METHODS FOR DEVELOPMENT OF BIOLOGICALLY EFFECTIVE MANAGEMENT STRATEGIES

3rd Edition

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Methods for Development of Biologically Effective Management Strategies

3rd Edition

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CONTENTS

Mismatch of Modern Beef Cattle Fed by Traditional Management Practices

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Report DREC 12-41b

Biologically efficient 12-month livestock pasture and harvested forage management strategies improve profit margins for beef production and enhance the regional agricultural economy by increasing value captured from land natural resources. Efforts of the beef production industry at correcting the problems of high production costs and low profit margins have been on improving animal performance. Traditional livestock production practices assume the source of income to be from the sale of the animals. After 50 years of improvements in animal performance, high production costs and low profit margins continue to be problems for beef production. These problems persist as a result of the mismatch of forage nutrients required and forage nutrients available between modern, high-performance cattle and traditional low-performance forage management practices. Forage management systems were not improved simultaneously with beef animal performance. Modern cattle on traditional forage management practices developed for old-style cattle have reduced production efficiencies that depress cow and calf weight performance below genetic potentials causing reduced value received at market and reduced profits.

The fundamental problem with traditional livestock forage management concepts is that the land resources are managed from the perspective of their use. It is imperative for future progress that management of renewable natural resources be directed away from placing priority on the use and to be focused towards meeting the requirements of all the living and nonliving components of the ecosystems for the purpose of improving ecosystem processes and maintaining land resource production at sustainable levels. The renewable forage plant nutrients produced on the land natural resources are the original source of new wealth generated by livestock agriculture. The quantity of new wealth generated from forage nutrients is proportional to the forage management strategies' capabilities to be effective at meeting the biological requirements of the plants and soil organisms, to be efficient at capturing produced forage nutrients, and to be efficient at converting forage nutrients into salable commodities like calf weight.

Effectively meeting the biological requirements of plants and soil organisms occurs when the defoliation resistance mechanisms of grass plants and the biogeochemical processes of ecosystems are activated by partial defoliation during phenological growth between the three and a half new leaf stage and the flowering (anthesis) stage. These mechanisms help grass tillers withstand and recover from grazing by triggering compensatory physiological processes that increase growth rates, increase photosynthetic capacity, and increase allocation of carbon and nitrogen; by stimulating vegetative reproduction of secondary tillers from axillary buds; and by stimulating rhizosphere organism activity and increasing conversion of inorganic nitrogen from soil organic nitrogen. Activation of these mechanisms results in increased herbage biomass production, increased plant density, increased available forage nutrients, increased soil aggregation, improved soil quality, increased soil water holding capacity, increased resistance to drought conditions, improved wildlife habitat, and improved grassland ecosystem health status.

Improvement in performance of forage management systems requires paradigm shifts that consider the land natural resources to be the source of new wealth generated from livestock agriculture with the renewable forage nutrients as the primary unit of production and the produced animal weight as the commodity sold at market. Biologically efficient 12-month pasture and harvested forage management strategies effectively meet the biological requirements of plants and soil organisms, and improve the characteristics of soil; efficiently capture forage produced nutrients; and efficiently convert nutrients into animal weight commodities. These improvements permit renewable natural resource ecosystems to perform at biologically sustainable levels and modern high-performance beef cattle to perform at genetic potentials. Results of these improvements reduce costs per pound of crude protein, reduce costs per pound of calf weight gain, reduce costs per day of forage feed, and increase returns after feed costs per acre. These changes in costs and returns effectively increase profit margins for land and cattle enterprises and improve the regional livestock agricultural economy.

Implementation of Biologically Effective Grazing Management Strategies

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Report DREC 12-48

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 3.5 new 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 3.5 new 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 and the rhizosphere organisms, 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 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. The renewable forage plant nutrients produced on the land are the original source of new wealth generated by livestock agriculture.

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 rhizosphere 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 periods 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 3.5 new 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 3.5 new 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 3.5 new leaf stage and flower phenophase.

Grazing that removes 25% to 33% 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 spring seeded winter annual cereal 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. Spring seeded winter cereal pastures provide adequate nutrient quality for lactating cows from mid October until mid or late November; some years until mid December.

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 rhizosphere organisms helping 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.

Acknowledgment

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Method for Conducting Pasture and Forage Inventories

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Report DREC 12-50

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 land natural resources. Development of a 12-month biologically effective pasture and forage management strategy 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 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 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 for each production period.

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.

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I am grateful to Sheri Schneider for assistance in production of this manuscript and for development of the worksheets.

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 10, 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 15, 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 22, 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 27, 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		

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

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												

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. Management of each range site separately is impractical in most grazingland pasture situations.

This report attempts to simplify grazingland management of pastures in the Northern Plains by grouping range sites with similar management requirements, similar herbage biomass production, and similar stocking rates into landscape management units.

Two major differences among landscape 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.

Range sites with similar levels of soil water and herbage production within each of the physiographic regions of the Northern Plains have been grouped into three generalized landscape management units. 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.

Acknowledgment

I am grateful to Sheri Schneider for assistance in production of this manuscript and development of the tables.

Table 1. Range sites composing the landscape management units.

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

Plant names follows Flora of the Great Plains (1986).

Simplified Assessment of Rangeland Health 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 rangeland health condition categories.

Most rangeland health 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 rangeland health condition categories can be illustrated by comparison to human health condition (table 1). A grassland ecosystem in (A) excellent condition is like a highly trained athlete. A grassland ecosystem in (B) good condition is like a person in average health. A grassland ecosystem in (C) fair condition is like a couch potato. A grassland ecosystem in (D) poor condition is like a chronically ill person.

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 categories. 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.

Acknowledgment

I am grateful to Sheri Schneider for assistance in production of this manuscript and for development of the table.

Table 1. Rangeland Health Condition Categories.

(A). Excellent Condition: 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.

(B). Good Condition: 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.

(C). Fair condition: 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.

(D). Poor condition: 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.

Animal Unit Equivalent for Beef Cattle Based on Metabolic Weight

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Report DREC 98-1020

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. As a rough guideline, 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 size (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

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Length of the Average Grazing Season Month

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Report DREC 12-1021c

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 grazinglands 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 the Gregorian 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 For the Northern Plains

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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 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 on native rangeland 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 native rangeland pastures are managed by seasonlong grazing for 4.5 to 5.0 months, June to October. If the pastures are managed by other grazing strategies or at other times of the year, appropriate adjustments will need to be made. The reported stocking rate value can serve as an initial starting point.

The mean average stocking rates for a 1000 lb cow on 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. 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. 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.

This report also summarizes the generalized stocking rate levels on fertilized and unfertilized domesticated grasslands of smooth bromegrass and crested wheatgrass for upland landscape sites in the

Drift Prairie, Missouri Coteau, and West River Regions of the Northern Plains (tables 4-6).

The stocking rate estimates in this report assume that the domesticated grassland pastures are managed as spring complementary pastures with one use from early to late May and in good or fair condition. If the pastures are managed for double use such as spring pasture and hayland, or hayland and fall pasture, the grass plants cannot endure these stocking rates.

The mean average stocking rate for a 1000 lb cow on unfertilized spring domesticated grassland pastures in the Drift Prairie, Missouri Coteau, and West River Regions are 0.80, 1.25, and 1.75 aces/AUM, respectively.

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. 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 cow live weights can be found on each table.

