum** 1/4 inch diameter x 1/8 inch deep) fragments from the soil surface, from beneath plants, from interspaces, and from any other areas which might differ in soil stability. Place each in a separate bottlecap filled with water. Fragments with low stability will appear to lose their structure or "melt" within 30 seconds. Fragments with extremely low stability will "melt" immediately upon contact with the water and the water will become cloudy as the soil particles disperse. Fragments with moderate stability will appear to retain their integrity until the water in the bottlecap is agitated or gently swirled. Highly stable aggregates will retain their shape, even when agitated indefinitely. For multiple samples, or where more precision is desired, a simple soil stability kit can be used to generate a rating from one (unstable) to six (stable) (Herrick et al. In Press) (Appendix 8). This indicator is most highly correlated with water erosion (Blackburn et al. 1994; Pierson et al. 1994). Susceptibility to wind erosion also declines with an increases in soil organic matter (Fryrear et al. 1994).

Biological crusts consist of microorganisms (e.g., lichens, algae, cyanobacteria, microfungi) and non-vascular plants (e.g., mosses, lichens) that grow on or just below the soil surface. Soil physical and chemical characteristics, along with seasonal precipitation patterns, largely determine the dominant organisms comprising the crust.

Biological crusts are primarily important as cover and in stabilizing soil surfaces (Bond and Harris 1964; Belnap and Gardner 1993). In some areas, depending on soil characteristics, they may increase or reduce the infiltration of water through the soil surface or enhance the retention of soil water (i.e., acting as living mulch). In general, the relative importance of biological crusts increases as annual precipitation and potential vascular plant cover decreases. If information on biological crusts is lacking in the ecological site descriptions, refer to the ecological reference area (ERA) for baseline information prior to conducting the evaluation.

Physical crusts are thin surface layers induced by the impact of raindrops on bare soil causing the soil surface to seal and absorb less water. Physical crusts are more common on silty, clayey, and loamy soils and relatively thin, if at all present, in sandy soils. Physical and chemical crusts tend to have very low organic matter content, or contain only relatively inert organic matter that is associated with relatively little biological activity. As this physical crust becomes more extensive, infiltration rates are reduced and overland water flow increases. Also, water can pond in flat crusted areas and is more likely to evaporate than infiltrate into the soil.

Physical soil crusts are identified by lifting the soil surface with a pen or other sharp object and looking for cohesive layers at the soil surface which are not perforated by pores or fissures and in which there is no apparent binding by visible strands of organic material, such as cyanobacteria.

Physical crusts may exert a positive influence on reducing wind erosion (see discussion in Indicator 6, Wind-Scoured, Blowouts, and/or Deposition Areas). However, their function in stabilizing the soil surface against water erosion is generally negative. Physical crusts also include vesicular crusts which contain numerous small air pockets or spaces similar to a sponge; however, these soils are still resistant to infiltration.

Chemical crusts rarely form in rangelands except on soils formed from particular parent materials (e.g., salt desert shrub communities–see the soil survey that covers the area of interest and/or the ERA) and in abandoned, irrigated agricultural fields. Where they do occur, they can reduce infiltration and increase overland water flow similar to physical crusts. They are usually identified by a white color on the soil surface.

This indicator is not applicable to areas in which there is no soil present at the surface due to the presence of an extensive erosion pavement (nearly 100 percent surface cover by stones) or there is continuous open water (e.g. marshes in the Southeast).

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
8. Soil Surface Resistance to Erosion	Extremely reduced throughout the site. Biological stabilization agents including organic matter and biological crusts virtually absent.	Significantly reduced in most plant canopy interspaces and moderately reduced beneath plant canopies. Stabilizing agents present only in isolated patches.	Significantly reduced in at least half of the plant canopy interspaces, or moderately reduced throughout the site.	Some reduction in soil surface stability in plant interspaces or slight reduction throughout the site. Stabilizing agents reduced below expected.	Matches that expected for the site. Surface soil is stabilized by organic matter decomposition products and/or a biological crust.

9. Soil Surface Loss or Degradation

The loss or degradation of part or all of the soil surface layer or horizon is an indicator of a loss in site potential (Dormaar and Willms 1998, Davenport et al. 1998). In most sites, the soil at and near the surface has the highest organic matter and nutrient content. This generally controls the maximum rate of water infiltration into the soil and is essential for successful seedling establishment (Wood et al. 1997). As erosion increases, the potential for loss of soil surface organic matter increases, resulting in further degradation of soil structure. Historic soil erosion may result in a complete loss of this layer (Satterlund and Adams 1992, O'Hara et al. 1993). In areas with limited slope, where wind erosion does not occur, the soil may remain in place, but all characteristics that distinguish the surface from the subsurface layers are lost. Except in soils with a clearly defined horizon immediately below the surface (e.g., argillic), it is often difficult to distinguish between the loss and degradation of the soil surface. For the purposes of this indicator, this distinction is unnecessary–the objective is to determine to what extent the functional characteristics of the surface layer have been degraded. Note also that visible soil erosion is covered in discussions of Indicator 3, Pedestals and Terracettes, and subsurface degradation in Indicator 11, Compaction Layer.

The two primary indicators used to make this evaluation are the organic matter content (Dormaar and Willms 1998) and structure (Karlen and Stott 1994) of the surface layer or horizon. Soil organic matter content is frequently reflected in a darker color of the soil, although high amounts of oxidized iron (common in humid climates) can obscure the organic matter. In arid soils where organic matter contents are low, this accumulation can be quite faint. The use of a mister to wet the soil profile can help make these layers more visible.

Soil structural degradation is reflected in the loss of clearly defined structural units or aggregates at one or more scales from <1/8 inch to 3-4 inches. In soils with good structure, pores of various sizes are visible within the aggregates. Structural degradation is reflected in a more massive, homogeneous surface horizon and is associated with a reduction in infiltration rates (Warren et al. 1986). Comparisons to intact soil profiles at reference sites can also be used, although in cases of severe degradation the removal of part or all of the A horizon, or of one or more textural components (e.g., Hennessey et al. 1986) may make identification of appropriate reference areas difficult.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
9. Soil Surface Loss or Degradation	Soil surface horizon absent. Soil structure near surface is similar to, or more degraded than, that in subsurface horizons. No distinguishable difference in subsurface organic matter content.	Soil loss or degradation severe throughout site. Minimal differences in soil organic matter content and structure of surface and subsurface layers.	Moderate soil loss or degradation in interspaces with some degradation beneath plant canopies. Soil structure is degraded and soil organic matter content is significantly reduced.	Some soil loss has occurred and/or soil structure shows signs of degradation, especially in plant interspaces.	Soil surface horizon intact. Soil structure and organic matter content match that expected for the site.

10. Plant Community Composition and Distribution Relative to Infiltration and Runoff

Vegetation growth form is an important determinant of infiltration rate and interrill erosion (Thurow et al. 1986, 1988a). The distribution of the amount and type of vegetation has been found to be an important factor controlling spatial and temporal variations in infiltration and interrill erosion rates on rangelands in Nevada (Blackburn 1975, Blackburn and Wood 1990), Idaho (Johnson and Gordon 1988, Blackburn et al. 1990), and Texas (Wood and Blackburn 1984, Thurow at al. 1986, 1988a).

Changes in plant community composition and the distribution of species can influence (positively or negatively) the ability of a site to capture and store precipitation. Plant rooting patterns, litter production and associated decomposition processes, basal area and spatial distribution can all affect infiltration and/or runoff. In the Edwards Plateau in Texas, shifts in plant composition between bunchgrass and short grasses over time have the greatest potential to influence infiltration and soil erosion (Thurow et al. 1986, 1988a, b). An example of a composition change that reduces infiltration and increases water runoff is the conversion of desert grasslands to shrub-dominated communities (Schlesinger et al. 1990). However, infiltration and runoff are also affected when sagebrush steppe rangeland is converted to a monoculture of annual grasses. These annual grasses provide excellent watershed protection although snow entrapment and soil water storage may be reduced by this vegetation type conversion. Care must be exercised in interpreting this indicator in different ecosystems as the same species may have different effects.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
10. Plant Community Composition and Distribution Relative to Infiltration and Runoff	Infiltration is severely decreased due to adverse changes in plant community composition and/or distribution. Adverse plant cover changes have occurred.	Infiltration is greatly decreased due to adverse changes in plant community composition and/or distribution. Detrimental plant cover changes have occurred.	Infiltration is moderately reduced due to adverse changes in plant community composition and/or distribution. Plant cover changes negatively affect infiltration.	Infiltration is slightly to moderately affected by minor changes in plant community composition and/or distribution. Plant cover changes have only a minor effect on infiltration.	Infiltration and runoff are equal to that expected for the site. Plant cover (distribution and amount) adequate for site protection.

11. Compaction Layer

A compaction layer is a near surface layer of dense soil caused by the repeated impact on or disturbance of the soil surface. Compaction becomes a problem when it begins to limit plant growth (Wallace 1987), water infiltration (Willat and Pullar 1983, Thurow et al. 1988a) or nutrient cycling processes (Hassink et al. 1993). Farm machinery, herbivore trampling (Willat and Pullar 1983, Warren et al. 1986, Chanysk and Naeth 1995), recreational and military vehicles (Webb and Wilshire 1983, Thurow et al. 1988a), foot traffic (Cole 1985), or any other activity that repeatedly causes an impact on the soil surface can cause a compaction layer. Moist soil is more easily compacted than dry or saturated soil (Hillel 1998). Recovery processes (e.g., earthworm activity and frost heaving) are generally sufficient to limit compaction by livestock in many upland systems (Thurow et al. 1988a).

A compaction layer is a structural change, not a textural change, as described in a soil survey or observed at an ecological reference area. Compacted layers in rangelands are usually less than 6 inches below the soil surface. They are detected by digging a small hole (generally less than 1-foot deep) with the determination of a compaction layer (i.e., a soil structure change) done by a person with soils experience. These layers may be detected in some soils with the use of a penetrometer (Larson and Pierce 1993) or by simply probing the soil with a sharp rod or shovel and "feeling" for the compaction layer (Barnes et al. 1971). However, any potential compaction layer should be confirmed using multiple indicators, including direct observation of physical features. Those physical features include such things as platy or blocky, dense soil structure over less dense soil layers and horizontal root growth, and increased density (measured by weighing a known volume of oven-dry soil) (Blake and Hartge 1986). Increased resistance to a probe can be simply due to lower soil moisture or higher clay content.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
11. Compaction Layer (below soil surface)	Extensive; severely restricts water movement and root penetration.	Widespread; greatly restricts water movement and root penetration.	Moderately widespread; moderately restricts water movement and root penetration.	Rarely present or is thin and weakly restrictive to water movement and root penetration.	None to minimal; not restrictive to water movement and root penetration.

12. Functional/Structural Groups

This indicator addresses the various roles that different species fulfill in energy flow and nutrient cycles. Functional/structural groups are a suite of species that because of similar shoot (height and volume) or root (fibrous vs. tap) structure, photosynthetic pathways, nitrogen fixing ability, or life cycle are grouped together on an ecological site basis (Chapin 1993, Dawson and Chapin 1993, Solbrig et al. 1996). Functional composition and functional diversity are the principal factors explaining plant productivity, plant percent nitrogen, plant total nitrogen, and light penetration (Tilman et al. 1997). The study by Tilman et al. (1997) showed that functional composition has a large impact on ecosystem processes. This and related studies have demonstrated that factors that change ecosystem composition, such as invasion by novel organisms, nitrogen deposition, disturbance frequency, fragmentation, predator decimation, species removal, and alternative management practices can have a strong effect on ecosystem processes.

The evaluator(s) must specify these groupings on the Functional/Structural Groups Worksheet (Appendix 5) after reviewing the ecological site description and/or ecological reference area(s) (ERAs). Each functional/structural group is classified as:

- Dominant (roughly 41 -100% composition)
- Subdominant (roughly 11 - 40% composition)
- Minor component (roughly 3-10% composition)
- Trace component (<3% composition)

This is based upon the relative weight or relative cover that each structural/functional group collectively contributes to the total. Composition by weight is the recommended protocol to use for grouping species. If the evaluator(s) doesn't have experience in estimating composition by weight, then composition by cover may be substituted. The potential for functional/structural groups is derived by placing species into the appropriate groups from information found in the ecological site/description, and/or at the ERA. This worksheet can be modified by changing or adding functional group categories at the top of the form for different ecological sites (see Tables 3 and 4). Functional groups that are now present, but were not original components of the site (e.g., weeds, introduced plants), need to be identified on the worksheet.

The number of species in each functional group is also considered when selecting the appropriate rating category on the Rangeland Health Evaluation Summary Worksheet. If the number of species in many of the functional/structural plant groups have been greatly reduced, this may be an indication of loss of biotic integrity. Both the presence of functional groups and the number of species within the groups have a significant effect on ecosystem processes (Tilman et al. 1997)

Table 3. Functional/structural groups that a prairie ecological site might include.

Warm Season Tall Grasses	Warm Season Midgrasses	Cool Season Midgrasses	Warm Season Shortgrass	Perennial Forbs	Leguminous Shrubs
Big bluestem	Sideoats grama	Western wheatgrass	Buffalograss	Dotted gayfeather	Leadplant
Indiangrass	Little bluestem	Green needlegrass	Blue grama	Prairie coneflower	
				Phlox	

Table 4. Functional/structural groups that a Great Basin Desert site might include.

