Grassland Ecosystem Monitoring:
A Nonquantitative Procedure for Assessing Rangeland Performance Status

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Introduction

Sustaining rangelands at high performance levels requires implementation of long-term management practices that beneficially manipulate plant biological mechanisms and ecological processes enabling the grassland ecosystem to perform at its peak potential. The response of biological mechanisms and ecological processes to modifications of manipulation strategies is slow, and the response of grassland ecosystem performance to management practices occurs in annual incremental changes, both positive and negative, which may be evident only through annual monitoring. Changes in the performance levels of several components of the rangeland ecosystem can be monitored over time to provide indirect indication of the status of grassland ecosystem health. Such monitoring allows management practices to be adjusted before problems lead to a grassland ecosystem with deteriorated health status and low performance that can be improved only through many years of corrective manipulation.

Management practices that focus on meeting the biological requirements of plants and rhizosphere organisms facilitate the operation of ecological processes that can sustain a healthy grassland ecosystem over time. The performance levels of the plant component of a grassland ecosystem regulate the performance levels of all the other components of the ecosystem. Plants are the primary producers, converting light energy into chemical energy during photosynthesis. This captured solar energy is the primary force driving all ecosystem functions and provides the foundation for all uses of grasslands. By meeting the biological requirements of the plants and facilitating the operation of ecological processes at potential levels, proper management practices improve the performance of all grassland ecosystem components or maintain the health status and productivity of a grassland ecosystem functioning at high performance levels. The most important components of grassland ecosystems are the plants and rhizosphere organisms, and they should have the highest priority in management decisions. Management practices that focus on a single use, an idealistic goal, or an objective that does not place plant and soil organism biological requirements as the first priority cannot sustain a healthy ecosystem over time.

Rangeland health can be evaluated only indirectly, and its complete assessment requires measurement of many complex interactive components of the ecosystem. Interpretation of ecosystem performance and ecological processes requires professional analysis of quantitative scientific data, and accurate application of quantitative scientific methods used to measure ecosystem components such as plant species composition, aboveground and belowground biomass production, available soil water, and soil organism activity requires professional training. These methods are expensive, complex, and time consuming. Simple and inexpensive methods that provide reliable quantitative information documenting the changes in rangeland ecosystem health have yet to be developed: scientific methods must be followed if data of scientific quality is desired. However, rapid and inexpensive procedures that provide nonquantitative information can be used to assess and monitor changes in rangeland health. Nonquantitative monitoring methods need not be executed with the precision of scientific methods but do require the use of valid standard procedures each year to allow accurate comparison of the collected information.

This report describes a simple nonquantitative grassland ecosystem monitoring method with three sections: plot photographs, major plant species present list, and rangeland health status assessment. Testing and development of monitoring procedures were conducted during the period between 1991 and 1999. Portions of this monitoring method are modified portions of monitoring methods reported by Taylor and Lacey (1992) and the National Research Council (1994). The nonquantitative information collected by the relatively inexpensive and easily mastered procedures presented in this report does provide sufficient information to permit

basic evaluation of management-practice effectiveness.

Monitoring Site Location

Selection of appropriate monitoring locations is necessary for accurate assessment of changes that occur in ecosystem performance as a result of the effects of management practices. The most basic monitoring approach requires that a minimum of one site representative of the area be established in each pasture of a management practice. This primary monitoring site should be located on an area that has silty soil and is relatively level: silty soil represents the standard soil development of a region, and the available soil water on this site type is equal to the potential amount that could be gained from precipitation. This monitoring site should not be located near a gate, water tank, or road, nor should it be located in other areas where factors in addition to environment or management practice might influence ecosystem response. While establishment of one site per pasture allows basic assessment of the effectiveness of management practices, the development of more than one site is advantageous. The number of monitoring sites per pasture should reflect the number of substantial land areas that have differences great enough to affect management decisions.

