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Stubble Height and Utilization Measurements:

Uses and Misuses

Agricultural Experiment Station
Oregon State University

A Western Regional Research Publication

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Under the procedure of cooperative publication, this regional report becomes, in effect, an identical publication of each of the participating experiment stations and agencies and is mailed under the indicia of each.

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Introduction

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This bulletin contains the papers from a symposium in February 1997 at the 50th annual meeting of the Society for Range Management, in Rapid City, SD. The symposium provided a venue for discussing the pros and cons of using utilization estimates as the primary source of information for managing grazing lands, particularly indigenous rangelands. The impetus was the belief of the members of the two sponsoring Western Coordinating Committees, WCC-40 (Rangeland Ecological Research and Assessment) and WCC-55 (Rangeland Resource Economics and Policy), that utilization estimates often are used incorrectly in making rangeland management decisions. Although the committees believe that utilization estimates can serve as important information on which rangeland management strategies and tactics can be based, we believe such estimates often are either inaccurate or easily misconstrued and misused.

The symposium examined both the technical and social aspects of utilization estimates as they relate to how such estimates should be made, interpreted, and used. The potential impact that utilization-based management strategies can have on livestock-dominated grazing economies was also explored. To accomplish this, the two committees invited a group of distinguished rangeland scientists and agricultural economists to present papers. After the symposium, the authors prepared written papers based on their presentations. The papers were then peer-reviewed and revised under the direction of the WCC-40 administrative advisor, Jim Jacobs.

Ken Sanders helps set the stage by reviewing the historical use of utilization estimates as a rangeland management tool. He reminds us that the current emphasis on using utilization estimates as the primary tool for making grazing management decisions is not new; history does repeat itself. Lamar Smith's paper examines how, when, and where utilization estimates should be made, with emphasis on the inherent risks of improperly using the tool. Bill Laycock focuses attention on the possible errors due to methods, observer difference, and time. These can lead to inappropriate use or interpretation of utilization estimates. He provides evidence of the risk associated with use of utilization as the primary variable for making management decisions.

Allen Rasmussen's paper provides a detailed analysis of the relationship between utilization and rangeland trend data. He shows that utilization estimates are not strongly correlated with ecological trend data which, in turn, emphasizes the need to include a wide array of ecological response data when developing rangeland management strategies. Quentin Skinner outlines the relationship between stubble height and function of riparian communities. He also reviews some of the fundamental relationships between vegetation stubble height and stream-channel dynamics, erosion and sediment deposition, plant growth dynamics, and ecological succession. He provides examples of the ecological risk associated with inappropriate utilization or stubble height standards.

The potential economic impacts of changes in grazing AUMs from federal land are examined in the papers by Larry Van Tassel and Bob Fletcher. Van Tassel examines the impact on individual enterprises; Fletcher focuses on regional impacts. Both demonstrate the devastating effect that erroneous and inappropriate use of utilization estimates can have on the economic well-being of rangeland agriculturists (i.e., ranchers) and associated business support enterprises. Fred Hall's paper outlines management steps to enable the USDA Forest

Service to more effectively set and achieve rangeland resource management objectives. He emphasizes the need to monitor management tactics and associated response variables using quantitative, sensitive, and repeatable methods. Utilization estimates are but one of many such measures.

The final paper, by Bill Krueger, summarizes and emphasizes that utilization estimates should be one part of a many-faceted monitoring program rather than an objective in themselves. Utilization is a tool to achieve management goals and should never be a management goal *per se*. Krueger advocates adopting management strategies that are both ecologically and economically sound and that lend themselves to quality monitoring programs designed to provide managers with accurate information to assure that goals and objectives are continually met.

Utilization Standards: The Quandary Revisited

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Abstract

It has often been said that history repeats itself. That is certainly the case with the current quandary over the use of utilization standards by many land management agencies. In the early part of this century, range managers encouraged the use of rotational grazing to maintain a satisfactory forage crop, with little concern for degree of use. From 1926 through the 1940s, considerable emphasis was placed on formulating utilization standards and proper use.

At the same time the concepts of range condition and trend were being developed. In the early 1950s, scientists began questioning the emphasis on utilization and urged the agencies to monitor range trend instead. In the past 10 years, with the heightened concern over riparian areas, some agencies have again returned to utilization as their primary —and, many times, their only—monitoring tool. Once again the use of utilization standards is being questioned. Utilization data, in conjunction with range trend data and information on weather, other uses, and past management actions, can help land managers interpret the cause of range trend. But utilization data alone do not provide adequate information to determine whether management actions are meeting management objectives.

Historical Perspective

History often repeats itself, especially if we do not occasionally review it. The current debate on the meaning and use of utilization measurements is a case in point. In an article titled "The Quandary of Utilization and Preference," Cook and Stoddart (1953) questioned the emphasis land management agencies were placing on utilization estimates. Current events suggest it is time to revisit this quandary, hence the title of this article.

Through the first couple of decades of this century, rotational grazing systems were advocated for managing western rangelands (Smith 1895, Sampson 1913). Jardine and Anderson (1919) also advocated deferred grazing for both cattle and sheep using national forests.

A later report by Sampson and Malmsten (1926) stressed the importance of intensity and frequency of grazing that might be allowed in order to maintain or improve plant cover and forage production. This report was interpreted as conflicting with Sampson's earlier support of specialized grazing systems. It led to the U.S. Forest Service's placing management emphasis on grazing intensity, rather than on systems, for the next two decades.

Campbell (1937) stated, "When continued productivity or gradual death of a good forage grass may depend upon a difference in foliage removal of as little as 10 percent, a more accurate measurement of utilization is necessary." He reported that the U.S. Forest Service was initiating a major research effort on utilization standards and proper use in cooperation with many state experiment stations. Proper use became the standard with which current utilization was compared. Proper-use guidelines for individual species were prepared by interagency committees for particular areas or regions, by season of use and by kind of livestock. These guidelines were based on experienced judgment and research available at that time and were arrived at by discussion and compromise. Unfortunately,

This paper is issued as Contribution Number 830 of the Idaho Forest, Wildlife and Range Experiment Station, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID 83844-1135. It is dedicated to the memory of Dr. Lee A. Sharp, who long advocated using long-term trends rather than utilization estimates to monitor rangelands.

over the years these estimates of proper use became sanctified as absolute numbers.

Campbell (1943) recognized the complexity of attempting to identify proper use standards. He stated that proper use of a species depended on "several stages of plant succession, considerable differences between species as to the relish with which they are eaten by livestock at different seasons, resistance to grazing, and processes of growth, maintenance and reproduction." But in spite of this complexity, Campbell went on to say the strategy of the cooperative studies was to formulate the results of previous and contemporary studies "...into simple, readily applicable facts for use by busy range administrators and managers." Thus began the syndrome of trying to oversimplify a complex subject, a syndrome that continues today (Sharp et al. 1994).

Regardless of whether one agrees with the emphasis that scientists and land managers placed on utilization and proper use in the 1930s and 1940s, there is no question that the research effort was very fruitful. It provided a stimulus for range research throughout the West by the U.S. Forest Service, land-grant universities, and other agencies (Division of Range Research 1944). Along with passage of the Taylor Grazing Act and formation of the Soil Conservation Service in the early 1930s, this stimulus for range research and the agencies' needs for range-trained personnel had much to do with the start-up of academic programs in range management at the various land-grant universities. Also in this period, the concepts of range condition and range trend were being developed. The range research literature of the period is a virtual who's who of the founders and early leaders of the Society for Range Management.

By the 1950s, range scientists began to question the emphasis that management agencies were placing on utilization and proper use. While pointing out the problems in estimating grazing capacity, Stoddart (1952) declared that "nothing but ecological knowledge plus range-managing experience will suffice to determine a standard utilization. No accurate method of grazing capacity determination has yet been devised which does not rely upon experience founded upon comparable range of proved grazing capacity." Cook and Stoddart (1953) added, "...if management is based upon the ecological principles considered in range condition and range trend analyses, it is not necessary for the rancher or land administrator to make precise determinations of percent utilization for individual forage species."

Although Hedrick (1958) supported the importance of proper use, he thoroughly reviewed the problems in determining what proper use is. One of his more interesting points is that grazing is generally not as damaging to the physiology of plants as clipping; however, most utilization standards are based on clipping studies. Blaisdell (1966) indicated that preoccupation with exact measurement of herbage utilization seemed to have retarded progress in grazing research and management. But even as these questions were being raised, Sharp (1971) pointed out that "rules of thumb" and simple guides, such as utilization standards, were still being used as a substitute for management guided by ecological monitoring.

Despite all of the early writings on the benefits of rotation grazing, until the 1960s most grazing on public lands consisted of season-long use (Sharp 1971). Both the Forest Service and later the Grazing Service/Bureau of Land Management emphasized inventorying the forage resource in order to balance animal numbers with resource capacities. The need for the inventory, together with limited manpower and funds for range improvements, were probably the principal factors in slowing implementation of grazing systems.

After Hormay and Talbot (1961) published their report, "Rest-Rotation Grazing—A New Management System for Perennial Bunchgrass Ranges," Gus Hormay started conducting schools on rest-rotation grazing, winning many converts as he questioned the need to be concerned about degree of utilization. Hormay (1970) questioned the proper-use "philosophy" and characterized as unrealistic the assumption that plants can be grazed to a proper level by regulating stocking. In addition, the existing proper use standards were predicated on the premise that the foliage would be removed annually at some given level, which made these standards inappropriate for rest-rotation grazing systems. Interest in developing and implementing grazing systems began to grow.

In my opinion, progress in grazing management and grazing systems has been impeded by legislation that places tremendous time demands on federal and state range managers. Beginning with the National Environmental Policy Act in 1969 and continuing today, range conservationists must spend too much of their time at their desks complying with a myriad of conflicting environmental regulations, rather than out on the ground applying the art and science of range management. A result is that land management agencies again place more emphasis on utilization standards than on grazing management (Sharp et al. 1994, Burkhardt 1997, McKinney 1997).

In a 1993 analysis of utilization monitoring in Nevada and elsewhere, Resource Concepts, Inc. (unpublished report) reported that the large majority of allotment evaluations and decisions they had reviewed relied exclusively on short-term monitoring data (i.e., actual use and utilization levels) as the sole determinant and justification for long-term livestock management decisions to adjust stocking rates. I, as well as others, have had similar experiences. Following a meeting of western range consultants in Jackson, WY in 1993 to discuss the problem, Lee Sharp was encouraged to dust off a paper he had presented in 1971, update it, and publish it in *Rangelands*. The resulting article (Sharp et al. 1994) is the basis of much of this paper.