Tall Shrubs (Deep Rooted)	Half Shrub	Warm Season Bunchgrass Bunchgrass	Cool Season Short Bunchgrass	Cool Season Mid Grasses	Perennial Forbs-N Fixers	Perennial Forbs-Not N Fixers	Biological Crust
Wyo. Big sagebrush	Broom snakeweed	Sand dropseed	Sandberg bluegrass	Squirreltail	Astragalus	Phlox	Moss
Bitterbrush		Red threeawn		Thurbers needlegrass	Lupine	Arrowleaf balsamroot	Lichens
				Indian ricegrass		Bisquitroot	

Non-vascular plants (e.g., biological crusts) are included in this example since they are an important component of this Great Basin ecological site. Biological crusts are components of many ecosystems and should be included in this evaluation when appropriate.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
12. Functional/ Structural Groups (F/S Groups) See Appendix 5 (Functional/ Structural Groups Worksheet)	Number of F/S groups greatly reduced; **and/or** relative dominance of F/S groups has been dramatically altered; **and/or** number of species within F/S groups dramatically reduced.	Number of F/S groups reduced; **and/or** one dominant group **and/or** one or more sub-dominate groups replaced by F/S groups not expected for the site; **and/or** number of species within F/S groups significantly reduced.	Number of F/S groups moderately reduced; **and/or** one or more sub-dominant F/S groups replaced by F/S groups not expected for the site; **and/or** number of species within F/S groups moderately reduced.	Number of F/S groups slightly reduced; **and/or** relative dominance of F/S groups has been modified from that expected for the site; **and/or** number of species within F/S groups slightly reduced.	F/S groups and number of species in each group closely match that expected for the site.

13. Plant Mortality/Decadence

The proportion of dead or decadent (e.g., moribund, dying) to young or mature plants in the community relative to that expected for the site, under normal disturbance regimes, is an indicator of the population dynamics of the stand. If recruitment is not occurring and existing plants are either dying or dead, the integrity of the stand would be expected to decline and other undesirable plants (e.g., weeds or invasives) may increase (Pyke 1995). A healthy range has a mixture of many age classes of plants relative to site potential and climatic conditions (Stoddard, Smith, and Box 1975)

Only plants native to the site (or seeded plants if in a seeding) are assessed for plant mortality. Plant mortality may vary considerably on the landscape depending on disturbance events (e.g., fire, drought, insect infestation, disease). The cover of standing dead vegetation from the Cover Worksheet may be compared to values found in the ecological site description or on the ecological reference area to assist in assessing the expected to actual plant mortality.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
13. Plant Mortality/ Decadence	Dead and/or decadent plants are common.	Dead and/or decadent plants are somewhat common.	Some dead and/or decadent plants are present.	Slight plant mortality and/or decadence.	Plant mortality and decadence matches that expected for the site.

14. Litter Amount

Litter is any dead plant material that is in contact with the soil surface. That portion of the litter component that is in contact with the soil surface (as opposed to standing dead vegetation which is not) provides a major source of the soil organic material and the raw materials for onsite nutrient cycling (Whitford 1988, 1996). Litter also helps moderate the soil microclimate and provides food for microorganisms (Hester et al. 1997). The amount of litter present is also a factor in enhancing the ability of the site to resist erosion. Litter helps to dissipate the energy of raindrops and overland flow, thereby reducing the potential detachment and transport of soil (Hester et al. 1997). Litter biomass represents a significant obstruction to runoff (Thurow et al. 1988a).

The amount of litter present is compared to the amount that would be expected for the same type of growing conditions under the historic climax plant community or to that observed on the ecological reference area. Litter is directly related to weather and to the degree of utilization of biomass each year. Therefore, climatic influences (e.g., drought, wet years) must be carefully considered in determining the rating for the litter amount.

Some plant communities have increased litter quantities relative to the site potential and current weather conditions. In this case, litter amount above what is expected results in downgrading the rating for the site. Note in the Comments Section for this indicator in the Rangeland Health Evaluation Summary Worksheet if the litter is undergoing decomposition (darker color) or oxidation (whitish color which may also be an indication of fungal growth).

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
14. Litter Amount	Largely absent or dominant relative to site potential and weather.	Greatly reduced or increased relative to site potential and weather.	Moderately more or less relative to site potential and weather.	Slightly more or less relative to site potential and weather.	Amount is what is expected for the site potential and weather.

15. Annual Production

Aboveground biomass (i.e., annual production) is an indicator of the energy captured by plants and its availability for secondary consumers in an ecosystem given current weather conditions. Production potential will change with communities or ecological sites (Whittaker 1975), biological diversity (Tilman and Downing 1994), and with latitude (Cooper 1975). Annual production of the area of interest is compared to the site potential from the rangeland ecological site description and/or the ecological reference area(s).

Comparisons to the ecological site description are based on peak above ground standing crop, no matter when the site is assessed. If utilization of vegetation has occurred, or plants are in early stages of growth, the evaluator(s) should estimate the production of the annual biomass removed or expected and include this amount when making the total site biomass estimate. Do not include standing dead vegetation (i.e., produced in previous years) as annual production.

All species (e.g., native, seeded, and weeds) are included in the determination of total aboveground biomass if they were alive in the year that the evaluation takes place. This indicator is simply a measure of the total amount of vegetation available to harvest the sun's energy at a given point in time, therefore type of vegetation (e.g., native or introduced) is not the issue. For example, Rickard and Vaughan (1988) found that conversion of a sagebrush steppe plant community to an exotic annual grassland greatly affected vegetation structure and function but not above-ground biomass production.

As with the other indicators, it is important to consider all other local and landscape level explanations for differences in production (e.g., runoff/run-on due to landscape position, weather, regional location, or different soils within an ecological site) before attributing production differences to differences in other site characteristics.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
15. Annual Production	Less than 20% of potential production.	20-40% of potential production.	40-60% of potential production.	60-80% of potential production.	Exceeds 80% of potential production.

16. Invasive Plants

This indicator deals with plants that are invasive to the area of interest. These plants may or may not be noxious and may or may not be exotic. Generally they are invaders or increasers to the site that can, and often do, continue to increase regardless of the management of the site and may eventually dominate the site.

Invasives can include noxious plants (i.e., plants that are listed by a state because of their unfavorable economic or ecological impacts), non-native, and native plants. Native invasive plants (e.g., pinyon pine or juniper) must be assessed by comparing current status with their potential status described in the rangeland ecological site description and/or observed in the ecological reference area(s). Historical accounts and photographs also provide information on the historical distribution of invasive native plants.

Invasive plants may impact an ecosystem's type and abundance of species, their interrelationships, and the processes by which energy and nutrients move through the ecosystem. These impacts can influence both biological organisms and physical properties of the site (Olson 1999). These impacts may range from slight to catastrophic depending on the species involved and their degree of dominance. Invasive species may adversely affect a site by increased water usage (e.g., salt cedar (tamarisk) in riparian areas) or rapid nutrient depletion (e.g., high nitrogen use by cheatgrass).

Some invasive plants (e.g., knapweeds) are capable of invading undisturbed climax bunchgrass communities (Lacey et al. 1990) further emphasizing their use as an indicator of new ecosystem stress. Even highly diverse, species-rich plant communities are susceptible to exotic species invasion (Stohlgren et al. 1999).

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
16. Invasive Plants	Dominate the site.	Common throughout the site.	Scattered throughout the site.	Present primarily on disturbed sites.	Rarely present on the site.

17. Reproductive Capability of Perennial Plants

Adequate seed production is essential to maintain populations of plants when sexual reproduction is the primary mechanism of individual plant replacement at a site; however, annual seed production of perennial plants is highly variable (Harper 1977). Since reproductive growth occurs in a modular fashion similar to the remainder of the plant (White 1979), inflorescence production (e.g., seedstalks) becomes a basic measure of reproductive potential for sexually reproducing plants and clonal production (e.g., tillers) for vegetatively reproducing plants.

Comparing number of seedstalks and/or number of seeds per seedstalk of native or seeded plants (not weeds or invasives) in the evaluation area with that produced on the associated ecological reference area (ERA) can be used to assess seed production. Mueggler (1975) recommended comparison of seedstalk numbers or culm length on grazed and ungrazed bluebunch wheatgrass plants as a measure of plant recruitment potential. Seed production is related to plant vigor since healthy plants are better able to produce adequate quantities of viable seed than are plants that are stressed or decadent (Hanson and Stoddart 1940).

For plants that reproduce vegetatively, the number and distribution of tillers or rhizomes is assessed relative to the production of these reproductive structures on perennial plants in the ERA. Only native or seeded plants are evaluated with this indicator; invasive plants are not included in the evaluation.

Recruitment is not assessed as a part of this indicator since plant recruitment from seed is an episodic event in many rangeland ecological sites. Therefore, evidence of recruitment (seedlings or vegetative spread) of perennial, native, or seeded plants is recorded in the comment section of Indicator 17 on the Rangeland Health Evaluation Summary Worksheet, but is not considered in rating the reproductive capabilities of perennial plants.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
17. Reproductive Capability of Perennial Plants (native or seeded)	Capability to produce seed or vegetative tillers is severely reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is greatly reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is somewhat limited relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is only slightly limited relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is not limited relative to recent climatic conditions.

18. Optional Indicators

The 17 indicators described previously represent the baseline indicators that must be assessed on all sites. Other indicators and descriptors may be developed to meet local needs. The only restriction on the development of optional indicators and their use is that they must be ecologically, not management related. For example, an indicator of "Suitability for Livestock Use" is not an appropriate indicator to determine the health of a land unit. It may be important in the allotment or ranch evaluation, but it is not a part of the determination of the status of soil/site stability, hydrologic function, or integrity of the biotic community.

An example of an optional indicator and descriptors for biological crust is provided in Table 5.

The indicators included in the worksheets are not intended to be all inclusive for all rangelands. It is not expected that many of the indicators would be eliminated given the extensive field testing results; however, additional indicators may be added to the worksheets to improve the sensitivity of worksheets in detecting changes in soil/site stability, hydrologic function, and integrity of the biotic community.

Table 5. Optional indicator and descriptors for biological crust.

Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
Biological Crusts	Found only in protected areas, very limited suite of functional groups.	Largely absent, occurring mostly in protected areas.	In protected areas and with a minor component in interspaces.	Evident throughout the site but continuity is broken.	Largely intact and nearly matches site capability.

Step 6. Determine the Functional Status of the Three Rangeland Health Attributes

Complete the Rangeland Health Evaluation Summary Worksheet (Appendix 1).

The critical link between observations of indicators and determining the degree of departure from the ecological site description and/or ecological reference area (ERA) for each health attribute of an area of interest is the interpretation process. The interpretation of the indicators and the selection of the degree of departure of the rangeland health attributes of: soil/site stability, hydrologic function, and integrity of the biotic community are made in Part 3 of the Rangeland Health Evaluation Summary Worksheet. This summary rating is made by reviewing the indicator ratings and comments on all of the worksheets to arrive at a single degree of departure from the ecological site description and/or ERA rating of each attribute.

A "preponderance of evidence" approach is used to determine which of the five departure categories are selected as best fits by the evaluator(s) for each attribute. This decision is based in part on where the majority of the indicators for each attribute fall under the five categories at the top of the worksheet. For example, if four of the soil/site stability indicators are in the "extreme" and six are in the "moderate to extreme" departure from the ecological site description/ERA categories, the soil/site stability attribute departure would be rated as "moderate to extreme assuming that the evaluator(s) interpretation of other information and local ecological knowledge supported this rating.

More information (inventory and/or monitoring) will generally be required if the preponderance of evidence indicates that an attribute falls in the "moderate departure" category. This information should be reviewed if available or if not available, it should be collected. The moderate rating is somewhat analogous to an "at risk" rating (NRC 1994). Therefore, these areas (i.e., moderate departure) are often good areas to implement monitoring studies on since they should be the most responsive to management activities. However, additional monitoring may be useful regardless of the departure rating, dependent upon future changes in uses or management of an area.

This procedure relies upon the collective experience and knowledge of the evaluator(s) to classify each indicator and then to interpret the collective rating for the indicators into one summary rating of departure for each attribute. The rating of each indicator and the interpretation into a collective rating for each attribute is not apprentice level work. This procedure has been developed for use by experienced, knowledgeable evaluator(s). It is not intended that this assessment procedure be used by new and/or inexperienced or temporary type employees without training and assistance by more experienced and knowledgeable employees.

Application to Larger Areas

Although the procedure described in this document is based upon a site-specific area of interest evaluation, it can be applied at a pasture, allotment, or ranch level with the proper study design. Tools to help with this application to larger areas include topographic maps, water locations, grazing use pattern maps, inventory or monitoring information, soil surveys, Geographical Information System (GIS) technology, and local knowledge. Individual site evaluations are made on selected rangeland ecological sites, exercising caution that different sites with different potentials are not assessed using the same rangeland ecological site description and/or ecological reference area. Areas in the same rangeland ecological site with the same ratings for the three rangeland health attributes may be mapped and consolidated within a pasture or management unit (e.g., ranch or allotment).

Additional studies or information may be required to confirm these ratings or to categorize the rangeland health attributes into healthy, at risk, or unhealthy recommended by the National Research Council (NRC 1994). The protocol described in this document is not intended to be used as a "stand-alone" tool to determine the final "health" or functional status of the three attributes of rangeland health.

Areas of interest with "moderate" to "extreme" ratings may stimulate other actions (e.g., review or initiation of inventory, monitoring, or different assessments; communication with various groups interested in the management of the area) to then determine the cause of the problems or if trend is satisfactory under existing management. Changes in management are not appropriate based solely on the evaluation of range health per the procedures in this document.