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Table 1. Generalized average stocking rates on native rangeland 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	11.00

	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 4. Generalized average stocking rates on domesticated grasslands 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)											
	Fertilized						Unfertilized					
Landscape Units	Good			Fair			Good			Fair		
	A	B	C	A	B	C	A	B	C	A	B	C
Upland Landscape Sites	0.30	0.50	0.70	0.50	0.70	1.00	0.60	1.00	1.50	1.00	1.50	2.00

	Stocking Rate in AUM's/Acre (1000lb cow=1.00 AUE)											
	Fertilized						Unfertrilized					
Landscape Units	Good			Fair			Good			Fair		
	A	B	C	A	B	C	A	B	C	A	B	C
Upland Landscape Sites	3.33	2.00	1.45	2.00	1.45	1.00	1.67	1.00	0.67	1.00	0.67	0.50

Table 2. Generalized average stocking rates on native rangeland 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 5. Generalized average stocking rates on domesticated grasslands 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)											
	Fertilized						Unfertilized					
Landscape Units	Good			Fair			Good			Fair		
	A	B	C	A	B	C	A	B	C	A	B	C
Upland Landscape Sites	0.35	0.60	0.80	0.60	0.80	1.15	0.70	1.15	1.75	1.15	1.75	2.30

	Stocking Rate in AUM's/Acre (1200lb cow=1.147 AUE)											
	Fertilized						Unfertrilized					
Landscape Units	Good			Fair			Good			Fair		
	A	B	C	A	B	C	A	B	C	A	B	C
Upland Landscape Sites	2.95	1.75	1.25	1.75	1.25	0.90	1.45	0.90	0.60	0.90	0.60	0.45

Table 3. Generalized average stocking rates on native rangeland 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

Table 6. Generalized average stocking rates on domesticated grasslands 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)											
	Fertilized						Unfertilized					
Landscape Units	Good			Fair			Good			Fair		
	A	B	C	A	B	C	A	B	C	A	B	C
Upland Landscape Sites	0.40	0.65	0.90	0.65	0.90	1.30	0.80	1.30	1.95	1.30	1.95	2.60

	Stocking Rate in AUM's/Acre (1400lb cow=1.287 AUE)											
	Fertilized						Unfertrilized					
Landscape Units	Good			Fair			Good			Fair		
	A	B	C	A	B	C	A	B	C	A	B	C
Upland Landscape Sites	2.60	1.60	1.10	1.60	1.10	0.75	1.30	0.75	0.50	0.75	0.50	0.40

To illustrate how to determine the historical stocking rate of a ranch with a West River location, 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, at 1,200 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	1.147AUE	=	80.3 AU

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

Animal units (AU)	X	number of months	=	animal unit months (AUM's)
80.3 AU	X	4.5 M	=	361 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	÷	361 AUM	=	1.77 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 2.29 acres per AUM for 1200-pound cows.

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

The historical stocking rate for 1,200-pound cows is 1.77 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.

The average monthly herbage biomass is determined by adding the monthly herbage biomass for the months of the grazing season and dividing the sum by the number of grazing-season months (step 1).

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 grass plant must retain 50% of the peak leaf material biomass produced that growing season. This value implies that the plant retains half the herbage and half the herbage is available for utilization (step 2, 1st process).

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 senescent leaves 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 (step 2, 2nd process).

The differences in daily dry matter allocation 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 allocation 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 (step 3, 1st process).

The amount of forage dry matter allocation per cow per month is the daily amount of dry matter allocation per day adjusted for cow size multiplied by the number of days per average month (30.5 days) (step 3, 2nd process).

The stocking rate, presented as AUM's per acre, is the pounds of available monthly forage, as determined in step 2, divided by the amount of dry matter allocation needed per cow per month, as determined in step 3.

Regions of the country that have forage production per acre sufficient for more than one AUM use stocking rates as AUM's/acre. Arid and semiarid regions of the country that require more than one acre to produce the need forage for one AUM use stocking rates as acres/AUM. The reciprocal stocking rate of acres per AUM can be determined by dividing the stocking rate as AUM's/acre into 1 (one) (step 5). This is the number of acres required to provide forage for one month for a cow of the adjust size 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 (step 6). 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, and cow size.

Acknowledgment

I am grateful to Sheri Schneider for assistance in production of this manuscript.

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

1. Average monthly herbage biomass is equal to the sum of monthly herbage biomass for the months of the grazing season (from table 2) divided by the number of grazing season months.
2. Pounds of available monthly forage is the average monthly herbage biomass (Step 1) multiplied by % proper utilization (50%) and multiplied by % forage consumed (50%).
3. Pounds of forage dry matter per Animal Unit Month (AUM) is the dry matter required per 1000 lb cow per day (26 lbs) multiplied by the Animal Unit Equivalent (AUE) for the herd cow size (from table 3) multiplied by 30.5 days (for average grazing season month).
4. Animal Unit Months per acre is equal to the pounds of available monthly forage (Step 2) divided by the pounds of forage dry matter per AUM (Step 3).
5. Acres per AUM is equal to 1 divided by AUM/ac (Step 4).
6. The number of cows that can graze the available forage is equal to the total number of acres in the grazing system divided by the acres/AUM (Step 5) and then divided by the number of grazing season months.

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

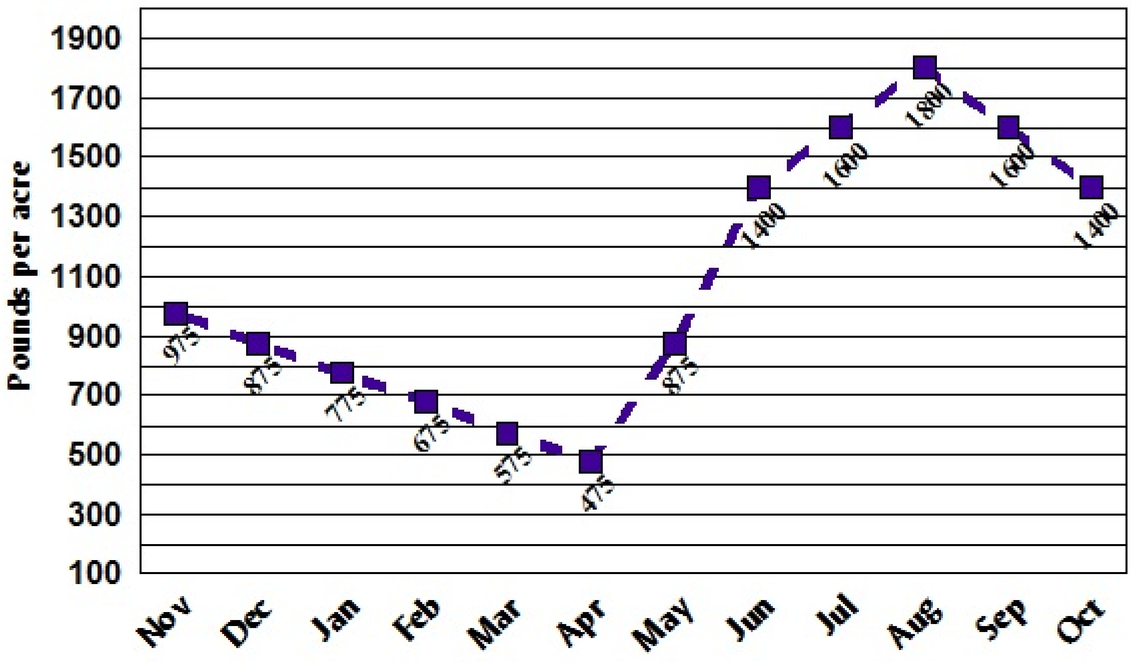

Table 3. Animal Unit Equivalent (AUE) and pounds of dry matter allocation per day.