Utilization as Management Tool, Not as an Objective

When used as just one of many management tools, utilization data can provide useful information. Utilization mapping is a very useful tool to assess livestock distribution. I feel strongly that today there are very few U.S. Forest Service or Bureau of Land Management allotments where stocking rate is a problem. But there are many allotments where livestock distribution, season of use, and/or an inappropriate grazing system *are* a problem. I also think it is safe to say that most of our riparian grazing problems are related to poor distribution in the pasture. So, by all means, agency personnel should do utilization mapping. But it should be done with the permittee(s) and simply mapped as no use, light, moderate, heavy, or very heavy use. Do not pretend greater accuracy by expressing use as a number or percentage. If there is a distribution problem, then figure out how to solve the problem, and remember that a reduction in livestock numbers is not likely to solve a distribution problem.

Utilization data, in conjunction with good range trend data and other information on weather, insects, wildlife use, and past management actions can help range managers interpret the cause of range trend. But utilization data alone do not provide adequate information to determine whether management actions are meeting management objectives. As pointed out by Sharp et al. (1994), time spent estimating utilization could be better spent taking photographs of the range at various times of the year. Photos will not only indicate utilization but also range trend.

With increased emphasis on riparian management and monitoring, utilization standards are once again receiving increased attention. And once again, some resource managers are using a management tool as a management objective.

Allowable use levels make poor and inconclusive allotment and riparian objectives because they provide no information by themselves on whether desired long-term conditions are being met. Surely everyone can agree that a given level of utilization on riparian areas is not the real objective but rather a tool to help achieve an objective such as improved plant vigor, more stable streambanks, or more desirable plant species composition. Once the objective is identified, a monitoring plan can be developed to gauge whether the objective is being achieved.

Although I believe that the emphasis on monitoring riparian areas should be on long-term trend, I think stubble height is a more useful measure than percent utilization. However, some permittees are more nervous about stubble height than percent utilization standards because permittees fear that "cow cops" will be more likely to monitor stubble height than utilization. When used properly, stubble height can be a helpful tool for managing livestock use (Hall and Bryant 1995).

Concerns about Utilization Standards

Much early research on utilization was to develop an accurate method of measurement. But how can anyone "measure" what is not there? All methods of determining utilization are estimates, some more accurate than others. All methods also are time-consuming;, thus, it is very difficult to adequately sample the heterogeneous mix of species and range sites found in most pastures or allotments. Should important management decisions, which may affect the livelihood of one or more families, be made on information so limited and of such questionable accuracy as utilization data?

Another concern about the accuracy and use of utilization data is that often the personnel using the methods are inadequately trained. One of the more common methods, ocular estimate by plot, requires intensive clipping and weighing during the training period and then periodic clipping and weighing in estimated plots to provide a correction factor. It is doubtful that most field personnel using this method conduct the time-consuming training and corrections necessary to accurately estimate utilization.

Most utilization estimates are based either on peak standing crop or on current-year production to date, the latter of which results in overestimating utilization. The Society for Range Management (1989) defines utilization as the proportion of the current year's forage production that is consumed or destroyed by grazing animals. It may refer to a single plant species or to the vegetation as a whole.

In an excellent discussion of utilization, Frost et al. (1994) pointed out that a strict interpretation of this definition means that the current annual aboveground net primary production must be known, which it seldom is. They also pointed out that most utilization studies use peak standing crop as an estimate of current-year production, which is always less than total production. This results in a built-in bias for overestimating utilization. In reality, many utilization estimates are based on current year's production to date, which usually results in an even greater overestimation.

Sharp et al. (1994) compared three studies to illustrate how utilization may be overestimated. Utilization of crested wheatgrass in studies in Utah and New Mexico were calculated on the basis of caged plants, whereas use in an Idaho study was calculated on the basis of total annual growth. Fifty-percent use in the Idaho study probably meant 15 to 20% more herbage removed than at the same indicated use level in the two other studies. Thus, when each investigator recommended 65% use on crested wheatgrass, one actually was recommending a substantially higher grazing intensity than the others. Frost et al. (1994) cited the example of a study in Arizona where De Muth (1990) clipped sideoats grama to simulate moderate and heavy grazing. Relative utilization (i.e., utilization of current year's growth to date) in April was 17% in the moderate and 49% in the heavy intensity. Actual utilization (i.e., utilization in relation to peak standing crop) was 6 and 17%, nearly one-third less than the relative utilization estimates. Measurements of relative utilization should not be compared with proper use standards derived from measurements of actual utilization.

In a 1993 review of utilization monitoring, Resource Concepts, Inc. (unpublished report) listed several other problems with how utilization monitoring was being conducted and analyzed. In many instances, riparian or other areas of animal concentration were used as key areas for monitoring utilization on the allotment. By definition, areas of animal concentration or otherwise sensitive resources are termed critical management areas, not key areas. Monitoring critical areas may be appropriate to meet specific management objectives, but a critical area should not be used as a key area to determine grazing effects across the entire pasture or allotment. Resource Concepts also questioned the use of visual aids, such as the visibility of golf and tennis balls, to estimate utilization classes on plots rather basing utilization on percent use by dry weight. The visibility of such aids is affected by plant density as much as the vegetation height on a plot. The method also does not account for the variability in annual forage production.

Heady (1949) discussed various methods of determining utilization and pointed out that the real problem is not the method used but rather the interpretation of the data. Hedrick (1958) also supports this conclusion. Caldwell (1984) stated, "Employment of proper use schemes as an integral component of forage allocation should be done with considerable reservation. If taken at face value, these factors imply a level of precision and understanding of plants and community dynamics that for the most part do not exist. While these factors might provide some guidelines for appropriate forage utilization, the numerical values may create an impression of more precision than is warranted."

Conclusions and Recommendations

Rules of thumb and simplistic guides, such as utilization standards, are not an acceptable substitute for experienced, on-the-ground management based on sound, long-term range trend information. As stated by Sharp et al. (1994), using utilization data to adjust management programs, particularly with a simple mathematical formula, is an oversimplification of resource management. And as Costello (1957) noted, oversimplification leads to poor interpretation, and poor interpretation leads to poor management.

Instead of relying on utilization standards, I recommend range managers make sure their goals and objectives are written to reflect what they want to happen to the resource. Do not use utilization standards as goals or objectives. Place monitoring emphasis on long-term trend, on both uplands and riparian areas. Permanent trend photo plots are much faster and easier to take than trying to estimate utilization and will provide a permanent record of not only trend but also use. Consider utilization and stubble height information as management tools rather than as the only bases for grazing decisions. Ranchers should take the initiative to suggest management options to correct unsatisfactory conditions that may be due to livestock grazing, such as poor distribution or inappropriate season of use.

In closing, I urge every professional range scientist and manager not to allow utilization standards to take precedence over the more important job of on-the-ground range management, based on monitoring long-term trend.

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Seasonal Effects on the Measurement and Interpretation of Utilization

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Abstract

Seasonal effects on measuring utilization, interpreting "proper use," and estimating carrying capacity are examined. Utilization is defined as the proportion of the current year's forage production that is removed or damaged by grazing animals. Peak standing crop is the best one-time estimate of current year's biomass production. Proportion of biomass removed to standing crop measured at any other time is not utilization but instead should be called relative or seasonal utilization.

Appropriate use levels (such as take half, leave half) should be developed for the phenological stage in which grazing takes place. Utilization standards, consistent with the accepted definition of utilization, should not be applied to relative utilization. Utilization of individual plants has little or no relevance to the subsequent growth or reproduction of the plant unless the phenological stage when use occurs is specified. Utilization should not be used to adjust stocking rates unless combined with other types of data because the fundamental assumptions for the use of utilization on key species are not met if plant growing conditions change within a grazing period.

Objectives

The objectives of this paper are to examine three questions.

1) How does season of the year affect the measurement of utilization?
2) How does season of the year affect the interpretation of "proper use"?
3) How does season of the year affect the validity of estimating "proper" stocking rates from utilization data?

Background

Cattle and sheep ranchers have always been well acquainted with the concept of utilization. Their informal estimates of the forage used—or, more likely, the amount remaining—told them when they would have to move, feed, or adjust the numbers of livestock. Traditionally, ranchers looked at utilization from the animals' point of view, not from the standpoint of the plants' welfare.

Early forest rangers recognized that some plant material must be left on desirable forage species if the plants were to be maintained on the range. Their estimates of "proper use" were usually around 80 to 85% removal of the forage available from the better plants (Stoddart and Smith 1955). The concept of "proper use factors" was developed about 1910 as part of the ocular reconnaissance method of range inventory. Utilization levels were based on ocular estimates. In the 1930s, quantitative methods were developed to measure utilization on individual plants (e.g., see Lommasson and Jensen 1938, Crafts 1938, Pechanec and Pickford 1937) and qualitative methods for inventory of utilization patterns (e.g., Deming 1939).

Experience and research during the 1930s, 1940s, and 1950s also changed, to a more conservative level, the perception of what constituted "proper use" of individuals forage plants. Crider's classic study (1955) and numerous other studies of defoliation effects on carbohydrate reserves, root growth, and biomass production resulted in the general "take half, leave half" rule of thumb still prevalent in range management.

The concepts of utilization and proper use, as well as the methods used to measure utilization, were developed mainly by Forest Service personnel before 1950. Most Forest Service rangelands, except perhaps in the Southwest Region, are characterized by spring–summer growing seasons and summer grazing seasons. Also, most studies of defoliation effects are based on clipping plants to various degrees and at various frequencies during the growing season. Thus, both the methodology and the interpretations were based mainly on season-long grazing which coincided more or less with the growing season. In this situation, use of utilization data to adjust livestock stocking rates worked reasonably well; but on year-long ranges or rotational grazing systems, both measurement and interpretation became more complex.

What Is Utilization?

The Society for Range Management defines utilization as "the proportion of current year's forage that is consumed or destroyed by grazing animals" (Glossary Revision Special Committee 1989). This definition is widely accepted by all range management agencies (Interagency Technical Reference 1996). Utilization (or use) commonly is said to apply to single plant species, groups of species, or to the vegetation as a whole.