Traditional concepts of range condition evaluation suggest that a monitoring site should be established for each range site in a pasture. The range site, or ecological site, is the basic unit of rangeland with similar characteristics. Each named range site has similar soil characteristics, topographic position, environmental conditions, and native plant composition. Classification and identification of range sites for a grassland unit are complex processes and require the use of soil survey maps, soil series descriptions, soil map unit descriptions, range site descriptions, and field information for specific sites. A monitoring approach using sites that represent the major identified range sites in each pasture would provide considerably more information than is essential for the formulation of most management decisions.

Some landscape positions vary sufficiently in their characteristics that the differences warrant consideration in management decisions, however. To allow consideration of these variations, a simplified classification method can be used to separate the landscape into a few categories with different productivity capabilities. Landscape areas can be sorted by soil parent material and average annual precipitation into physiographic regions. The land within these physiographic regions can then be classified into three general landscape site categories based on whether the amount of soil water is greater than, equal to, or less than the potential amount that could be gained from precipitation. The three categories are lowland, upland, and xeric sites. Lowland landscape sites have high levels of soil water in the rooting zone for most of the year. Because of water run-in, the water levels in these sites are greater than precipitation levels. The amount of water run-in is variable with landscape position. Depressions or basins on lower portions of slopes receive greater amounts of run-in water than concave portions of side slopes. Upland landscape sites have well-drained soils and are usually not at field capacity for much of the growing season. The amount of soil water in these sites usually reflects the potential amount that could be gained from precipitation. The primary monitoring site located on silty soil is an upland landscape site. Xeric landscape sites have restricted infiltration or water-holding capacity, and, for most of the growing season, available soil water is below the levels that could be gained from precipitation. The dryness of xeric sites usually results from the physical characteristics of the site rather than from lack of precipitation. The landscape of management-practice pastures can be classified into these three general landscape type categories, and a monitoring site for each landscape type present in each pasture can be established to differentiate variations in productivity that are great enough to affect management decisions. This monitoring approach provides useful information and is strongly recommended, however, additional sites require additional monitoring time.

These additional monitoring sites may also be designated to document the health status of the pasture more thoroughly. In pastures that contain plant communities at different levels of health, selection of monitoring sites representative of the different levels is suggested to facilitate evaluation of the communities' response to management practices. Location of other sites in areas of particular concern may be useful to monitor the response of special plant communities to the effects of management practices.

Inclusion of a monitoring site in control areas of long-term (seven or more years) nongrazing and/or six-month seasonlong grazing treatment is recommended. Monitoring sites in control areas should be located on the same types of range sites or landscape sites selected in the management-practice pastures. Comparison of changes observed on the management-practice pastures to changes observed

on control areas can help distinguish changes caused by the management practice from changes caused by variability in environmental factors.

Monitoring Site Description

A description of each monitoring site should be prepared at the start of the monitoring process. Forms on which to record pertinent information follow the text of this report. Each monitoring site description should include pasture name or number, legal description, soil type, range site or landscape site, physical characteristics, implemented management practices, and weather conditions. The record of physical characteristics should include topography, percent slope, and aspect (exposure). A map of the monitoring sites should be made and directions enabling someone not familiar with the operation to locate each monitoring site should be provided. The description of pasture management practices should be completed annually and should document type of grazing management, pasture size in acres, number and type of livestock, and dates of grazing periods. A general description of each year's prevailing weather conditions should also be provided. Descriptions should be organized by monitoring site and placed in a three-ring binder or other type of orderly filing system.

Photo Plot Method

Photographs taken at designated monitoring sites can reveal a considerable amount of information about changes in a rangeland ecosystem when standard procedures are followed for several years. To depict the current characteristics of the ecosystem, a vertical and a horizontal photograph should be taken for each monitoring plot during each sampling period. Monitoring site photographs can aid in the evaluation process and serve as documentation for the results of the pasture's health status assessment.