Animal Live Weight (lbs)	Animal Unit Equivalent $y^{x\ 0.75}$ (% of 1000 lbs)	Dry Matter Allocation (lbs/Day)
600	0.682	18
650	0.724	19
700	0.765	20
750	0.806	21
800	0.846	22
850	0.885	23
900	0.924	24
950	0.962	25
1000	**1.000**	26
1100	1.074	28
1200	1.147	30
1300	1.217	32
1400	1.287	33
1500	1.355	35
1600	1.423	37
1700	1.489	39
1800	1.554	40
1900	1.618	42
2000	1.682	44
2200	1.806	47
2400	1.928	50
2600	2.048	53
2800	2.165	56
3000	2.280	59

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

Determination of 12-Month Nutrient Requirements for Beef Cows

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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 or annual grass pastures of spring seed winter cereals 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 Sheri Schneider for assistance in production of this manuscript and for development of the tables and worksheets.

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') 3rd Trimester 3.0m, 90d Calf Birth	RATION 3rd Trimester 3.0m, 90d Calf Birth	Dry Gestation 1.0m, 32d	RATION Dry Gestation 2.0m, 62d
Dec				
Jan			RATION 3rd Trimester 3.0m, 90d Calf Birth	
Feb	Early Lactation 1.0m, 32d			3rd Trimester 3.0m, 90d Calf Birth
Mar	Lactation 2.5m, 75d	Early Lactation 1.0m, 32d		
Apr		Lactation 1.5m, 45d	Early Lactation 1.5m, 45d	
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 Calf age-9m Calf Weaning	Lactation (summer) 4.5m, 137d	Lactation (summer) 4.5m, 137d	Lactation (summer) 4.5m, 137d
Aug				
Sep				
Oct				
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 of dry matter 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.

Acknowledgment

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

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

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

Monitoring Site Location

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

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

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

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

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

Monitoring Site Description

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

Photo Plot Method

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

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

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

The greater the number of sampling periods at which photographs are taken at each monitoring site, the more thoroughly the conditions will be represented. A minimum of three photo sampling periods per site per year is necessary to depict annual seasonal changes. The first photo should be taken in early June, when plants are at the grazing-ready stage. The second should be taken when peak herbage biomass has been produced, usually between mid July and the first week in August. The third should be taken during the late portion of the growing season, sometime between mid and late September, when the status of cool-season fall-tiller growth is evident. If grazing continues in one or two pastures after mid October, a fourth photo should be taken in these pastures at the end of grazing, even if snow covers the ground.

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

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

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

Major Plant Species Present List

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

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

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

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

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

Table 2. Major grasses of the upland landscape sites.

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

Table 3. Major grasses of the xeric landscape sites.

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

Nonquantitative Assessment of Rangeland Health Status

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

I. Distribution pattern of plants across the site is nearly continuous, with foliage covering nearly the entire ground surface.

II. Plant species composition is diverse, with numerous desirable species in a mature community.

III. Age-class distribution of plants is diverse, with numerous plants of each age group. Recruitment of numerous young desirable plants is supported.

IV. Plants are vigorous, support robust growth, and show no signs of deformed growth patterns.

V. Plant roots are distributed throughout the available soil profile.

VI. The leaf area of the plants is adequate throughout the growing season so that rates of photosynthetic activity are sufficient to provide all the requirements for growth of leaves and roots.

VII. Litter distribution across the site is nearly continuous, with only a few bare soil areas.

VIII. The humic layer of decomposed organic matter is well developed across the site.

IX. The top layer of soil appears stable and is consistent across the site.

X. Soil removal by wind or water is not evident.

XI. Deposition of wind- or water-eroded material is not evident.

XII. Recent gully formation is not evident. If any gullies are present, they are small, smooth featured, and vegetated.

XIII. Plant pedestaling is not evident.

XIV. Scouring or sheet erosion from wind or water is not evident.

XV. Nutrient cycles and energy flow are functioning at adequate levels.

XVI. Plant community dynamics and processes are sufficient to maintain highly productive community structure and function.

XVII. Almost all the precipitation infiltrates the soil, and only a very small amount runs off.

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

I. Distribution pattern of plants across the site is somewhat continuous, with foliage covering almost all the ground surface.

II. Plant species composition is diverse, with numerous desirable species and a few less desirable species in a mature community.

III. Age-class distribution of plants is diverse, with many plants of each age group. Recruitment of many young desirable plants is supported.

IV. Plants are vigorous and show no signs of deformed growth patterns.

V. Plant roots are distributed throughout nearly all the available soil profile.

VI. The leaf area of the plants is adequate throughout the growing season so that rates of photosynthetic activity are sufficient to provide nearly all the requirements for growth of leaves and roots.

VII. Litter distribution across the site is somewhat continuous, with only a small amount of bare soil area.

VIII. The humic layer of decomposed organic matter is present over most of the site.

IX. The top layer of soil appears stable and nearly uniform across the site.

X. Soil removal by wind or water shows very little evidence.

XI. Deposition of wind- or water-eroded material shows very little evidence.

XII. Recent gully formation shows very little evidence. If some gullies are present, they are smooth featured and vegetated.

XIII. Plant pedestaling shows little evidence.

XIV. Scouring or sheet erosion from wind or water shows very little evidence.

XV. Nutrient cycles and energy flow are functioning at adequate levels.

XVI. Plant community dynamics and processes are sufficient to maintain the existing community structure and function.

XVII. Most of the precipitation infiltrates the soil, and only a small amount runs off.

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

I. Distribution pattern of plants across the site is patchy, with some large bare ground areas not covered by foliage.

II. Plant species composition is restricted, with some desirable species, some less desirable species, and a few undesirable species in a mature community.

III. Age-class distribution of plants is incomplete, with some age classes missing. Recruitment of young desirable plants is restricted.

IV. Plants have reduced vigor, and some show deformed growth patterns, developing close to the ground.

V. Plant roots are not present in all portions of the available soil profile but are restricted to patches.

VI. The leaf area of the plants is reduced during portions of the growing season so that rates of photosynthetic activity are insufficient to provide all the requirements for growth of leaves and roots.

VII. Litter distribution across the site is sparse and uneven, characterized by some large bare soil areas and by accumulations in depressions and around prominent grass plants.

VIII. The humic layer of decomposed organic matter is sparsely distributed and is being incorporated into the soil only in depressions or around prominent grass plants.

IX. The top layer of soil is beginning to show a fragmented distribution pattern.

X. Some soil particles, organic matter, and nutrients are being redistributed by wind or water erosion but remain on the site.

XI. Some sediment deposition of wind- or water-eroded material is evident.

XII. Recent gully formation is evident but structures are not yet well developed or integrated into a branching pattern.

XIII. Plant pedestaling is evident but is not so severe that roots are exposed.

XIV. Bare soil with scours and dunes from wind erosion is evident, but the structures are small and not well developed. Sheet erosion from water is evident on small areas after thunderstorms.

XV. Nutrient cycles and energy flow are functioning, but the distribution across the site is in the early stages of a fragmented pattern.

XVI. Plant community dynamics and processes are not sufficient to maintain productive community structure and function.

XVII. Some of the precipitation infiltrates the soil, and some runs off.

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

I. Distribution pattern of plants across the site is clumped or fragmented, with numerous large bare ground areas not covered by foliage.

II. Plant species composition is restricted, with few desirable species, many less desirable species, and many undesirable species in a developing community.

III. Age-class distribution of plants is restricted, with predominantly old or deteriorated plants. Recruitment of young desirable plants is nearly absent.

IV. Plants are weak, and many plants show deformed growth patterns, developing close to the ground.

V. Plant roots occupy only a small portion of the available soil profile.

VI. The leaf area of the plants is greatly reduced during portions of the growing season so that photosynthetic activity is restricted to rates too low to provide much of the energy or many of the nutrients required for growth of leaves and roots.

VII. Litter distribution across the site is sparse or absent, with numerous large bare soil areas.

VIII. The humic layer of decomposed organic matter is sparse or absent from most of the site.

IX. The top layer of soil is sparse or absent from large areas of the site or is present only in association with depressions or prominent obstructions.