The preceding statement may be a point of confusion. Stoddart and Smith (1955, p.138) state:

> Utilization of a range means the degree to which animals have consumed the usable forage production expressed in percentage. This production should be based on animal-months consumed compared to animal-months available when the range is correctly used.
>
> When dealing with an individual plant, however, utilization has a different usage and is defined as the degree to which animals have consumed the total current herbage production expressed in percentage. These two usages are confusing and will require clarification whenever the term is used. It is suggested that range use might be a better term for the first meaning and percentage utilization better for the second meaning.

The current definition is generally applied to both concepts presented by Stoddart and Smith without the clarification they recommended. "Range use" is defined in terms of available forage and therefore is related to proper grazing use of the range as a whole. "Utilization" relates only to use of individual plants and has no necessary relation to proper stocking rate or carrying capacity.

Some have suggested that it is more important, and more straightforward, to measure the amount of residual vegetation (stubble height or biomass) than the percentage removed (e.g., Hyder 1954). They argue that it is the amount of residual biomass that is important to the plant's ability to recover or to the amount of soil protection provided. Removal of a certain percentage of annual forage production would result in greatly different amounts of both forage removed and residual vegetation left because production varies greatly from year to year. Emphasis on residual vegetation has increased due to the interest in leaving residual vegetation for wildlife cover, soil cover, and sediment trapping on floodplains. However, measurement and interpretation of residual biomass suffers from some of the same difficulties as utilization measurement.

Purpose of Measuring Utilization

The new Interagency Technical Manual on Utilization Studies and Residual Measurements (1996) states, "Residual measurements and utilization data can be used: (1) to identify use patterns; (2) to help establish cause-and-effect interpretations of range trend data; and (3) to aid in adjusting stocking rates when combined with other monitoring data."

Most range professionals would agree with those uses of utilization data. However, the federal land management agencies increasingly have been using utilization data alone to estimate carrying capacity and to establish standards for allowable range use within single grazing seasons. This is not consistent with acceptable range management principles. For example, Stoddart and Smith (1955) discussed a number of methods of estimating percentage utilization of individual species and the Deming method of evaluating overall level of range use. They concluded the discussion with the following statement:

> It should be emphasized that, of the methods discussed here, only the latter (the Deming method) gives its answer directly in terms of correctness of range use. The other methods all

are aimed at determining percentage utilization of a single species or a group of species presumed to be the most important forage species. The resulting percentage tells nothing as to whether the range is underused, overused, or correctly used. Since for virtually no species do we know what percentage utilization is correct (i.e., what the plant can endure), the value of these percentages is limited to general interpretation or to comparisons of one range with another, or of one year with another. Utilization determination is not an exact science either in method or interpretation.

Although that statement was made in 1955 and we have learned a lot about plants' physiological responses to herbivory since then, the statement is still true. The "correct" level of utilization depends not only on the species (or even the ecotype) of plant but also on such variables as site, weather, time and environmental conditions since the last defoliation, kind and level of utilization of associated species, and the phenological development of the plant.

Seasonal Effects on Measurement of Utilization

By definition, measuring utilization requires knowing the total production for the year for the species in question. This requirement makes a *true* measurement of utilization virtually impossible under management conditions. Total yearly production cannot be measured at one time. The best that can be done in a one-time effort is to estimate peak standing crop of current-year production which usually occurs near the end of the growing season. Peak standing crop is always less than total production because herbage is continually lost even during the growing season. Measurement before the point of peak standing crop results in an even lower estimate of total biomass because annual production has not been completed. Measurement after peak standing crop is reached also results in lower values because biomass is lost to weathering, insects, and decay. However, peak standing crop is the best estimate of total production that can be made in a single measurement, and it is the value that most accepted utilization measurement techniques take for "total" production. Using ungrazed peak standing crop to estimate total annual production assumes that grazing during the growing season does not increase total production.

Measuring utilization by the SRM definition requires measuring production at the end of the *growing season,* while utilization should be measured at the end of the *grazing season.* It often is not feasible or practical to do this, as the following examples show.

Example 1. Continuous grazing during the growing season. Both production and utilization would be measured at the same time, i.e., at the end of the grazing season and at the end of the growing season. In this case, utilization can be estimated reasonably if regrowth is ignored. The concept of utilization and most of the utilization standards are best suited to this situation.

Example 2. Continuous grazing during the dormant season. In this case, production and utilization cannot be measured at the same time. Utilization standards developed for growing-season use may not apply for dormant-season use.

Example 3. Continuous, year-long grazing. Utilization most logically would be measured at the end of the dormant season for vegetation, but production cannot be measured reliably at this time.

Example 4. Rotational grazing. There are many possible rotational grazing situations. Short grazing periods during the growing season mean animals are removed from a pasture before growth is complete. Thus, as noted previously, utilization and production cannot be measured at the same time. In some rest-rotation situations, forage utilized may represent growth from two different growing seasons, which makes the concept of utilization even more difficult to apply. Some form of rotational grazing is practiced on most rangeland today.

Recognition that utilization, as defined by SRM, cannot be measured under these conditions has led to the use of other terms such as "relative use" (Frost, Smith, and Ogden 1994) or "seasonal use" (Interagency Technical Reference 1996) to describe a comparison of grazed versus ungrazed plants at any time of year, recognizing that the difference does not represent "utilization." Difficulty in measuring and interpreting utilization has also led to more emphasis on residual vegetation measurements, e.g., stubble height or residual biomass, which are less affected by seasonal considerations.

"Relative use" (or seasonal use) measured during the growing season is always a higher percentage than "utilization" expressed by the standard definition. The amount of herbage removed is the same in both cases, but the ungrazed amount against which use is measured is always less for relative use than for utilization.

To illustrate this point, Table 1 shows data calculated from Ganskopp's clipping study (1988) on Thurber needlegrass. Plants were clipped at various phenological stages during the growth period. Relative use was calculated from the mg/cm^2 removed at each date as a percentage of standing crop on that date. Utilization was expressed as herbage removed as a percentage of total unclipped production at seed shatter on July 17. Utilization and relative use are equal at the time of peak standing crop (hard seed/seed shatter stage). Residual herbage was estimated as 10 mg/cm^2 for all clipping dates.

In 1985, relative use increased from 80% in the vegetative stage to 96% at the time of hard seed/seed shatter. Utilization ranged from 17% in the vegetative stage to 96% at the hard seed stage. In 1986, growing conditions later in the season were more favorable than in 1985. Consequently, both relative use and utilization are lower in the earlier phenological stages than in 1985. Relative use increased from 60 to 96% during the growing season. Utilization on the earliest clipping date was only 7% of total annual production and increased to 96% at seed shatter. Some regrowth occurred after the final clipping in 1986, but this was ignored in my calculations.

Table 1 shows the relationship of utilization to relative use during the growing season. Utilization

Table 1. Effect of clipping at various phenological stages on subsequent growth of Thurber needlegrass (Ganskopp 1988).

	Phenological stage						
Utilization/ growth	Preboot (%)	Early boot (%)	Late boot (%)	Anthesis (%)	Soft dough (%)	Hard seed (%)	Seed shatter (%)
1985							
Relative use[1]	80	84	92	93	94	96	96
Utilization[2]	17	27	48	53	71	94	96
Total production[3]	51	37	71	71	73	97	100
Top growth[4]	78	53	53	80	89	95	100
Roots[5]	70	55	70	93	94	95	100
1986							
Relative use	60	70	82	92	94	96	96
Utilization	7	10	20	51	69	96	96
Total production	61	54	71	86	79	100	88
Top growth	63	50	72	91	93	100	98
Roots	68	61	68	87	84	100	93

[1] Relative use is biomass removed/total production to date.

[2] Utilization is biomass removed/total production at last clipping date.

[3] Total production is preclip + postclip production for the year.

[4] Top growth is aboveground production in the year after treatment.

[5] Roots is root biomass in year after treatment.

cannot be predicted from relative use measured during the growing season because we cannot predict the amount of growth that will occur after relative use is measured. For this reason, it is not feasible to measure relative use during the growing season and adjust the resulting value to some standard utilization target.

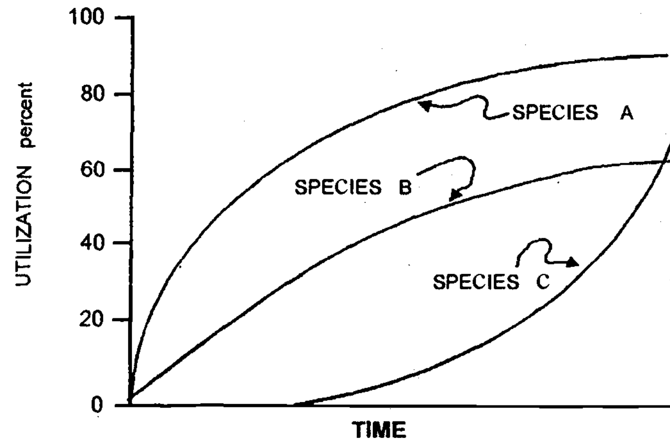

Figure 1. Theoretical relationship of utilization on key species as a function of time (from Smith 1965).

Seasonal Effects on Interpretation of Proper Use

Proper use is "a degree and time of use of current year's growth which, if continued, will either maintain or improve the range condition consistent with conservation of other natural resources" (Glossary Revision Committee 1989). This definition refers to the range as a whole.

A proper use factor (PUF) is "an index to the grazing use that may be made of forage species based on a system of range management that will maintain the economically important forage species, or achieve other management objectives...." The PUF for a key species typically represents the amount of utilization a plant can receive and still maintain or improve its productivity and reproduction. It is, therefore, related to the physiological and morphological ability of the species to withstand grazing.

PUFs for associated species are a measure of relative *preference* of those species compared to the key species. PUFs are influenced by kind of grazing animal, season of the year, frequency of grazing, vegetation type, site conditions, and management objectives.

Utilization standards (or PUFs) for key species typically are derived from studies of effects of clipping or grazing during mid to late growing season. Such studies (e.g., Crider 1955) are mainly responsible for the "take half, leave half" standard widely applied in range management. However, such studies cannot be applied for utilization standards during other seasons of the year, nor do they usually account for frequency of grazing. In addition, an average utilization of 50% on a key species may result in widely varying amounts of utilization on each individual plant due to the way many animals graze. Finally, PUFs based on the physiological and/or morphological tolerance to grazing of key species and relative preference of other species have no direct relevance to other management concerns such as adequate soil cover, residual cover for nesting birds, or stubble height requirements for sediment capture.