Summary

Qualitative assessments of rangeland health provide land managers and technical assistance specialists with a good communication tool for use with the public. This technique, in association with quantitative monitoring and inventory information, can be used to provide early warnings of resource problems. This procedure does not establish the cause of rangeland health problems; it simply identifies where a problem exists. This procedure is not intended nor designed to replace quantitative monitoring, serve as a trend study, or provide data that can alone be aggregated for a national report on rangeland health.

However, more research is needed to quantify indicator attributes and identify thresholds for rangeland health. Once this information is available, the assessment of rangeland health will become more quantitative and less reliant on qualitative assessment of the indicators. As a result of continued research and application of this procedure, this document will continue to be revised. Where possible, ecological site-specific indicators and descriptors will be developed. The interpretation of the indicators will continue to evolve as our understanding of ecological dynamics (e.g., as described in state and transition diagrams) continues to grow. As the concept of rangeland health continues to evolve and mature, the application of this concept and protocol will also evolve.

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Glossary

Abundance: The total number of individuals of a species in an area, population, or community (SRM 1999).

Accelerated erosion: Erosion in excess of natural rates, usually as a result of anthropogenic activities (SSSA 1997).

Age classes: The distribution of different ages of the same species or group of species on a site.

Annual plant: A plant that completes its life cycle and dies in one year or less (SRM 1999).

Annual production (syn. primary production): The conversion of solar energy to chemical energy through the process of photosynthesis. It is represented by the total quantity of organic material produced within a given period of time (SRM 1999).

Area of interest: The area where the evaluation of rangeland health attributes takes place.

Assessment: The process of estimating or judging the value or functional status of ecological processes (e.g., rangeland health).

At risk: Rangelands that have a reversible loss in productive capability and increased vulnerability to irreversible degradation based upon an evaluation of current conditions of the soil and ecological processes (NRC 1994). At risk designation may point out the need for additional information to better quantify the functional status of an attribute.

Attribute: One of the three components, soil/site stability, hydrologic function, and integrity of the biotic community that collectively define rangeland health.

Badland: A land type consisting of steep or very steep barren land, usually broken by an intricate maze of narrow ravines, sharp crests, and pinnacles resulting from serious erosion of soft geologic materials (SRM 1999).

Bare ground (bare soil): All land surface not covered by vegetation, rock or litter (SRM 1999). As used in this document, visible biological crusts and standing dead vegetation are included in cover estimates as a type of vegetation and therefore are not bare ground.

Basal area (plants): The cross-sectional area of the stem or stems of a plant or of all plants in a stand. Herbaceous and small woody plants are measured at or near ground level; larger woody plants are measured at breast or other designated height. Syn. basal area. (SRM 1999).

Benchmark: A standard for an ecological site that is used to compare functional status of areas on the same ecological site.

Biological crust: Microorganisms (e.g., lichens, algae, cyanobacteria, microfungi) and nonvascular plants (e.g., mosses, lichens) that grow on or just below the soil surface.

Biomass (plants): The total amount of living plants above and below ground in an area at a given time (SRM 1999).

Biotic integrity: Synonymous with "integrity of the biotic community" (see definition).

Blowout: An excavation in areas of loose soil, usually sand, produced by wind; a breakthrough or rupture of a soil surface attributable to hydraulic pressure, usually associated with sand boils (SRM 1999).

Bunchgrass: A grass having the characteristic growth habit of forming a bunch; lacking stolons or rhizomes (SRM 1999).

Canopy cover: The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included. It may exceed 100 percent. Syn. crown cover. (SRM 1999).

Chemical soil crust: A soil-surface layer, ranging in thickness from a few millimeters to a few centimeters, that is formed when chemical compounds become concentrated on the soil surface. They can reduce infiltration and increase overland water flow similar to physical crusts. They are usually identified by a white color on the soil surface.

Climate: The average or prevailing weather conditions of a place over a period of years (SRM 1999).

Climax plant community (e.g., climax): The final or stable biotic community in a successional series; it is self-perpetuating and in equilibrium with the physical habitat (SRM 1999).

Compaction layer: A near surface layer of dense soil caused by the repeated impact on or disturbance of the soil surface. When soil is compacted, soil grains are rearranged to decrease the void space and bring them into closer contact with one another, thereby increasing the bulk density (SSSA 1997).

Composition: The proportions of various plant species in relation to the total on a given area; it may be expressed in terms of cover, density, weight, etc. Syn. species composition. (SRM 1999).

Cool-season plant: A plant which generally makes the major portion of its growth during the late fall, winter, and early spring. Cool season grasses generally exhibit the C-3 photosynthetic pathway. cf. warm-season plants (SRM 1999).

Cover: The plant or plant parts, living or dead, on the surface of the ground. Vegetative cover or herbage cover is composed of living plants (including biological crusts), and the litter cover of dead parts of plants (SRM 1999).

Decomposition: The biochemical breakdown of organic matter into its original compounds and nutrients.

Deposition area: An area offsite from where the original soil erosion occurred that now has the soil deposits from the original soil erosion area.

Descriptor: The narrative that describes the indicator characteristics under each of the five rating categories (Extreme, Moderate to Extreme, Moderate, Slight to Moderate, and None to Slight) in the Rangeland Health Indicator Evaluation Matrix. The "default descriptor" is printed in the Matrix, while the "revised descriptor" is completed by the evaluators if the default descriptor does not fit the characteristics of a particular indicator for a particular ecological site.

Desired plant community: Of the several plant communities that may occupy a site, the one that has been identified through a management plan to best meet the plan's objectives for the site. It must protect the site as a minimum (SRM 1999).

Dominant species: Plant species or species groups, which by means of their number, coverage, or size, have considerable influence or control upon the conditions of existence of associated species (SRM 1999).

Ecological processes: Ecological processes include the water cycle (the capture, storage, and redistribution of precipitation), energy flow (conversion of sunlight to plant and animal matter), and nutrient cycle (the cycle of nutrients such as nitrogen and phosphorus through the physical and biotic components of the environment). Ecological processes functioning within a normal range of variation will support specific plant and animal communities.

Ecological reference area: A landscape unit in which ecological processes are functioning within a normal range of variability and the plant community has adequate resistance to and resiliency from most disturbances. These areas do not need to be pristine, historically unused lands (e.g., climax plant communities or relict areas).

Ecological site: A kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management. Apparently synonymous with ecological type used by USDA Forest Service. Syn. rangeland ecological site. (SRM 1999).

Ecological site description: Description of the soils, uses, and potential of a kind of land with specific physical characteristics to produce distinctive kinds and amounts of vegetation.

Ecosystem: Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space (SRM 1999).

Energy flow: Conversion of sunlight to plant and animal matter; one of the ecological processes.

Erodibility: The degree or intensity of a soils state or condition of, or susceptibility to, being erodible (SSSA 1997).

Erosion: Detachment and movement of soil or rock fragments by water, wind, ice, gravity; the land surface worn away by running water, wind, ice, or other geological agents, including such processes as gravitational creep (SRM 1999).

Evaluation area: See definition of "area of interest."

Evaluator(s): The person or persons conducting the evaluation of rangeland health on an area of interest.

Exclosure: An area fenced to exclude animals (SRM 1999).

Exotic plant: A plant that is not born, growing, or produced naturally (native) in an area, region, or country. Syn. non-indigenous plant. (SRM 1999).

Flow pattern: The path that water takes (i.e., accumulates) as it moves across the soil surface during overland flow.

Forb: Any broad-leafed, herbaceous plant other than those in the Poaceae, Cyperaceae, and Juncaceae families (SRM 1999).

Functional/structural groups: A suite or group of species that because of similar shoot or root structure, photosynthetic pathways, nitrogen fixing ability, life cycle, etc. are grouped together on an ecological site basis.

Functioning: Refers to the rangeland health attributes where the majority (see definition of "preponderance of evidence") of the associated indicators are functioning properly relative to the ecological site description and/or ecological reference area given the normal range of variability associated with the site and climate.

Geomorphology: The science that studies the evolution of the earth's surface. The science of landforms (SSSA 1997).

Grass: Members of the plant family Poaceae (SRM 1999).

Ground cover: The percentage of material (e.g., litter, standing dead vegetation, gravel/rocks, vegetation, and biological crust), excluding bare soil, covering the land surface.

Gully: A furrow, channel, or miniature valley, usually with steep sides through which water commonly flows during and immediately after rains or snow melt (SRM 1999). Small channels eroded by concentrated water flow.

Headcut: Abrupt elevation drops in the channel of a gully that accelerate erosion as it undercuts the gully floor and migrates upstream.

Half-shrub: A perennial plant with a woody base whose annually produced stems die each year (SRM 1999).

Healthy rangelands: See definition of "rangeland health."

Hydrologic function: The capacity of the site to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity following degradation (one of the three attributes of rangeland health).

Increaser: For a given plant community, those species that increase in amount as a result of a specific abiotic/biotic influence or management practice (SRM 1999).

Indicator: Components of a system whose characteristics (e.g., presence or absence, quantity, distribution) are used as an index of an attribute (e.g., rangeland health) that are too difficult, inconvenient, or expensive to measure.

Infiltration: The entry of water into the soil (SSSA 1997).

Integrity of the Biotic Community: Capacity of a site to support characteristic functional and structural communities in the context of normal variability, to resist loss of this function and structure due to a disturbance, and to recover following such disturbance.

Interrill erosion: The removal of a fairly uniform layer of soil on a multitude of relatively small areas by splash due to raindrop impact and by sheet flow (SSSA 1997).

Invader: Plant species that were absent in undisturbed portions of the original vegetation of a specific range site and that will invade or increase following disturbance or continued heavy grazing (SRM 1999).

Invasive plant: Plants that are not part of (exotic) or a minor component of (native) the original plant community or communities that increase above what's expected given the normal range of variability of a site.

Inventory (rangeland inventory): The systematic acquisition and analysis of resource information needed for planning and management of rangeland (SRM 1999).

Life form: Characteristic form or appearance of a species at maturity (e.g., tree, shrub, herb) (SRM 1999).

Litter: The uppermost layer of organic debris on the soil surface, essentially the freshly fallen or slightly decomposed vegetal material (SRM 1999). In this document, it includes persistent and non-persistent organic matter that is in contact with the soil surface.

Monitoring: The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives. The process must be conducted over time in order to determine whether or not management objectives are being met (SRM 1999).

Native invasive: A native plant that has migrated to a site where it was not a part of the original plant community, or a native plant that because of management or other changes is now increasing beyond its original composition on the site.

Nitrogen fixation (fixers): The biological reduction of molecular nitrogen to chemical forms that can be used by organisms in the synthesis of organic molecules.

Normal variability or normal range of variability: The deviation of characteristics of biotic communities and their environment that can be expected given natural variability in climate and disturbance regimes.

Noxious weed: Plant species declared noxious by laws concerned with plants that are weedy in cultivated crops and on the range.

Nutrient cycle: The cycle of nutrients such as nitrogen and phosphorus through the physical and biotic components of the environment; one of the ecological processes.

Organic matter: Living plant tissue, and decomposed or partially decomposed material from living organisms.

Oxidation: The loss of one or more electrons by an ion or molecule (SSSA 1997). Oxidation is a chemical process of decomposition whereby nutrients are released into the atmosphere instead of into the soil. Oxidation commonly increases as aridity increases.

Pedestal (erosional): Plants or rocks that appear elevated as a result of soil loss by wind or water erosion (does not include plant or rock elevation as a result of non-erosional processes such as frost heaving).

Perennial plant: A plant that has a life span of 3 or more years (USDA 1997).

Physical crust: Thin surface layers induced by impact of raindrops on bare soil causing the soil surface to seal and absorb less water.

Plant decadence: Plants that are old or deteriorating. In a plant community, decadence refers to an overabundance of dead or dying plants relative to what is expected for a site given the natural range of variability in disease, climate, and management influences.

Plant mortality: The death of a plant or in a plant community the death of a number of plants in the community.

Preponderance of evidence: The rating of an attribute of rangeland health by observing where the majority of indicators fall in respect to the five categories that are used to rate each indicator (SRM 1999).

Qualitative: Observational type data that is recorded but not measured.

Quantitative: Collection of data by measuring vegetation or soil characteristics.

Range condition: The present status of vegetation of a range site in relation to the climax (natural potential) plant community for that site. It is an expression of the relative degree to which the kinds, proportions, and amounts of plants in a plant community resemble that of the climax plant community for the site (SRM 1999).

Rangeland: Land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangelands include natural grasslands, savannas, shrublands, many deserts, tundra, alpine communities, marshes, and wet meadows (SRM 1999). The authors also include oak and pinyon-juniper woodlands in this definition.

Rangeland health: The degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem, are balanced and sustained. Integrity is defined as maintenance of the structure and functional attributes characteristic of a locale, including normal variability (SRM 1999).

Recruitment: The successful entry of new individuals into the breeding population.

Relict (area): A remnant or fragment of the climax plant community that remains from a former period when it was more widely distributed. Syn. pristine. (SRM 1999).

Rhizomatous plant: A plant that reproduces by rhizomes. Rhizomes are a horizontal underground stem, usually sending out roots and aboveground shoots from the nodes (SRM 1999).

Rill: A small, intermittent water course with steep sides, usually only several centimeters deep (SSSA 1997). Rills generally are linear erosion features.