X. Soil degradation resulting from soil particle, organic matter, and nutrient removal from the site by wind or water is evident.

XI. Deposition of wind- or water-eroded material is evident, appearing as large bare deposits, as dunes, or in association with prominent plants.

XII. Recent gully formation is evident, and structures are well developed, active, and integrated into a branching pattern.

XIII. Plant pedestaling is severe enough that roots are exposed.

XIV. Bare soil with scours and dunes from wind erosion is evident. The structures are active and well developed. Sheet erosion from water is evident on large areas after thunderstorms.

XV. Nutrient cycles and energy flow are decelerated, and the distribution pattern is fragmented, with numerous large bare areas between fragments.

XVI. Plant community dynamics and processes are not sufficient to maintain viable community structure and function.

XVII. Only a small amount of the precipitation infiltrates the soil, and most runs off.

Interpretation

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

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

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

Acknowledgment

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

Description of Monitoring Site

Monitoring Site Name:____

Pasture Name:____

Physical Characteristics

Range Site or Landscape Site:________________________________

Soil Type (sand, silt, clay):________________________________

Topography:____

Percent Slope (rise/distance):________________________________

Aspect (compass direction of slope):____________________________

Legal Description (quarter, quarter, quarter section):________________________

Location Description:____

____

____

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

Photo Plot Frame Size:____

Attach a map of the location of the monitoring sites.

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

____

____

____

____

____

Annual Description of Management Practices

Monitoring Site Name:____

Pasture Name:_ ____

Year:____

Grazing Practice Size in Acres:_ ___________________________________

Pasture Size in Acres:____

Type of Livestock:____

Number of Livestock:____

Dates of Grazing Periods:_ _____________________________________

_ ____

Description of Grazing Management Practices:___________________________

_ ____

_ ____

_ ____

_ ____

_ ____

General Description of Weather Conditions

Previous Fall:____

Previous Winter:____

Before 1st Photo Period:_______________________________________

Before 2nd Photo Period:_______________________________________

Before 3rd Photo Period:_______________________________________

____

Rangeland Ecosystem Health Status Assessment

Monitoring Site Name:

Range Site or Landscape Site:

Health Condition Categories

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										

Methods for the Comparison of Costs and Returns for Pasture Forage and Harvested Forage Management Strategies for Each Range Cow Production Period

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Dickinson Research Extension Center
Report DREC 14-3064

The three major areas of investment for a beef operation are the land, the cattle, and the labor and equipment. The natural tendency for agricultural producers to focus on the product sold at market has placed an industry wide priority on the livestock when management and economic decisions are made. This traditional approach assumes the livestock to be the source of revenue and the dry matter weight to be the sought after product from grazinglands and haylands for livestock forage feed. However, this long held paradigm has not reduced production costs nor increased income for beef producers.

Traditional management strategies for grazinglands and haylands concentrate on a single use of the land as feed for livestock, promote harvesting greater amounts of forage dry matter weight, and compensate for deficiencies in forage nutritional qualities with the practices of crude protein supplementation, creep feeding, and early weaning. These traditional practices are inherently inefficient at capturing forage produced nutrients and consequently they only generate a small portion of the potential new wealth from the land resources.

Forage dry matter does not have a real economic value because it is not incorporated into the beef weight produced. The dry matter is simply the carrier of the nutrients it contains; therefore, the cost of the forage dry matter is only indirectly related to forage feed costs. The nutrients are the valuable products produced by forage plants on the land. The cow processes the forage nutrients and produces milk resulting in calf weight accumulation. This calf weight is the commodity sold at the market, nevertheless, the original source of the income from the sale of beef weight is the forage nutrients. The renewable forage nutrients are the primary unit of production in a beef operation, and they are the source of new wealth from agricultural use of grazingland and hayland resources.

The quantity of new wealth generated from agricultural use of land resources is limited by the biological capacity of the forage plants to produce herbage and nutrients from soil, sunlight, water, and carbon dioxide and by the effectiveness of management treatments in capturing value from plant production. Increasing value captured from the land requires using management strategies that place priority on plant health and stimulate ecological biogeochemical processes, enhance vegetative plant growth, capture a high proportion of the produced nutrients, and efficiently convert these nutrients into saleable commodities such as calf weight.

The quantity of crude protein captured per acre as livestock feed is the factor that has the greatest influence on the costs of pasture forage and harvested forage and on the amount of new wealth generated from the land resources. The weight of crude protein captured per acre is related to the percent crude protein content and the weight of the forage dry matter at the time of grazing or haying. The cost per pound of crude protein is determined by the weight of the crude protein captured per acre prorated against the forage production costs which include the land costs, equipment costs, and labor costs per acre. Reductions in livestock feed costs result from capturing greater quantities of crude protein per acre. Capturing greater quantities of the produced crude protein from a land base causes a reduction in the amount of land area required to feed a cow-calf pair and results in lowering the forage feed costs because the forage production costs per acre are spread over a greater number of pounds of crude protein.

Reductions in forage dry matter costs, forage production costs, land rent costs, equipment costs, or labor costs may cause some reduction in cash expenditures but reductions in these costs do not directly regulate livestock forage feed costs because these costs do not respond proportionally to the variation in quantities of forage needed to provide livestock with adequate amounts of nutrients resulting from the differences in the weight of crude protein captured per acre through the grazing or haying of various forage types at different plant growth stages.

Generally, perennial and annual grass forages that are grazed or hayed at a mature plant stage, after flowering, are high-cost forages; the quantity of dry matter per acre is greater causing a reduction in production costs per ton of forage dry matter, however, the quantity of crude protein per acre is lower causing an increase in cost per pound of crude protein and requiring greater land area to provide adequate feed for a cow-calf pair resulting in an increase of forage feed costs. Perennial grass forages that are grazed or hayed at an early plant stage, after the three and a half new leaf stage and before flowering, and annual cereal forages that are cut between the boot stage and the milk stage are low-cost forages; the quantity of forage dry matter per acre is less causing an increase in production costs per ton of forage dry matter but the quantity of crude protein captured per acre is greater causing a decrease in cost per pound of crude protein and requiring less land area to provide adequate feed for a cow-calf pair resulting in a decrease of forage feed costs.

Generally, legume forages yield the greatest weight of crude protein per acre when the plants are at full growth but before the leaves start drying from senescence. The cost per pound of crude protein is lower for legume forages when plants are cut one time per year during a late full-growth stage resulting in lower forage feed costs. Legume forages cut at early plant growth stages yield higher crude protein percentages but because the weight of the crude protein captured per acre is lower, the cost per pound of crude protein is higher and the forage feed costs are higher.

Selection of pasture forage types and harvested forage types that effectively increase new wealth generated from land natural resources and reduce forage feed costs during each range cow production period can be made through comparisons of the cost per pound of captured crude protein, cost per day of forage feed, cost per pound of calf weight gain, land area required per cow-calf pair, and returns after feed costs per acre. Counterintuitively, comparisons of the traditional evaluation criteria of forage dry matter costs, forage production costs, land rent costs, equipment costs, or labor costs do not identify pasture forage types and harvested forage types that provide low forage feed costs.

This procedure uses forage feed production costs and returns after feed costs to compare and evaluate pasture forage types and harvested forage types during range cow production periods. This procedure is not a complete economic analysis of total livestock production costs or a study in livestock marketing schemes.

A positive profit margin can be achieved for a 12-month period from the production of beef during a low market cycle with calf weight valued at $0.70 per pound at weaning time when the forage feed costs average $0.62 or less per day, captured crude protein costs average $0.25 or less per pound, and calf weight gain costs average $0.42 or less per pound.

