# METHODS FOR DEVELOPMENT OF BIOLOGICALLY EFFECTIVE MANAGEMENT STRATEGIES

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# Methods for Development of Biologically Effective Management Strategies

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# Development of Biologically Effective Management Strategies

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Grasslands that are not performing close to their potential reduce the profit margins from the production of beef. Healthy grassland ecosystems produce greater quantities of herbage and more pounds of calf per acre than grasslands in good condition. The result is greater profit margins on healthy grasslands. Improving grasslands from an average condition to a healthy status

- increases herbage production
- reduces acres per cow-calf pair per month
- reduces pasture costs per year
- reduces feed costs per day
- increases calf weight gain
- increases calf weaning weight
- reduces cost per pound of calf gain
- increases net return per cow-calf pair
- increases net return per acre
- improves wildlife habitat, water and air quality, and aesthetic quality.

Improving the health performance status of grassland ecosystems requires two steps: first, implementing biologically effective grazing management practices that meet the biological requirements of the plants and that coordinate grazing periods with grass growth stages so that both vegetative reproduction by tillering and activity of rhizosphere organisms are stimulated, and second, monitoring the response of grassland ecosystem performance to the changes in management practices. The response of biological mechanisms and ecosystem processes to changes in management strategy 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.

Management practices that focus on meeting the biological requirements of plants 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 levels of all grassland ecosystem components or maintain the health status and productivity of a grassland ecosystem functioning at high performance levels.

Monitoring the changes in the performance levels of several components of the grassland ecosystem over time provides indirect indication of the status of grassland ecosystem health. Grassland ecosystem monitoring can be accomplished rapidly and inexpensively through the use of the grassland ecosystem monitoring (GEM) method developed by North Dakota State University range scientists. This method comprises three simple procedures: taking plot photographs, compiling a major plant species present list, and completing a health status assessment. Ecosystem components considered during health status assessment procedures are aboveground vegetation, belowground plant structures, soil development processes, levels and types of erosion, ecological processes, and precipitation infiltration. With the grassland ecosystem monitoring procedures, ranchers can collect nonscientific, nonquantitative information that can be used to assess the performance status of grassland ecosystems, document changes in the ecosystem, and evaluate the effectiveness of management practices.

Implementation of beneficial management practices will improve the status of grassland ecosystem health, and annual monitoring will allow managers to evaluate changes in performance levels and to adjust management practices to ensure that the grassland ecosystems are functioning at high performance levels. Strengthening the status of health of the grassland ecosystem will provide improvement in livestock weight performance, reductions in livestock production costs, and increases in profit margins.

# A Method of Conducting Pasture and Forage Inventories to Be Used in the Development of Biologically Effective Management Strategies

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The goal of a biologically effective pasture and forage management strategy is to match the forage quantity and nutritional needs of the livestock with the herbage production curves and the nutrient-available curves of the various forage types so that the combination of forage types provides efficient use of the ranch natural resources. Development of a biologically effective pasture and forage management strategy for a ranch requires knowledge of the current quantity and quality of the available pasture and forage types. A pasture and forage inventory is needed to identify the resource types that will provide the forage needs of the livestock at their various production stages.

A major goal of the inventory is to identify the pasture and forage assets of the ranch and to identify the features that cause bottlenecks restricting the management unit from reaching its optimum potential production levels. The strongest pasture and forage asset of the ranch is the resource that determines what the ceiling for the livestock numbers would be if the resource were used during its optimum period and if the forage types used during the other livestock production stages could be brought up to an equivalent level. The bottleneck asset is the resource that limits livestock production and shows what the potential bottom for the livestock numbers would be if this problem were not corrected. The development of a biologically effective management strategy requires adjustments in the quantities of the natural resource types so that the needs of the livestock can be met efficiently during the entire 12-month period.

A pasture and forage inventory is a list of information about each parcel of land included in a livestock production operation. The main categories are pasture land, including native rangeland and domesticated perennial grass; hayland, including native rangeland, domesticated grass, and alfalfa; and cropland, including grazed annual forage, annual forage hay, and annual crops for grain used for feed or cash sale. The information needed for hayland and cropland inventory includes the size in acres, forage type, and average yield in tons per acre or bushels per acre. The information needed for pasture land inventory includes the size in acres, stocking rate in ac/AUM, and carrying capacity in AUM's of available forage. A worksheet will help organize the pasture land information.

One of the major causes of low profit margins from livestock production is the inefficiency of capturing economic value from the land resources inherent in old-style traditional management practices; in addition, the common practice of changing livestock forage sources on short notice or in crisis situations is expensive. Increasing the economic value captured from the land requires effective planning. One of the first steps in this planning process is to designate specific parcels of land for forage production for each group of livestock.

The pasture location of livestock groups should be predetermined for an entire year. A monthly time line for livestock inventory worksheet is a useful planning tool. This worksheet is a planning list of each category of livestock, the number of livestock in each category, and the pasture name or forage type used for feed on a monthly schedule.

If gathering information for this worksheet is part of the initial stages of changing pasture and forage management from traditional practices to biologically effective methods, a monthly time line for livestock inventory should be completed according to the old-style management practices. After a biologically effective management plan is developed, a second monthly time line for livestock inventory should be completed.

Worksheets for the methods described in this report should be copied before procedures are begun.

Acknowledgment

I am grateful to Amy M. Kraus for assistance in preparation of this manuscript. I am grateful to Sheri Schneider for assistance in production of this manuscript.

**Steps in conducting a pasture and forage inventory for pasture land.**

1. List pasture by name or number.
2. List total acreage of pasture.
3. List vegetation types in pasture (for example, native rangeland, crested wheat, smooth brome).
4. List acreage of each vegetation type in pasture.
5. List landscape sites in pasture (for example, lowland, upland, xeric) (see page 7, Generalized landscape site management units).
6. Estimate percentage of each landscape site in pasture.
7. Determine acreage of each landscape site in pasture by multiplying total pasture acres (Step 2) by % landscape site (Step 6).
8. Identify range condition as one of four broad categories of condition: excellent, good, fair, or poor (see page 13, Simplified assessment of range condition).
9. Determine stocking rates (ac/AUM) of landscape sites from average stocking rate value in ac/AUM tables (see page 19, Generalized average stocking rates).
10. Determine carrying capacity in AUM's by dividing the acreage of each landscape site (Step 7) by average stocking rate (Step 9).
11. Determine historical stocking rate (ac/AUM) for pasture by simple method (see page 24, Generalized average stocking rate).
12. Determine historical carrying capacity in AUM's by dividing total pasture acres (Step 2) by historical stocking rate (Step 11).

Example of Pasture Land Inventory

To illustrate how to fill out the pasture and forage inventory worksheet for a ranch, we will use an example of a West River Region pasture of one section (640 acres) with 10% crested wheat and 10% lowland, 50% upland, and 30% xeric landscape sites. The area is grazed for 4.5 months, from 1 June to 15 October, by 70 cow-calf pairs with the cow average weight at 1,000 pounds.

**Pasture and Forage Inventory Worksheet**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pasture Name | Pasture Total Acres | Vegetation Type | Vegetation Type Acres | Landscape Site | | | Range Condition | Determined | | Historical | |
| | | | | Group | % | Acres | | Stocking rate | Carrying capacity | Stocking rate | Carrying capacity |
| West | 640 | | | | | | | | | 2.04 | 313.7 |
| | | Crested | 64 | | 10 | 64 | | 1.25 | 51.2 | | AUM’s |
| | | Native | 576 | Lowland | 10 | 64 | Good | 1.25 | 51.2 | | |
| | | | | Upland | 50 | 320 | Good | 2.00 | 160.0 | | |
| | | | | Xeric | 30 | 192 | Good | 4.00 | 48.0 | | |
| | | | | | | | | | 310.4 | | |
| | | | | | | | | | AUM’s | | |
| | | | | | | | | | | | |
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**Pasture and Forage Inventory Worksheet**

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pasture Name | Pasture Total Acres | Vegetation Type | Vegetation Type Acres | Landscape Site | | | Range Condition | Determined | | Historical | |
| | | | | Group | % | Acres | | Stocking rate | Carrying capacity | Stocking rate | Carrying capacity |
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**Steps in conducting monthly time line for livestock inventory.**

1. Separate livestock into production categories.
2. List the number of head in each category for each month.
3. List the pasture name or forage type that each livestock category is planned to use for feed for each month.

**Monthly Time Line for Livestock Inventory Worksheet**

Identify number of head and pasture location per month

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mature Cows (A) 4's + | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Mature Cows (B) 4's + | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Mature Cows (C) 4's + | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Young Cows 2's, 3's | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Replacement Heifers | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Weaned Heifers | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Weaned Steers | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Bulls | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Horses (AUE X 1.5) | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Sick | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |
| Other | #head | | | | | | | | | | | | |
| | Pasture | | | | | | | | | | | | |

# Range Sites Grouped into Generalized Landscape Management Units

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Range site is the basic unit of rangeland with similar characteristics. Each named range site has similar soil characteristics, topographic position, environmental factors, and potential native vegetation composition. Range sites can be described and separated to a finer degree than is practical for application of specific management practices. Theoretically, enough differences exist among the range sites to warrant the use of different management and stocking rates for each range site. Such specific management requires that each range site be identified and considered separately but as a part of the entire grassland management unit.

Classification of individual range sites for a grassland management unit is a complex process that requires the use of soil survey maps, soil series descriptions, soil map unit descriptions, and range site descriptions. Most grassland mangers have not had and most likely will not have a detailed range site identification completed for their land. However, completion of some level of range site identification is a critical step in the development of a pasture and forage inventory.

Management of each range site separately is impractical in most grazingland pasture situations. Range sites with similar levels of soil water and herbage production can be grouped into three generalized landscape site management units to simplify grazingland management of pastures in the Northern Plains.

This report attempts to simplify the process of range site identification by grouping categories of range sites into landscapes sites with similar management requirements and similar stocking rates. Two major differences among the landscape site management units are the type of soil parent material and the average annual precipitation. The average annual precipitation and the types of parent material from which soils have developed are variable across the Northern Plains and form four distinct physiographic regions: the Red River Valley, the Drift Prairie, the Missouri Coteau, and the West River Regions.

The **Red River Valley Region**, part of the Central Lowland Physiographic Province, is an exceptionally flat plain of glacial lake sedimentary deposits and is characterized by very gentle slopes over 95% of the area. The region has poorly developed stream systems. The range of average annual precipitation is 18 to 20 inches. The major native vegetation is the Bluestem, Switchgrass, and Indiangrass Type of the Tall Grass Prairie. Most of this region has been converted to cropland, and only fragments of tall grass prairie vegetation remain. Management considerations for this region are not included in this report.