Ganskopp's study (1988) again can be used as an example of the effects of season, or phenological stage, "proper use" levels. Table 1 shows that clipping Thurber needlegrass to a 2.5-cm stubble height in anthesis or a later growth stage had little effect on total annual production, nor did it have much effect on total root weight or top growth the next year. Clipping during early or late boot stage did reduce annual production and root weight and top growth the next year. Clipping in the preboot stage was somewhat less prejudicial. These results were fairly consistent in 2 consecutive years even though the growth pattern between the years was quite different.

Clipping at anthesis resulted in about 50% *utilization* by weight. Clipping at later phenological stages ranged up to 96% by weight. Thus, clipping to 50% or more had little or no effect, while utilization of 7 to 50% earlier in the year did reduce subsequent plant growth. (These are short-term effects and do not necessarily indicate that late-season clipping rates could be maintained if clipped for several years in succession.) *Relative use* was 60% or more at every stage of growth, but the amount of relative use was not correlated with effects on subsequent plant growth. Thus, relative use appears to have little value as a "utilization" standard, and because subsequent growth varies from year to year, relative use cannot be used reliably to predict utilization values.

It may be argued that residual measurements (stubble height) would avoid many problems in measuring utilization. From the standpoint of the individual plant, that may not be true. In Ganskopp's (1988) study, residual weight was the same for all clipping treatments, but effects varied considerably among phenological stages. Thus, in this case, a standard residual stubble height or biomass could not be applied without considering phenological stage.

Although residual stubble height or biomass is important for the welfare of the individual plant, most current uses of this approach seem to be based on other factors, e.g., residual cover for wildlife or residual height for sediment accumulation. Such "standards" need to be justified by showing relationships of residual vegetation to the factor of interest. They cannot be justified based on clipping studies which show effects of residual amounts on the physiological response of the individual plant.

Seasonal Effects on Estimation of Proper Stocking Rates

Range scientists and the new Interagency Technical Reference (1996) agree that utilization should not be used to establish proper stocking rates unless supported by other monitoring data. However, both the Bureau of Land Management and the Forest Service currently use utilization data as a basis for adjusting livestock numbers and for removing livestock when certain utilization or residual levels are reached. Therefore, it is important to consider seasonal effects on the estimation of livestock's proper range use. The distinction between range use and utilization, mentioned earlier, is important in this regard.

Using utilization on key species to estimate proper stocking levels implies there is a known relation

Table 2. Cattle diet composition percentages by phenological seasons at the Santa Rita Experimental Range, AZ (Smith, Ogden, and Gomes 1993).

	Season[1]			
Plant species	Summer	Winter	Early spring	Dry spring
Grasses	78.2	40.0	38.5	58.3
Aristida spp.	9.8	7.0	3.8	1.1
Bouteloua spp.	14.2	7.6	16.5	13.2
Botriochloa barbinodes	4.3	1.3	0.3	0.2
Eragrostis lehmanniana	5.1	2.2	9.4	3.5
Heteropogon contortus	27.2	2.5	0.2	0.6
Muhlenbergia porteri	4.6	15.3	4.8	26.5
Sporobolus spp.	7.6	0.6	1.3	1.4
Others	5.4	3.5	2.2	11.8
Shrubs	7.9	58.7	28.3	41.4
Atriplex spp.	-	-	-	1.3
Opuntia spp.	4.5	42.4	23.6	25.5
Prosopis juliflora	2.3	10.9	1.6	14.0
Others	1.1	5.4	3.1	0.6
Forbs	13.9	1.3	33.2	0.3

[1] Seasons, assigned according to plant phenology, roughly correspond to: summer = July–October; winter = November–January; spring = February–March; and dry spring = April–June.

between such utilization and the total AUMs of forage removed from a pasture. Smith (1965) discussed the use of PUFs on key species to estimate stocking rates. He stated that the key-species concept implies a unique relationship between the percentage utilization of the key species and the utilization of the other important forage species. Further, the key species must be used gradually and continually throughout the grazing season with no sudden or marked changes in utilization.

Figure 1 shows acceptable and unacceptable patterns of seasonal use on key species. Smith (1965) concluded that, under most levels of utilization, these conditions probably were met sufficiently to allow carrying capacity estimates to be made. That conclusion may be justified under some conditions, e.g., if grazing use is confined to only a short time or entirely to one growth period. However, if longer grazing seasons are used, or if grazing periods overlap two or more growth phases of plants, the conclusion seems highly doubtful.

I did not find any studies showing changes in utilization on different species as a function of time of grazing. But, seasonal diet studies are fairly common. For example, Table 2 shows diet composition of cattle in four seasons of the year at the Santa Rita Experimental Range in southern Arizona. Percentages of shrubs, grasses, and forbs vary markedly by season. Percentages of the diet made up by different major forage species also vary by season. The assumption that use of key species is continuous throughout the grazing period and has a consistent relation to use of other species clearly is not met if grazing is through more than one season.

Conclusions

1. Utilization by accepted definitions cannot be measured under most practical grazing management situations, especially when grazing is not coincident with the growing season.

2. Relative or seasonal use can be measured whenever livestock are removed from a pasture, but utilization standards developed from studies using the standard definition cannot be applied.

3. Utilization of individual species has little or no relevance to the subsequent growth or reproduction of the plant unless the phenological stage of growth when use occurs is specified. Timing of use has more impact than amount of use as far as the physiology of the plant is concerned.

4. Utilization should not be used to adjust stocking unless combined with other data. The fundamental assumptions of the use of utilization on key species to estimate total forage removed are not met if grazing periods extend into different growing conditions.

5. Utilization standards for key species that are based on the grazing tolerance of the plant have no direct relevance to standards of utilization or residual vegetation aimed at wildlife or soil cover, sediment capture, or other nongrazing effects.

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Variation in Utilization Estimates Caused by Differences among Methods, Years, and Observers

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Abstract

A number of characteristics make utilization estimates inexact and unreliable. Errors and differences in estimates of utilization can be significant depending on methods, areas measured, observers, and years. Rather large differences in utilization estimates can be obtained from different methods. Both the ocular estimate by plot and the caged/open clipped plot methods appear to overestimate utilization. In a given area, year-to-year variation in utilization can be quite large. Grazing by herbivores is never uniform which leads to a great deal of variation in utilization from one plot to another or from one area to another within a given grazing season. Utilization estimates can vary considerably among observers, even those receiving intensive training. Vegetation under cages has been shown to produce as much as 30% more than uncaged areas, mainly because of environmental conditions under the cage. Utilization is a tool, not a land management objective, and should never be used as an objective or used to set or adjust stocking rates without measuring trends. Utilization should be measured only at the end of the growing season.

Introduction

A number of characteristics make utilization an inexact and often unreliable indicator of the amount of actual use and, more important, the significance of a given level of measured utilization to the health of a plant or of the rangeland. I will describe briefly the differences that occur in the measurement of utilization among methods, plots or areas, years, and observers. I also will describe some of the environmental and other factors that may influence the difference between caged and uncaged areas other than removal of foliage by grazing. Because of these and other factors pointed out by other authors in this symposium, utilization should be used as only one tool in managing rangelands, and it should not be the primary factor in determining stocking rates.

Differences among Methods

The earliest comparison of methods of determining utilization was that of Pechanec and Pickford (1937). The trial used bluebunch wheatgrass *(Agropyron spicatum)* on a sagebrush–grass rangeland at Dubois, ID. The authors experimentally removed a prescribed amount of foliage from bluebunch wheatgrass plants on 100 plots 5 x 5 feet in size. Three observers then independently estimated amount of utilization using four different methods. Two of the observers were experienced in the methods compared, and one was not.

The ocular estimate by plot, ocular estimate of plants by plot, and the leaf length methods yielded somewhat similar results; however, all but the ocular estimate of plants by plot overestimated actual utilization (Table 1). Average utilization was estimated at 44%, 38%, and 43% respectively for these three methods (actual clipped utilization was 37%).

For the plant-count method, Pechanec and Pickford (1937) counted grazed and ungrazed plants, and the percentage of plants grazed (54%) was considered equivalent to percentage removal by weight. This resulted in an inherent bias because the method assumed utilization at 54% instead of the actual 37%. In addition, the average of the three observers yielded estimates of 68% utilization, a considerable overestimate of the actual 37% removal. The differences among observers will be discussed below.

In contrast to Pechanec and Pickford's (1937) results, Springfield (1961) found that the grazed-plant method gave similar estimates of utilization as the "difference" method for crested wheatgrass *(Agropyron desertorum)* in northern New Mexico. Grazed and ungrazed plants were counted on plots, and the difference in weight was measured between caged and uncaged areas.

On a tall forb community grazed by sheep in southwest Montana, Laycock, Buchanan, and Krueger (1972) tested three methods of determining utilization: caged and open plots clipped after grazing, ocular estimate by plot, and botanical composition of esophageal fistula samples converted to percentage of each species in the plant community the sheep grazed.

Twenty pairs of caged/uncaged plots, each 4.8 square feet, were clipped immediately after sheep grazing, 10 pairs in each of two pastures grazed in early, middle, and late summer. Only data from the early summer trial are presented.

Before clipping the plots, two observers estimated the percentage utilization by weight for each species. The observers had been trained intensively in the ocular estimate by plot method (Pechanec and Pickford 1937). Each observer estimated half the 40 plots in each pasture (a total of 80 plots, each 4.8 square feet). The percentage composition of species in the fistula samples of seven sheep, collected for 3 days during the grazing trial, was converted to percent utilization by multiplying the composition by the assumed consumption and then comparing that to the amount of each species in the caged plots.

Even though the fistula method was considered not very accurate because of rather complicated calculations, the fistula method and the ocular estimate by plot method yielded similar results (Table 2). Pechanec and Pickford (1937) indicated that the ocular estimate by plot method probably *overesti-*

Table 1. Comparison among utilization methods using three observers on bluebunch wheatgrass at Dubois, ID (Pechanec and Pickford 1937).

Method	Observer	Actual % removed	Estimated % removed	Error (%)
Ocular estimate by plot	1	37	41	+11
	2	37	44	+19
	3	37	47	+27
	Avg.	37	44	+19
Ocular estimate by plant	1	37	35	- 5
	2	37	40	+ 8
	3	37	38	+ 3
	Avg.	37	38	+ 2
Leaf length measurements	1	37	42	+14
	2	37	35	- 5
	3	37	52	+40
	Avg.	37	43	+16
Plant count (% plants grazed)	Average of three observers	54*	68	+26

* Percentage of plants grazed (54%) overestimated by 46% the actual percentage of foliage removed by weight (37%).

mates utilization. The estimated utilization of forbs and all vegetation from the paired, clipped plots was more than twice that from the two other methods and 75% higher for grasses. This unexpectedly large difference was attributed partly to "trampling" damage and other "invisible" utilization. Entire leaves of some forbs, such as yarrow *(Achillea millefolium)*, may be broken off easily by activities other than actual consumption. This is difficult to recognize when making ocular estimates. Other unknown factors may have contributed to the differences. Whatever the cause, two of the most widely used methods of determining utilization yielded very different results.