Procedure

This procedure determines and compares forage feed costs and returns after feed costs of pasture forage types and harvested forage types during range cow production periods. Production periods were differentiated when there was a change in cow nutrient requirements or a change in forage type use resulting from biological variations in plant growth curves. The 12-month range cow production cycle included the development and growth of a calf starting from late middle gestation in mid November through birth in mid March and continuing until weaning during the consecutive mid November.

The format of this report is intended to assist beef producers with the evaluation of the pasture forage and harvested forage management practices that they currently use and to assist in the development of efficient and biologically effective pasture forage and harvested forage strategies that reduce forage feed costs, increase returns after feed costs, and increase new wealth captured from the land resources.

Pasture forage and harvested forage costs of feed to meet range cow dry matter and crude protein requirements and the resulting net returns after feed costs per cow-calf pair and per acre were determined for each of the different range cow production periods during this procedure. Production costs per acre were determined by adding average land rent per acre, custom farm work rates, seed costs per acre, and baling costs at per half ton rates. Costs per ton of forage dry matter (DM) were determined by dividing production costs per acre by pounds of forage dry matter yield per acre and multiplying the quotient by 2000 pounds. Costs per pound of crude protein (CP) were determined in two stages: first, pounds of forage dry matter per acre were multiplied by percentage of forage crude protein to derive pounds of captured crude protein per acre; then, production costs per acre were divided by pounds of captured crude protein per acre.

Grazingland area per cow-calf pair per month and per production period were determined in two stages: first, pounds of forage dry matter per acre were divided by pounds of forage dry matter required per cow-calf pair per day to derive number of grazing days per acre; then, the average number of days per month (30.5d) or the number of days per production period was divided by the number of grazing days per acre. Pasture forage costs per production period was determined by multiplying the acres of grazingland per cow-calf pair per production period by the production cost per acre.

Harvested forage land area per cow-calf pair per production period was determined in two stages: first, pounds of crude protein required per cow per day during the production period were divided by percentage of crude protein of forage type to derive pounds of forage dry matter to provide as feed per cow-calf pair per day; then, pounds of forage dry matter to feed per day were divided by pounds of forage dry matter per acre, and the quotient was multiplied by the number of days per production period. Harvested forage cost per production period was determined by multiplying the pounds of harvested forage to feed per cow-calf pair per production period by the harvested forage cost per pound.

Roughage supplementation costs per production period were determined in three stages: first, the pounds of harvested forage to feed per cow-calf pair per day were subtracted from the pounds of harvested forage allocation per cow-calf pair per day; next, the pounds of roughage supplementation to feed per cow-calf pair per day was multiplied by the number of days per production period; then, the pounds of roughage supplement per period was multiplied by the market cost of the roughage per pound.

Crude protein supplementation costs per production period were determined in three stages: first, the pounds of crude protein provided by the forage allocation per day was subtracted from the pounds of crude protein required per cow per day; next, the pounds of crude protein supplementation to feed per cow-calf pair per day was multiplied by the number of days per production period; then, the pounds of crude protein supplement per period was multiplied by the market cost of the crude protein per pound.

Total feed cost per production period were determined by the sum of the pasture or harvested forage costs and the roughage or crude protein supplementation costs per production period. The total feed costs per production period were divided by the number of days per production period to determine the total feed cost per day.

Dollar value of calf weight gain per production period was determined in two stages: first, accumulated calf weight gain was determined by subtracting calf live weight at the beginning of a growth period from calf live weight at the end of a growth period; then, calf weight gain per period was multiplied by an assumed low market value of $0.70 per pound. The low market value of $0.70 per pound was used to evaluate and identify pasture forage and harvested forage types that would produce positive returns after feed costs during low portions in the cattle cycle. Net returns after feed costs per cow-calf pair was determined by subtracting the total feed costs per production period from the dollar value of calf weight gain per production period. Net returns after feed costs per acre was determined by dividing the net returns after feed costs per cow-calf pair per production period by the number of acres per cow-calf pair per period. Costs per pound of calf weight gain per production period were determined by dividing the total feed costs per production period by the pounds of calf weight accumulated per period.

The terms "herbage" and "forage" are not synonymous. Herbage is the total amount of aboveground biomass of herbaceous plants like grasses and forbs. Forage is the portion of the herbage that can be removed without detriment to the plants and can provide feed for grazing animals or be harvested mechanically for feeding. About 50% of the herbage produced by a perennial plant on grazinglands must remain with the plant to sustain healthy and productive growth. About 50% of the herbage biomass produced during the growing season can be removed from the plant without harmful effects to plant health. The amount of forage ingested by grazing livestock is actually only about 50% of this quantity, or about 25% of the aboveground herbage biomass on seasonlong and single-grazing-period treatments. The remainder of the herbage that can be removed is broken from the plant, soiled by animal waste, consumed by insects and wildlife, and lost to other natural processes.

Forage plants in pastures saved for grazing during fall and winter are categorized as reserved forage in this study. Some articles in the popular press have incorrectly used the term "stockpiled forage" to refer to late-season pastures. The word "stockpile" is not correctly used in reference with natural resources or living organisms. Manufactured products, like steel pipe, charcoal briquets, diesel fuel, lumber, and processed food, can be stockpiled at storage locations during periods of surplus and used later in their original prestored condition during periods of deficiency. Natural resources, like iron ore, lignite coal, and crude oil deposits, that are left in place as raw material until needed for manufacturing products are reserves, not stockpiles. Living organisms, like trees in a forest and fish in the ocean, that are left in place until needed and continue biological processes of life, growth, and death are reserves, not stockpiles. Perennial grass resources that are left in place and saved as unprocessed pasture forage until needed in fall and winter are living organisms that continue to change their dry matter weight and nutritional quality during the growing season and the nongrowing season and are, therefore, reserves, not stockpiles. The term "stockpiled forage" can correctly be used to refer only to processed forages that do not change in dry matter or nutrient content during storage.

Base Line Forage and Livestock Data

The base line pasture forage and harvested forage data and cow and calf weight performance data used in the current evaluation to determine 12-month range cow production period forage feed costs and returns after forage costs were developed from numerous pasture forage and harvested forage management research projects conducted at the NDSU Dickinson Research Extension Center, located in western North Dakota.

Herbage weight for pasture forage types (tables 1-5) were based on the means of the average monthly herbage biomass data (Manske 2003c) collected by the clipping method during the period grazed on pasture management treatments involved in grazingland research projects conducted between 1983 and 1998 (Manske 2001). Forage dry matter weight was 25% of the pasture herbage weight (Manske 2003c). Percent crude protein data for native rangeland and crested wheatgrass forages during the period grazed (tables 1-5) were taken from Whitman et al. (1951) and Manske (1999a, b, c). Herbage weight data used in determination of stocking rates for the native rangeland repeated seasonal treatments were collected monthly from ungrazed plots (Manske 2001). Grazing dates and stocking rates for pasture forage types were means of data collected on the grazingland research projects (Manske 2001). Monthly herbage dry matter yield per acre on spring seeded winter cereal pastures (tables 1 and 5) was taken from Manske (2004). Herbage dry matter yield per acre on standing corn pastures (tables 1 and 2) was taken from Nelson et al. (2002).

Forage dry matter yield per acre and percent crude protein for annual crop varieties harvested as hay were collected on agronomic forage crop studies and reported annually (Carr 1995-1999). A summary of harvested forage production data for annual cereal and annual legume hays and perennial domesticated grass hay (table 6) were reported by Manske and Carr (2000).