Runoff: The portion of precipitation or irrigation on an area which does not infiltrate, but instead is discharged by the area (SSSA 1997).

Saltation: A particular type of momentum-dependent transport involving the rolling, bouncing, or jumping action of soil particles 0.1 to 0.5 mm in diameter by wind, usually at a height of <15 cm above the soil surface, for relatively short distances; the rolling, bouncing or jumping action of mineral grains, gravel, stones, or soil aggregates affected by the energy of following water; the bouncing or jumping movement of material downslope in response to gravity (SSSA 1997).

Shrub: A plant that has persistent, woody stems and a relatively low-growth habit, and that generally produces several basal shoots instead of a single bole. It differs from a tree by its low stature (generally less than 5 meters, or 16 feet) and non-arborescent form (SRM 1999).

Similarity index (rangeland): The present state of vegetation and soil protection on an ecological site in relation to the historic climax plant community. Syn. range condition. (SRM 1999).

Soil aggregates: A group of primary soil particles that cohere to each other more strongly than to other surrounding particles (SSSA 1997).

Soil association: A kind of map unit used in soil surveys comprised of delineations, each of which shows the size, shape, and location of a landscape unit composed of two or more kinds of component soils or component soils and miscellaneous areas, plus allowable inclusions in either case. The individual bodies of component soils and miscellaneous areas are large enough to be delineated at the scale of 1:24,000. Several to numerous bodies of each kind of component soil or miscellaneous area are apt to occur in each delineation, and they occur in a fairly repetitive and describable pattern (SSSA 1997).

Soil classification: The systematic arrangement of soil units into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdiviions on the basis of more detailed differences in specific properties (SSSA 1997).

Soil complex: A kind of map unit used in soil surveys comprised of delineations, each of which shows the size, shape, and location of a landscape unit composed of two or more kinds of component soils or component soils and a miscellaneous area, plus allowable inclusions in either case. The individual bodies of component soils and miscellaneous areas are too small to be delineated at the scale of 1:24,000. Several to numerous bodies of each kind of component soil or miscellaneous area are apt to occur in each delineation (SSSA 1997).

Soil inclusions: One or more polypedons or parts of polypedons within a delineation of a map unit, not identified by the map unit name (i.e., is not one of the named component soils or named miscellaneous area components). Such soils or areas are either too small to be delineated separately without creating excessive map or legend detail, occur too erratically to be considered a component, or are not identified by practical mapping methods (SSSA 1997).

Soil/site stability: The capacity of a site to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water (one of the three attributes of rangeland health).

Soil structure: The combination or arrangement of primary soil particles into secondary units or peds. The secondary units are characterized on the basis of size, shape, and grade (degree of distinctiveness) (SSSA 1997).

Soil survey: The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examination (SSSA 1997).

Species composition: The proportions of various plant species in relation to the total on a given area. It may be expressed in terms of cover, density, weight, etc. (SRM 1999).

Stable state: A condition of an ecological site's characteristics; as characteristics change, there is a transition to a new state (USDA 1997).

Standing dead vegetation: The total amount of dead plant material, in aboveground parts, per unit of space at a given time (USDA 1997). This component includes all standing dead vegetation produced in previous (not the current) growing seasons not in contact with the soil surface.

Structure (soils): The combination or arrangement of primary soil particles into secondary units or peds. The secondary units are characterized on the basis of size, shape, and grade (degree of distinctness) (SSSA 1997).

Structure (vegetation): The height and area occupied by different plants or life forms in a community.

Succulent: Generally a type of cactus.

Terracette: "Benches" of soil deposition behind obstacles caused by water not wind erosion.

Threshold: A transition boundary that an ecosystem crosses resulting in a new stable state that is not easily reversed without significant inputs of resources.

Tiller: A plant shoot that arises from the root or base of a plant.

Transition: A shift in plant composition that results in relatively stable states, as reflected in composition and structure. These shifts can occur by natural forces or as a result of human actions.

Tree: A woody perennial, usually single-stemmed plant that has a definite crown shape and reaches a mature height of at least 4 meters. The distinction between woody plants known as trees and those called shrubs is gradual. Some plants, such as oaks (Quercus spp.), may grow as either trees or shrubs (SRM 1999).

Trend: The direction of change in ecological status or resource value rating observed over time (SRM 1999).

Unhealthy rangelands: Rangelands on which degradation has resulted in the loss of ecological processes which function properly and the capacity to provide values and commodities to a degree that external inputs are required to restore the health of the land (NRC 1994).

Vascular plants: Higher plants with vessels that conduct sap throughout the plant.

Vesicular crust: A type of physical crust which contains numerous small air pockets or spaces similar to a sponge causing a reduction in infiltration.

Viable seed: Wildland plant seed that is capable of germination given appropriate environmental conditions.

Warm season plant: A plant which makes most or all its growth during the spring, summer, and fall and is usually dormant in winter; a plant that exhibits the C-4 photosynthetic pathway (SRM 1999).

Water cycle (e.g., hydrologic cycle): The capture, storage, and redistribution of precipitation.

Weather: The current state of the atmosphere with regards to wind, temperature, cloudiness, moisture, pressure, etc.

Well-managed rangelands: Rangelands that have properly functioning ecological processes, biotic integrity, and soil stability associated with human uses of the land.

Wind-scoured area: Areas, generally in interspaces, where the finer soil particles have blown away sometimes leaving residual gravel, rock, or exposed roots on the soil surface.

Appendix 1

Rangeland Health Evaluation Summary Worksheet

Rangeland Health Evaluation Summary Worksheet

Part 1. Area of Interest Documentation (**Bold** items require completion, other information is optional)

State _____ **Office** _____ **Management Unit** _____

Pasture/Watershed _____ ID# _____ Major Land Resource Area _____

Location (description) _____

Legal T ____ ,R ____ ,Sec ____ , ____ 1/4, ____ 1/4 or Lat ____ ,Long ____ or UTM Coord _____

Size of Evaluation Area _____ **Photo(s) Taken** Yes ___ No ___

Observer(s) _____ **Date** _____

Ecological Site _____ Soil Map Unit Name _____

Soil/Site Verification

Rangeland Ecological Site Description and/or Soil Survey

Surface Texture _____

Depth: Very Shallow ☐ Shallow ☐ Moderate ☐ Deep ☐
(<10") (10"-20") (20"-40") (>40")

List diagnostic horizons in profile and depth

1 _____ 3 _____

2 _____ 4 _____

Area of Interest Determination

Surface Texture _____

Depth: Very Shallow ☐ Shallow ☐ Moderate ☐ Deep ☐
(<10") (10"-20") (20"-40") (>40")

List diagnostic horizons in profile and depth

1 _____ 3 _____

2 _____ 4 _____

Parent Material _____ **Slope** ____ % Elevation ____ ft Topographic Position _____ **Aspect** _____

Avg Annual Precip _____ **Recent Weather (last 2 years)** Drought ____ Normal ____ Wet _____

Describe wildlife and livestock use and recent disturbances _____

_____

Describe offsite influences on area of interest _____

_____

Part 2. Indicator Rating

		Departure from Ecological Site Description/ Ecological Reference Area(s)				
Attribute	**Indicators**	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
S,H	1. Rills					
Comments:						
S,H	2. Water Flow Patterns					
Comments:						
S,H	3. Pedestals and/or Terracettes					
Comments:						
S,H	4. Bare Ground					
Comments:						
S,H	5. Gullies					
Comments:						
S	6. Wind-Scoured, Blowouts, and/or Deposition Areas					
Comments:						

Part 2. Indicator Rating (continued)

		Departure from Ecological Site Description/ Ecological Reference Area(s)				
Attribute	**Indicators**	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
H	7. Litter Movement					
Comments:						
S,H,B	8. Soil Surface Resistance to Erosion					
Comments:						
S,H,B	9. Soil Surface Loss or Degradation					
Comments:						
H	10. Plant Community Composition and Distribution Relative to Infiltration and Runoff					
Comments:						
S,H,B	11. Compaction Layer					
Comments:						
B	12. Functional/Structural Groups					
Comments:						
B	13. Plant Mortality/Decadence					
Comments:						
H,B	14. Litter Amount					
Comments:						
B	15. Annual Production					
Comments:						
B	16. Invasive Plants					
Comments:						
B	17. Reproductive Capability of Perennial Plants					
Comments:						

Part 3. Summary

A. Indicator Summary

Departure from Ecological Site Description/ Ecological Reference Area(s)

Rangeland Health Attributes		**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**	Σ
S	Soil/Site Stability (Indicators 1-6, 8, 9 &11)						9
H	Hydrologic Function (Indicators 1-5, 7-11 & 14)						11
B	Biotic Integrity (Indicators 8-9 & 11-17)						9

B. Attribute Summary - Check the category that best fits the "preponderance of evidence" for each of the three attributes relative to the distribution of indicator ratings in the preceding Indicator Summary table.

Attribute	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
Soil/Site Stability Rationale:					
Hydrologic Function Rationale:					
Biotic Integrity Rationale:					

Rangeland Health Evaluation Summary Worksheet

Part 1. Area of Interest Documentation (**Bold** items require completion, other information is optional)

State ID **Office** Big Butte **Management Unit** West Valley

Pasture/Watershed Grass Hollow ID# S-1 Major Land Resource Area _____

Location (description) Wright Mesa

Legal T 9S ,R 6E ,Sec 9 , SW 1/4, NE 1/4 or Lat ____ ,Long ____ or UTM Coord _____

Size of Evaluation Area 10Acres **Photo(s) Taken** Yes X No ___

Observer(s) J. Long, P. Wide, M. High **Date** 8/5/00

Ecological Site Loamy "10-14 P.Z." (Artr/Sstth) Soil Map Unit Name Garbutt silt loam

Soil/Site Verification

Rangeland Ecological Site Description and/or Soil Survey
Surface Texture silt loam
Depth: Very Shallow ☐ Shallow ☐ Moderate ☒ Deep ☐
(<10") (10"-20") (20"-40") (>40")
List diagnostic horizons in profile and depth
1 Calcic at 18-24" 3 _____
2 _____ 4 _____

Area of Interest Determination
Surface Texture silt loam
Depth: Very Shallow ☐ Shallow ☐ Moderate ☒ Deep ☐
(<10") (10"-20") (20"-40") (>40")
List diagnostic horizons in profile and depth
1 Calcic at 20" 3 _____
2 _____ 4 _____

Parent Material _____ **Slope** 4 % Elevation 3,200 ft Topographic Position Plains **Aspect** SE

Avg Annual Precip 12" **Recent Weather (last 2 years)** Drought X Normal ____ Wet _____

Describe wildlife and livestock use and recent disturbances Sheep in area in spring (May)

Describe offsite influences on area of interest One road with drainage culverts affects a small area within evaluation area, not significant

Part 2. Indicator Rating

		Departure from Ecological Site Description/ Ecological Reference Area(s)				
Attribute	**Indicators**	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
S,H	1. Rills					X
Comments:						
S,H	2. Water Flow Patterns				X	
Comments: Few, mostly old.						
S,H	3. Pedestals and/or Terracettes				X	
Comments:						
S,H	4. Bare Ground				X	
Comments: Bare ground slightly higher than expected due to loss of some biological crust.						
S,H	5. Gullies					X
Comments:						
S	6. Wind-Scoured, Blowouts, and/or Deposition Areas					X
Comments: No wind erosion on this site.						

Part 2. Indicator Rating (continued)

		Departure from Ecological Site Description/ Ecological Reference Area(s)				
Attribute	**Indicators**	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
H	7. Litter Movement				X	
Comments:						
S,H,B	8. Soil Surface Resistance to Erosion			X		
Comments:	*Interspaces are showing loss of stability.*					
S,H,B	9. Soil Surface Loss or Degradation			X		
Comments:	*Signs of past losses, minimal signs of current losses.*					
H	10. Plant Community Composition and Distribution Relative to Infiltration and Runoff				X	
Comments:	*Less sagebrush than expected for site which would slightly reduce snow accumulation and therefore soil water recharge.*					
S,H,B	11. Compaction Layer			X		
Comments:	*Compaction layer common in shrub interspaces.*					
B	12. Functional/Structural Groups			X		
Comments:	*Cheatgrass is the dominant understory species with expected native herbaceous species considerably reduced.*					
B	13. Plant Mortality/Decadence		X			
Comments:	*Native perennial herbaceous plants are dead or decadent with little reproduction occurring due to cheatgrass competition.*					
H,B	14. Litter Amount			X		
Comments:	*Above what is expected due to cheatgrass dominance in the understory.*					
B	15. Annual Production			X		
Comments:	*Cheatgrass production is poor due to dry spring.*					
B	16. Invasive Plants		X			
Comments:	*Cheatgrass is a dominant with rush skeletonweed and halogeton locally common.*					
B	17. Reproductive Capability of Perennial Plants			X		
Comments:	*Perennial plants (except sagebrush) have very few seedheads. Rhizomatous grasses (western wheatgrass) have moderate rhizome.*					

Part 3. Summary

A. Indicator Summary

Departure from Ecological Site Description/ Ecological Reference Area(s)

Rangeland Health Attributes		**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**	Σ
S	Soil/Site Stability (Indicators 1-6, 8, 9 &11)			XXX	XXX	XXX	9
H	Hydrologic Function (Indicators 1-5, 7-11 & 14)			XXXX	XXXXX	XX	11
B	Biotic Integrity (Indicators 8-9 & 11-17)		XX	XXXXXXX			9

B. Attribute Summary - Check the category that best fits the "preponderance of evidence" for each of the three attributes relative to the distribution of indicator ratings in the preceding Indicator Summary table.