The needed materials are a camera, film, (or digital camera), a plot frame, a portable elevated photo platform, plot and date information tags, pins, posts, and a photo album (or computer photo filing program). The same camera and film type should be used for all plot photographs. A plot frame with inside dimensions of a square yard or square meter is used to demarcate the plot boundaries in the photographs. The photo plot frame should be painted a bright color or with alternated stripes of known length. A portable elevated platform is needed to provide enough vertical distance between the camera and the plot that the entire plot frame will be captured in the photograph. People of average height require a platform elevated 18" to 24". The distance between camera and plot should be constant among all vertical photographs, so it is desirable that photographs be taken by persons who are of similar height and who use the same portable platform. A plastic 5-gallon restaurant pickle bucket serves as an inexpensive portable elevated platform that can also be used to carry equipment between sites. A modestly priced three-step stool can serve as a safe elevated platform if balancing on an overturned bucket seems too reckless. Plot tags, which bear the identifying name or number assigned the monitoring plot to be photographed, and date identification tags, which record the exact date of the plot photograph, can be made from cardboard shipping tags. The lettering on the tags should be large and dark enough to be read easily on the photographs. The identification tag and date tag should be placed just outside the plot frame when the photograph is taken and can be held in place with large nails.

Each photo plot requires four pins to mark the corners permanently and two steel posts to indicate the location of the plot. Inexpensive pins can be made from large washers welded onto reinforcement rod. One pin should be driven into the soil at each corner of the plot, and the tops of the washers should be painted a bright color. A location post should be set at a known distance and in a known direction from the plot, and a sight post should be set further away, in line with the location post and the center of the plot. All photo monitoring plots should follow the same master plan: for example, a steel location post might be set 50 feet north of the center of the photo plot and a sight post 20 to 30 feet past the location post to assist in the relocation of the plot. A rope with a loop on one end and with the same length as the distance between the location post and the plot center can be used to assist in the relocation of a plot when the photographer places the loop over the location post and walks in an arc at the end of the outstretched rope.

The greater the number of sampling periods at which photographs are taken at each monitoring site, the more thoroughly the conditions will be represented. A minimum of three photo sampling periods per site per year is necessary to depict annual seasonal changes. The first photo should be taken in early June, when plants are at the grazing-ready stage. The second should be taken when peak herbage biomass has been produced, usually between mid July and the first week in August. The third should be taken during the late portion of the growing season, sometime between mid and late September, when the

status of cool-season fall-tiller growth is evident. If grazing continues in one or two pastures after mid October, a fourth photo should be taken in these pastures at the end of grazing, even if snow covers the ground.

Photographs should be taken during the same periods each year. The vertical photographs should be taken with the photographer always positioned on the same side of the plot, preferably on the north so that his or her shadow is not cast on the photo plot. The camera should be elevated the same distance above the plot for each photograph, and the same platform should be used each time. Sharp focus on the photo plot is critical, and the focus should be checked through the viewfinder of the camera while the photograph is taken.

After the vertical photograph for each sampling period has been taken, a horizontal photograph across the plot should be taken from a point 15 feet from the plot and opposite the location post; the horizontal photograph should be taken from the same spot each time. For this shot, the plot frame should be positioned upright to give perspective to the plot. The plot frame will stand in an upright position if one side is supported by a rod struck into the soil.

Monitoring site photographs should be organized by year and preserved in a photo album or in a computer file. Photographic negatives should be stored separately in case damage to the photographs occurs.

Major Plant Species Present List

Major plant species composition on a monitoring site undergoes dynamic changes. Plant species composition changes both in response to environmental factors such as precipitation levels and pattern, hail, drought, and abnormal hot or cold periods and in response to defoliation management practices of grazing and fire. The effects of fire or grazing vary with time of season, frequency, and severity of defoliation. Percent composition of individual plant species may increase or decrease under one set of conditions and reverse that response under another set of conditions. To help document the dynamic changes in plant species composition that occur over time, a list of major plant species present on each monitoring site should be made once each year, between mid July and mid August. During this period most plants will be at an identifiable stage, including plants with their primary growth occurring during the early or late portions of the growing season. The major plant species, including grasses, forbs, and shrubs, should be listed from most to least dominant. The minor plant species may be recorded but need not be. The book *Range Plants*, written by K.K. Sedivec and W. T. Barker and published by NDSU in 1997, can aid in proper identification of species. The major plant species present list will assist in the evaluation of the monitoring site and in the identification of plants observed in the monitoring site photographs. The list will also serve as documentation for the rangeland health assessment.