Differences among Years

Because of journals' space restrictions, most published grazing studies document only mean utilization figures. Thus, the magnitude of variation in utilization among years is seldom reported. A study on sandhill rangeland in eastern Colorado reported yearly utilization for pastures that steers grazed lightly, moderately, and heavily from May 1 to October 1 for 10 years (Sims et al. 1976). Utilization was determined using the difference between 60 to 80 caged and uncaged plots in each pasture. Utilization was reported for all major species, but only those for needle-and-thread *(Stipa comata)* are presented here as an example of yearly variations in utilization. Other species had similar variation.

Average use of needle-and-thread over the 10-year period was 26%, 60%, and 77% for the light, moderate, and heavy grazing respectively (Table 3). Under moderate grazing rate, the utilization rate over 10 years (average 60%) ranged from a low of 27% to a high of 85%. The confidence interval at the 95% level was 14%, meaning that the true mean utilization for the 10-year period was between 46 and 74%. This relatively wide confidence interval was in spite of 10 years of data. Each year, 60 to 80 pairs of caged/uncaged plots were clipped in each pasture. Smaller sample sizes of 10 or fewer plots, such as are used for utilization samples in most management situations, probably would yield much wider confidence intervals.

Many other examples of year-to-year variation exist. On cattle range in north-central Oregon,

Table 2. Early-summer percentage utilization by sheep, comparing three methods in the tall forb type, Centennial Mountains, MT (Laycock et al. 1972).

Category	Paired plots[1]	Estimated plots[2]	Fistula samples
All grass	49	28	30
Yarrow	57	1	4
Sticky geranium	23	2	1
Knotweed	43	2	25
Northwest cinquefoil	37	42	26
All forbs	39	16	16
All vegetation	40	17	17

[1] 20 pairs of caged/uncaged plots clipped after grazing (10 pairs per pasture)

[2] 80 plots using ocular-estimate by plot method (40 plots/pasture) after intensive training

Elliott (1976) reported wide variation between utilization over 2 years. Utilization in Areas I and V and for the pasture on average differed considerably between years (Table 4). In the Blue Mountains of Oregon, Clark (1996) reported similarly

Table 3. Percentage utilization of *Stipa comata* on sandhill rangeland in eastern Colorado, 1957-1966 (Sims et al. 1976).

	Stocking rate[1]					
	Light		Moderate		Heavy	
Utilization for each of 10 years	8	10	82	36	68	59
	9	52	50	73	93	71
	44	4	70	85	93	96
	34	32	60	71	87	29
	43	—	27	45	75	77
Average	26		60		77	
Range	4-52		27-85		29-96	
Years above average	5		5		4	
Stipa comata response	Increase		Slight increase		Decrease	

Grazing season was May 1-October 1 every year.

[1] Stocking rates were:
light = 10 A/steer (2.8 A/AUM or 0.35 AUM/A)
moderate = 5 A/steer (1.4 A/AUM or 0.7 AUM/A)
heavy = 3.3 A/steer (0.9 A/AUM or 1.06 AUM/A)

Table 4. Cattle utilization on rockpile improved pasture in north-central Oregon, 1974-1975 (Elliott 1976).

	Utilization (%)	
Area	1974	1975
I	8	57
II	4	7
III	5	9
IV	5	5
V	24	55
Avg.	9	27

wide variations in utilization over 2 years on both elk sedge *(Carex geyeri)* and Idaho fescue *(Festuca idahoensis)* on ranges grazed by sheep (Table 5).

Burkhardt (1996) reviewed the evolutionary history of grazing in the intermountain region and found no evidence that conservative, uniform utilization every year ever naturally existed on rangelands. He concluded that "conservative utilization limits do not appear to be part of natural herbivories such as in Africa today, the plains bison of the 1800s, or the Pleistocene megafauna. Utilization limits appear to be a human-made concept. The fossil record gives no indication of prehistoric forest rangers attempting to enforce use limits on megafauna.... Managing grazing by utilization standards or guidelines reduces range management from an applied science and an art to a policing action."

Burkhardt (1997) stated that utilization limits were developed to manage season-long grazing during the growing season every year. Burkhardt (1997) said further, "The current agency approach to grazing management is in reality a non-management scheme. By rigorous and subjective application of utilization standards, livestock grazing will be reduced to a token activity which no longer causes administrative or political headaches."

Table 5. Sheep utilization percentages on bluebunch wheatgrass rangeland in the Blue Mountains of Oregon, 1993-1994 (Clark 1996).

Utilization (%)			
Elk sedge		Idaho fescue	
1993	1994	1993	1994
18	50	11	53
7	20	11	31
2	31	5	33
1	16		
4	29	9	39

Variation among Plots or Areas

Any herbivore's utilization pattern is never uniform, unless use levels are very high. Grazing, especially light to moderate grazing, naturally is in patches (Kellner and Bosch 1992). This leads to a great deal of variation from one plot to another, especially for estimation methods using plots. This, coupled with the fact that relatively few plots usually are estimated or measured, leads to relatively high standard errors and wide confidence intervals.

The same variation caused by uneven grazing occurs in various parts of a pasture or allotment when grazed. Tables 4 and 5 show, in addition to great differences in utilization between years, that utilization among areas in the same pasture or grazing area can vary considerably within a given year.

The assumption usually is that utilization levels (usually measured on key areas) reflect the level of use on the pasture or area as a whole (see the later section on "tacky tricks"). This may or may not be true depending upon the location(s) where utilization is measured and the particular pattern of grazing in a particular year.

Thetford (1975) measured sheep utilization in the Coast Range of Oregon for 2 years in areas grazed at moderate, heavy, and "overstocked" rates. In 1973, results were as most would have predicted—the lightest utilization (64%) was in the moderately grazed area, and the heaviest utilization (86%) was in the overstocked area (Table 6). However, in 1974, the exact opposite occurred—heaviest utilization (67%) was in the moderate pasture, and the lightest utilization (37%) was in the overstocked pasture even though the same areas apparently were sampled for utilization in both years. These results also illustrate differences that occur between years, especially in the overstocked pasture.

Differences among Observers

In Pechanec and Pickford's (1937) trial, three observers tested four methods of determining

Table 6. Sheep utilization percentages in white oak/ Douglas-fir vegetation in the Coast Range of Oregon (Thetford 11975).

Grazing treatment	Intensity	Utilization (%) 1973	1974
Moderate	3.7 AU/A	64	67
Heavy	4.9 AU/A	81	59
Overstocked (6.2 AU/A)	6.2 AU/A	86	37

utilization of bluebunch wheatgrass. For the ocular estimate by plot method; the three observers estimated utilization of 44%, 47%, and 41% (Table 1). The average was 44% which overestimated the measured foliage removal (which was 37%) by 19%. The authors concluded that the method was subject to personal error, and the estimated percentage removed differed appreciably from that actually removed.

In a variation of the ocular estimate by plot method, percent removal of every plant was estimated and averaged over the plot. This was considerably more accurate. There was less variation among observers, and the three observers overestimated by an average of only 3%. However, the method was very time consuming.

In the method that measured each plant's leaves, the percent of length removed was assumed to equal percent of weight removed. The three observers estimated 42%, 35%, and 52% removal (Table 1), an average overestimate of 16% more than the actual removed, which was 37%. Pechanec and Pickford (1937) concluded that this method yielded large and significant difference among observers, was slow, and was not recommended.

Table 7. Differences among teams in sampling alder utilization in the Pacific Northwest (Fred Hall, personal communication).[1,2]

	Average difference (%) in browsed vs. unbrowsed twig length				
Transect 1	-1	-44	-40	-18	-8
Transect 2	-21	+7	+27	-5	0
Transect 3	-6	+4			

[1] A negative percentage means the average length of the browsed leaders was greater than the average length of the unbrowsed leaders.

[2] Each value is the mean for one team of two observers.

Using the method that counted plants grazed, the estimated weight removed was 54%, which overestimated actual percentage foliage removed by weight (37%) by 46%. The three observers estimated that 68% of the plants had been grazed, which further exaggerated the overestimate to 84% greater than the measured weight removal. Little difference was noted among observers, but the method was the least accurate one tested because estimated percentages of plants grazed were uniformly greater than the actual. Pechanec and Pickford (1937) stated that this method was not suited for bunchgrasses.

In the Pacific Northwest, experienced teams measured browsed and unbrowsed twigs to determine utilization alder (Frederick C. Hall, personal communication). Each team read at least two transects, with erratic results (Table 7). The negative figures indicate that browsed leaders were longer than unbrowsed leaders. All but three team estimates on the three transects were negative, and the estimates varied from -40% to 27%, which indicates a great difference among individuals and teams.

Effects of Cages on Utilization Estimates

In Britain, Cowlishaw (1951) found that yields from areas under cages were significantly greater than from unprotected areas due to reduced wind and increased humidity inside the cages. Cook and Stoddart (1953) found rather large errors in interpreting utilization of crested wheatgrass using the paired caged/uncaged method during different periods in the growing season. Cook and Stubbendieck (1986) stated, "A common objection (to use of cages) is that differences in growth on the protected and grazed areas may distort utilization. The greater the period of time between caging and clipping the larger this becomes."

The distortion caused by cages was quantified by Heady (1957) on California annual grassland vegetation. He located 25 to 38 cages, each 2.5 x 3.5 feet, in ungrazed pastures. The uncaged and ungrazed plots produced 33% less than the caged plots in the open grass and 21% less in a grassland under thin tree cover (Table 8). Thus, apparent measured utilization would have been 33% and 21% when actual utilization was zero.

In a tallgrass prairie area, Owensby (1969) used 10 cages of 1 square meter in one 60-acre pasture and 30 cages in another 44-acre pasture. Both pastures were ungrazed. The uncaged and ungrazed plots produced 33% less than the caged plots (1,518 versus 2,158 lb/A respectively). This would indicate 33% utilization in the uncaged plot when, in fact, no utilization occurred. When Owensby (1969) calculated the utilization using cages in nearby pastures, he found that the cage effect would account for 47% of the apparent utilization under moderate stocking, 45% under light stocking, and 31% under heavy stocking. Of what value are utilization figures that are wrong by that magnitude?