Attribute	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
Soil/Site Stability Rationale:				X	
Hydrologic Function Rationale:				X	
Biotic Integrity Rationale:			X		

Appendix 2

Ecological Reference Area Worksheet

Ecological Reference Area Worksheet

(**Bold** items require completion, other information is optional)

Source of Information (√): Actual Site _____ Or from site/soils description and/or experience _____

State _____ **Office** _____ **Management Unit** _____

Pasture/Watershed _____ ID# _____ Major Land Resource Area _____

Location (description) _____

Legal T ____ ,R ____ ,Sec ____ , ____ 1/4, ____ 1/4 or Lat ____ ,Long ____ or UTM Coord _____

Size/Type of Reference Area _____ **Photo(s) Taken** Yes ____ No ____

Observer(s) _____ **Date** _____

Ecological Site _____ **Soil Map Unit/Component Name** _____

Soil/Site Verification

Rangeland Ecological Site Description and/or Soil Survey

Surface Texture _____

Depth: Very Shallow ☐ (<10") Shallow ☐ (10"-20") Moderate ☐ (20"-40") Deep ☐ (>40")

List diagnostic horizons in profile and depth

1 _____ 3 _____

2 _____ 4 _____

Ecological Reference Area Determination

Surface Texture _____

Depth: Very Shallow ☐ (<10") Shallow ☐ (10"-20") Moderate ☐ (20"-40") Deep ☐ (>40")

List diagnostic horizons in profile and depth

1 _____ 3 _____

2 _____ 4 _____

Parent Material _____ **Slope** ____ % Elevation ____ ft Topographic Position _____ **Aspect** _____

Avg Annual Precip _____ **Recent Weather (last 2 years)** Drought ____ Normal ____ Wet _____

Describe wildlife and livestock use and recent disturbances _____

_____

_____

Describe offsite influences on area of interest _____

_____

_____

_____

Indicators	Extremely High	High or Abundant	Moderate or Common	Slight or Low	None
1. Number and extent of rills					
Comments:					
2. Presence of water flow patterns					
Comments:					
3. Number and height of erosional pedestals or terracettes					
Comments:					
4. Bare ground from Cover Worksheet or other studies: %					
Comments:					
5. Number of gullies and erosion associated with gullies					
Comments:					
6. Extent of wind-scoured, blowouts, and/or deposition areas					
Comments:					

Ecological Reference Area Worksheet

(continued)

Indicators	Extremely High	High or Abundant	Moderate or Common	Slight or Low	None
7. Amount of litter movement					
Comments:					
8. Reduction in soil surface resistance to erosion					
Comments:					
9. Amount of soil surface loss or degradation					
Comments:					
10. Problems resulting from plant community composition and distribution relative to infiltration and runoff					
Comments:					
11. Presence and thickness of compaction layer					
Comments:					
12. Departure of functional/structural groups from site description or appropriate historical plant community (See Functional/Structural Groups Worksheet)					
Comments:					
13. Amount of plant mortality and decadence					
Comments:					
14. Deviation of litter amount from expected					
Comments:					
15. Deviation from expected annual production					
Comments:					
16. Presence of invasive (including noxious) plants					
Comments:					
17. Reduction in perennial plant reproductive capability					
Comments:					

How well do the rangeland health indicators at the ecological reference area match information or interpretations made from these information sources?

	Degree of Agreement					Comments
	Poor	Marginal	Adequate	Good	NA	
Ecological Site Description						
Soil Series Description						
Other Sources/Knowledge						

This site can function as an Ecological Reference Area with

No Limitations (√) ____

Or the following limitations _____

_____

Ecological Reference Area Worksheet

EXAMPLE

(**Bold** items require completion, other information is optional)

Source of Information (√): Actual Site √ Or from site/soils description and/or experience _____

State ID **Office** Big Butte **Management Unit** Copper Butte Mesa

Pasture/Watershed Juniper Point ID# _____ Major Land Resource Area _____

Location (description) West end of Juniper Point

Legal T 10S ,R 7E ,Sec 12 , SE 1/4, ___ 1/4 or Lat ___ ,Long ___ or UTM Coord _____

Size/Type of Reference Area Lightly grazed mesa top **Photo(s) Taken** Yes X No ___

Observer(s) J. Long, P. Wide, M. High **Date** 8/1/00

Ecological Site Loamy "10-14 P.Z." (Artr/Sith) **Soil Map Unit/Component Name** Tindahay silt loam

Soil/Site Verification

Rangeland Ecological Site Description and/or Soil Survey
Surface Texture silt loam
Depth: Very Shallow ☐ Shallow ☐ Moderate ☒ Deep ☐
(<10") (10"-20") (20"-40") (>40")
List diagnostic horizons in profile and depth
1 Calcic at 18-24" 3 _____
2 _____ 4 _____

Ecological Reference Area Determination
Surface Texture silt loam
Depth: Very Shallow ☐ Shallow ☐ Moderate ☒ Deep ☐
(<10") (10"-20") (20"-40") (>40")
List diagnostic horizons in profile and depth
1 Calcic at 18" 3 _____
2 _____ 4 _____

Parent Material _____ **Slope** 6 % Elevation 2,900 ft Topographic Position Plains **Aspect** SW

Avg Annual Precip 12 **Recent Weather (last 2 years)** Drought X Normal ___ Wet ___

Describe wildlife and livestock use and recent disturbances Some deer use in spring, little livestock use

Describe offsite influences on area of interest None

Indicators	Extremely High	High or Abundant	Moderate or Common	Slight or Low	None
1. Number and extent of rills					X
Comments:					
2. Presence of water flow patterns				X	
Comments: Signs of a few old flow patterns.					
3. Number and height of erosional pedestals or terracettes					X
Comments:					
4. Bare ground from Cover Worksheet or other studies: 15%				X	
Comments:					
5. Number of gullies and erosion associated with gullies					X
Comments:					
6. Extent of wind-scoured, blowouts, and/or deposition areas					X
Comments:					

Ecological Reference Area Worksheet

(continued)

Indicators	Extremely High	High or Abundant	Moderate or Common	Slight or Low	None
7. Amount of litter movement					X
Comments:					
8. Reduction in soil surface resistance to erosion				X	
Comments: *Slight loss of stability of soil surface in interspaces.*					
9. Amount of soil surface loss or degradation				X	
Comments:					
10. Problems resulting from plant community composition and distribution relative to infiltration and runoff					X
Comments:					
11. Presence and thickness of compaction layer				X	
Comments: *Occurs only in interspace.*					
12. Departure of functional/structural groups from site description or appropriate historical plant community (See Functional/Structural Groups Worksheet)					X
Comments:					
13. Amount of plant mortality and decadence					X
Comments:					
14. Deviation of litter amount from expected					X
Comments:					
15. Deviation from expected annual production					X
Comments:					
16. Presence of invasive (including noxious) plants				X	
Comments: *Cheatgrass is present on disturbed areas such as badger mounds.*					
17. Reduction in perennial plant reproductive capability					X
Comments:					

How well do the rangeland health indicators at the ecological reference area match information or interpretations made from these information sources?

	Degree of Agreement					Comments
	Poor	Marginal	Adequate	Good	NA	
Ecological Site Description				X		
Soil Series Description				X		
Other Sources/Knowledge				X		

This site can function as an Ecological Reference Area with

No Limitations (√) ____

Or the following limitations *Some cheatgrass on the site and signs of past erosion but not enough to limit this areas value as an ERA for a loamy 10-14" PZ ecological site.*

Appendix 3

Cover Worksheet

Cover Worksheet

State _____ **Office** _____ **Ecological Site** _____

Observer(s) _____ **Date** _____ **Site ID** _____

	COVER CLASSES (% Canopy)							
LIFE FORMS[1]	0	0-1	2-5	6-15	16-30	31-50	51-75	76-100
I - Grass								
Annual								
Native Perennial								
Exotic Perennial								
II - Forb								
Annual								
Perennial								
III - Shrub								
IV - Tree								
V - Succulent								
VI - Biological Crust								

% GROUND COVER[2]	0	0-1	2-5	6-15	16-30	31-50	51-75	76-100
I - Vascular Plants								
II - Standing Dead Vegetation								
III - Litter (in contact with the soil surface)								
IV - Biological Crust								
V - Rock/Gravel								
VI - Bare Ground								

[1] **Life Forms Cover** - Record multiple canopy cover classes; total plant canopy may exceed 100%. Small openings (less than 2" in diameter) are included as cover.

[2] **Ground Cover** - Category I is an estimate of total vascular plant cover; overlapping canopies are counted as only **one** canopy (record life form with first point of contact). Total vascular plant cover (I) together with the sum of cover in Categories II-VI should total to approximately 100%.

Notes: Include source of cover data (e.g., estimates or measurements)

Cover Worksheet

State ID **Office** Big Butte **Ecological Site** Loamy 10-14" P.Z.

Observer(s) Long, Wide, High **Date** 8/5/00 **Site ID** S-1

	COVER CLASSES (% Canopy)							
LIFE FORMS[1]	0	0-1	2-5	6-15	16-30	31-50	51-75	76-100
I - Grass								
Annual						X		
Native Perennial			X					
Exotic Perennial		X						
II - Forb								
Annual				X				
Perennial			X					
III - Shrub					X			
IV - Tree	X							
V - Succulent		X						
VI - Biological Crust			X					

% GROUND COVER[2]	0	0-1	2-5	6-15	16-30	31-50	51-75	76-100
I - Vascular Plants							X	
II - Standing Dead Vegetation			X					
III - Litter (in contact with the soil surface)				X				
IV - Biological Crust			X					
V - Rock/Gravel			X					
VI - Bare Ground				X				

[1] **Life Forms Cover** - Record multiple canopy cover classes; total plant canopy may exceed 100%. Small openings (less than 2" in diameter) are included as cover.

[2] **Ground Cover** - Category I is an estimate of total vascular plant cover; overlapping canopies are counted as only **one** canopy (record life form with first point of contact). Total vascular plant cover (I) together with the sum of cover in Categories II-VI should total to approximately 100%.

Notes: Include source of cover data (e.g., estimates or measurements)

Appendix 4

Species Dominance Worksheet

Species Dominance Worksheet

Part 1 (Required)

The most common species, noxious weeds (state-listed plants), invasive natives, invasive exotics (non-noxious) are **ranked** according to dominance using cover ☐ or weight ☐ .

Dominant Species on Site

1 _____
2 _____
3 _____
4 _____

Noxious Weeds

1 _____
2 _____
3 _____

Invasive Natives

1 _____
2 _____
3 _____

Invasive Exotics

1 _____
2 _____
3 _____

Part 2 (Optional) **Dominant Species by Life Form**

The most common species are ranked according to dominance using cover ☐ or weight ☐ by life form.

Annual Grasses

1 _____
2 _____
3 _____

Annual Forbs

1 _____
2 _____
3 _____

Perennial Grasses

1 _____
2 _____
3 _____

Perennial Forbs

1 _____
2 _____
3 _____

Shrubs and Trees

1 _____
2 _____
3 _____

Succulents

1 _____
2 _____
3 _____

Biological Crust (rate by component not species, e.g., lichen, moss, or algae)

1 _____
2 _____
3 _____

Species Dominance Worksheet

Part 1 (Required)

The most common species, noxious weeds (state-listed plants), invasive natives, invasive exotics (non-noxious) are **ranked** according to dominance using cover ☐ or weight ☒ .

Dominant Species on Site

1 Wyoming big sagebrush
2 Cheatgrass
3 Sandbergs Bluegrass
4 Bottlebrush Squirreltail

Noxious Weeds

1 Rush Skeletonweed
2
3

Invasive Natives

1
2
3

Invasive Exotics

1 Cheatgrass
2 Bur buttercup
3 Mustard spp.

Part 2 (Optional) **Dominant Species by Life Form**

The most common species are ranked according to dominance using cover ☐ or weight ☒ by life form.

Annual Grasses

1 Cheatgrass
2 Six weeks fescue
3

Annual Forbs

1 Bur buttercup
2 Mustard spp.
3

Perennial Grasses

1 Sandbergs Bluegrass
2 Bottlebrush Squirreltail
3 Basin Wildrye

Perennial Forbs

1 Astragalus spp.
2 Lomatium
3

Shrubs and Trees

1 Wyoming Big Sagebrush
2 Green rabbitbrush
3

Succulents

1 Prickly Pear Cactus
2
3

Biological Crust (rate by component not species, e.g., lichen, moss, or algae)

1 Moss
2 Lichen
3

Appendix 5

Functional/Structural Groups Worksheet

Functional/Structural Groups Worksheet

State _____ **Office** _____ **Ecological Site** _____ **Site ID** _____

Observer(s) _____ **Date** _____

Functional/Structural Groups			**Species List for Functional/Structural Groups**
Name	Potential[1]	Actual[2]	Plant Names
Biological Crust[3]			

Indicate whether each "structural/functional group" is a Dominant (D) (roughly 41-100% composition), a **Subdominant (S)** (roughly 11-40% composition), a **Minor Component (M)** (roughly 3-10% composition), or a **Trace Component (T)** (<3 % composition) based on weight or cover composition in the area of interest (e.g., "Actual[2]" column) relative to the "Potential[1]" column derived from information found in the ecological site description and/or at the ecological reference area.

Biological Crust[3] dominance is evaluated solely on **cover** not composition by weight.