The **Drift Prairie Region,** part of the Central Lowland Physiographic Province, is characterized by rolling, hummocky, or hilly glacial till deposits; gentle slopes of less than 8% on more than 80% of the area; and relief generally of less than 100 feet. The hills are closely spaced, with valleys containing numerous closed depressions called pot holes. The region has poorly developed stream systems. The range of average annual precipitation is 16 to 20 inches. The major vegetation is the Wheatgrass, Bluestem, and Needlegrass Type of the Mixed Grass Prairie. This region is considered the transition zone between the Tall Grass Prairie and the Mixed Grass Prairie.

The **Missouri Coteau Region,** part of the Great Plains Physiographic Province, is the glaciated portion of the Missouri Plateau. This region is a hummocky plain of terminal moraine and dead-ice moraine deposits and is characterized by gentle slopes of less than 8% on 50 to 80% of the area and relief generally of 100 to 300 feet. Some portions of the region are well drained with streams, and other portions have depressions containing closed basins with small bodies of water. The range of average annual precipitation is 14 to 18 inches. The major native vegetation is the Wheatgrass and Needlegrass Type of the Mixed Grass Prairie.

The **West River Region**, part of the Great Plains Physiographic Province, is the unglaciated portion of the Missouri Plateau. In this region sedimentary deposits have been eroded and formed into a rolling to hilly plain with large buttes. The region is characterized by gentle slopes of less than

8% on 50 to 80% of the area and relief generally of 300 to 500 feet. The region is well drained with a developed stream system. On an 8- to 25-mile-wide and nearly 200-mile-long strip along the Little Missouri River exists a subregion of badlands. This subregion is a rugged, deeply eroded, hilly area with gentle slopes of less than 8% on 20 to 50% of the area and relief commonly over 500 feet. The range of average annual precipitation is 13 to 16 inches for the region. The major native vegetation is the Wheatgrass and Needlegrass Type of the Mixed Grass Prairie.

The range sites within each of the different physiographic regions of the Northern Plains can be grouped into three landscape site categories based on the soil water holding capacity and the position of the water table. These three landscape site categories are easily identified and can be used for pasture and forage inventories during the development of biologically effective pasture and forage management strategies. The three landscape site categories are lowland, upland, and xeric sites. The lowland landscape sites have high levels of soil water in the rooting zone of the soil for most of the year. Because of water run in, these sites receive greater amounts of water than the precipitation levels. The upland landscape sites have well-drained soils and are usually below field capacity for much of the growing season. The xeric landscape sites have restricted water infiltration or water-holding capacity, and for much of the growing season, available soil water is below the potential to be gained from precipitation.

Among the physiographic regions, the characteristics of a landscape site type differ slightly. Therefore, management requirements and stocking rates differ slightly for areas of a particular landscape site type located in different physiographic regions.

**Lowland Landscape Sites for the Drift Prairie Region**

Topography is nearly level, low-lying swales, depressions, shallow basins, and drainageways. Slopes are less than 3%. Soils are deep and are poorly drained to moderately well drained. Permeability is very slow, slow, moderately slow, or moderate. Available water capacity is moderate, high, or very high. Lowland landscape sites receive additional amounts of water from run in from higher land, surface runoff, flooding, and/or underground seepage.

**Upland Landscape Sites for the Drift Prairie Region**

Topography is nearly level to rolling, with some areas gently sloping to moderately steep. Slopes are mostly 1 to 15%, with some 3 to 25%. Soils are deep to moderately deep; most are moderately well drained to well drained, and some are excessively well drained. Permeability is slow, moderate, moderately rapid, or rapid. Available water capacity is low, moderate, or high.

**Xeric Landscape Sites for the Drift Prairie Region**

Topography is nearly level, undulating, or gently sloping. Slopes are 1 to 6%. Soils are mostly very shallow or shallow; some are deep. Most are poorly drained or moderately well drained; some are excessively drained. Permeability is very slow, moderate, moderately rapid, or rapid. Available water capacity is very low, low, or moderate. Most xeric landscape sites have thin surface soils with an underlying hardpan that is nearly impervious to water.

**Lowland Landscape Sites of the Missouri Coteau Region**

Topography is nearly level swales, basins, and depressions, or nearly level and gently undulating low-lying bottomlands and stream terraces. Slopes are less than 3%. Soils are deep and poorly drained. Permeability is very slow to moderate. Available water capacity is moderate, high, or very high. Lowland landscape sites receive additional amounts of water from run in from higher land, surface runoff, flooding, and/or underground seepage. Lowland landscape sites are usually briefly flooded, with water standing over the surface for part of the growing season, and have a high water table for the majority of the growing season. Some lowland landscape sites have surface areas with salts, and some have sodium effects throughout the profile.

**Upland Landscape Sites of the Missouri Coteau Region**

Topography is nearly level, rolling, undulating, gently sloping, strongly sloping, or steep. Slopes are 1 to 35%. Soils are deep and moderately deep to shallow and are moderately well drained, well drained, or excessively drained. Permeability is slow, moderate, moderately rapid, or rapid. Available water capacity is low, moderate, or high. Upland landscape sites are usually underlain by sand, gravel, or weathered bedrock that restricts plant root penetration.

**Xeric Landscape Sites of the Missouri Coteau Region**

Topography is nearly level, undulating, gently sloping, or strongly sloping. Slopes are 1 to 9%. Soils are very shallow, shallow, or deep, and are well drained or excessively drained. Permeability is very slow, slow, moderate, or rapid. Available water capacity is low to moderate. Xeric landscape sites are usually underlain by sand or gravel or by hardpan that contains high accumulations of sodium and is nearly impervious to water.

**Lowland Landscape Sites of the West River Region**

Topography is slightly concave basins and depressions or nearly level low terraces and flood plains along streams and channels. Slopes are 1 to 3%. Soils are deep and are poorly drained to well drained. Permeability is very slow, slow, or moderate. Available water capacity is low, moderate, high, or very high. Lowland landscape sites receive additional amounts of water from run in from higher land, surface runoff, flooding, and/or underground seepage. The water table is at the surface for the early part of the growing season and remains high for most of the growing season. Some lowland landscape sites are saline and/or alkaline and calcareous with salts at the surface and sodium effects throughout the profile.

**Upland Landscape Sites of the West River Region**

Topography is nearly level, undulating, rolling, gently sloping, or strongly sloping. Slopes are mostly 1 to 15%, with some 25 to 50%. Soils are deep, moderately deep, or shallow, and are well drained to excessively drained. Permeability is moderately slow, moderate, moderately rapid, or rapid. Available water capacity is low, moderate, or high. Upland landscape sites are underlain by shale, siltstone, or sandstone that restricts root depth.

**Xeric Landscape Sites of the West River Region**

Topography is nearly level, undulating, gently sloping, moderately sloping, or steep plains. Slopes are mostly 1 to 9%, and some are 2 to 35%. Soils are very shallow or shallow. Permeability is moderate to very rapid near the surface and very slow to slow in the substratum. Available water capacity is very low, low, or moderate. Xeric landscape sites have thin surface soils underlain by coarse sand, gravel, weathered bedrock, scoria, or by a hardpan that has a high accumulation of sodium and is nearly impervious to water. These substratum materials restrict plant root depth.

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Table 1. Range sites composing landscape site management units.

| |
|---|
| **Lowland Landscape Sites** |
| Wetland range site |
| Wet Meadow range site |
| Subirrigated range site |
| Overflow range site |
| Closed Depression range site |
| Saline Lowland range site |
| **Upland Landscape Sites** |
| Sands range site |
| Sandy range site |
| Silty range site |
| Clayey range site |
| Shallow range site |
| Thin Upland range site |
| Thin Sands range site |
| **Xeric Landscape Sites** |
| Shallow to Gravel range site |
| Shallow Clay range site |
| Claypan range site |
| Thin Claypan range site |
| Very Shallow range site |

Table 2. Major grasses of 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. (Continued) Major grasses of 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.* |
| **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.* |

# Simplified Assessment of Range Condition

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Rangeland management and land use planning require a system for assessing the health of parcels of land. Range evaluation is essential to assess the effectiveness of implemented practices and to identify the ecological problems in a grassland before its condition becomes seriously degraded. The development of the concepts used in rangeland condition assessment started about 100 years ago with the introduction of the concept of plant succession. Most succeeding methods have based assessment primarily on the condition of the vegetation and soil compared to the degree of difference from a standard. Only recently has the approach changed to base the assessment of the status of rangeland health on the functional levels of the ecological processes and the integrity of the vegetation, the soil, the air, and the water composing the ecosystem.

Several interactive components of a grassland ecosystem should be considered during general condition assessment procedures: the status of the aboveground and belowground vegetation; the status of soil development processes; the status of the levels and types of erosion; the status of ecological processes; and the status of precipitation infiltration. These major ecosystem components vary in degree of performance and level of functional status on grasslands at different health conditions, and the changes can be used as evaluation criteria for ranking range condition categories.

Most range condition 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.

The four general health condition categories should be used in this preliminary estimated assessment of grasslands based on the producer's previous experience and knowledge of the parcels of land. The four range condition categories can be illustrated by comparison to human health condition. A grassland ecosystem in excellent 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 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 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 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.

Each parcel of land in a management plan should be placed into one of the four health condition categories based on the producer's objective observations during the past years of managing it. Only a few parcels of land in the Northern Plains are in the excellent and poor condition categories. Most grasslands are in either the good or fair condition category. The main separation between good and fair is the relative amount of herbage produced by desirable and less desirable species and the length of time needed to recover from stress.

A report explaining the field methods for the assessment of rangeland health status from monitoring plots located in each pasture is available at http://www.ag.ndsu.nodak.edu/dickinso/research/2001/range01j.htm.

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# Animal Unit Equivalent for Beef Cattle Based on Metabolic Weight

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Should producers allocate more grass to large cows than to cows of average size during planning of grazing management strategies?

Body size affects the quantity of dry matter intake. Large cows eat more forage than do cows of average size. Numerous methods have been devised to predict or plan for livestock demand for forage. A rough guideline for daily dry matter intake can be estimated relatively quickly by using 2% of body weight (Holechek et al. 1989). This technique is useful for general decisions, but when used to estimate forage needs in a grazing system, it tends to underestimate the forage needs of lighter animals and overestimate the forage needs of heavier animals.