Each rangeland plant species grows best within a suite of environmental parameters. Plant species with similar requirements generally grow together on landscape positions that have similar physical and environmental conditions. Landscape positions with different physical and environmental conditions support plant communities with different major plant species composition. Landscape positions can be classified into three general landscape sites that have different physical and environmental conditions. The major grass species present on lowland, upland, and xeric landscape sites are listed in Tables 1, 2, and 3, respectively. Not all species listed in each table will be found on all respective landscape sites. The groupings of grass species in these tables may assist in the identification of the three general landscape sites on the pasture landscape and can be used as a reference guide during the recording of the major plant species present list. The plant list for each site should be placed in the three-ring binder with the descriptions of the monitoring site and management practices.

Table 1. Major grasses of the lowland and saline lowland landscape sites.

Lowland Landscape Sites	
Western wheatgrass	*Agropyron smithii*
Big bluestem	*Andropogon gerardi*
Northern reedgrass	*Calamagrostis stricta*
Canada wildrye	*Elymus canadensis*
Switchgrass	*Panicum virgatum*
Reed canarygrass	*Phalaris arundinacea*
Sprangletop	*Scolochloa festucacea*
Indiangrass	*Sorghastrum nutans*
Prairie cordgrass	*Spartina pectinata*
Slough sedge	*Carex atherodes*
Wooly sedge	*Carex lanuginosa*
Lowland sedges	*Carex spp.*
Saline Lowland Landscape Sites	
Inland saltgrass	*Distichlis spicata*
Foxtail barley	*Hordeum jubatum*
Nuttall alkaligrass	*Puccinellia nuttalliana*
Tumblegrass	*Schedonnardus paniculatus*
Squirreltail	*Sitanion hystrix*
Alkali cordgrass	*Spartina gracilis*

Plant names on tables 1, 2, and 3 follows Flora of the Great Plains (1986).

Table 2. Major grasses of the upland landscape sites.

Upland Landscape Sites	
Western wheatgrass	*Agropyron smithii*
Sand bluestem	*Andropogon hallii*
Sideoats grama	*Bouteloua curtipendula*
Blue grama	*Bouteloua gracilis*
Plains reedgrass	*Calamagrostis montanensis*
Prairie sandreed	*Calamovilfa longifolia*
Prairie junegrass	*Koeleria pyramidata*
Little bluestem	*Schizachyrium scoparium*
Sand dropseed	*Sporobolus cryptandrus*
Needle and thread	*Stipa comata*
Porcupine grass	*Stipa spartea*
Green needlegrass	*Stipa viridula*
Upland sedges	*Carex spp.*

Table 3. Major grasses of the xeric landscape sites.

Xeric Landscape Sites	
Western wheatgrass	*Agropyron smithii*
Blue grama	*Bouteloua gracilis*
Buffalograss	*Buchloe dactyloides*
Prairie junegrass	*Koeleria pyramidata*
Plains muhly	*Muhlenbergia cuspidata*
Sandberg bluegrass	*Poa sandbergii*
Little bluestem	*Schizachyrium scoparium*
Needle and thread	*Stipa comata*
Green needlegrass	*Stipa viridula*
Upland sedges	*Carex spp.*

Nonquantitative Assessment of Rangeland Health Status

Assessment of rangeland health status is different from the traditional method for determination of range condition, which compares the current successional stage of the plant community to the theoretical climax plant community. Rangeland health assessment evaluates both the performance levels at which ecosystem components are functioning and the interactions among climate, soil, vegetation, and animals. Rangeland health is not a physical characteristic of the ecosystem, and the status of health can be assessed only indirectly, through evaluation of the levels of performance of many ecosystem components. The ecosystem components considered during health status assessment procedures are aboveground and belowground vegetation, soil development processes, levels and types of erosion, ecological processes, and precipitation infiltration.