Another error that can affect caged/uncaged comparisons is the fact that grazing, especially heavy grazing, can reduce production compared to ungrazed areas. This difference is more likely on areas grazed heavily for a number of years, but even a single year could reduce production and influence the caged/uncaged comparison.

In a long-term grazing trial at the Streeter Station in North Dakota (Patton et al. 1996), production was severely reduced on heavier than normal grazing treatments compared to the long-term ungrazed pasture (Table 9). This effect certainly is not what would be expected from grazing for 1 year in a caged/uncaged comparison, but it does point out another potential for error. Based on production of the grazed pastures compared to the ungrazed pasture in this study, apparent utilization *before* any grazing would have been 18%, 36%, and 44% for the normal grazing, one and one-half times normal

Table 9. Effect of long-term grazing on total forage production at Central Grasslands Research Center, Streeter, ND (Patton et al. 1996).

Grazing treatment	Production (lb/A)[1]	Reduction in production (%)[2]
No grazing	2,608 a	—
Half normal	2,438 a	7
Normal	2,149 ab	18
1.5 times normal	1,668 b	36
Twice normal	1,462 b	44

[1] Means followed by the same letter are not significantly different at $p = .05$.

[2] Reduction in production compared to no grazing.

grazing, and twice normal grazing treatments, respectively. This effect, added to any environmental effect of the cage, could increase the error of the computation even more. That is why any long-term exclosures must not be used for the ungrazed comparison in making utilization estimates.

"Tacky Tricks" with Utilization

McKinney (1997) presented nine "Tacky Tricks" that illustrate how management agencies sometimes use utilization inappropriately to reduce stocking rates on an allotment. The tricks are:

1) Measure utilization *during* the growing season (when animals are in pasture)—not *after* the growing season (as required by definition).

2) Monitor only most favored plant species for the season grazed. Ignore all other species even if *they* become most favored in other seasons.

3) Produce use-pattern maps from driving along roads. *Never* get out of the pickup to

Table 8. Effect of cages (2.5 x 3.5 ft.) on production on California annual grassland (Heady 1957).

		Average production (lb/A)			
Vegetation type	Pairs (#)	Caged	Uncaged	Diff. (lb.)	Diff. (%)
Open grass	38	332	224	108	-33
Grass under thin tree cover	25	228	180	48	-21

get away from the travel route for animals provided by the road.

4) Manage for a **Utilization Standard** at a **Key Area** and get this written up in a **Land Use Plan**. This allows you to give it the force of *law* and pretend that it is *management.*

5) To get even greater reductions in animal numbers, use #4 with a *floating* Key Area moved to coincide with heavy use areas each year.

6) Obtain *major* reductions in livestock numbers by picking *riparian* areas for doing #4.

7) To completely rid the range of livestock, combine #6 with #1.

8) When calculating pasture averages, throw out any utilization lower than moderate. You can average moderate (50%) with heavy (70%) and *always* show the range is overstocked, no matter how few animals are present and how good the management is. This technique sounds reasonable and *conservative* when explained in a sincere voice.

9) To dodge those obnoxious unwanted comments, leave the utilization standards out of the draft Land Use Plan, but slide 'em into the final.

McKinney (1997) summarized, "And that's the story on utilization: a fine old range management tool with valuable but limited application is now being used less as a management tool and more as a political tool for removing livestock and wild horses from rangelands. In the resulting brouhaha, everyone involved soon forgets all the really interesting stuff we have learned about management over the past 40 years."

Summary

Accuracy and precision of utilization estimates generally are not very high because:

1) Patterns of utilization are highly variable in both space and time. Herbivory, by nature, is not uniform across the landscape nor is it uniform from year to year.
2) Different methods of determining utilization will yield different results.
3) Different observers get different results using the same method to estimate utilization.
4) An average utilization figure is, at best an index to amount of use and is not an exact figure.
5) Using the paired cage/uncaged plot technique *overestimates* utilization by 30% or more because:
   a. The cage environment enhances forage production.
   b. Grazing can decrease production outside cages.
6) Based on early research, the ocular-estimate by plot method probably also overestimates utilization.

How should utilization be used?

1) Utilization, by definition, must be measured at the end of the growing season, not earlier.
2) Utilization is only one tool to achieve a land management objective (such as a Desired Plant Community). It never should be *the objective* of management.
3) Without a measured trend over time, utilization alone is not an accurate indicator of the effect of grazing on a pasture and never should be used as the sole factor to adjust stocking rates. "Tacky tricks" to adjust stocking rates are being used in some areas by both the Forest Service and Bureau of Land Management. The papers by Van Tassell and Richardson and by Fletcher in this publication address the economic impacts of reducing AUMs caused by imposing utilization standards or other management actions.
4) Utilization standards should be applied as an average over years (such as the number of years for a complete cycle in a grazing system), not imposed every year.

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Interpretation of Utilization and Long-term Frequency Measurements for Rangeland Management

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Abstract

As a tool, vegetation utilization has been used to help make management decisions for many years. It is recommended that utilization should be combined with long-term trend measurements to help interpret these measurements. It has been assumed that yearly utilization measurements taken over several years would relate to long-term trend of rangeland vegetation. However, long-term data sets in western Utah (1982-1995) show no significant correlations between yearly utilization and long-term trend measured (by frequency of key species).

It has been assumed that degree of use relates to the physiological needs of the plant, but recent studies have shown that phenological stage of plant growth is more important than degree of use. Numerous management strategies have adapted this knowledge where use levels as high as 70% are accepted on riparian areas and big game winter range when these areas are grazed early in the growing season. However, recent data have shown that for some shrubs (e.g., *Artemisa tridentata)*, degree of use is very important for the subsequent year's production and for long-term survival.

These data suggest utilization is not very useful in determining the relationship between management and long-term trend of rangelands in western Utah. It is an important tool to help determine livestock distribution and is suggested where management could be intensified in the future.

The range management profession has had a long and sometimes arduous debate on how to integrate annual utilization measurements with long-term trend data to manage rangelands. Basic range management courses have taught that these two measurements should be used together in making long-term management changes. Under the assumption that if changes in long-term trend were undesirable and the utilization level exceeded a desired objective, then the utilization level could be used to help establish the cause of the undesirable trend. Reasoning for this argument is based on the plants' physiological needs, which assumes there is a proper use of a key species. Excessive use (beyond the estimated proper use level; see Sanders, this volume) will lead to changes in the plant community. In addition, the excessive use of a plant would lead to the decline of that particular plant.

Crider (1955) found that root growth was reduced as aboveground phytomass was removed. Root growth was virtually stopped when 50% of the current growth was removed, and root growth was dramatically reduced when use exceeded 50% on many plants (Table 1). These data have been interpreted to mean that if root growth is inhibited,

Table 1. Smooth brome *(Bromus inermis)* root growth 3 weeks after defoliation (adapted from Crider 1955).

Percent removed (by weight)	Percent root growth
0	127
50	2
60	-20
70	-60

then the ability of the plant to compete with its neighbors will be reduced; therefore, over a period of time, use relates to changes in the plant community. This supports the widely accepted generality that range managers should allow only 50% use of current-year growth on key species to maintain them in the plant community. Using this information, many land managers have a hard time understanding why utilization data cannot be used to make long-term decisions.

Data from Cook (1966) and Olsen and Richards (1989) suggested that it is not utilization level that primarily drives response to grazing but rather the phenological stage of plant growth when use occurs. These studies have helped lead to confusion and conflict on how utilization data should be used in interpreting long-term changes in rangeland plant communities and the consequences of rangeland management practices.

If land managers are to use utilization data and long-term trend data together to establish cause, there should be a direct relationship between the average yearly utilization levels over a period and the changes in trend over that same period. Few data are published on the relationship between trend data and utilization levels.

Bureau of Land Management has provided a data set containing 33 sampling sites from a grazing allotment in western Utah that I used to determine how well annual utilization levels and frequency of the key species were correlated. The allotment contained 153,333 hectares (378,734 acres) consisting primarily of two community types, salt desert shrub and Wyoming sagebrush steppe. The average annual precipitation was 76 millimeters. A total of 8,673 AUMs were allocated. However, actual use ranged from 867 to 8,673 AUMs depending on yearly weather conditions. The allotment was grazed from November to June, using a deferred rotation system. From 1982 to 1994, average utilization on the allotment was 40% (standard error = 6.8). The change in the frequency during this period was -0.4% (standard error = 2.9). The key species on the salt desert shrub communities were shadscale *(Atriplex confertifolia)*, galleta grass *(Hilaria jamesii)*, and Indian rice grass *(Stipa hymenoides)*. On the sagebrush steppe, the key species were Wyoming sagebrush *(Artemisa tridentata* var. *wyomingensis)*, and bluebunch wheatgrass *(Agropyron spicatum)*.

Table 2. Regression analysis of the change in long-term trend (plot frequency) and average utilization levels for the previous 4, 3, 2, and 1 years.

Number of previous years	R-squared	P value	Average utilization (%)	
			Max.	Min.
4	0.0037	0.634	65	12
3	0.0167	0.301	67	8
2	0.0304	0.162	67	2
1	0.0173	0.293	80	3

Regression analysis was used to evaluate the relationship between utilization of and change in the frequency of the key species. Complete data on all sites were available from 1986 to 1994 for yearly utilization of key species. Plot frequency of the key species was read in 1986, 1991, and 1994 on all sites. This allowed comparisons between changes in frequency for two periods, 1986 to 1991 and 1991 to 1994. A separate regression analysis used the average utilization levels on each site for the previous one, two, three, and four grazing periods (years). No difference was found between the sagebrush steppe and salt desert shrub communities, so they were combined in the analysis.

No significant relationship was found between average annual utilization levels, regardless of the number of years of utilization data used, and changes in long-term trend using plot frequency (Table 2). Average allotment use was only moderate, less than 40% over the entire period of analysis. However, the average utilization on the individual sampling sites for the previous four grazing periods ranged from 8 to 65%. While land managers have been taught that utilization and long-term trend should be used together to determine the consequences of their rangeland management, these data indicate little relationship between utilization levels and changes in long-term trend.

Many land managers disagree with this conclusion, often citing both observations from their experience and studies like Crider's (1955). It is easy to understand their concerns if one accepts the assumptions of the impact of root growth and plant competitiveness behind Crider's (1955) work. The study suggests that when a plant has to reduce its root growth, its ability to compete in the community will be reduced, and over time the plant can be eliminated from the plant community. By this reasoning, plants that can maintain root growth will have the greatest success in the community.