A more accurate estimate of daily or monthly forage demand of livestock on a grazing system can be reached by using the metabolic weight of the livestock rather than the live weight of the animals. It has been found that metabolic weight accounts for significant variation in dry matter intake among animals of different sizes (NRC 1996). Metabolic weight is the live weight to the 0.75 power. Beef cattle animal unit equivalents can be determined for animals of different sizes by calculating their metabolic weight as a percentage of the metabolic weight of a 1000-pound cow. A 1000-pound cow with or without a calf is defined as 1.00 animal unit, which has a daily dry matter allocation of 26 pounds of forage.

Method to calculate Animal Unit Equivalent (AUE) for beef animals of different weights based on metabolic weight (live animal weight $^{0.75}$) with a 1000-pound cow equal to 1.00 Animal Unit (AU). This method requires a calculator with [$y^x$] function and memory.

$$\frac{(\text{Live animal weight})^{0.75}}{1000^{\,0.75}} = \text{Animal Unit Equivalent (AUE)}$$

Enter Data
1000 [$y^x$] 0.75 = {177.827941} store memory

(Live animal weight) [$y^x$] 0.75 = { } ÷ recall memory = AUE

Table 1 lists the calculated animal unit equivalents based on metabolic weight for a wide range of live animal weights. Calculating the animal unit equivalent for each cow in a herd would yield an accurate estimate of the quantity of forage required by grazing livestock; however, this does not seem practical or necessary for proper management of a grazing system. But increasing the accuracy of the forage demand estimate by grouping similarly sized animals of a herd into a few size categories and assigning appropriate animal unit equivalents to each group does seem practical and beneficial. This would enable the manager to allocate the pasture forage resources more accurately. Table 2 suggests a few beef cattle size categories and corresponding animal unit equivalents that could be used for planning grazing management strategies.

Table 1. Animal Unit Equivalent (AUE) based on metabolic weight (live animal weight $^{0.75}$).

| Animal Live Weight (lbs) | Animal Unit Equivalent $y^{x\ 0.75}$ (% of 1000 lbs) |
|---|---|
| 600 | 0.682 |
| 650 | 0.724 |
| 700 | 0.765 |
| 750 | 0.806 |
| 800 | 0.846 |
| 850 | 0.885 |
| 900 | 0.924 |
| 950 | 0.962 |
| **1000** | **1.000** |
| 1100 | 1.074 |
| 1200 | 1.147 |
| 1300 | 1.217 |
| 1400 | 1.287 |
| 1500 | 1.355 |
| 1600 | 1.423 |
| 1700 | 1.489 |
| 1800 | 1.554 |
| 1900 | 1.618 |
| 2000 | 1.682 |
| 2200 | 1.806 |
| 2400 | 1.928 |
| 2600 | 2.048 |
| 2800 | 2.165 |
| 3000 | 2.280 |

Table 2. Suggested practical application of Animal Unit Equivalent based on metabolic weight (live animal weight $^{0.75}$).

| Beef Animal Category | Animal Unit Equivalent |
|---|---|
| Weaned animal lighter than 800 lbs | 0.75 |
| Young animal 800-900 lbs | 0.85 |
| Cow 900-1100 lbs with calf | 1.00 |
| Cow 1100-1300 lbs with calf | 1.15 |
| Cow heavier than 1300 lbs with calf | 1.25 |
| Bull lighter than 2000 lbs | 1.50 |
| Bull heavier than 2000 lbs | 2.00 |

Definitions from Society for Range Management Glossary, Jacoby, Chair., 1989.

Animal-unit. Considered to be one mature cow of approximately 1,000 pounds, either dry or with calf up to 6 months of age, or their equivalent, based on a standardized amount of forage consumed.

Animal-unit-month. The amount of dry forage required by one animal unit for one month based on a forage allowance of 26 pounds per day.

## Literature Cited

**Holechek, J.L., R.D. Pieper, and C.H. Herbel. 1989.** Range management principles and practices. Prentice Hall, NJ.

**National Research Council. 1996.** Nutrient requirements of beef cattle. Seventh revised edition. National Academy Press, Washington DC.

# Length of the Average Grazing Season Month

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When designing grazing management strategies, range managers need to know the number of days in the average grazing season month in order to calculate the number of cow-calf pairs to turn out onto a pasture. The calculation is based on the size of the pasture in acres (AC), the evaluated stocking rate potential (acres (AC)/animal unit month (AUM)), and the number of days in the grazing season (converted to months (M)):

> Total number of pasture acres (AC) ÷ evaluated stocking rate (AC/AUM) ÷ length of grazing season in months (M) = number of cow-calf pairs (AU)

An animal unit (AU) is the equivalent of one mature cow of about 1000 pounds, with or without a calf. An animal unit month (AUM) is the amount of forage dry matter required by one animal unit (AU) for 1 month (M). The length of the grazing season in months is calculated by dividing the number of days in the grazing season by the number of days in the average grazing season month. How many days are in the average grazing season month? This seemingly superficial question does not have a simple answer, and because of its importance to range managers, this question should be given careful consideration. Currently, three values for the length of an average grazing season month are used relatively indiscriminately: 30 days, 30.5 days, and 31 days.

The results of calculations of the number of cow-calf pairs to be turned onto a pasture are greatly affected by the value used for the length of an average month. For example, the solution to the equation determining the number of cow-calf pairs to be supported on a pasture that covers 3840 acres, has a potential stocking rate of 3.0AC/AUM, and is to be grazed seasonlong for 183 days, from 16 May to 15 November, would vary according to different average month lengths used. The calculations would indicate that the number of cow-calf pairs to be turned out onto this pasture would be 210 pairs if 30 days per month (183d ÷ 30d = 6.1M) were used, 213 pairs if 30.5 days per month (183d ÷ 30.5d = 6.0M) were used, and 217 pairs if 31 days per month (183d ÷ 31d = 5.9M) were used. This paper will attempt to present justifications for the acceptance of one value for the length of an average grazing season month and for its uniform use in calculations applied to grazing in the Northern Plains.

The earth completes 1 rotation on its axis in a period of time called a day. The earth revolves around the sun in a period of time called a year. One year is equal to 365.2425 days. The additional quarter of a day is corrected by adding 1 day every 4th year. In our calendar, each year comprises 12 months: 7 with 31 days, 4 with 30 days, and 1 with 28 days for 3 years and 29 days every 4th year. There are 1461 days in a cycle of 48 months. The average month in this 4-year cycle contains 30.44 days. This would be an accurate value to use in calculating stocking rates of grazing systems in areas that graze 12 months per year.

The climate in the Northern Plains does not permit grazing for 12 months, however. In the calculation of the average length of a grazing season month, a logical practice would be to eliminate from the data set the months during which grazing does not occur. Debate exists over the period to be considered grazing season months in the Northern Plains, and the determination depends on specific situations, including available forage types and management strategy applied. The length of the average grazing season month could range from 30.3 days to 30.7 days, depending on which months were selected. The probability of occurrences of inclement weather conditions is high in December, January, February, and March; these months are also characterized by average monthly temperatures too low to support plant growth. Grazing during this 4-month period would not be dependable. The active growing season for perennial plants is from about mid April to mid October. The 8-month period of April through November has the potential to have some livestock grazing, although grazing during this time is not recommended as a universal practice. This period has 244 days and an average month length of 30.5 days.

The results of the practical application of the average month length in a 4-year cycle and of the average month length in the 8-month grazing season in the Northern Plains are the same. In the example presented earlier, if 30.44 days were the

value used for the average month length, the calculation would indicate that 213 cow-calf pairs should be turned onto the pasture (3840AC ÷ 3.0AC/AUM ÷ 6.01M = 212.91 AU). Likewise, if the value used for the average month length were 30.5 days, the calculation would indicate that 213 cow-calf pairs should be turned onto the pasture (3840AC ÷ 3.0AC/AUM ÷ 6.0M = 213.33 AU). This paper demonstrates that in calculations of stocking rates for grazing management strategies in the Northern Plains, 30.5 days more accurately reflects the length of the average grazing season month than 30 or 31 days.

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# Generalized Average Stocking Rates

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Each piece of grassland can withstand grazing to a certain biological level before negative effects occur. This biological level varies slightly with amount of annual precipitation, ecological condition of the grassland, and type of grazing system used. Moving cattle from a pasture only when all the aboveground herbage has been removed is not a sound management practice. To manage grasslands properly, the producer must know the number of cows that can be grazed on a grassland unit for a specified length of time. This number is termed the stocking rate.

Stocking rate is commonly stated as acres per animal unit month (AUM) or its reciprocal, AUM's per acre. An animal unit month (AUM) is the amount of dry forage one mature cow of approximately 1,000 pounds with a calf requires for one month.

Forage dry matter intake of grazing animals is affected by the size of the cow. Large cows consume more forage than medium- and standard-sized cows. A more accurate estimate of daily or monthly forage demand of livestock on grazinglands can be determined with the metabolic weight of the animal than with its live weight. Metabolic weight is live weight to the 0.75 power. A 1000-pound cow with a calf is the standard, which is defined as 1.00 animal unit (AU) and has a daily dry matter allocation of 26 pounds of pasture forage. The metabolic weight of a 1200-pound cow with a calf is 1.147 animal unit equivalent (AUE), which has a daily dry matter allocation of 30 pounds of pasture forage. The metabolic weight of a 1400-pound cow with a calf is 1.287 animal unit equivalent (AUE), which has a daily dry matter allocation of 33 pounds of pasture forage. The amount of forage dry matter consumed in one month by one animal unit, a 1000-pound cow with a calf, is an animal unit month (AUM). The daily dry matter allocation for a cow with a calf on pasture is different from the daily dry matter requirement for just the cow during the same production periods.

Determining stocking rate for a parcel of grassland by using range site identification and range condition assessment is a complex, time-consuming process. Most grassland managers have not had and most likely will not have a detailed range stocking rate evaluation completed for their land. However, completion of some level of stocking rate evaluation is an essential step in the development of a pasture and forage inventory. This report summarizes the long-term generalized stocking rate levels for three landscape site management units in the Drift Prairie, Missouri Coteau, and West River Regions of the Northern Plains (tables 1-3). The three landscape site categories are lowland, upland, and xeric landscape sites. The areas of each landscape site that are located in the three different physiographic regions have slightly different average stocking rates. The average stocking rates of the three landscape sites are highly variable with changes in ecological range condition.