Average production costs per acre for pasture forage types and harvested forage types (Manske 2002) were determined by adding applicable average land rent per acre from western North Dakota (table 8), average custom farm work rates (Beard 1998) (table 9), average seed costs per acre (Swenson and Haugen 1999) (table 10), and average custom baling rate per half ton of hay (table 9). Production costs do not include costs of fertilizer, pesticides, or transporting of feed, forages, and livestock unless specified. One pasture treatment of crested wheatgrass was fertilized annually with 50 pounds of nitrogen per acre at an average cost of $12.50 per acre. The pasture rent value of $8.76 per acre was used to determine costs for native rangeland and domesticated grassland grazingland (table 8). The value of $2.00 per acre was used for cropland aftermath grazing costs (table 8). Land rent values of $22.07 per acre for cropland and $14.22 per acre for domesticated grass hayland were used in the determination of production costs for harvested forage types (table 8). Supplemental crude protein was provided as 20% crude protein range cake at a cost of $120.00 per ton ($0.30/lb CP). Supplemental forage dry matter was provided as roughage at a cost of $35.00 per ton ($0.0175/lb) (Manske 2001). Production costs per acre ($126.67), crude protein supplementation per day (0.54 lb/d), and feed costs per day ($1.23/d) for standing corn pastures were taken from Nelson et al. (2002).

Commercial Hereford and Angus-Hereford cows with calves were used on the pasture forage treatments. Individual animals were weighed on and off each treatment and at biweekly or monthly intervals during the grazing season. Average livestock weight data collected during a production period (tables 1-5) were used to determine cow and calf weight performance (Manske 2003a, b). Cow performance on spring seeded winter cereal pastures (tables 1 and 5) was taken from Manske (2004). Cow performance on standing corn pastures (tables 1 and 2) was taken from Nelson et al. (2002). Calf fetus weight gain was estimated to be 0.78 pounds per day from an average birth weight of 95 pounds accumulated over 122 days during the 32-day dry gestation period and the 90-day third trimester period (table 7). Calf weight gain on harvested forage treatments was estimated to be 1.90 pounds per day during the early lactation period and 2.00 pounds per day during spring, summer, and fall lactation periods (table 7).

Range cow daily nutritional requirements, which change with cow size, level of milk production, and production period (table 11) were taken from NRC (1996). Pasture forage dry matter allocation is a little greater than cow dry matter intake requirements. Daily dry matter allocation of pasture forage is 26 lbs for 1000 lb cows, 30 lbs for 1200 lb cows, and 33 lbs for 1400 lb cows (Manske 2003c) (table 12). Cow nutrient requirements change during the different production periods. The time of year during which the production periods occur is effected by the calf birth date. During this study, the dry matter and crude protein requirements for range cows with an average weight of 1200 lbs and an average calf birth date in mid March were used. The 12-month sequence of range cow production periods is shown in table 13. The dollar value of calf weight accumulated during each range cow production period was determined by the assumed low market price of $0.70 per pound.

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Pasture Forage Types

The pasture forage types evaluated during the dry gestation production period were: native rangeland repeated seasonal, cropland aftermath, spring seeded winter cereal, and standing corn seasonal pastures. The pasture forage types evaluated during the third trimester production period were: native rangeland repeated seasonal and standing corn seasonal pasture. The pasture forage type evaluated during the early lactation production period was: native rangeland repeated seasonal. The pasture forage types evaluated during the spring lactation production period were: native rangeland repeated seasonal, 6.0-month seasonlong, crested wheatgrass unfertilized, crested wheatgrass extended use, and crested wheatgrass fertilized pastures. The pasture forage types evaluated during the summer lactation production period were: native rangeland repeated seasonal, 6.0-month seasonlong, 4.5-month seasonlong started early June, deferred grazing, and twice-over rotation management strategies. The pasture forage types evaluated during the fall lactation production period were: native rangeland repeated seasonal, 6.0-month seasonlong, 5.5-month seasonlong, deferred grazing, and 4.5-month seasonlong started mid June management strategies and Altai wildrye, cropland aftermath, and spring seeded winter cereal seasonal pastures.

Procedures to determine forage feed costs and returns after feed costs for pasture forage types during range cow production periods.

A. Select calf birth month: mid March
B. Select cow size on 1 June: 1200 lbs
C. Select range cow production period: table 13
D. Select pasture forage type: tables 1-5
E. Complete the following steps

1. Forage weight per acre is equal to
   mean monthly pasture herbage weight per acre during period grazed multiplied by 25% (tables 1-5).

2. Production cost per acre is equal to
   land rent per acre (table 8) plus any custom farm work costs (table 9).

3. Forage dry matter cost per pound is equal to
   production cost per acre (#2) divided by forage weight per acre (#1).

4. Forage dry matter cost per ton is equal to
   forage dry matter cost per pound (#3) multiplied by 2000 pounds (1 ton).

5. Crude protein weight per acre is equal to
   forage weight per acre (#1) multiplied by % crude protein of forage type (tables 1-5).

6. Crude protein cost per pound is equal to
   production cost per acre (#2) divided by pounds of crude protein per acre (#5).

7. Pounds of pasture forage allocation per cow-calf pair per day is equal to
   30 lb/d for 1200 lb cows (table 12).

8. Number of grazing days per acre on pasture forage types is equal to
   forage weight per acre (#1) divided by pounds of forage allocation per cow-calf pair per day (#7).

9. Acres of grazingland per cow-calf pair per month is equal to
   average number of days per month (30.5d) divided by number of grazing days per acre (#8).

10. Acres of grazingland per cow-calf pair per production period is equal to
    number of days per period (table 13) divided by number of grazing days per acre (#8).

11. Pasture forage cost per production period is equal to
    acres of grazingland per cow-calf pair per period (#10) multiplied by production cost per acre (#2).

12. Pounds of crude protein supplementation per day is equal to
    pounds of crude protein required per cow per day (table 11) minus (pounds of forage allocation per cow-calf pair per day (#7) multiplied by % crude protein of forage type (tables 1-5)).

13. Pounds of crude protein supplementation per production period is equal to
    pounds of crude protein supplementation per day (#12) multiplied by number of days per period (table 13).

14. Crude protein cost per production period is equal to
    pounds of crude protein supplementation per period (#13) multiplied by market cost of crude protein per pound ($0.30/lb CP).

15. Total feed costs per production period is equal to
    forage cost per period (#11 for pasture forage) plus supplementation costs per period (#14 for crude protein supplement).

16. Total feed costs per day is equal to
    total feed costs per production period (#15) divided by number of days per period (table 13).

17. Calf accumulated weight per production period is equal to
    weight of calf at end of period minus weight of calf at beginning of period (tables 1-5, calf gain/period).

18. Dollar value of calf weight per production period is equal to
    calf weight accumulated during production period (#17) multiplied by market price per pound ($0.70/lb).

19. Net returns after feed costs per cow-calf pair is equal to
    dollar value of calf weight per period (#18) minus total feed cost per period (#15).

20. Net returns after feed costs per acre is equal to
    net returns per cow-calf pair (#19) divided by number of acres per cow-calf pair per period (#10).

21. Cost per pound of calf weight gain per production period is equal to
    total feed costs per period (#15) divided by pounds of calf weight accumulated per period (#17).

Harvested Forage Types

The selected harvested forage types were evaluated during each range cow production period as hay cut by swathing and rolled into large round bales. Late crested wheatgrass hay was cut at a mature plant stage. Early crested wheatgrass hay was cut at the boot stage. Forage barley hay was cut both at the milk stage and at the hard dough stage. Oat forage hay was cut both at the milk stage and at the hard dough stage. Pea forage hay was cut at both early and late plant stages. Forage lentil hay was cut at both early and late plant stages. Oat-pea forage hay was cut at compromised plant stages of later than optimum for oat and earlier than optimum for pea.

Procedures to determine forage feed costs and returns after feed costs for harvested forage types during range cow production periods.