However, more recent studies (Richards 1984) compared the root growth of crested wheatgrass and bluebunch wheatgrass (Table 3). He found crested wheatgrass after defoliation reduced its root growth significantly compared to control plants, but bluebunch wheatgrass only slightly altered its root growth after defoliation. Of these two species, crested wheatgrass is considered the more tolerant of grazing, but it has the greater reduction in root growth after defoliation. Crested wheatgrass may tolerate grazing better because it is able to adjust the root biomass to a level that can be supported by the remaining photosynthetic tissue on the plant.

While many argue that experience shows utilization drives the long-term change in the plant community, other literature indicates that it is not the level of utilization but the timing of use that drives changes in the plant community (Cook 1966, Olsen and Richards 1989). Cook originally related this plant response to the available carbohydrates in the plant. That work led to the opinion that early-season grazing would be detrimental to plants because their available carbohydrates are declining or at a low point. This does affect a plant, but Caldwell et al. (1981) found the stored energy was less important than the photosynthetic capacity. Olsen and Richards (1989) agreed with Cook's conclusion that the phenological stage at which the plant is grazed will have a greater effect on the plant's ability to compete than the utilization level. Their work indicates that removing the apical meristem before seed set determined the plant's long-term production and its ability to compete in the environment. They found early-season (vegetative growth stage) and late-season (seed ripe) heavy use had little long-term impact on plant production. Moderate use, because it removed the apical meristem during the stem elongation stage, reduced long-term production. The findings suggest a plant's ability to withstand grazing is related more to use in a narrow season than to the actual level of use.

Table 3. Relative root growth of bluebunch wheatgrass (BW) and crested wheatgrass (CW) following defoliation (adapted from Richards 1984).

	Relative root growth after defoliation(%)	
Treatment	40 days	100 days
BW control	15	36
BW defoliation	13	39
CW control	20	43
CW defoliation	10	26

The BLM data presented here and the literature indicate that utilization levels have little to do with changes in long-term trend. With all this evidence, why is there still debate on using utilization?

I have found that land managers who cite their experience with the correlation of utilization and long-term trend were using season-long grazing systems in which plants were grazed every year during their active growth stages. I suspect heavy use (>50%) in these grazing systems removes apical meristems during the active growth period, leading to reduced competitiveness of some species and species frequency changes in the plant community. Moderate use levels ($\leq$50%) left many plants with their apical meristems intact, and so long-term changes were minimized. Many of the grazing systems that have been developed prevent repeated defoliation of the same plants each year during the critical phenological stage.

Another possible explanation for the lack of correlation between utilization and trend is that the communities studied may have been in a stable state because of grazing history or other factors.

Laycock (1994) stated that lower successional steady states are common in the sagebrush–grass vegetation type. When a shrub-dominated community is in such a state, reducing grazing pressure or even stopping grazing completely does not result in changes in vegetation composition, even over decades (Laycock 1994). Continued heavy use might push the vegetation over a threshold into a lower successional steady state, but often that use has to be quite heavy and prolonged.

If utilization measurements do not relate to changes in plant communities, what help is this measurement in managing rangelands?

Utilization is most helpful in determining animal distribution; second, it can help to estimate stocking rates if the total forage base is known. This can be very important in helping design the most appropriate management strategy for an area. For some shrubs, utilization levels *can* be important. Wyoming sagebrush will reduce its reproductive effort and production if more than 50% of current growth is removed; however, bitterbrush will increase its growth the more it is utilized. These opposite responses relate to where the meristematic tissue is located when the plant is grazed (Bilbrough and Richards 1993).

In light of this information, which indicates utilization is difficult to interpret and measure, I suggest annual management focus on other techniques that can be useful for other objectives as well as livestock or wildlife use. These would include cover, stubble height, or "other residual" measurements.

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Stubble Height and Function of Riparian Communities

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Abstract

Stubble height, a measurement of remaining vegetation, will be discussed as it influences attributes of channels and floodplains, sediment deposition, plant vigor, physical stability of riparian zones, and use of woody plant species. Because vegetation in channels causes sediment deposition, water relationships of plants growing along banks may change with time and channel succession. Consequently, as channel banks build, plant species composition of the near-bank riparian zone also may change.

Evidence will be presented that plants requiring high water tables most of the growing season may be at a disadvantage in competing with plants that can withstand a rapid decline in the water table; and, therefore, the latter may become dominant along a mature channel system. Furthermore, stubble height required to maintain plant vigor also may decrease when plant succession occurs. However, higher stubble heights of all plants may be required to maintain channel bank integrity and to reduce grazing of other desired woody plants during specific seasons. In conclusion, when stubble height is used as an indicator of when to manipulate herbivores' grazing, other important factors—flood frequency, soils' draining capacity, plant regrowth, and plant dormancy—should be considered and related to how they and stubble height standards may alter specific management objectives.

Introduction

Livestock and wildlife grazing on western rangeland is essential to maintain the economic and social values now realized by the livestock industry and general public. However, livestock grazing impacts on riparian zones are most often cited as reason to change how public lands are managed as a natural resource (U.S. GAO 1988). Kauffman and Krueger (1984) review and illustrate the importance of riparian zones and how livestock grazing may impact this wetland resource.

Because livestock utilize vegetation as forage, it is common practice to measure utilization to evaluate how livestock grazing alters attributes of riparian zones. The impact of grazing on plant communities, however, may be estimated in two ways: by estimating the amount of vegetation that has disappeared by being consumed (utilization); or, by measuring the amount of vegetation that remains after herbivores have used an area (stubble height). Clary and Webster (1989) address the latter method of evaluating utilization and support it as a valid way to determine when to stop grazing riparian habitat. In part, this paper endorses Clary and Webster's school of thought because stubble height is a measure of remaining vegetation and can be seen by the observer. However, like Hall and Bryant (1995), this paper also addresses how stubble height relates to function of riparian zones.

In particular, the overall goal of this paper will be to help illustrate that measuring stubble height of riparian plants can serve as a viable plant community attribute for helping manage riparian zones.

Specific objectives toward reaching this goal will be to show:

1) How sediment deposition alters stream channel and plant succession and, then, how stubble height relates to sediment deposition; and
2) How plant vigor, stream channel characteristics, and plant community stubble height relationships relate to each other so that land

managers can further evaluate a riparian zone's capacity to function while being grazed by all classes of herbivores.

Background

Chaney et al. (1990) generally address function of riparian zones. Their work indirectly suggests that stream channels may go through a successional sequence from unincised to incised. The authors suggest that unincised is functioning properly as a riparian zone but the incised is not. This school of thought has been extended by the Bureau of Land Management (BLM) to the point that a rating of functional condition is a way to evaluate riparian zones within lands they manage (USDI 1993).

The BLM manual "Riparian Area Management. Process for Assessing Proper Functioning Condition" suggests that stream channels may move through a successional sequence from bare ground to late seral (USDI 1993). The manual also suggests that as stream channels move through succession, associated plant community composition may change until the late seral stage. According to this assessment, the late seral channel condition and expected associated plant communities constitute BLM's definition of properly functioning riparian zones. Unfortunately, this assumption does not recognize that the basic function of a stream is to remove water and sediment from its drainage basin. Instead, it addresses only the deposition half of the natural and cyclic process of erosion.

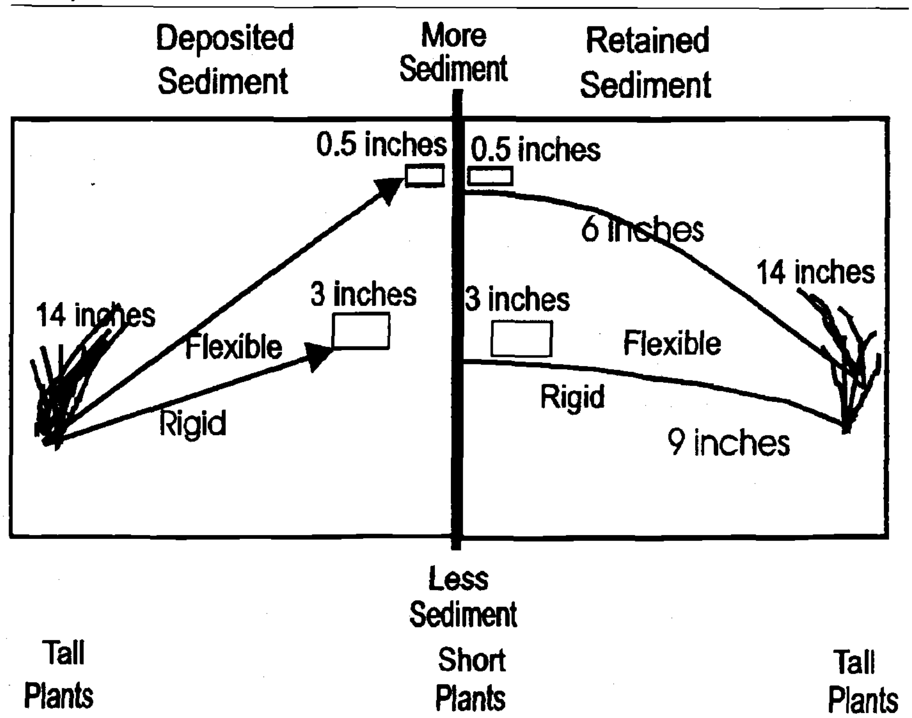
This paper, in contrast, follows Cooke and Reeves (1976) who show that arroyos in the southwestern United States form and fill in a cyclic process. Thus, it is assumed that in the erosion cycle, sediment deposited at one time eventually may be removed and transported farther down the stream. Also, different stages in this cyclic process may occur along the course of any one stream at any given time. Thus, all stages in channel succession may be functioning properly when the potential for each successional stage is considered.

Given these facts, measured stubble height is not just a way to estimate utilization by grazing animals; it also has great value in evaluating how well vegetation and grazing management meets an objective of moving from one stage in channel succession to another.

Because it appears that water and sediment transport in part may create the successional sequence the BLM uses (USDI 1993) to evaluate riparian zone condition, this paper builds on that thought by addressing how sediment deposition and erosion relate to channel succession and, then, plant succession. The purpose of this approach is to illustrate that available soil water may vary for different stream channel configurations and therefore may be responsible for changing riparian zone plant species composition.

Stubble heights of individual species may alter functions of riparian zones in different ways. This paper discusses the influence of stubble height on sediment deposition, plant vigor, physical impacts from grazing activity, and animal foraging behavior.