The stocking rate estimates in this report assume that the grasslands are managed by seasonlong grazing for 4.5 to 5.0 months, June to October. If the grasslands are managed by 6-month seasonlong grazing from mid May to mid November, the manager can expect the stocking rate to be 140% of the acres/AUM rate for the 4.5- to 5.0-month seasonlong strategy. If the seasonlong grazing is started earlier than mid May and/or continued later than mid November, the manager can expect the stocking rate to be 200% or more of the acres/AUM rate for the 4.5- to 5.0-month seasonlong strategy.

The manager using a grazing system can expect stocking rates higher than 4.5- to 5.0-month seasonlong stocking rates (Manske 1995). The manager using the deferred grazing system, on which grazing is delayed until after grass seed development, can expect the deferred pasture to support a stocking rate about 80% of the acres/AUM rate supported by a 4.5- to 5.0-month seasonlong grazing strategy during the first 4 to 6 years. The manager using the short duration grazing system can expect the stocking rate to be 75% of the acres/AUM rate supported by a 4.5- to 5.0-month seasonlong grazing strategy. The manager using the twice-over rotation grazing system can expect the stocking rate to be 70% of the acres/AUM rate supported by a 4.5- to 5.0-month seasonlong grazing strategy. A long-term, well-managed twice-over grazing system can support a stocking rate about 55% of the acres/AUM rate of a 4.5- to 5.0-month seasonlong grazing strategy.

The mean average stocking rates for the Drift Prairie, Missouri Coteau, and West River Regions' lowland landscape sites of the good and fair condition categories are 1.10, 1.25, and 1.60 acres/AUM, respectively, and the mean for the three regions is 1.30 acres/AUM. The mean average stocking rates for the Drift Prairie, Missouri Coteau, and West River Regions' upland landscape sites of the good and fair condition categories are 1.75, 2.10 and 2.50 acres/AUM, respectively, and the mean for the three regions is 2.10 acres/AUM. The mean average stocking rates for the the Drift Prairie, Missouri Coteau, and West River Regions' xeric landscape sites of the good and fair condition categories are 2.90, 3.65, and 5.00 acres/AUM, respectively, and the mean for the three regions is 3.85 acres/AUM.

Much of the Northern Plains' native rangeland has been grazed by domesticated livestock for over 100 years. Knowledge of a grassland parcel's historical use is very valuable for determining the future stocking rates of the biologically effective pasture and forage management strategies. Determining the historical stocking rates for a parcel of grassland is not difficult. The only information needed is the average number of days grazed and the number of cow-calf pairs grazed during the recent past.

The first step is to convert the average number of days to average length in months by dividing by 30.5, the average number of days in the average grazing season month (Manske 1998b). The next step is to determine the number of average animal unit months (AUM's) of grazing. Each cow-calf pair is an animal unit. The number of animal units (AU) multiplied by the number of months (M) will give the average total number of AUM's for that parcel of grassland. If the cows are larger than 1,000 pounds, the animal units should be converted to animal unit equivalents (AUE). The current method used to convert AU to AUE is based on the metabolic weight of the animals. The AUE values for various live weights can be found on tables 1 and 2 of Manske 1998a (see pages 15 and 16).

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**Literature Cited**

**Manske, L.L. 1995.** Economic returns as affected by grazing strategies. NDSU Dickinson Research Extension Center. Range Research Report DREC 95-1012. Dickinson, ND. 20p.

**Manske, L.L. 1998a.** Animal unit equivalent for beef cattle based on metabolic weight. NDSU Dickinson Research Extension Center. Range Management Report DREC 98-1020. Dickinson, ND. 3p.

**Manske, L.L. 1998b.** How long is the average grazing season month? NDSU Dickinson Research Extension Center. Range Management Report DREC 98-1021. Dickinson, ND. 2p.

Table 1. Generalized average stocking rates for 1000 lb cows (1.00 AUE) for the Drift Prairie (A), Missouri Coteau (B), and West River (C) Regions of the Northern Plains.

| | Stocking Rate in Acres/AUM (1000lb cow=1.00 AUE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range Condition Category | | | | | | | | | | | |
| Landscape Units | Excellent | | | Good | | | Fair | | | Poor | | |
| | A | B | C | A | B | C | A | B | C | A | B | C |
| Lowland Landscape Sites | 0.75 | 0.75 | 1.00 | 1.00 | 1.00 | 1.25 | 1.25 | 1.50 | 2.00 | 2.50 | 2.75 | 3.50 |
| Upland Landscape Sites | 1.00 | 1.25 | 1.50 | 1.50 | 1.75 | 2.00 | 2.00 | 2.50 | 3.00 | 4.00 | 5.00 | 6.00 |
| Xeric Landscape Sites | 1.75 | 2.25 | 3.00 | 2.25 | 3.00 | 4.00 | 3.50 | 4.25 | 6.00 | 7.00 | 8.00 | 11.0 |

| | Stocking Rate in AUM's/Acre (1000lb cow=1.00 AUE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range Condition Category | | | | | | | | | | | |
| Landscape Units | Excellent | | | Good | | | Fair | | | Poor | | |
| | A | B | C | A | B | C | A | B | C | A | B | C |
| Lowland Landscape Sites | 1.33 | 1.33 | 1.00 | 1.00 | 1.00 | 0.80 | 0.80 | 0.67 | 0.50 | 0.40 | 0.36 | 0.29 |
| Upland Landscape Sites | 1.00 | 0.80 | 0.67 | 0.67 | 0.57 | 0.50 | 0.50 | 0.40 | 0.33 | 0.25 | 0.20 | 0.17 |
| Xeric Landscape Sites | 0.57 | 0.44 | 0.33 | 0.44 | 0.33 | 0.25 | 0.29 | 0.24 | 0.17 | 0.14 | 0.13 | 0.09 |

Table 2. Generalized average stocking rates for 1200 lb cows (1.147 AUE) for the Drift Prairie (A), Missouri Coteau (B), and West River (C) Regions of the Northern Plains.

| | Stocking Rate in Acres/AUM (1200lb cow=1.147 AUE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range Condition Category | | | | | | | | | | | |
| Landscape Units | Excellent | | | Good | | | Fair | | | Poor | | |
| | A | B | C | A | B | C | A | B | C | A | B | C |
| Lowland Landscape Sites | 0.86 | 0.86 | 1.15 | 1.15 | 1.15 | 1.43 | 1.43 | 1.72 | 2.29 | 2.87 | 3.15 | 4.00 |
| Upland Landscape Sites | 1.15 | 1.43 | 1.72 | 1.72 | 2.00 | 2.29 | 2.29 | 2.87 | 3.44 | 4.59 | 5.74 | 6.88 |
| Xeric Landscape Sites | 2.00 | 2.58 | 3.44 | 2.58 | 3.44 | 4.59 | 4.00 | 4.87 | 6.88 | 8.03 | 9.18 | 12.62 |

| | Stocking Rate in AUM's/Acre (1200lb cow=1.147 AUE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range Condition Category | | | | | | | | | | | |
| Landscape Units | Excellent | | | Good | | | Fair | | | Poor | | |
| | A | B | C | A | B | C | A | B | C | A | B | C |
| Lowland Landscape Sites | 1.16 | 1.16 | 0.87 | 0.87 | 0.87 | 0.70 | 0.70 | 0.58 | 0.44 | 0.35 | 0.32 | 0.25 |
| Upland Landscape Sites | 0.87 | 0.70 | 0.58 | 0.58 | 0.50 | 0.44 | 0.44 | 0.35 | 0.29 | 0.22 | 0.17 | 0.15 |
| Xeric Landscape Sites | 0.50 | 0.39 | 0.29 | 0.39 | 0.29 | 0.22 | 0.25 | 0.21 | 0.15 | 0.12 | 0.11 | 0.08 |

Table 3. Generalized average stocking rates for 1400 lb cows (1.287 AUE) for the Drift Prairie (A), Missouri Coteau (B), and West River (C) Regions of the Northern Plains.

| | Stocking Rate in Acres/AUM (1400lb cow=1.287 AUE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range Condition Category | | | | | | | | | | | |
| Landscape Units | Excellent | | | Good | | | Fair | | | Poor | | |
| | A | B | C | A | B | C | A | B | C | A | B | C |
| Lowland Landscape Sites | 0.97 | 0.97 | 1.29 | 1.29 | 1.29 | 1.61 | 1.61 | 1.93 | 2.57 | 3.22 | 3.54 | 4.50 |
| Upland Landscape Sites | 1.29 | 1.61 | 1.93 | 1.93 | 2.25 | 2.57 | 2.57 | 3.22 | 3.86 | 5.15 | 6.44 | 7.72 |
| Xeric Landscape Sites | 2.25 | 2.90 | 3.86 | 2.90 | 3.86 | 5.15 | 4.50 | 5.47 | 7.72 | 9.00 | 10.30 | 14.16 |

| | Stocking Rate in AUM's/Acre (1400lb cow=1.287 AUE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range Condition Category | | | | | | | | | | | |
| Landscape Units | Excellent | | | Good | | | Fair | | | Poor | | |
| | A | B | C | A | B | C | A | B | C | A | B | C |
| Lowland Landscape Sites | 1.03 | 1.03 | 0.78 | 0.78 | 0.78 | 0.62 | 0.62 | 0.52 | 0.39 | 0.31 | 0.28 | 0.22 |
| Upland Landscape Sites | 0.78 | 0.62 | 0.52 | 0.52 | 0.44 | 0.39 | 0.39 | 0.31 | 0.26 | 0.19 | 0.16 | 0.13 |
| Xeric Landscape Sites | 0.44 | 0.34 | 0.26 | 0.34 | 0.26 | 0.19 | 0.22 | 0.18 | 0.13 | 0.11 | 0.10 | 0.07 |

To illustrate how to determine the historical stocking rate of a ranch, we will use an example of a pasture of one section (640 acres) that has usually been grazed from 1 June to 15 October by 70 cow-calf pairs with the cow average weight at 1,000 pounds. The average historical stocking rate can be determined by a few easy steps.