A. Select calf birth month:	mid March
B. Select cow size on 1 June:	1200 lbs
C. Select range cow production period:	table 13
D. Select harvested forage type:	table 6
E. Complete the following steps	

1. Forage weight per acre is equal to
   the harvested forage weight per acre removed by harvest methods (table 6).

2. Production cost per acre is equal to
   land rent per acre (table 8) plus custom farm work costs (table 9) plus seed cost per acre (table 10) plus baling cost [baling rate/1000 lbs (table 9) multiplied by (forage weight per acre (#1) divided by 1000 lbs (½ ton))].

3. Forage dry matter cost per pound is equal to
   production cost per acre (#2) divided by forage weight per acre (#1).

4. Forage dry matter cost per ton is equal to
   forage dry matter cost per pound (#3) multiplied by 2000 pounds (1 ton).

5. Crude protein weight per acre is equal to
   forage weight per acre (#1) multiplied by % crude protein of forage type (table 6).

6. Crude protein cost per pound is equal to
   production cost per acre (#2) divided by pounds of crude protein per acre (#5).

7. Pounds of harvested forage allocation per cow-calf pair per day is equal to
   pounds of dry matter intake required per cow per day (table 11) or use pounds of pasture forage allocation per cow-calf pair per day which is 30 lb/d for 1200 lb cows (table 12).

8. Pounds of harvested forage to feed per cow-calf pair per day is equal to
   pounds of crude protein intake required per cow per day (table 11) divided by % crude protein of forage type (table 6).

9. Pounds of harvested forage to feed per cow-calf pair per production period is equal to
   pounds of harvested forage to feed per day (#8) multiplied by number of days per period (table 13).

10. Acres of land harvested per cow-calf pair per production period is equal to
    pounds of harvested forage to feed per period (#9) divided by forage weight per acre (#1), (table 6, land area/period).

11. Harvested forage cost per production period is equal to
    pounds of harvested forage to feed per cow-calf pair per period (#9) multiplied by
    harvested forage cost per pound (#3).

12. Pounds of roughage supplementation per day is equal to
    pounds of harvested forage allocation per cow-calf pair per day (#7) minus pounds of harvested forage to feed per cow-calf pair per day (#8).

13. Pounds of roughage supplementation per production period is equal to
    pounds of roughage supplementation per day (#12) multiplied by number of days per period (table 13).

14. Roughage cost per production period is equal to
    pounds of roughage supplementation per period (#13) multiplied by market cost of roughage per pound ($0.0175/lb).

15. Pounds of crude protein supplementation per day is equal to
    pounds of crude protein required per cow per day (table 11) minus (pounds of forage allocation per cow-calf pair per day (#7) multiplied by % crude protein of forage type (table 6)).

16. Pounds of crude protein supplementation per production period is equal to
    pounds of crude protein supplementation per day (#15) multiplied by number of days per period (table 13).

17. Crude protein cost per production period is equal to
    pounds of crude protein supplementation per period (#16) multiplied by market cost of crude protein per pound ($0.30/lb).

18. Total feed costs per production period is equal to
    forage cost per period (#11) plus supplementation costs per period (#14 for roughage supplement) or (#17 for crude protein supplement).

19. Total feed costs per day is equal to
    total feed costs per production period (#18) divided by number of days per period (table 13).

20. Calf accumulated weight per production period is equal to
    weight of calf at end of period minus weight of calf at beginning of period (table 7).

21. Dollar value of calf weight is equal to
    calf weight accumulated during production period (#20) multiplied by market price per pound ($0.70/lb)

22. Net returns after feed costs per cow-calf pair is equal to
    dollar value of calf weight per period (#21) minus total feed cost per period (#18).

23. Net returns after feed costs per acre is equal to
    net returns per cow-calf pair (#22) divided by number of acres per cow-calf pair per period (#10).

24. Cost per pound of calf weight gain per production period is equal to
    total feed costs per period (#18) divided by pounds of calf weight accumulated per period (#20).

Table 1. Vegetation and livestock production values on pasture forage types during the dry gestation period.

	Native Rangeland Repeated Seasonal	Cropland Aftermath Seasonal Pasture	Spring Seeded Winter Cereal Seasonal Pasture	Standing Corn Seasonal Pasture
Production Period	Dry Gestation	Dry Gestation	Dry Gestation	Dry Gestation
Days	32	32	32	32
Herbage Wt. lb/ac	725	270	2487	9940
Forage Wt. lb/ac	180	135	1745	3840
Crude Protein %	4.8			
Crude Protein lb/ac	8.64			
Acres/Month ac	5.08	6.63	0.53	0.24
Acres/Period ac	5.33	7.10	0.56	0.25
Cow Gain/Day lb		-1.14	1.05	3.30
Cow Gain/Acre lb		-4.82	60.14	422.40
Cow Gain/Period lb		-36.48	33.68	105.60
Calf Gain/Day lb	0.78	0.78	0.78	0.78
Calf Gain/Acre lb	4.68	3.51	44.50	99.68
Calf Gain/Period lb	24.92	24.92	24.92	24.92

Table 2. Vegetation and livestock production values on pasture forage types during the third trimester and early lactation periods.

	Native Rangeland Repeated Seasonal	Standing Corn Seasonal Pasture	Native Rangeland Repeated Seasonal
Production Period	Third Trimester	Third Trimester	Early Lactation
Days	90	90	45
Herbage Wt. lb/ac	580	9940	480
Forage Wt. lb/ac	145	3840	125
Crude Protein %	4.8		9.2
Crude Protein lb/ac	6.96		11.50
Acres/Month ac	6.31	0.24	7.32
Acres/Period ac	18.62	0.70	10.80
Cow Gain/Day lb		0.86	
Cow Gain/Acre lb		110.57	
Cow Gain/Period lb		77.40	
Calf Gain/Day lb	0.78	0.78	1.80
Calf Gain/Acre lb	3.76	100.11	7.50
Calf Gain/Period lb	70.08	70.08	81.00

Table 3. Vegetation and livestock production values on pasture forage types during the spring lactation period.

		Native Rangeland Repeated Seasonal	Native Rangeland 6.0-m Seasonlong	Crested Wheatgrass Unfertilized	Crested Wheatgrass Unfertilized Extended Use	Crested Wheatgrass Fertilized
Production Period		Spring Lactation	Late Spring Lactation	Spring Lactation	Spring and Early Summer Lactation	Spring Lactation
Days		31	16	31	76	31
Herbage Wt.	lb/ac	780	906	1980	2192	4960
Forage Wt.	lb/ac	195	226	495	548	1240
Crude Protein	%	16.3		16.8		
Crude Protein	lb/ac	31.79		83.36		
Acres/Month	ac	4.62	4.04	1.82	1.67	0.73
Acres/Period	ac	4.77	2.10	1.88	4.16	0.75
Cow Gain/Day	lb		0.14	1.95	0.91	2.68
Cow Gain/Acre	lb		1.09	32.15	16.63	110.77
Cow Gain/Period	lb		2.30	60.45	69.16	83.08
Calf Gain/Day	lb	1.80	1.80	1.91	1.79	2.18
Calf Gain/Acre	lb	11.70	13.64	31.49	32.70	90.11
Calf Gain/Period	lb	55.80	28.80	59.21	136.04	67.58

Table 4. Vegetation and livestock production values on pasture forage types during the summer lactation period.