Functional/Structural Groups Worksheet

State ID **Office** Big Butte **Ecological Site** Loamy 10-14" PZ **Site ID** S-1

Observer(s) Long, Wide, High **Date** 8/5/00

Functional/Structural Groups			Species List for Functional/Structural Groups
Name	Potential[1]	Actual[2]	Plant Names
Annual Grasses	T	S	Cheatgrass, six weeks fescue
Short Pern. bunchgrasses	M	M	Sandberg bluegrass
Mid Pern. bunchgrasses	D	M	Thurbers Needlegrass, bottlebrush squirreltail
Tall Pern. bunchgrass	M	T	Basin wildrye
N fixing forb	M	T	Astragalus spp., Lupine
Deep tap rooted forb	M	T	Hookers balsamroot, Lomatium
Non resprouting shrub	D	D	Big sagebrush
Resprouting Shrubs	M	T	Green rabbitbrush, Gray Horsebush
Succulents	T	T	prickly pear cactus
Biological Crust[3]	S	M	Lichen & Mosses

Indicate whether each "structural/functional group" is a Dominant (D) (roughly 41-100% composition), a **Subdominant (S)** (roughly 11-40% composition), a **Minor Component (M)** (roughly 3-10% composition), or a **Trace Component (T)** (<3 % composition) based on weight or cover composition in the area of interest (e.g., "Actual[2]" column) relative to the "Potential[1]" column derived from information found in the ecological site description and/or at the ecological reference area.

Biological Crust[3] dominance is evaluated solely on **cover** not composition by weight.

Appendix 6

Rangeland Health Indicator Evaluation Matrix

Rangeland Health Indicator Evaluation Matrix

State _____ **Office** _____ **Ecological Site** _____ **Site ID** _____

If indicator(s) revised - Observer(s) _____ **Date** _____

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
1. Rills (Default Descriptor)	Rill formation is severe and well defined throughout most of the area.	Rill formation is moderately active and well defined throughout most of the area.	Active rill formation is slight at infrequent intervals, mostly in exposed areas.	No recent formation of rills; old rills have blunted or muted features.	Current or past formation of rills as expected for the site.
1. Rills (Revised Descriptor)					
2. Water Flow Patterns (Default Descriptor)	Extensive and numerous; unstable with active erosion; usually connected.	More numerous than expected; deposition and cut areas common; occasionally connected.	Nearly matches what is expected for the site; erosion is minor with some instability and deposition.	Matches what is expected for the site; some evidence of minor erosion. Flow patterns are stable and short.	Matches what is expected for the site; minimal evidence of past or current soil deposition or erosion.
2. Water Flow Patterns (Revised Descriptor)					
3. Pedestals and/or Terracettes (Default Descriptor)	Abundant active pedestalling and numerous terracettes. Many rocks and plants are pedestalled; exposed plant roots are common.	Moderate active pedestalling; terracettes common. Some rocks and plants are pedestalled with occasional exposed roots.	Slight active pedestalling; most pedestals are in flow paths and interspaces and/or on exposed slopes. Occasional terracettes present.	Active pedestalling or terracette formation is rare; some evidence of past pedestal formation, especially in water flow patterns and/or on exposed slopes.	Current or past evidence of pedestalled plants or rocks as expected for the site. Terracettes absent or uncommon.
3. Pedestals and/or Terracettes (Revised Descriptor)					

Rangeland Health Indicator Evaluation Matrix

(continued)

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
4. Bare Ground (Default Descriptor)	Much higher than expected for the site. Bare areas are large and generally connected.	Moderately to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas nearly to totally match that expected for the site.
4. Bare Ground (Revised Descriptor)					
5. Gullies (Default Descriptor)	Common with indications of active erosion and downcutting; vegetation is infrequent on slopes and/or bed. Nickpoints and headcuts are numerous and active.	Moderate to common with indications of active erosion; vegetation is intermittent on slopes and/or bed. Headcuts are active; downcutting is not apparent.	Moderate in number with indications of active erosion; vegetation is intermittent on slopes and/or bed. Occasional headcuts may be present.	Uncommon with vegetation stabilizing the bed and slopes; no signs of active headcuts, nickpoints, or bed erosion.	Drainages are represented as natural stable channels; no signs of erosion with vegetation common.
5. Gullies (Revised Descriptor)					
6. Wind-Scoured, Blowouts, and/or Deposition Areas (Default Descriptor)	Extensive.	Common.	Occasionally present.	Infrequent and few.	Matches what is expected for the site.
6. Wind-Scoured, Blowouts, and/or Deposition Areas (Revised Descriptor)					

Rangeland Health Indicator Evaluation Matrix

(continued)

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
7. Litter Movement (wind or water) (Default Descriptor)	Extreme; concentrated around obstructions. Most size classes of litter have been displaced.	Moderate to extreme; loosely concentrated near obstructions. Moderate to small size classes of litter have been displaced.	Moderate movement of smaller size classes in scattered concentrations around obstructions and in depressions.	Slightly to moderately more than expected for the site with only small size classes of litter being displaced.	Matches that expected for the site with a fairly uniform distribution of litter.
7. Litter Movement (wind or water) (Revised Descriptor)					
8. Soil Surface Resistance to Erosion (Default Descriptor)	Extremely reduced throughout the site. Biological stabilization agents including organic matter and biological crusts virtually absent.	Significantly reduced in most plant canopy interspaces and moderately reduced beneath plant canopies. Stabilizing agents present only in isolated patches.	Significantly reduced in at least half of the plant canopy interspaces, or moderately reduced throughout the site.	Some reduction in soil surface stability in plant interspaces or slight reduction throughout the site. Stabilizing agents reduced below expected.	Matches that expected for the site. Surface soil is stabilized by organic matter decomposition products and/or a biological crust.
8. Soil Surface Resistance to Erosion (Revised Descriptor)					

Rangeland Health Indicator Evaluation Matrix

(continued)

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
9. Soil Surface Loss or Degradation (Default Descriptor)	Soil surface horizon absent. Soil structure near surface is similar to, or more degraded than, that in subsurface horizons. No distinguishable difference in subsurface organic matter content.	Soil loss or degradation severe throughout site. Minimal differences in soil organic matter content and structure of surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some degradation beneath plant canopies. Soil structure is degraded and soil organic matter content is significantly reduced.	Some soil loss has occurred and/or soil structure shows signs of degradation, especially in plant interspaces.	Soil surface horizon intact. Soil structure and organic matter content match that expected for the site.
9. Soil Surface Loss or Degradation (Revised Descriptor)					
10. Plant Community Composition and Distribution Relative to Infiltration and Runoff (Default Descriptor)	Infiltration is severely decreased due to adverse changes in plant community composition and/or distribution. Adverse plant cover changes have occurred.	Infiltration is greatly decreased due to adverse changes in plant community composition and/or distribution. Detrimental plant cover changes have occurred.	Infiltration is moderately reduced due to adverse changes in plant community composition and/or distribution. Plant cover changes negatively affect infiltration.	Infiltration is slightly to moderately affected by minor changes in plant community composition and/or distribution. Plant cover changes have only a minor effect on infiltration.	Infiltration and runoff are equal to that expected for the site. Plant cover (distribution and amount) adequate for site protection.
10. Plant Community Composition and Distribution Relative to Infiltration and Runoff (Revised Descriptor)					

Rangeland Health Indicator Evaluation Matrix

(continued)

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
11. Compaction Layer (below soil surface) (Default Descriptor)	Extensive; severely restricts water movement and root penetration.	Widespread; greatly restricts water movement and root penetration.	Moderately widespread; moderately restricts water movement and root penetration.	Rarely present or is thin and weakly restrictive to water movement and root penetration.	None to minimal; not restrictive to water movement and root penetration.
11. Compaction Layer (below soil surface) (Revised Descriptor)					
12. Functional/ Structural Groups (F/S Groups) (Default Descriptor) (See Appendix 5 - Functional/ Structural Groups Worksheet)	Number of F/S groups greatly reduced; **and/ or** relative dominance of F/S groups has been dramatically altered; **and/or** number of species within F/S groups dramatically reduced.	Number of F/S groups reduced; **and/or** one dominant group **and/or** one or more subdominant groups replaced by F/S groups not expected for the site; **and/or** number of species within F/S groups significantly reduced.	Number of F/S groups moderately reduced; **and/ or** one or more subdominant F/S groups replaced by F/S groups not expected for the site; **and/or** number of species within F/S groups moderately reduced.	Number of F/S groups slightly reduced; **and/or** relative dominance of F/S groups has been modified from that expected for the site; **and/ or** number of species within F/S groups slightly reduced.	F/S groups and number of species in each group closely match that expected for the site.
12. Functional/ Structural Groups (F/S Groups) (Revised Descriptor) (See Appendix 5 - Functional/ Structural Groups Worksheet)					

Rangeland Health Indicator Evaluation Matrix

(continued)

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
13. Plant Mortality/ Decadence (Default Descriptor)	Dead and/or decadent plants are common.	Dead and/or decadent plants are somewhat common.	Some dead and/ or decadent plants are present.	Slight plant mortality and/ or decadence.	Plant mortality and decadence matches that expected for the site.
13. Plant Mortality/ Decadence (Revised Descriptor)					
14. Litter Amount (Default Descriptor)	Largely absent or dominant relative to site potential and weather.	Greatly reduced or increased relative to site potential and weather.	Moderately more or less relative to site potential and weather.	Slightly more or less relative to site potential and weather.	Amount is what is expected for the site potential and weather.
14. Litter Amount (Revised Descriptor)					
15. Annual Production (Default Descriptor)	Less than 20% of potential production.	20-40% of potential production.	40-60% of potential production.	60-80% of potential production.	Exceeds 80% of potential production.
15. Annual Production (Revised Descriptor)					
16. Invasive Plants (Default Descriptor)	Dominate the site.	Common throughout the site.	Scattered throughout the site.	Present primarily on disturbed sites.	Rarely present on the site.
16. Invasive Plants (Revised Descriptor)					

Rangeland Health Indicator Evaluation Matrix

(concluded)

	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
Indicator	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
17. Reproductive Capability of Perennial Plants (native or seeded) (Default Descriptor)	Capability to produce seed or vegetative tillers is severely reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is greatly reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is somewhat limited relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is only slightly limited relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is not limited relative to recent climatic conditions.
17. Reproductive Capability of Perennial Plants (native or seeded) (Revised Descriptor)					

Rangeland Health Indicator Evaluation Matrix

Table 2 from page 16 of the text provides an example of how a revised descriptor narrative could read for the bare ground indicator. Similar changes can be made when appropriate for other indicators.

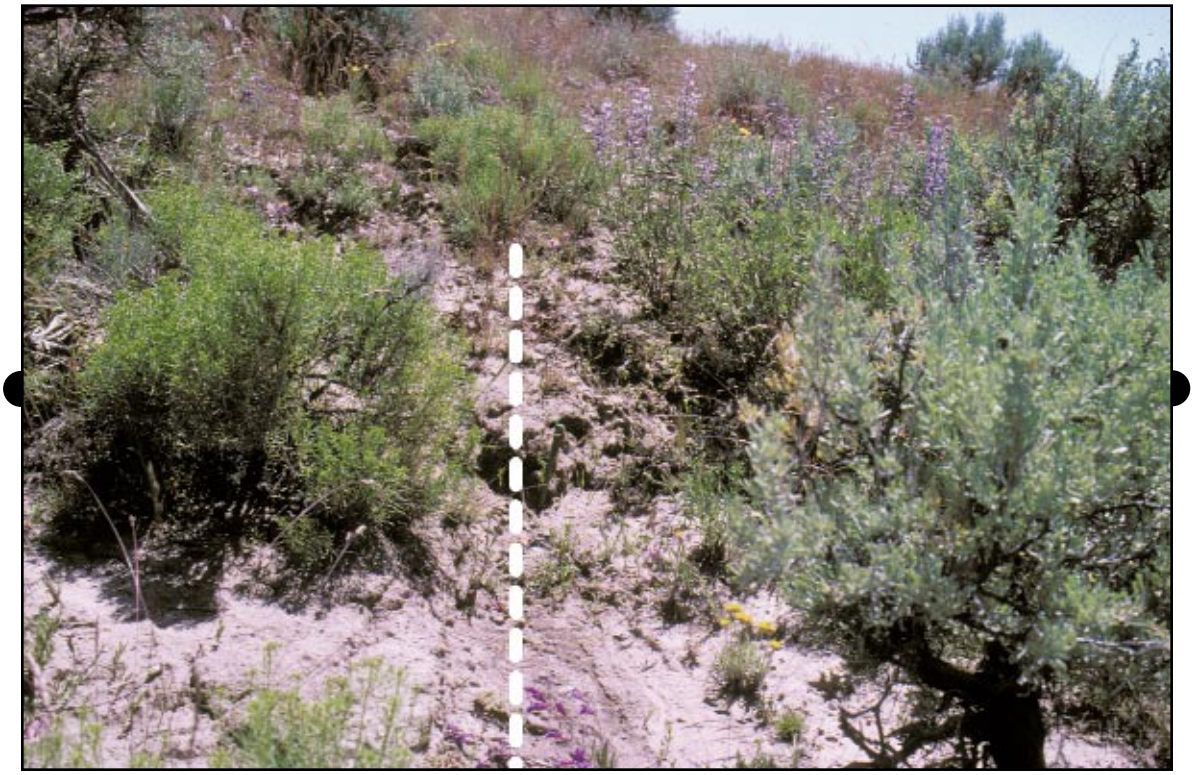
Indicator	Degree of Departure from Ecological Site Description and/or Ecological Reference Area(s)				
	Extreme	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
4. Bare Ground (Default Descriptor)	Much higher than expected for the site. Bare areas are large and generally connected.	Moderate to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas nearly to totally matches that expected for the site.
4. Bare Ground (Revised Descriptor)	Much higher than expected for the site. Bare areas are extensive with little ground cover.	Moderately higher than expected for the site. Bare areas are very large and usually connected.	Moderately to slightly higher than expected for the site. Bare areas are large and usually connected.	Slightly higher than expected for the site. Bare areas are of moderate size and usually connected.	Same as default descriptor.