1. Determine the grazing season length in months.

| | | | | |
|---|---|---|---|---|
| number of days in total grazing season | ÷ | average number of days in grazing season months | = | number of months in grazing season |
| 137 days | ÷ | 30.5 d | = | 4.5 M |

2. Determine the number of animal units (AU).

| | | | | |
|---|---|---|---|---|
| Number of cow-calf pairs | X | animal unit equivalents | = | Animal units (AU) |
| 70 c-c prs | X | 1.0 AUE | = | 70 AU |

3. Determine the total number of animal unit months (AUM's).

| | | | | |
|---|---|---|---|---|
| Animal units (AU) | X | number of months | = | animal unit months (AUM's) |
| 70 AU | X | 4.5 M | = | 314 AUM's |

4a. Determine the average stocking rate in acres/AUM.

| | | | | |
|---|---|---|---|---|
| Pasture size in acres | ÷ | number of animal unit months | = | acres per AUM |
| 640 acres | ÷ | 314 AUM's | = | 2.04 ac/AUM |

4b. Determine the average stocking rate in AUM's/acre.

| | | | | |
|---|---|---|---|---|
| Animal unit months | ÷ | pasture acres | = | AUM's per acre |
| 314 AUM's | ÷ | 640 acres | = | 0.49 AUM's/ac |

If the cows' average weight is heavier than 1,300 pounds, the procedure is as follows:

1. Determine the grazing season length in months.

Use the same procedure as with 1,000-pound cows.

2. Determine the number of animal units (AU).

| Number of cow-calf pairs | X | animal unit equivalents | = | Animal units (AU) |
|---|---|---|---|---|
| 70 c-c prs | X | 1.25AUE | = | 87.5 AU |

3. Determine the total number of animal unit months (AUMs).

| Animal units (AU) | X | number of months | = | animal unit months (AUM's) |
|---|---|---|---|---|
| 87.5 AU | X | 4.5 M | = | 394 AUM's |

4a. Determine the average stocking rate in acres/AUM.

| Pasture size in acres | ÷ | number of animal unit months | = | acres per AUM |
|---|---|---|---|---|
| 640 acres | ÷ | 394 AUM | = | 1.62 ac/AUM |

Three stocking rates for a parcel of grassland can serve as guidelines for the development of 12-month pasture and forage management strategies.

The mean average upland landscape sites' stocking rate is 2.10 acres per AUM.

The historical stocking rate for 1,000-pound cows is 2.04 acres per AUM.

The historical stocking rate for 1,300-pound cows is 1.62 acres per AUM.

These three stocking rate values should be evaluated in relation to the condition of the grassland parcel. If the historical stocking rate is greater than the average stocking rate and the condition of the grassland is low good or fair, the producer should consider a change in grazing management system and/or stocking rate.

# A Method of Determining Stocking Rate Based on Monthly Standing Herbage Biomass

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Stocking rate is the number of animals (animal unit) for which a grassland unit (acre) can provide adequate dry matter forage for a specified length of time (month). Stocking rate depends on the amount of herbage biomass available to grazing animals, the time of year, the type of grazing system used, and the amount of forage consumed by livestock per month. Stocking rate is commonly presented as acres per animal unit month (AUM) or its reciprocal, AUM's per acre.

Forage dry matter intake of grazing animals is affected by the size of the cow. Large cows consume more forage than do medium- and standard-sized cows. A more accurate estimate of daily or monthly forage demand of livestock on grazinglands can be determined with the metabolic weight of the animal than with its live weight. Metabolic weight is live weight to the 0.75 power. A 1000-pound cow with a calf is the standard, which is defined as 1.00 animal unit (AU) and has a daily dry matter allocation of 26 pounds of pasture forage. The metabolic weight of a 1200-pound cow with a calf is 1.147 animal unit equivalent (AUE), which has a daily dry matter allocation of 30 pounds of pasture forage. The metabolic weight of a 1400-pound cow with a calf is 1.287 animal unit equivalent (AUE), which has a daily dry matter allocation of 33 pounds of pasture forage. The amount of forage dry matter consumed in one month by one animal unit, a 1000-pound cow with a calf, is an animal unit month (AUM). The daily dry matter allocation for a cow with a calf on pasture is different from the daily dry matter requirement for just the cow during the same production periods. During the grazing season from May through November, the length of the average month is 30.5 days.

The mathematical process used to determine stocking rate from herbage biomass is presented in table 1. The amount of herbage available during the grazing season is the average value of the mean monthly standing herbage biomass values for the grazing-season months. The mean monthly standing herbage biomass should be determined by clipping and weighing the dry herbage from each pasture and averaging the weights over several years. If these values are not available, the generalized values for western North Dakota native rangeland (table 2) can be substituted. The general monthly herbage values on the herbage weight curve in table 2 are averages of herbage production on well-managed pastures during years with normal precipitation.

Each of the monthly herbage biomass values needs to be adjusted to reflect the differing effects various grazing treatments have on the quantity of herbage biomass produced. Time of year and intensity of defoliation vary with different grazing treatments; these variations affect plant biological mechanisms and result in the production of different amounts of herbage. The percentages of the potential amount of herbage biomass produced on various grazing treatments are summarized in table 2. The monthly herbage biomass values for the months of the grazing season can be adjusted for differences in herbage biomass on specific grazing treatments by multiplying monthly herbage weight by the percentage of potential herbage produced on a particular grazing treatment.

The effects of drought conditions can suppress herbage biomass production for 1 to 4 years, depending on the health status of plants prior to water deficiency periods. This reduction in herbage production must be reflected in the calculations to determine accurate stocking rates during the drought and recovery periods. These adjustments need not be determined for growing seasons in which herbage biomass is not affected by current or previous drought conditions.

Each of the monthly herbage biomass values during drought and during the perennial plant recovery period needs to be adjusted to reflect the percentage of herbage weight reduction that resulted from the effects of drought conditions. The percent reduction that results from the effects of drought conditions can be determined by a comparison of normal-year herbage biomass and drought-year or recovery-year herbage biomass. If these data are not available, estimations based on several years of experience can be used. The estimate of percent herbage reduction needs to be converted to percent of herbage biomass produced. The percent of herbage produced is determined by subtracting the percent

reduction in herbage from 100%. The monthly normal-year herbage biomass values adjusted for the effects of grazing system are multiplied by percent of herbage produced to adjust for the effects of drought conditions.

The average monthly herbage biomass is determined by adding the adjusted monthly herbage biomass for the months of the grazing season and dividing the sum by the number of grazing-season months.

Not all of the average herbage biomass for the planned months of the grazing season is consumable forage. Perennial plants must retain a portion of the leaf material to conduct photosynthesis and provide carbohydrates and other products necessary to sustain healthy and productive growth. The amount of leaf material the plant must retain ranges from 40% to 60%, depending on grassland type (40% on the shortgrass, 50% on the midgrass, and 60% on the tallgrass prairies). When specific values for percent proper utilization are not known for the grassland type, an average value of 50% may be used. This value implies that the plant retains half the herbage and half the herbage is available for utilization.

Not all standing herbage available for proper utilization is ingested by grazing animals. Grazing livestock consume only about 50% of herbage available for utilization. The remainder of the utilized herbage is broken from the plant, soiled by animal waste, consumed by insects and wildlife, and lost to other natural processes. Data to allow comparison of forage-harvest efficiency on different grazing systems are not available. However, the quantity of herbage ingested by livestock would be expected to increase with improvement in efficiency of harvest from some grazing systems.

The differences in daily dry matter intake for cows of different weights are used to adjust stocking rates for cow size. The standard 1000-lb cow requires 26 lbs of dry matter per day. The dry matter intake for lighter or heavier cows can be determined by multiplying 26 lbs by the animal unit equivalent (table 3), which is based on the metabolic weight of the cow.

For determination of stocking rate, the available monthly forage for intake value adjusted for grazing system and drought conditions is divided by the amount of dry matter per cow per month--the daily amount of dry matter per cow adjusted for cow size and multiplied by the number of days per average month (30.5 days). This stocking rate is presented as AUM's per acre. The reciprocal can be determined by dividing that number into 1 to give acres per AUM. This is the number of acres required to provide forage for one month for a cow with a calf.

Stocking rates vary with the amount of herbage production and are determined from the average monthly herbage biomass for the months of the grazing season and the weight of the cows. The quantity of the standing herbage in grassland pastures is not constant during the period grazed. The weight of the herbage dry matter per acre increases during the early growth stages until the maximum plant height is reached, and then the dry matter weight decreases as the mature plants dry during senescence. Table 4 shows the stocking rates for different average monthly herbage biomass quantities and cow sizes.

The number of cows to turn onto the grazing system is determined by dividing the total number of acres in the pastures of a grazing system by the acres per AUM value and dividing this total number of AUM's by the number of months of the grazing season. The number of cows that can graze the pastures subtracted from the total number of cows in the herd will show any forage shortfall.

The stocking rate value determined by this mathematical process is based on the average monthly standing herbage biomass for the grazing-season months and has been adjusted for percentage utilization, percentage forage intake, grazing system, cow size, and the effects of drought conditions.

Acknowledgment

I am grateful to Amy M. Kraus for assistance in preparation of this manuscript. I am grateful to Sheri Schneider for assistance in production of this manuscript.

Table 1. Process to determine stocking rate from monthly herbage biomass.

Adjustment for grazing treatment

Monthly herbage biomass value (from clipped and dried samples or from table 2) X % of potential herbage produced on appropriate grazing treatment (from table 2)

Adjustment for effects of drought conditions

Monthly herbage biomass value adjusted for grazing treatment X (100 % - % herbage reduction)

Average monthly herbage biomass

Sum of adjusted monthly herbage biomass for the months of the grazing season

÷ number of grazing season months

Adjustment for size of cow

26 lbs daily dry matter intake X Animal Unit Equivalent for appropriate cow size (from table 3).