		Native Rangeland Repeated Seasonal	Native Rangeland 6.0-m Seasonlong	Native Rangeland 4.5-m Seasonlong	Native Rangeland Deferred Grazing	Native Rangeland Twice-over Rotation
Production Period		Summer Lactation	Summer Lactation	Summer Lactation	Late Summer Lactation	Summer Lactation
Days		137	137	137	92	137
Herbage Wt.	lb/ac	1450	906	1280	1649	1794
Forage Wt.	lb/ac	363	226	320	412	449
Crude Protein	%	9.6				
Crude Protein	lb/ac	34.85				
Acres/Month	ac	2.52	4.04	2.86	2.22	2.04
Acres/Period	ac	11.32	18.10	12.70	6.70	9.00
Cow Gain/Day	lb		0.14	0.34	0.32	0.62
Cow Gain/Acre	lb		1.09	3.67	4.40	9.44
Cow Gain/Period	lb		19.66	46.58	29.44	84.94
Calf Gain/Day	lb	1.80	1.80	2.09	1.80	2.21
Calf Gain/Acre	lb	21.78	15.63	22.55	24.73	33.64
Calf Gain/Period	lb	246.60	282.87	286.33	196.50	302.77

Table 5. Vegetation and livestock production values on pasture forage types during the fall lactation period.

		Native Rangeland Repeated Seasonal	Native Rangeland 6.0-m Seasonlong	Native Rangeland 5.5-m Seasonlong	Native Rangeland Deferred Grazing	Native Rangeland 4.5-m Seasonlong
Production Period		Fall Lactation	Fall Lactation	Fall Lactation	Fall Lactation	Early Fall Lactation
Days		30	30	30	30	15
Herbage Wt.	lb/ac	797	891	1423	1649	973
Forage Wt.	lb/ac	199	223	356	412	243
Crude Protein	%	4.8				
Crude Protein	lb/ac	9.55				
Acres/Month	ac	4.60	4.04	2.53	2.22	3.26
Acres/Period	ac	4.60	4.04	2.53	2.18	1.63
Cow Gain/Day	lb		-1.74	-0.82	-0.74	-0.52
Cow Gain/Acre	lb		-12.90	-9.77	-9.96	-4.75
Cow Gain/Period	lb		-52.20	-24.60	-22.20	-7.74
Calf Gain/Day	lb	1.80	0.59	0.92	0.77	1.35
Calf Gain/Acre	lb	11.83	4.38	10.90	10.36	6.71
Calf Gain/Period	lb	54.00	17.73	27.60	23.10	20.33

Table 5 (cont). Vegetation and livestock production values on pasture forage types during the fall lactation period.

	Altai Wildrye	Cropland Aftermath	Spring Seeded Winter Cereal
Production Period	Fall Lactation	Fall Lactation	Fall Lactation
Days	30	30	30
Herbage Wt. lb/ac	2590	270	
Forage Wt. lb/ac	648	135	1908
Crude Protein %			
Crude Protein lb/ac			
Acres/Month ac	1.39	6.63	0.47
Acres/Period ac	1.39	6.63	0.47
Cow Gain/Day lb	0.55	-1.61	1.05
Cow Gain/Acre lb	11.87	-7.27	67.02
Cow Gain/Period lb	16.50	-48.17	31.50
Calf Gain/Day lb	1.73	0.42	2.00
Calf Gain/Acre lb	37.96	1.90	127.66
Calf Gain/Period lb	52.77	12.57	60.00

Table 6. Vegetation production values on harvested forage types during range cow production periods.

		Crested Wheatgrass mature	Crested Wheatgrass early	Forage Barley early	Forage Barley late	Oat Forage early	Oat Forage late
Herbage Wt.	lb/ac						
Forage Wt.	lb/ac	1600	1300	4733	5133	4667	5667
Crude Protein	%	6.4	14.5	13.0	9.2	11.5	7.8
Crude Protein	lb/ac	102	189	606	468	535	435
Land Area/Period							
Dry Gestation	ac	0.47	0.26	0.08	0.10	0.09	0.11
Third Trimester	ac	1.35	0.89	0.27	0.36	0.31	0.38
Early Lactation	ac	0.76	0.65	0.20	0.24	0.23	0.21
Spring Lactation	ac	0.58	0.41	0.13	0.16	0.14	0.16
Summer Lactation	ac	2.57	1.82	0.56	0.73	0.64	0.73
Fall Lactation	ac	0.56	0.40	0.12	0.16	0.14	0.16

Table 6 (cont). Vegetation production values on harvested forage types during range cow production periods.

		Pea Forage early	Pea Forage late	Forage Lentil early	Forage Lentil late	Oat-Pea Forage
Herbage Wt.	lb/ac					
Forage Wt.	lb/ac	2800	4650	1667	3867	5143
Crude Protein	%	18.9	14.4	21.8	14.7	12.5
Crude Protein	lb/ac	526	685	361	567	611
Land Area/Period						
Dry Gestation	ac	0.09	0.07	0.13	0.09	0.07
Third Trimester	ac	0.32	0.25	0.46	0.30	0.26
Early Lactation	ac	0.23	0.18	0.34	0.22	0.19
Spring Lactation	ac	0.15	0.12	0.21	0.14	0.12
Summer Lactation	ac	0.65	0.51	0.95	0.60	0.53
Fall Lactation	ac	0.14	0.11	0.21	0.13	0.12

Table 7. Estimated calf weight performance on harvested forage types during range cow production periods.

Production Periods	Days	Calf Gain per Day lb	Calf Gain per Period lb
Dry Gestation	32	0.78	24.92
Third Trimester	90	0.78	70.08
Early Lactation	45	1.90	85.50
Spring Lactation	31	2.00	62.00
Summer Lactation	137	2.00	274.00
Fall Lactation	30	2.00	60.00

Table 8. Land rent values for western North Dakota.

		Cropland*	Hayland*	Grazingland*	Cropland Aftermath
Mean rent	$/ac	22.07	14.22	8.76	2.00

*Data from North Dakota Agricultural Statistics Service

Table 9. Custom farm work rates in North Dakota.

		Annual Cereal Hay	Annual Legume Hay	Cereal Legume Hay	Perennial Grass Hay
Min till drill	$/ac	9.32	9.32	9.32	
Swath/Condition	$/ac	6.76	6.76	6.76	
Swathing	$/ac				5.31
Custom Work	$/ac	16.08	16.08	16.08	5.31
Baling/1000 lbs	$	5.36	5.36	5.36	5.36

Data from North Dakota Agricultural Statistics Service (Beard 1998)

Table 10. Seed costs per acre.

		Barley	Oat	Pea	Lentil	Oat-Pea
Seed Cost	$/ac	4.69	6.00	23.80	12.60	29.80

Data from NDSU Extension Service (Swenson and Haugen 1999)

Table 11. Intake dry matter and crude protein requirements for range cows with average milk production during the livestock production periods.

Production Period		Dry Gestation	Third Trimester	Early Lactation	Spring Lactation	Summer Lactation	Fall Lactation
Days		32	90	45	31	137	30
1000 lb Cows							
Dry Matter	lb/d	21	21	24	24	24	24
Crude Protein	lb/d	1.30	1.64	2.52	2.30	2.30	2.30
1200 lb Cows							
Dry Matter	lb/d	24	24	27	27	27	27
Crude Protein	lb/d	1.49	1.87	2.73	2.51	2.51	2.51
1400 lb Cows							
Dry Matter	lb/d	27	27	30	30	30	30
Crude Protein	lb/d	1.67	2.13	2.94	2.70	2.70	2.70

Data from NRC 1996

Table 12. Daily dry matter allocation for cows grazing pasture forage.

		1000 lb cow	1200 lb cow	1400 lb cow
Dry Matter	lb/d	26	30	33

Data from Manske 2003c

Table 13. Range cow production periods for calf birth in mid March.

Production Periods	Days	Months of Occurrence
Dry Gestation	32	mid November to mid December
Third Trimester	90	mid December to mid March
Mean Calf Birth		mid March
Early Lactation	45	mid March to late April
Spring Lactation	31	early May to late May
Summer Lactation	137	early June to mid October
Fall Lactation	30	mid October to mid November
Mean Calf Weaning		mid November

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