Most rangeland health status assessment methods separate the relative rankings of the performance and health of rangeland ecosystems into four condition categories, from extremely healthy to extremely unhealthy. The most commonly used condition category names are excellent, good, fair, and poor. In the nonquantitative rangeland health status assessment method presented, these four general categories will be used to separate the levels of ecosystem health. Evaluation criteria and characteristics of the major components vary in degree and functional status for the four rangeland health condition categories.

The four rangeland health condition categories can be illustrated by comparison to human health condition. A grassland ecosystem in excellent (A) condition is like a highly trained athlete: highly productive, with all processes functioning at high rates and high efficiency; able to endure considerable stress; and capable of rebounding from stress quickly. A grassland ecosystem in good (B) condition is like a person in average health: productive, with all processes functioning at moderate rates and moderate efficiency; able to endure some stress; and capable of gradual recovery from stress. A grassland ecosystem in fair (C) condition is like a couch potato: marginally productive, with all processes functioning at low rates and reduced efficiency; able to endure only minimal stress; and requiring long periods to recover from stress. A grassland ecosystem in poor (D) condition is like a chronically ill person: unproductive, with all processes functioning ineffectively and inefficiently; unable to endure stress; and capable of recovering from stress only over considerable time and with special treatment.

Assessment of the status of rangeland ecosystem health should be conducted for each monitoring site each year, between early June and late July. The evaluation criteria and characteristics for excellent (A), good (B), fair (C), and poor (D) rangeland health condition categories are on Tables 4, 5, 6, and 7, respectively. All seventeen health status criteria and characteristics should be assessed for the monitoring site, and the ecosystem's condition for each characteristic should be placed at one of the four levels though determination of whether the grassland ecosystem performs like a highly trained athlete (A), a person in average health (B), a couch potato (C), or a chronically ill person (D). A set of questions to help the evaluator interpret the seventeen health status criteria and characteristics is provided.

A form on which ten years of assessments may be recorded is located at the end of this report. The health status assessment form for each site should be placed in the three-ring binder with the site descriptions and the major plant species present lists.

The following set of questions can be used to help interpret the rangeland health status criteria and characteristics on tables 4-7 and to help place the grassland ecosystem into a health condition category.

I. What is the density of the plants? Are they close together with few open spaces, or are numerous large open spaces evident?

II. What is the plant species composition? Are most of the plants desirable prairie species, or are most undesirable species?

III. What are the age groups of the plants? Are there numerous young plants, or are there very few young plants?

IV. How vigorous are the plants? Are the plants large and robust, or are they weak?

V. What is the root distribution in the soil? Are roots growing throughout the soil profile, or are roots restricted to a small portion of the soil profile?

VI. What is the quantity of leaf material present throughout the growing season? Are substantial quantities of grass leaves present at the end of the season, or are the grass leaves grazed short during any portion of the season?

VII. How much litter is present? Does litter cover the entire area, or is litter present only in small amounts and distributed only in small patches?

VIII. What is the distribution of decomposed organic matter? Is the organic matter spread over the entire area, or is it present only in small patches?

IX. What is the distribution of developing soil? Is the soil top layer dark and continuous, or is it light colored?

X. What is the extent of erosion? Is very little soil moved by wind or water, or is a considerable amount of soil moved?

XI. What is the extent of soil deposition? Are small or large quantities of recently deposited soil present?

XII. What is the extent of recent gully formation? Are the gullies relatively shallow and gently sloping, or are they deep and branching?