Stocking Rate

Average monthly herbage biomass adjusted for grazing treatment and for drought conditions

X % proper utilization (50%)

X % consumed (50%)

= lbs of available monthly forage

÷ dry matter per AUM (26 lbs X AUE X 30.5 days)

= AUM/ac

reciprocal
1.0 ÷ AUM/ac = ac/AUM

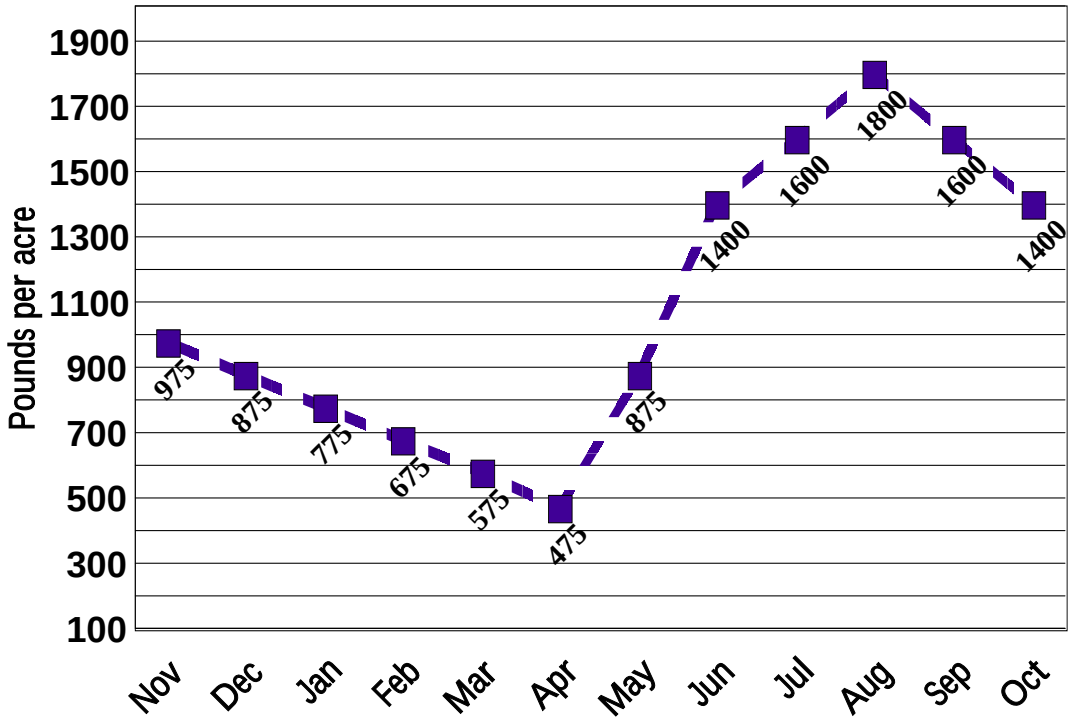
The number of cows that can graze the available forage

Total number of acres in grazing system

÷ acres/AUM

÷ number of grazing season months

Table 2. Generalized Standing Herbage Biomass for Well-Managed Native Rangeland during Normal Precipitation Years




| | | |
|---|---|---|
| Seasonlong | start 1 May | 30% of Potential Herbage |
| 6.0 Seasonlong | start 15 May | 50% of Potential Herbage |
| 4.5 Seasonlong | start 15 Jun | 70% of Potential Herbage |
| 4.0 Deferred | start 15 Jul | 90% of Potential Herbage |
| 4.5 Short Duration | start 15 Jun | 95% of Potential Herbage |
| 4.5 Twice Over | start 1 Jun | 100% of Potential Herbage |

Table 3. Animal Unit Equivalent (AUE) based on metabolic weight (live animal weight $^{0.75}$).

| Animal Live Weight (lbs) | Animal Unit Equivalent $y^{x\ 0.75}$ (% of 1000 lbs) |
|---|---|
| 600 | 0.682 |
| 650 | 0.724 |
| 700 | 0.765 |
| 750 | 0.806 |
| 800 | 0.846 |
| 850 | 0.885 |
| 900 | 0.924 |
| 950 | 0.962 |
| **1000** | **1.000** |
| 1100 | 1.074 |
| 1200 | 1.147 |
| 1300 | 1.217 |
| 1400 | 1.287 |
| 1500 | 1.355 |
| 1600 | 1.423 |
| 1700 | 1.489 |
| 1800 | 1.554 |
| 1900 | 1.618 |
| 2000 | 1.682 |
| 2200 | 1.806 |
| 2400 | 1.928 |
| 2600 | 2.048 |
| 2800 | 2.165 |
| 3000 | 2.280 |

Table 4. Stocking rates (acre/AUM) for different quantities of average monthly herbage dry matter biomass (DM lb/acre) and three weights of cows.

| Stocking Rates acre/AUM | 1000 lb Cows Herbage Biomass DM lb/acre | 1200 lb Cows Herbage Biomass DM lb/acre | 1400 lb Cows Herbage Biomass DM lb/acre |
|---|---|---|---|
| 1.00 | 3172 | 3660 | 4084 |
| 1.25 | 2538 | 2928 | 3267 |
| 1.50 | 2115 | 2440 | 2723 |
| 1.75 | 1813 | 2091 | 2334 |
| 2.00 | 1586 | 1830 | 2042 |
| 2.25 | 1410 | 1627 | 1815 |
| 2.50 | 1269 | 1464 | 1634 |
| 2.75 | 1153 | 1331 | 1485 |
| 3.00 | 1057 | 1220 | 1361 |
| 3.25 | 976 | 1126 | 1257 |
| 3.50 | 906 | 1046 | 1167 |
| 3.75 | 846 | 976 | 1089 |
| 4.00 | 793 | 915 | 1021 |
| 4.25 | 746 | 861 | 961 |
| 4.50 | 705 | 813 | 908 |
| 4.75 | 668 | 771 | 860 |
| 5.00 | 634 | 732 | 817 |

# Procedure to Estimate Percent Reduction in Stocking Rate during Drought Conditions

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Stocking rates are affected by the amount of herbage biomass plants produce. During periods of below-normal precipitation, decreased herbage production may necessitate adjustments in stocking rates. The required percent reduction in the stocking rate can be estimated from the percent reduction in peak herbage biomass in healthy plants.

Effective grazing management can help minimize herbage reductions during periods of below-normal precipitation because herbage production is affected by both the type of management practices used and the level of precipitation in relation to normal amounts. The quantity of herbage biomass produced is related to plant size and plant density. These two characteristics are directly affected by the level of plant health, which is determined by the biological effectiveness of the management strategy used.

Management practices that do not meet the biological requirements of the plants slow plant processes. The resulting deterioration in the level of plant health is manifested as decreased plant density and diminished plant size that lead to reduced herbage production during periods with normal precipitation. Herbage reduction percentages caused by detrimental grazing management practices such as grazing before the third-leaf stage, grazing seasonlong, or grazing during the fall usually vary between 40 and 60 percent below the potential herbage biomass. The greatest reductions in herbage production observed in western North Dakota have occurred on domesticated grass spring pastures that were hayed during the summer and/or grazed during the fall, on native rangeland summer pastures that were grazed during the fall, and on domesticated grass and alfalfa haylands that were hayed late and/or grazed during the fall.

Herbage weight of perennial plants increases from early season through May, June, and July until peak herbage biomass, which occurs during the last couple weeks of July. Herbage weight then decreases as plants age and dry. The amount of herbage biomass produced by healthy plants is related to precipitation levels during January through July, which affect plant size and plant density.

Herbage reduction percentages caused by low precipitation are usually proportional to the levels of precipitation below the normal range. An estimate of the amount of herbage reduction low precipitation causes in healthy plants can be determined by a comparison between the local long-term mean precipitation received during January through July and the current year's precipitation for that period. The range of normal precipitation is plus or minus 25 percent of the long-term mean.

The procedure to estimate percent reduction in peak herbage biomass caused by below-normal precipitation requires just three simple calculations: first, the monthly precipitation for January through July is totaled to give the current seasonal precipitation; then, this precipitation amount is divided by the local long-term January through July precipitation amount to determine the current seasonal precipitation as a percentage of the long-term mean precipitation; next, that percentage is subtracted from 75 percent, which is the low-normal long-term precipitation value.

The resulting estimated percentage of reduction that below-normal precipitation has caused in peak herbage biomass provides a guideline for the percent reduction in stocking rate needed for the remainder of the grazing season--until mid October--on pastures that have been properly managed and have healthy plants. For example, if the January through July seasonal precipitation amount is 65 percent of the long-term mean, the estimated 10 percent reduction from normal herbage biomass would suggest a 10 percent reduction in stocking rate--assuming the proper stocking rate was being used. This method does not determine the amount for stocking rate adjustments required on pastures managed by practices that diminish the health status of plants below potential levels.

The long-term mean monthly precipitation amounts for numerous locations are available on the National Weather Service (NOAA) web site for North Dakota (www5.ncdc.noaa.gov/climatenormals/clim81/NDnorm.pdf). For the current season's precipitation, amounts collected at individual ranches and marked on the calendar can be used if a complete January through July data set is available. Another

source for the current season's precipitation amounts for many locations is the NDAWN web site (http://ndawn.ndsu.nodak.edu ). These data start in April because NDAWN does not collect data for precipitation that occurs as snow. The precipitation amounts for January through March and the amount of precipitation that falls as snow during other periods must be obtained from other sources. Current season's precipitation data that include snow moisture amounts are available on the National Weather Service site (www.crh.noaa.gov/bis/OtherHydro.htm Click on "text" for the desired month's precipitation data).

If the percentages of reduction in herbage biomass produced on domesticated grass spring pastures, native rangeland pastures, or grass and alfalfa haylands are greater than the estimated percentage of herbage reduction reached by the comparison between the long-term and current seasonal precipitation amounts, the health of the plants is below the potential level because management practices have not met the plant biological requirements. When management practices meet the biological requirements of the plants and the level of plant health is high, the percentages in herbage biomass reduction that occur during periods of below-normal precipitation are about equal to the percent reduction in precipitation. These herbage biomass reduction percentages are smaller and less problematic than reduction percentages on areas with diminished plant health.

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I am grateful to Amy M. Kraus for assistance in preparation of this manuscript. I am grateful to Sheri Schneider for assistance in production of this manuscript.

Table 1. Examples from three locations to illustrate the procedure to estimate percent reduction in peak herbage biomass in healthy plants as a result of below-normal January through July seasonal precipitation.

| | Bowman | | Hettinger | | Pretty Rock | |
|---|---|---|---|---|---|---|
| | Long-term | 2002 | Long-term | 2002 | Long-term | 2002 |
| Jan | 0.49 | 0.62 | 0.30 | 0.37 | 0.33 | 0.47 |
| Feb | 0.48 | 0.33 | 0.32 | 0.12 | 0.41 | 0.20 |
| Mar | 0.73 | 0.69 | 0.60 | 0.62 | 0.86 | 0.72 |
| Apr | 1.32 | 1.23 | 1.59 | 1.14 | 1.89 | 1.03 |
| May | 2.53 | 0.56 | 2.54 | 0.80 | 2.64 | 0.55 |
| Jun | 3.07 | 2.94 | 2.95 | 1.24 | 3.02 | 0.89 |
| Jul | 2.03 | 1.43 | 2.16 | 1.36 | 2.34 | 1.91 |
| Total | 10.65 | 7.80 | 10.46 | 5.65 | 11.49 | 5.77 |
| % of long-term | | 73.24 | | 54.02 | | 50.22 |
| 75% - % of long-term | | 1.76% | | 20.98% | | 24.78% |
| % reduction of peak herbage biomass in healthy plants | | 2% | | 21% | | 25% |
| % stocking rate reduction on pastures with healthy plants | | 2% | | 21% | | 25% |

# Procedure to Determine 12-Month Nutrient Requirements for Cows with Different Calf Birth Dates

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Beef cows require energy, protein, minerals, vitamins, and water. The daily quantities of each nutrient required by the cow depend on the size of cow, level of milk production, and production period (dry gestation, 3rd trimester, early lactation, lactation). The quantities of nutrients required by cows for 12 months depend on the month in which calf birth occurs. Calf birth date affects the time of year during which the production periods occur and the length of the production periods. The length of the production periods and the time of the year during which they occur determine the type of forage available during any given production period and the amount of forage needed from pasture or from harvested forage.