Appendix 7

Photographs of Indicators

1. Rills

1a - Rills are a natural component of this site due to erodible soils.



1b - Short linear rill caused by accelerated water flow.

2. Water Flow Patterns

2a - Extensive water flow pattern in plant interspace indicative of high overland water flow.

2b - Short water flow pattern (white dotted line) in plant interspaces.

3. Pedestals and/or Terracettes

3a - Plant pedestal caused by wind erosion. Note the exposed roots (arrow).

3b - Terracette (arrow) caused by litter obstruction in water flow pattern.

3. Pedestals and/or Terracettes (continued)

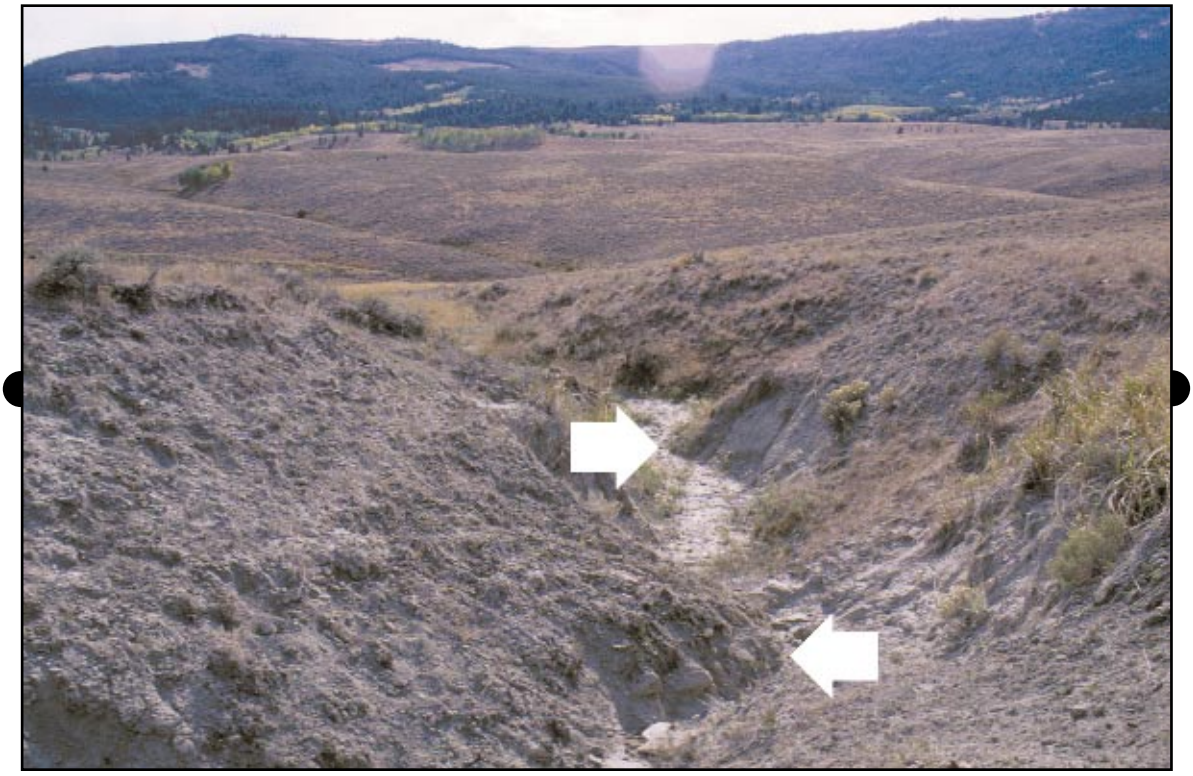
3c - Terraces formed by ungulate grazing on hillsides are not evaluated with this indicator. Other indicators that may be applicable in this situation include numbers 4, 8, 9, and 11.

4. Bare Ground

4a - Amount of bare ground is slight relative to site potential and recent weather.

4b - Amount of bare ground is excessive relative to site potential and recent weather.

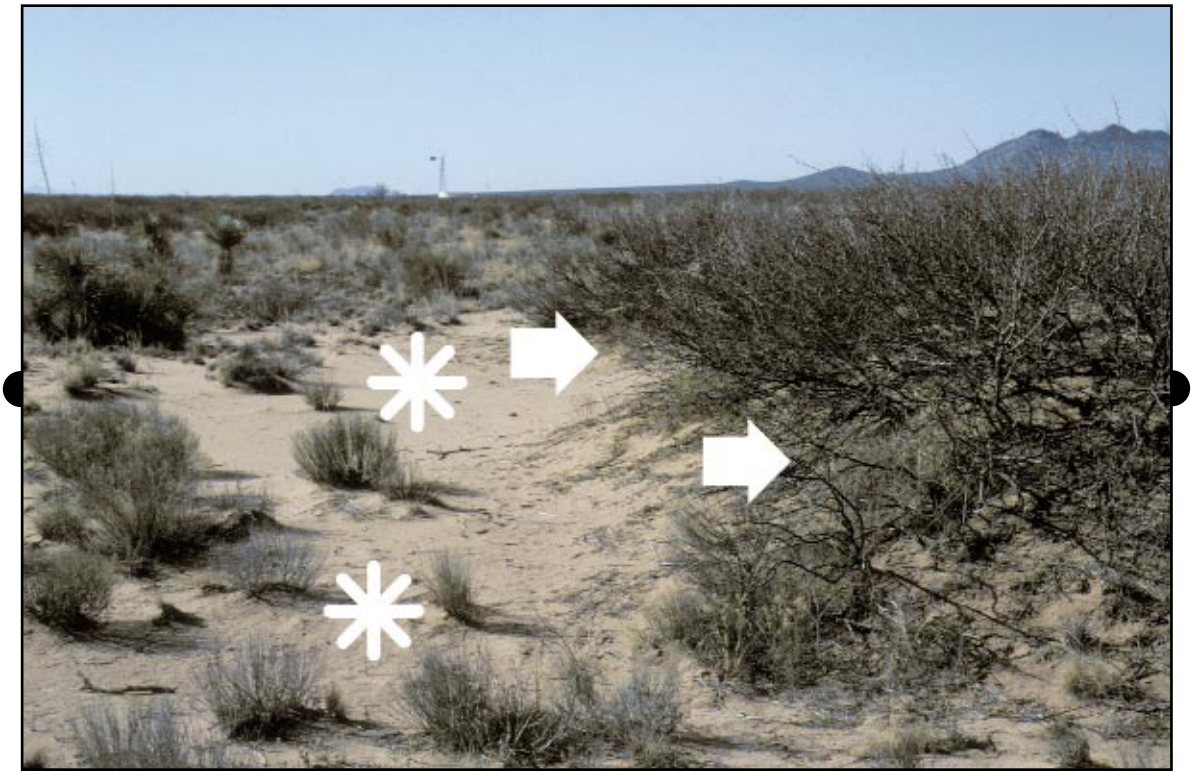
5. Gullies



5a - Gully that shows signs of active erosion (nickpoints - see arrows) and downcutting.

5b - Relatively stable gully with few signs of active erosion with good vegetation recovery occurring.

6. Wind-Scoured, Blowouts, and/or Deposition Areas



6a - Wind-scoured areas in plant interspaces (star) with soil and litter deposition occurring at plant bases (arrows).

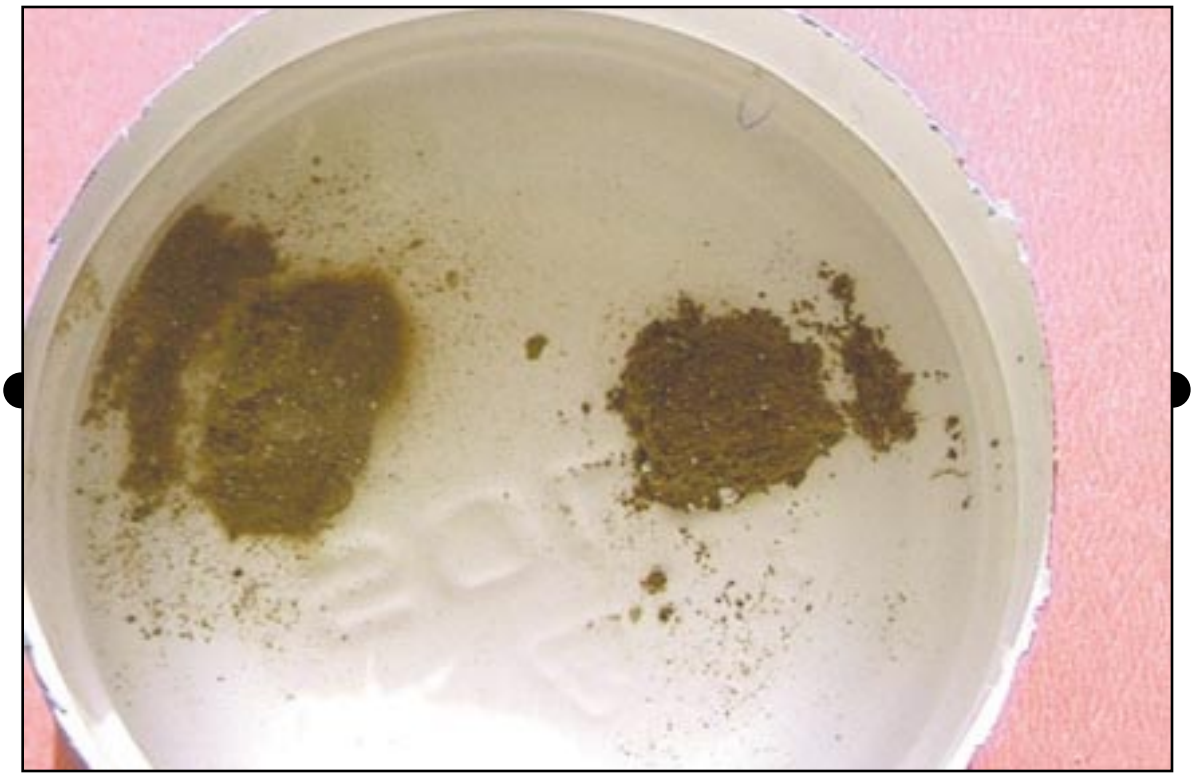
7. Litter Movement

7a - Litter movement and accumulation in a water flow pattern.

7b - Litter redistributed by wind under shrub canopy and around obstructions in the interspaces.

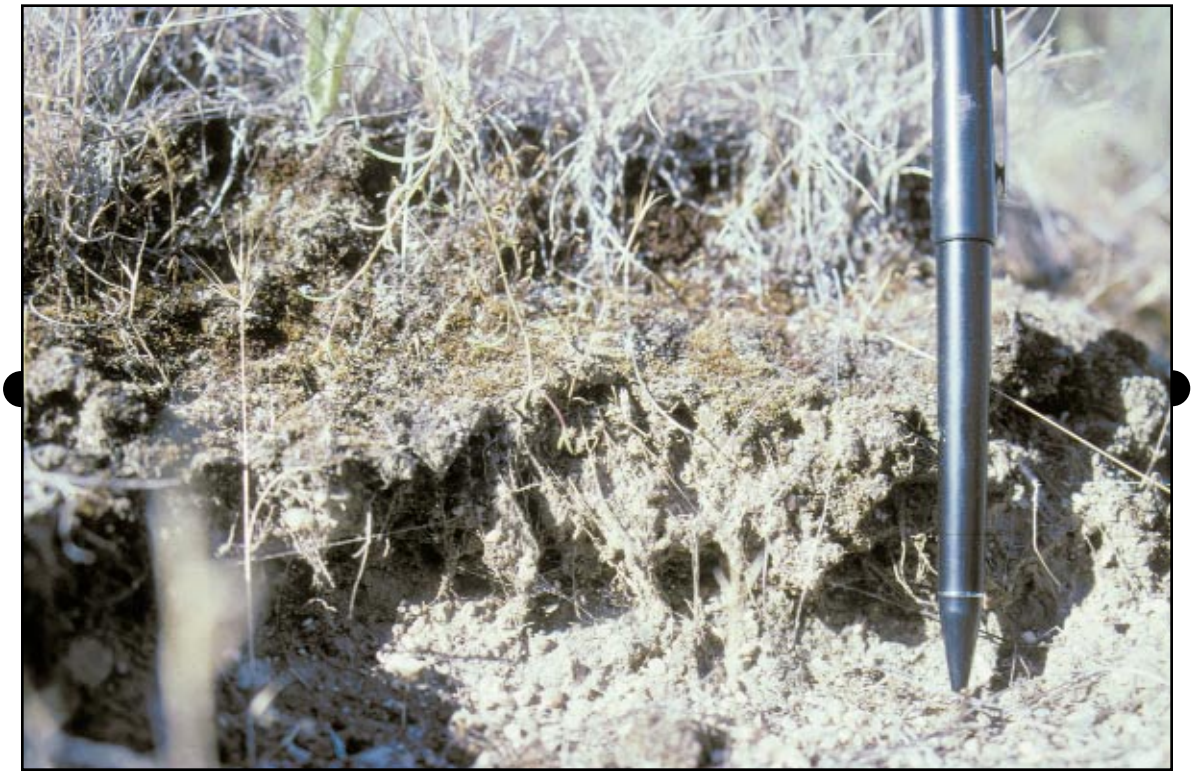
8. Soil Surface Resistance to Erosion

8a - Surface physical crusts in plant interspaces can increase overland flow of water while providing some protection against wind erosion.



