2002 Annual Report

Grassland Section

Dickinson Research Extension Center
1089 State Avenue
Dickinson, ND 58601

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

Llewellyn L. Manske PhD
Range Scientist

North Dakota State University
Dickinson Research Extension Center

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 facilitate the operation of ecological processes 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 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 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 not been 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 some 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 not constitute an adequate substitute for scientific data and has only limited application, but this nonquantitative information is sufficient to allow 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.

Additional monitoring sites may 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, a plot frame, a portable elevated photo platform, plot and date information tags, pins, posts, and a photo album. 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 binder. 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

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?

Interpretation

The Grassland Ecosystem Monitoring (GEM) procedures can be mastered easily and can be implemented and conducted effectively by grassland managers who have received training in the fundamentals of the method. The information collected with this three-part grassland ecosystem monitoring procedure is adequate to allow basic evaluation of 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.

Acknowledgment

I am grateful to Amy M. Kraus for assistance in the preparation of this manuscript. I am grateful to Sheri Schneider for assistance in production of this manuscript and for development of the tables and forms.

References

Manske, L.L. 1999. Generalized range sites group categories. NDSU Dickinson Research Extension Center. Range Program Information Sheet #7. Dickinson, North Dakota. 6p.

Manske, L.L. 1999. Simplified method for assessment of range condition. NDSU Dickinson Research Extension Center. Range Program Information Sheet #8. Dickinson, North Dakota. 7p.

Manske, L.L. 1999. Historical steps in the development of the concept of range condition. NDSU Dickinson Research Extension Center. Range Program Information Sheet #11. Dickinson, North Dakota. 2p.

National Research Council. 1994. Rangeland health: New methods to classify, inventory, and monitor rangelands. National Academy

Press, Washington, D.C.

Sedivec, K.K., and W.T. Barker. 1997. Selected North Dakota and Minnesota range plants. NDSU Extension Service. EB-69. Fargo, North Dakota. 270p.

Taylor, J.E., and J. Lacey. 1992. Monitoring Montana rangeland. MSU Extension Service. Bulletin 369. Bozeman, Montana. 22p.

Tables and Forms

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

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

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

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

Form 1. Rangeland Ecosystem Health Status Assessment (pdf format - requires Adobe Acrobat)

Form 2. Monitoring Procedure Time Table (pdf format - requires Adobe Acrobat)

Form 3. Description of Monitoring Site (pdf format - requires Adobe Acrobat)

Form 4. Annual Description of Mangement Practices (pdf format - requires Adobe Acrobat)

[Back to 2002 Annual Report Index] [Back to Grassland Reports]

[DREC Home] [Contact DREC] [Top of Page]