XIII. What is the extent of pedestaling? Is pedestaling absent, or are roots exposed on some pedestals?

XIV. What is the extent to which wind erosion and water erosion are changing the surface? Are there areas that are polished clean, or are there areas that have windrows of plant material near the base of a hill after a rain storm?

XV. The nutrient cycles and energy flow cannot be directly observed, but the presence of dark soil and healthy desirable plants with robust leaves and roots indicates adequate energy flow and function of nutrient cycles.

XVI. The dynamics and processes of an ecosystem cannot be directly observed, but the presence of dark soil and healthy desirable plants with robust leaves and roots indicates healthy ecosystem dynamics and processes.

XVII. What is the level of precipitation infiltration? Does most of the rain soak into the soil, or does a significant amount run off?

Table 4. Rangeland health status criteria and characteristics for the (A) excellent health condition category.

I.	Distribution pattern of plants across the site is nearly continuous, with foliage covering nearly the entire ground surface.
II.	Plant species composition is diverse, with numerous desirable species in a mature community.
III.	Age-class distribution of plants is diverse, with numerous plants of each age group. Recruitment of numerous young desirable plants is supported.
IV.	Plants are vigorous, support robust growth, and show no signs of deformed growth patterns.
V.	Plant roots are distributed throughout the available soil profile.
VI.	The leaf area of the plants is adequate throughout the growing season so that rates of photosynthetic activity are sufficient to provide all the requirements for growth of leaves and roots.
VII.	Litter distribution across the site is nearly continuous, with only a few bare soil areas.
VIII.	The humic layer of decomposed organic matter is well developed across the site.
IX.	The top layer of soil appears stable and is consistent across the site.
X.	Soil removal by wind or water is not evident.
XI.	Deposition of wind- or water-eroded material is not evident.
XII.	Recent gully formation is not evident. If any gullies are present, they are small, smooth featured, and vegetated.
XIII.	Plant pedestaling is not evident.
XIV.	Scouring or sheet erosion from wind or water is not evident.
XV.	Nutrient cycles and energy flow are functioning at adequate levels.
XVI.	Plant community dynamics and processes are sufficient to maintain highly productive community structure and function.
XVII.	Almost all the precipitation infiltrates the soil, and only a very small amount runs off.

Table 5. Rangeland health status criteria and characteristics for the (B) good health condition category.

I.	Distribution pattern of plants across the site is somewhat continuous, with foliage covering almost all the ground surface.
II.	Plant species composition is diverse, with numerous desirable species and a few less desirable species in a mature community.
III.	Age-class distribution of plants is diverse, with many plants of each age group. Recruitment of many young desirable plants is supported.
IV.	Plants are vigorous and show no signs of deformed growth patterns.
V.	Plant roots are distributed throughout nearly all the available soil profile.
VI.	The leaf area of the plants is adequate throughout the growing season so that rates of photosynthetic activity are sufficient to provide nearly all the requirements for growth of leaves and roots.
VII.	Litter distribution across the site is somewhat continuous, with only a small amount of bare soil area.
VIII.	The humic layer of decomposed organic matter is present over most of the site.
IX.	The top layer of soil appears stable and nearly uniform across the site.
X.	Soil removal by wind or water shows very little evidence.
XI.	Deposition of wind- or water-eroded material shows very little evidence.
XII.	Recent gully formation shows very little evidence. If some gullies are present, they are smooth featured and vegetated.
XIII.	Plant pedestaling shows little evidence.
XIV.	Scouring or sheet erosion from wind or water shows very little evidence.
XV.	Nutrient cycles and energy flow are functioning at adequate levels.
XVI.	Plant community dynamics and processes are sufficient to maintain the existing community structure and function.
XVII.	Most of the precipitation infiltrates the soil, and only a small amount runs off.

Table 6. Rangeland health status criteria and characteristics for the (C) fair health condition category.