8b - Soil surface fragment on right is resistant to breakdown in water indicating presence of soil-binding organic matter. Soil surface fragment on left is "melting" indicating less organic matter and stability.

9. Soil Surface Loss or Degradation



9a - Evidence of soil surface loss (foreground) is evident when compared to the cover of the plant and biological crust in the background.

10. Plant Community Composition and Distribution Relative to Infiltration and Runoff

10a - Desert grassland site where grasses promote infiltration and minimize runoff.

10b - Degraded desert grassland site where runoff has dramatically increased due to conversion from grass to shrubs.

11. Compaction Layer

11a - An example of a restrictive compaction layer that reduces root penetration and water percolation.

12. Functional/Structural Groups

12a - Nitrogen-fixing forb (*Astragalus* spp.) that is included in a different functional group than non-nitrogen-fixing forbs.

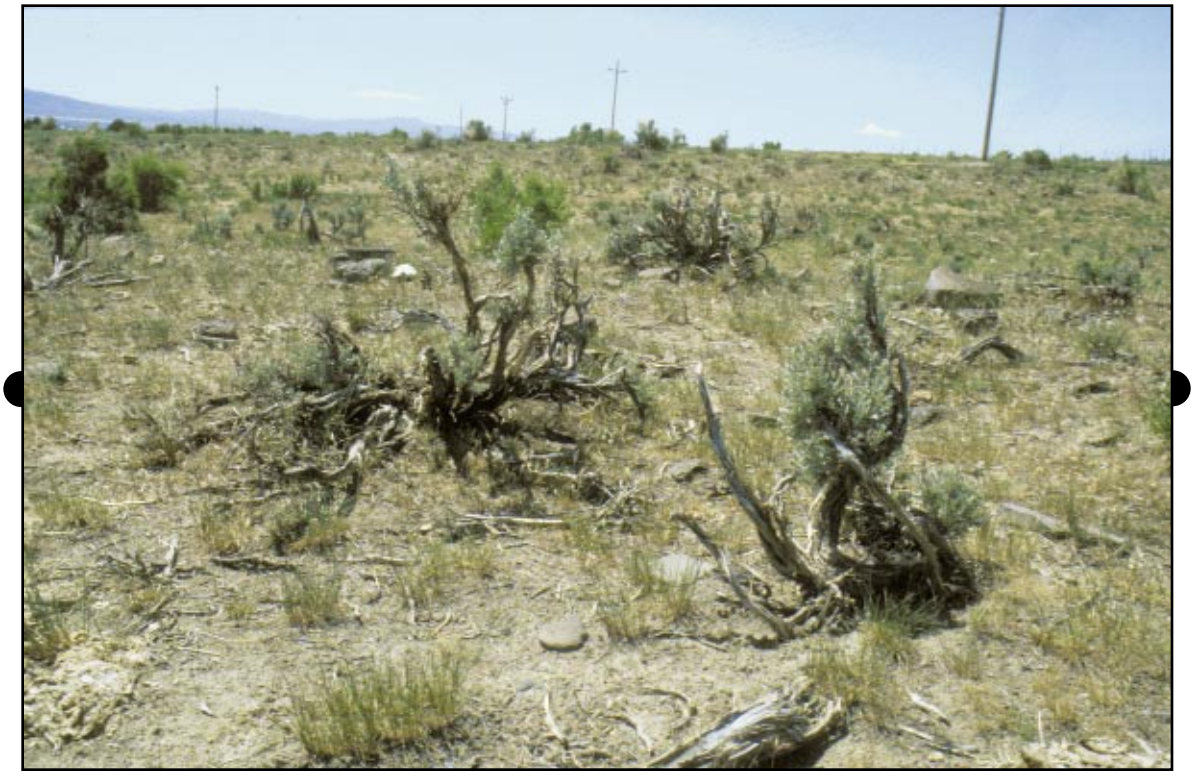
12b - Biological crusts (foreground) are an important functional/structural component in many plant communities.

12. Functional/Structural Groups (continued)

12c - Sagebrush-perennial bunchgrass site near potential. Native annual grasses are a minor component of the vegetation mix.

12d - Perennial bunchgrasses have been replaced with cheatgrass, an exotic annual grass. Accelerated erosion is also evident.

13. Plant Mortality/Decadence



13a - Dead and decadent sagebrush (*Artemisia* spp.) plants.

13b - Decadent shrub with dead branches and "hedged" look.

14. Litter Amount

14a - Amount of litter is in balance with site potential and recent weather.

14b - Litter is uncommon compared to what is expected given the site potential and recent weather.

14. Litter Amount (continued)

14c - Amount of litter and standing dead vegetation is well above what is expected due to the presence of an exotic annual grass.

15. Annual Production

15a - Production of current year's aboveground biomass is consistent with site potential and recent weather.

15b - Production of current year's aboveground biomass is well below site potential relative to recent weather.

16. Invasive Plants

16a - Cheatgrass (*Bromus tectorum*) is an exotic invasive annual grass that can dominate the understory in disturbed shrublands.

16b - State-listed noxious weeds, such as this knapweed in Idaho, are another category of invasive plants.

16. Invasive Plants (continued)

16c - Juniper, a native tree, is invasive when it invades rangeland sites where the potential is for shrubs and herbaceous plants.

17. Reproductive Capability of Perennial Plants

17a - Perennial forbs and grasses show good potential for reproduction as evidenced by flowers and seed-stalk production.

17b - Reproduction potential of this shrub is low due to lack of seed production.

Appendix 8

Soil Stability Kit Diagram and Rating Categories to Determine Surface Soil Stability

Soil stability kit diagram and rating categories to determine surface soil stability. Protocol is described in detail in Herrick, J.E., W.G. Whitford, A.G. de Soyza, J.W. Van Zee, K.M. Havstad, C.A. Seybold, M. Walton. In Press. Field soil aggregate stability kit for soil quality and rangeland health evaluations. Catena.

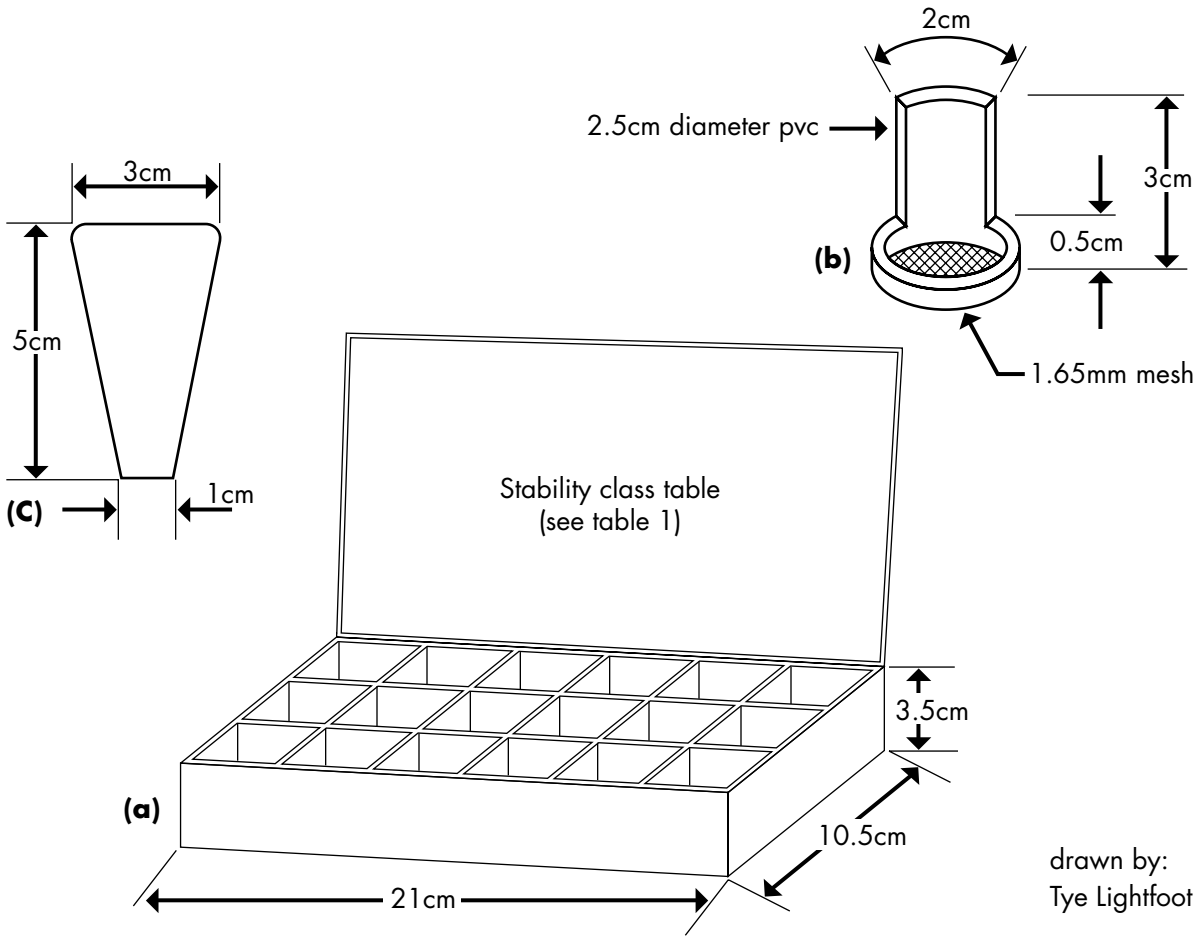


Table 1. Soil Stability Evaluation for 1/4"-diameter Air-Dry Samples

ALWAYS Sieve Soils (even if rated ≤ 3) to Verify Class

Stability class	Criteria for assignment to stability class (for Standard Characterization)[a]
0	Soil too unstable to sample (falls through sieve)*.
1	**50 %** of structural integrity lost within **5 seconds** of insertion in water.
2	**50 %** of structural integrity lost **5—30 seconds** after insertion.
3	**50 %** of structural integrity lost **30—300 seconds** after insertion or <10% of soil remains on sieve after 5 dipping cycles.
4	**10 - 25%** of soil remains on sieve after 5 dipping cycles.
5	**25 - 75%** of soil remains on sieve after 5 dipping cycles.
6	**75 - 100%** of soil remains on sieve after 5 dipping cycles.

* If too unstable to sample, try gently wetting with a mister (perfume bottle available at drug stores), remove sample, and allow to air-dry before testing.

Record rating (1-6) in shaded cells. Cells are arranged in 3 x 6 pattern of typical kit (see diagram)

	Surface			1 inch				Surface			1 inch				Surface			1 inch		
Loc	In Time	Dip Time	#	In Time	Dip Time	#	Loc	In Time	Dip Time	#	In Time	Dip Time	#	Loc	In Time	Dip Time	#	In Time	Dip Time	#
	0:00	5:00		0:45	5:45			1:30	6:30		2:15	7:15			3:00	8:00		3:45	8:45	
	0:15	5:15		1:00	6:00			1:45	6:45		2:30	7:30			3:15	8:15		4:00	9:00	
	0:30	5:30		1:15	6:15			2:00	7:00		2:45	7:45			3:30	8:30		4:15	9:15	

"Loc" is location (e.g., location along a line transect if used). It is optional.
Samples should be less than 1/4" in diameter and less than 1/8" thick.
"Surface" is soil surface sample. "1 inch" is removed from soil 3/4 - 1" below surface.

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13. ABSTRACT *(Maximum 200 words)*

This technical reference describes a new qualitative assessment protocol to be used for interpreting indicators of rangeland health. Use of the reference will allow for more consistent interpretations of rangeland health indicators, thus making assessment results more comparable. The procedure has been developed for use by experienced, knowledgeable land managers as it requires a good understanding of ecological processes, vegetation, and soils for each of the sites to which it is applied. If used by knowledgeable and experienced people, they will be able to make rapid and preliminary evaluations of soil and site stability, hydrologic function, and biotic integrity on rangelands. Land managers should not use this technique for monitoring.

The procedure requires that evaluators rate 17 indicators to assess three attributes (soil/site stability, hydrologic function, and biotic integrity) for a given location. The six steps to complete the procedure are as follows: 1) determine the soil series and ecological site for the evaluation area, 2) visit ecological reference areas, verify soil series, characterize canopy cover, ground cover, dominance and soil surface characteristics, and rate the status of the indicators, 3) accept or modify rating criteria for each indicator, 4) return to the evaluation area and characterize the site using estimates of canopy cover, ground cover, and dominance, 5) rate each indicator relative to its degree of departure from the ecological site description or the reference area, and 6) rate the site for the three attributes based on the preponderance of evidence from the relevant indicators.

14. SUBJECT TERMS
Rangeland Health Indicators, Rangeland Health Attributes, Soil/Site Stability, Hydrologic Function, Biotic Integrity, Ecological Site Description, Ecological Reference Area

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