The 12-month quantities of dry matter, energy (TDN), crude protein, calcium, and phosphorus required by cows having average milk production but different weights and different calf birth months can be determined with the procedures presented in this report, the worksheet provided, and the information provided about the daily nutrient requirements (table 1) and the length in days of the production periods and forage types for calf birth dates for 4 months (table 2). A separate worksheet for each cow-size category and month of calf birth will need to be completed. A worksheet for 1200-pound cows with calf birth dates in March is provided as an example to illustrate the procedures.

In the appropriate spaces near the top of the worksheet, record the cow weight and calf birth month. On the appropriate line in the top section of the worksheet, place the number of days for the production periods and forage types corresponding to the selected calf birth month. These figures can be found in table 2, which was developed to have low numbers of acres per cow per year and to implement management strategies that graze domesticated grass and native rangeland pastures at the proper time of year. Domesticated grasses reach grazing readiness about a month earlier than native rangeland and can be grazed starting in early May. Native rangeland is ready to be grazed starting in early June. With the use of rotation grazing systems based on grass phenology, the nutritional quality of native rangeland can be manipulated to match requirements of lactating cows until mid October. Domesticated grass pastures of wildrye types can provide adequate nutrients for lactating cows until mid November. Harvested-forage rations will provide adequate nutrient levels during the remainder of the year.

Check the values for the days at the right side of the worksheet to ensure that the total number of days on ration and days on pasture equals 365. Locate the daily nutrient requirements in pounds for the various production periods from the appropriate cow-weight category on table 1, and record these requirements in pounds on the middle section of the worksheet.

To determine the number of pounds of nutrients required for each production period and forage type, multiply the pounds of nutrients required per day by the number of days in the period and for the available forage type. Record these values in the appropriate spaces on the bottom section of the worksheet. Combine the nutrient quantity values for ration-forage and pasture-forage types. Then add the total values for ration forage to the total values for pasture forage to determine the total quantity of required nutrients for a 12-month period for the selected cow weight and calf birth month. Record these values in the bottom right section of the worksheet.

The quantity of nutrients required by a cow for 12 months is variable and depends on cow weight and calf birth month. The quantity of nutrients provided from harvested forage in rations and from pasture forages varies with calf birth month because different forage types are available during production periods that occur at different times of the year.

Worksheets for the methods described in this report should be copied before procedures are begun.

Acknowledgment

I am grateful to Amy M. Kraus for assistance in preparation of this manuscript. I am grateful to Sheri Schneider for assistance in production of this manuscript.

Table 1. Intake nutrient requirements in pounds per day for beef cows with average milk production during four production periods (data from NRC 1996).

| | Dry Gestation | 3rd Trimester | Early Lactation | Lactation |
|---|---|---|---|---|
| 1000 lb cows | | | | |
| Dry matter | 21 | 21 | 24 | 24 |
| Energy (TDN) | 9.64 | 10.98 | 14.30 | 13.73 |
| Crude protein | 1.30 | 1.64 | 2.52 | 2.30 |
| Calcium | 0.03 | 0.05 | 0.07 | 0.06 |
| Phosphorus | 0.02 | 0.03 | 0.05 | 0.04 |
| 1200 lb cows | | | | |
| Dry matter | 24 | 24 | 27 | 27 |
| Energy (TDN) | 11.02 | 12.62 | 15.85 | 15.23 |
| Crude protein | 1.49 | 1.87 | 2.73 | 2.51 |
| Calcium | 0.04 | 0.06 | 0.08 | 0.07 |
| Phosphorus | 0.03 | 0.04 | 0.05 | 0.05 |
| 1400 lb cows | | | | |
| Dry matter | 27 | 27 | 30 | 30 |
| Energy (TDN) | 12.42 | 14.28 | 17.40 | 16.71 |
| Crude protein | 1.67 | 2.13 | 2.94 | 2.70 |
| Calcium | 0.04 | 0.07 | 0.08 | 0.08 |
| Phosphorus | 0.03 | 0.05 | 0.06 | 0.05 |

Data compiled from National Research Council. 1996. Nutrient requirements of beef cattle, 7th rev. ed. National Academy Press, Washington, DC.

Table 2. Twelve-month range cow production period sequences for calf birth dates in January to April.

| 12-Months | Calf Birth Month | | | |
|---|---|---|---|---|
| | January | February | March | April |
| late Nov | RATION (cont') | RATION | | RATION |
| Dec | 3rd Trimester 3.0m, 90d | 3rd Trimester 3.0m, 90d | Dry Gestation 1.0m, 32d | Dry Gestation 2.0m, 62d |
| Jan | Calf Birth | | RATION 3rd Trimester 3.0m, 90d | |
| Feb | Early Lactation 1.0m, 32d | Calf Birth | | 3rd Trimester 3.0m, 90d |
| Mar | Lactation 2.5m, 75d | Early Lactation 1.0m, 32d | Calf Birth | |
| Apr | | Lactation 1.5m, 45d | Early Lactation 1.5m, 45d | Calf Birth |
| May | | | | Early Lactation 0.5m, 15d |
| Jun | PASTURE Lactation (spring) 1.0m, 31d | PASTURE Lactation (spring) 1.0m, 31d | PASTURE Lactation (spring) 1.0m, 31d | PASTURE Lactation (spring) 1.0m, 31d |
| Jul | Lactation (summer) 4.5m, 137d | Lactation (summer) 4.5m, 137d | Lactation (summer) 4.5m, 137d | Lactation (summer) 4.5m, 137d |
| Aug | | | | |
| Sep | | | | |
| Oct | Calf age-9m Calf Weaning | | | |
| early Nov | RATION 3rd Trimester 3.0m, 90d | Lactation (fall) 1.0m, 30d Calf age-9m Calf Weaning | Lactation (fall) 1.0m, 30d Calf age-8m Calf Weaning | Lactation (fall) 1.0m, 30d Calf age-7m Calf Weaning |

Worksheet to determine 12-month nutrient requirements for cows of different sizes and with different calf birth dates.

Cow size (weight)___1200 lbs__

Calf birth month ___March___

| Production Periods | Dry Gestation | | 3rd Trimester | | Early Lactation | | Lactation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forage Type | Ration | Pasture | Ration | Pasture | Ration | Pasture | Ration | Pasture | | # Days Ration | # Days Pasture | # Days 12 months |
| Number Days from table 2 | | 32 | 90 | | 45 | | | 198 | | 135 | 230 | 365 |

Requirements lbs/day from table 1.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dry matter | | 24 | 24 | | 27 | | | 27 |
| Energy (TDN) | | 11.02 | 12.62 | | 15.85 | | | 15.23 |
| Crude Protein | | 1.49 | 1.87 | | 2.73 | | | 2.51 |
| Calcium | | 0.04 | 0.06 | | 0.08 | | | 0.07 |
| Phosphorus | | 0.03 | 0.04 | | 0.05 | | | 0.05 |

Nutrient lbs/day X #days = Nutrient lbs/period

| Totals for periods | | | | | | | | | | Totals for Ration | Totals for Pasture | Totals for 12 months |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry matter | | 768 | 2160 | | 1215 | | | 5346 | | 3375 | 6114 | 9489 |
| Energy (TDN) | | 352.64 | 1135.80 | | 713.25 | | | 3015.54 | | 1849.05 | 3368.18 | 5217.23 |
| Crude Protein | | 47.68 | 168.30 | | 122.85 | | | 496.98 | | 291.15 | 544.66 | 835.80 |
| Calcium | | 1.28 | 5.40 | | 3.60 | | | 13.86 | | 9.00 | 15.14 | 24.14 |
| Phosphorus | | 0.96 | 3.60 | | 2.25 | | | 9.90 | | 5.85 | 10.86 | 16.71 |

Worksheet to determine 12-month nutrient requirements for cows of different sizes and with different calf birth dates.

Cow size (weight)_____

Calf birth month _____

| Production Periods | Dry Gestation | | 3rd Trimester | | Early Lactation | | Lactation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forage Type | Ration | Pasture | Ration | Pasture | Ration | Pasture | Ration | Pasture | | # Days Ration | # Days Pasture | # Days 12 months |
| Number Days from table 2 | | | | | | | | | | | | |

Requirements lbs/day from table 1.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dry matter | | | | | | | | |
| Energy (TDN) | | | | | | | | |
| Crude Protein | | | | | | | | |
| Calcium | | | | | | | | |
| Phosphorus | | | | | | | | |

Nutrient lbs/day X #days = Nutrient lbs/period

| Totals for periods | | | | | | | | | | Totals for Ration | Totals for Pasture | Totals for 12 months |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry matter | | | | | | | | | | | | |
| Energy (TDN) | | | | | | | | | | | | |
| Crude Protein | | | | | | | | | | | | |
| Calcium | | | | | | | | | | | | |
| Phosphorus | | | | | | | | | | | | |

# Reducing Beef Production Costs by Reducing Nutrient Costs

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A major concern for the beef production industry in the Northern Plains is low profit margin. A major increase in prices appears unlikely because competition from poultry and hogs is not diminishing and consumer demand for beef is weak. The beef production industry requires true reductions in costs to remain competitive. Beef production is the last remaining meat industry to seriously evaluate input costs as a system. The future of the beef production industry depends on the development of long-term whole-farm management systems that are biologically efficient and ecologically and economically sound.

Annual forage costs, which include the costs of pasture and harvested feed, are the major expense for a cow-calf operation, and feed costs represent the major expense of adding weight to growing calves from weaning to finish. Traditionally, beef producers have based evaluation of production costs on the rent value per acre for pasture and the market value per ton for harvested forages. These market values do not determine the profit or loss from forages. The profitability for forages can be accurately determined from the costs and returns per unit of nutrient consumed, and total profits from forages and beef animals can be determined from the quantities of nutrients required daily by the livestock. The nutrients beef animals require are energy, protein, minerals, vitamins, and water.

Most beef producers in the Northern Plains have not determined their unit costs of nutrients. Unit costs of required nutrients must be determined to allow evaluation of production costs and identify management practices that can be modified to reduce input costs. Determining the unit cost of the required nutrients is important to reducing production costs.