I.	Distribution pattern of plants across the site is patchy, with some large bare ground areas not covered by foliage.
II.	Plant species composition is restricted, with some desirable species, some less desirable species, and a few undesirable species in a mature community.
III.	Age-class distribution of plants is incomplete, with some age classes missing. Recruitment of young desirable plants is restricted.
IV.	Plants have reduced vigor, and some show deformed growth patterns, developing close to the ground.
V.	Plant roots are not present in all portions of the available soil profile but are restricted to patches.
VI.	The leaf area of the plants is reduced during portions of the growing season so that rates of photosynthetic activity are insufficient to provide all the requirements for growth of leaves and roots.
VII.	Litter distribution across the site is sparse and uneven, characterized by some large bare soil areas and by accumulations in depressions and around prominent grass plants.
VIII.	The humic layer of decomposed organic matter is sparsely distributed and is being incorporated into the soil only in depressions or around prominent grass plants.
IX.	The top layer of soil is beginning to show a fragmented distribution pattern.
X.	Some soil particles, organic matter, and nutrients are being redistributed by wind or water erosion but remain on the site.
XI.	Some sediment deposition of wind- or water-eroded material is evident.
XII.	Recent gully formation is evident but structures are not yet well developed or integrated into a branching pattern.
XIII.	Plant pedestaling is evident but is not so severe that roots are exposed.
XIV.	Bare soil with scours and dunes from wind erosion is evident, but the structures are small and not well developed. Sheet erosion from water is evident on small areas after thunderstorms.
XV.	Nutrient cycles and energy flow are functioning, but the distribution across the site is in the early stages of a fragmented pattern.
XVI.	Plant community dynamics and processes are not sufficient to maintain productive community structure and function.
XVII.	Some of the precipitation infiltrates the soil, and some runs off.

Table 7. Rangeland health status criteria and characteristics for the (D) poor health condition category.

I.	Distribution pattern of plants across the site is clumped or fragmented, with numerous large bare ground areas not covered by foliage.
II.	Plant species composition is restricted, with few desirable species, many less desirable species, and many undesirable species in a developing community.
III.	Age-class distribution of plants is restricted, with predominantly old or deteriorated plants. Recruitment of young desirable plants is nearly absent.
IV.	Plants are weak, and many plants show deformed growth patterns, developing close to the ground.
V.	Plant roots occupy only a small portion of the available soil profile.
VI.	The leaf area of the plants is greatly reduced during portions of the growing season so that photosynthetic activity is restricted to rates too low to provide much of the energy or many of the nutrients required for growth of leaves and roots.
VII.	Litter distribution across the site is sparse or absent, with numerous large bare soil areas.
VIII.	The humic layer of decomposed organic matter is sparse or absent from most of the site.
IX.	The top layer of soil is sparse or absent from large areas of the site or is present only in association with depressions or prominent obstructions.
X.	Soil degradation resulting from soil particle, organic matter, and nutrient removal from the site by wind or water is evident.
XI.	Deposition of wind- or water-eroded material is evident, appearing as large bare deposits, as dunes, or in association with prominent plants.
XII.	Recent gully formation is evident, and structures are well developed, active, and integrated into a branching pattern.
XIII.	Plant pedestaling is severe enough that roots are exposed.
XIV.	Bare soil with scours and dunes from wind erosion is evident. The structures are active and well developed. Sheet erosion from water is evident on large areas after thunderstorms.
XV.	Nutrient cycles and energy flow are decelerated, and the distribution pattern is fragmented, with numerous large bare areas between fragments.
XVI.	Plant community dynamics and processes are not sufficient to maintain viable community structure and function.
XVII.	Only a small amount of the precipitation infiltrates the soil, and most runs off.

Interpretation

The Grassland Ecosystem Monitoring (GEM) procedures can be mastered easily and can be implemented and conducted effectively by grassland managers. The information collected with this three-part grassland ecosystem monitoring procedure is adequate to assess the preformance status of grassland ecosystems, document changes in the ecosystem processes and biological mechanisms, and evaluate the effectiveness of management practices. Current year's photographs, major plants species list, and nonquantitative assessment of rangeland health status for each monitoring site should be compared to previous years' records for the site. The interpretation of observed changes will be aided by reference to the rangeland health status criteria and characteristics in Tables 4 to 7. Changes on the management-practice monitoring sites should also be compared to changes on control-treatment areas of long-term nongrazing and/or six-month seasonlong grazing so that changes caused by the effect of the management practice can be distinguished from changes caused by variability in environmental factors. An annual narrative description of the observed changes in the photographs, plant list, and ecosystem health assessment information should be completed for each monitoring site.

Changes in the status of the grassland ecosystem performance will be positive or negative. Evaluation of the collected material will allow managers to follow incremental improvement in performance or to make adjustments to management practices before problems lead to deterioration of the ecosystem health status. When the grassland ecosystems are performing at potential levels, this monitoring procedure will provide documentation that management practices meet the biological requirements of the plants and facilitate ecological processes.

Worksheets for the methods described in this report should be copied before procedures are begun. Additional worksheets are available on the web at http://www.ag.ndsu.edu/archive/dickinso/research/2001/range01j.htm.

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Monitoring Procedure Time Table		
Photo Plot Method		
Minimum of 3 photo periods per year: information collected from permanent photo plot		
1 st	early June	grazing-ready stage
2 nd	mid July to early August	peak herbage biomass
3 rd	mid to late September	fall tiller growth
4 th	pastures grazed after mid October	end of grazing
Major Plant Species Present List		
Once a year: information collected from permanent photo plot		
	mid July to mid August	plants identifiable
Nonquantitative Assessment of Rangeland Health Status		
Once a year: information collected from vicinity of permanent photo plot		
	early June to late July	characteristics observable

Description of Monitoring Site

Monitoring Site Name:_____

Pasture Name:_ _____

Physical Characteristics

Range Site or Landscape Site:_____

Soil Type (sand, silt, clay):_ _____

Topography:_ _____

Percent Slope (rise/distance):_ _____

Aspect (compass direction of slope):_____

Legal Description (quarter, quarter, quarter section):_ _____

Location Description:_____

_____

_____

Direction and Distance of Location Post from Photo Plot Center:_____

Photo Plot Frame Size:_____

Attach a map of the location of the monitoring sites.

Provide directions that someone not familiar with the operation could follow to reach this monitoring site.

_____

_____

_____

_____

_____

Annual Description of Management Practices

Monitoring Site Name:_____

Pasture Name:_ _____

Year:_____

Grazing Practice Size in Acres:_ _____

Pasture Size in Acres:_____

Type of Livestock:_____

Number of Livestock:_____

Dates of Grazing Periods:_ _____

_ _____

Description of Grazing Management Practices:_____

_ _____

_ _____

_ _____

_ _____

_ _____

General Description of Weather Conditions

Previous Fall:_____

Previous Winter:_____

Before 1st Photo Period:_____

Before 2nd Photo Period:_____

Before 3rd Photo Period:_____

_____

Rangeland Ecosystem Health Status Assessment

Monitoring Site Name: _____

Range Site or Landscape Site: _____

Health Condition Categories

T rained Athlete	(A)	Excellent
A verage Person	(B)	Good
Co uch Potato	(C)	Fair
Ch ronically Ill	(D)	Poor

		Evaluation Number									
		1	2	3	4	5	6	7	8	9	10
	Day										
	Month										
	Year										
I.	Plant distribution										
II.	Plant species diversity										
III.	Plant age class										
IV.	Plant vigor										
V.	Plant root distribution										
VI.	Amount of leaf area remaining										
VII.	Litter distribution										
VIII.	Humic layer development										
IX.	Soil development processes										
X.	Extent of soil erosion										
XI.	Extent of soil deposition										
XII.	Extent of gully development										
XIII.	Plant pedestaling										
XIV.	Erosional changes of soil surface										
XV.	Ecological processes										
XVI.	Ecosystem dynamics										
XVII.	Precipitation infiltration										
	Name of Evaluator										