Crude protein will be used in the following examples to illustrate the method of calculating unit costs of nutrients derived from purchased and harvested forage. Two values are needed to determine costs per pound of protein for harvested forages: the cost of the bulk forage per ton and the percentage of crude protein contained in the forage.

Example #1

Purchased crested wheatgrass hay has a value of $30.00 per 1000 lb bale, or $60.00 per ton. The crude protein content of forage tested from this hayfield is 6.0%.

The quantity of crude protein (CP) in pounds per ton can be determined by the following procedure.

2000 lbs (one ton) x 6.0% = 120 lbs CP/ton

The cost per pound of crude protein can be determined by the following procedure.

$60.00 per ton ÷ 120 lbs CP = $0.50/lb of CP

Example #2

Purchased alfalfa hay has a value of $120.00 per ton. The crude protein content of hay tested from this truckload is 18.0%.

The quantity of crude protein in pounds per ton can be determined by the following procedure.

2000 lbs (one ton) x 18.0% = 360 lbs CP/ton

The cost per pound of crude protein can be determined by the following procedure.

$120.00 per ton ÷ 360 lbs CP = $0.33/lb of CP

Management decisions based on the bulk cost of harvested forage will be different from management decisions based on per unit of nutrient costs. An illustration of the potential for reduction of production costs by prudent selection and carefully timed use of forage types at different stages of the year can be made with 3 types of hay used for feed for a 1200 lb cow during the 3rd trimester. A 1200 lb cow in the 3rd trimester requires 24 lbs dry matter (DM) per day at 7.8% crude protein (CP) (1.9 lbs CP/day). The standard cost rates used were tame-hay land rent at $14.22/acre and cropland rent at $22.07/acre. The standard custom farm work rates

were $16.08/acre and production of round bales at $5.36 per 1000 lb bale.

Crested wheatgrass cut at a mature plant stage and having the average dry matter yield of 1600 lbs/acre and 6.4% CP (102 lbs CP/acre) would cost $34.80 per ton of dry matter and $0.28 per pound of crude protein. This late-cut hay would need to be fed at 24.0 lbs DM/day to provide 1.5 lbs CP/day. This crested wheatgrass forage would cost $0.52 per day, or $46.80 for the 90-day period of the 3rd trimester. Production of this amount of crested wheatgrass hay would require 1.35 acres. An additional 0.33 lbs of crude protein per day would need to be provided, at a cost of $9.02 per period. Total forage and supplement costs would be $55.82 per period, or $0.62 per day.

Crested wheatgrass cut early, at the boot stage, and having the average dry matter yield of 1300 lbs DM/acre and 14.5% CP (189 lbs CP/acre) would cost $40.80 per ton of dry matter and $0.14 per pound of crude protein. This early cut hay would be fed at 12.9 lbs DM/day to provide 1.9 lbs CP/day. This crested wheatgrass forage would cost $0.26 per day, or $23.40 for the 90-day period of the 3rd trimester. Production of this amount of crested wheatgrass hay would require 0.89 acres. An additional 11.1 lbs of roughage per day would need to be provided, at a cost of $17.48 per period. Total forage and supplement costs would be $40.88 per period, or $0.45 per day.

Forage barley that has seed costs of $4.69 per acre, is cut at the milk stage, and has the average dry matter yield of 4733 lbs DM/acre and 13.0% CP (606 lbs CP/acre) would cost $28.80 per ton of dry matter and $0.11 per pound of crude protein. The forage barley hay would be fed at 14.4 lbs DM/day to provide 1.9 lbs CP/day. This forage barley hay would cost $0.21 per day, or $18.90 for the 90-day period of the 3rd trimester. Production of this amount of forage barley hay would require 0.27 acres. An additional 9.6 lbs of roughage per day would need to be provided, at a cost of $14.96 per period. Total forage and supplement costs would be $33.86 per period, or $0.38 per day.

These simple illustrations show that when the amount of crude protein harvested per acre increases and standard costs remain constant, the cost per pound of crude protein decreases, the land area needed for forage production per animal decreases, and the cost of feed for an animal during a production period is reduced. The cost per pound of crude protein is a reliable indicator of relative forage costs. The cost per ton of dry matter for the forage types is not a very reliable indicator of the actual feed costs. Improvements in harvest efficiency of the nutrients produced on a land base will reduce the costs per unit of nutrient and the size of the land area needed for forage production per animal and offer considerable opportunity for reductions in beef production costs.

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# Implementing Biologically Effective Grazing Management

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Management of grasslands for a "use", whether for livestock forage, wildlife habitat, or aesthetics, is management of the use, not management of the grassland resources. The typical grassland management for a use is not sustainable on a long-term basis. Plant-friendly grassland management that meets the biological requirements of the plants and facilitates ecological processes enhances the grassland ecosystem as a natural resource for numerous simultaneous uses. A healthy grassland ecosystem managed by biologically effective practices produces more livestock forage, better wildlife habitat, and inspirational beauty. The same results cannot be achieved through practices based on management-for-a-use concepts.

Three biologically effective management practices that benefit the grassland resources and improve plant health are recommended:

- Begin grazing in the spring only after plants have reached the third-leaf stage (early May for crested wheatgrass and smooth bromegrass and early June for native rangeland).
- Coordinate grazing rotation dates with grass growth stages. Plant density increases when secondary tiller growth is stimulated by grazing for 7 to 17 days during the period between the third-leaf and flowering growth stages (early June to mid July for native rangeland).
- Do not graze spring and summer pastures or haylands during the fall. Fall grazing decreases the carryover secondary tillers and the new fall growth tillers and reduces the amount of herbage biomass produced the following season.

Implementation of biologically effective grazing management strategies that meet the biological requirements of the plants, enhance plant health status, and facilitate the operation of ecological processes is the long-term solution to management-caused herbage reduction problems. The result of these management effects is sustained high performance levels of healthy grassland ecosystems.

The twice-over rotation system is a biologically effective grazing management strategy developed for use in the Northern Plains. It was designed to manipulate processes that result in beneficial changes to plant growth, soil organisms, and biogeochemical cycles in the ecosystem. The twice-over rotation system on native rangeland with complementary domesticated grass spring and fall pastures coordinates defoliation with grass phenological growth stages to enhance vegetation, livestock, and wildlife performance.

The twice-over rotation system begins grazing in May, on a spring pasture of crested wheatgrass or other early growing domesticated cool-season grass that has reached the third-leaf stage, the earliest plant-growth stage at which grasses can be grazed without damage. Native grasses begin seasonal development more slowly, and the use of domesticated grass pastures in May protects native pastures by delaying grazing on them until the plants have reached the third-leaf stage.

A 3- to 6-pasture native range rotation system is used from early June until mid October, with each pasture grazed for two periods. Each native rangeland pasture is grazed for 7 to 17 days during the first period, the 45-day interval from 1 June to 15 July. The number of days each pasture is grazed during the first period is the same percentage of 45 days as the percentage of the total season's grazeable forage each pasture contributes.

During the first period, grasses are between the third-leaf stage and flowering phenophase. Grazing that removes a small amount of leaf area from grasses between these stages of plant development stimulates both tillering from axillary buds and enhanced activity of rhizosphere organisms. Increased vegetative reproduction by tillering contributes to the production of greater herbage weight and nutrient quality, and increased activity of the symbiotic soil organisms supplies the plants with greater quantities of nutrients to support additional grass tiller growth. During the second period, after mid July and before mid October, each pasture is grazed for double the number of days it was grazed during the first period. Increasing the number of secondary tillers improves herbage quality and extends the period of improved livestock performance two to two and a half months, until late September or mid October. The biology of native grass plants does not permit extending these conditions beyond mid

October, when native rangeland herbage quality is insufficient to meet the nutritional requirements of lactating cows.

Cows and calves graze a fall pasture of Altai wildrye or other type of wildrye from mid October until weaning in early or mid November. Wildryes are the only perennial grasses that retain nutrient quality in the aboveground portions of the plant later than mid October. Removing livestock from native rangeland pastures at the end of the perennial-plant growing season allows native grasses to conserve stored nutrients that will maintain plant processes over the winter and early spring and to retain the leaf area of secondary tillers and the fall vegetative growth that will become next season's lead tillers. This practice ensures healthy plants in the spring and greater herbage production during the following growing season.

The twice-over rotation system's elevation of plant health and stimulation of beneficial ecosystem processes result in increased plant basal cover and aboveground herbage biomass and improved nutritional quality of forage. The twice-over rotation grazing management system with complementary domesticated grass pastures has a grazing season of more than 6.5 months, with the available herbage above, at, or only slightly below the nutritional requirements for a lactating cow for the entire grazing season.

The increase in quantity and quality of herbage on the twice-over rotation system permits an increase in stocking rate levels; improves individual animal performance; increases total accumulated weight gain, weight gain per acre, and weight gain per day; reduces acreage required to carry a cow-calf pair for the season; improves net return per cow-calf pair; and improves net return per acre. The increase in basal cover and herbage biomass reduces the number and size of bare soil areas and increases the quantity of residual vegetation. These changes in vegetation produce conditions favorable to the limitation of grasshopper pestiferous species populations. The increase in plant density, herbage production, residual vegetation, and ecosystem health improves the habitat for prairie grouse, ducks, and other waterfowl and ground nesting birds.

Effective management practices meet the biological requirements of the plants and help the ecosystem processes function at their full potential. These management practices improve the performance levels of all grassland ecosystem components, elevate plant health status, and increase productivity of grassland ecosystems. The result is sustained greater herbage weight production, higher quality habitat for wildlife, and stronger livestock weight gain performance.

The benefits of biologically effective grazing practices are both ecological and economic. By implementing the twice-over rotation grazing management strategy, producers protect rangeland health, increase their profits, and help to ensure that the grassland will sustain their cow-calf operation for years to come.

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# 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 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?

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 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.

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/dickinso/research/2001/range01j.htm.

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## 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, DC.

**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.

| Monitoring Procedure Time Table | | |
|---|---|---|
| **Photo Plot Method** | | |
| Minimum of 3 photo periods per year: information collected from permanent photo plot | | |
| 1st | early June | grazing-ready stage |
| 2nd | mid July to early August | peak herbage biomass |
| 3rd | mid to late September | fall tiller growth |
| 4th | 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

| | | |
|---|---|---|
| Trained Athlete | (A) | Excellent |
| Average Person | (B) | Good |
| Couch Potato | (C) | Fair |
| Chronically 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 | | | | | | | | | | |