Figure 1. Stubble height and sediment deposition (after Clary et al. 1996).



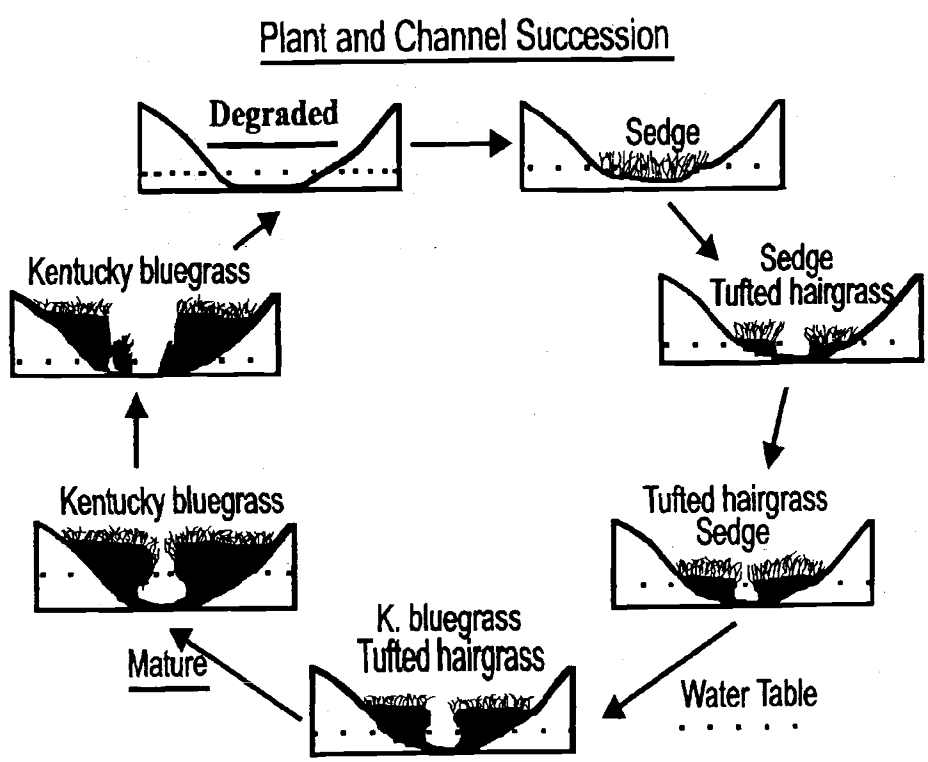
Stubble Height and Channel and Plant Succession

Assuming that vegetation remaining on flood plains (stubble height) can filter and stabilize sediment, then channels should move through a successional sequence from incised to unincised (Chaney et al. 1990) or from early seral to late seral (USDI 1993). The relationship between riparian zone function and stubble height is that stubble height should alter how channels move from a degraded or empty state of sediment storage to a state where sediment is being stabilized and channel banks reach stability or maturity (Chaney et al. 1990, USDI 1993).

This paper accepts that channel succession occurs because evidence shows that vegetation causes sediment deposition and then stabilizes it. However, evidence also suggests that erosion removes stored sediment at a point in space and time when storage is greater than the system's capacity to hold it in place. This is not new information but follows Cooke and Reeves' (1976) review of sediment cut and fill cycling within arroyos. The process of removing stored sediment deposition from channels and flood plains appears to be caused by stream channel meandering and slope adjustment (Leopold et al. 1964, Morisawa 1968, Schumm 1977, and Heede 1980). The implications of cut and fill cycling of stored sediment is that channels systems degrade and fill within an erosion cycle. As stream channels "cut" and "fill," there may be corresponding change in plant communities. Because managers of riparian zones recognize and judge condition of riparian zones, in part by plant species composition, it is imperative to discuss how and why channel and plant succession relate to each other.

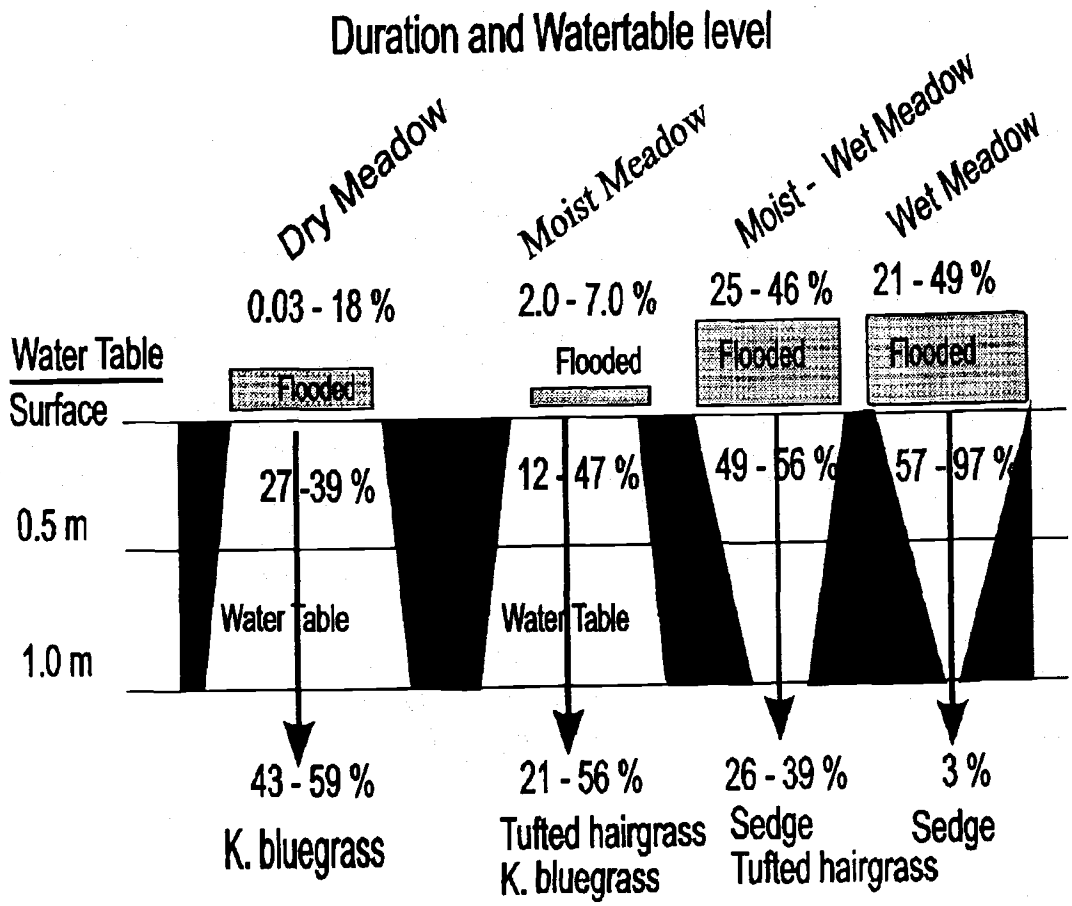
As sediment deposited on flood plains increases the height of channel banks, the soil surface moves higher and farther away from the water table during low streamflows. As distance to groundwater increases, water-loving plant species will be replaced by those more resistant to drier conditions. It also can be assumed that during periods of flood plain saturation, the rate and depth of drainage will vary with the soil attributes of the sediment material stabilized in the flood plain and channel bank. Therefore, it is likely that plant species composition also may vary depending on the riparian zone's drainage characteristics and not just according to the plants' relative positions next to stream channels. If differences in plant and water table relationships or in drainage and the soil's water-holding capacity determine plant species composition, then the potential for plant stubble to cause sediment deposition during flooding also may vary.

Figure 2. A hypothetical sequence illustrating channel and plant succession assuming erosion is a cyclic process.



To illustrate this point, Clary et al. (1996) made a flume study in which treatments controlled stream flow, sediment supply, and stubble height of flexible and rigid herbaceous vegetation (Figure 1). Flexible vegetation (Kentucky bluegrass and native sod) maintained at 0.5 inch high caused more sediment deposition than higher stubble and more than rigid plants tested. More sediment was deposited using 3-inch rigid vegetation (sedge and corn seedlings) than using higher rigid vegetation. When test plots with deposited sediment were subjected to flooding trials with no sediment, the 0.5-inch flexible vegetation lost its captured sediment rather fast at the beginning of the flood compared to rigid vegetation, but flexible vegetation had a higher net gain at the end of the trials. No time was allowed for vegetation to regrow between the period of deposition and repeated flooding.

Figure 3. Water table and riparian zone plant community relationships (after Henszey 1993). Percentages are the amount of time the water table level is above the ground surface, at 0.5 m deep, and below 1.0 m deep.



Considering evidence presented by Clary et al. (1996), the function and significance of using stubble height to evaluate riparian zone management objectives is that the importance of agency standards may have to be altered as plant species composition changes from rigid to flexible or from flexible to rigid in relation to different stages in channel succession. Figure 2 provides an example of stream channel configurations observed in field surveys and dominant plant species that often occur with them. The drawings illustrate that sediment deposition not only alters channel configuration but also that Kentucky bluegrass may replace sedge and tufted hairgrass as banks build high above the water table or as the channel incises during the degradation part of the erosion cycle.

Henszey (1993) explored the relationship of riparian plant communities to depth-to-groundwater levels over an 8-year period (Figure 3). He found that the Wet Meadow type supported mostly a tall sedge plant community, and the Moist–Wet Meadow type supported tall and short growing sedges and tufted hairgrass. Although both community types were flooded from 21 to 49% of the time, drainage to a water table deeper than 1 meter during the summer occurred only 3% of the time in the Wet Meadow type and 26 to 39% of the time in the Moist–Wet Meadow type. Drainage to a water table deeper than 1 meter increased in the Moist Meadow type to 21 to 56% of the time and to 43 to 59% of the time in the Dry Meadow type. The Moist Meadow type supported mostly tufted hairgrass and Kentucky bluegrass , the Dry Meadow type mostly Kentucky bluegrass. This study suggests that depth to groundwater and rate of drainage or drainage and plants' use of soil water may cause a change in plant species composition along stream channels as they move through a successional sequence from degraded to mature, as presented in Figure 2.

To further illustrate that sediment deposition may favor change in plant composition, Henszey's (1993) plant communities can be placed on a hypothetical degraded straight reach or a building point bar of a meandering stream, as in Figure 4. Tall sedges often occupy the area close to the low-flow level of this type of stream channel configuration. Based on the concept presented in Figure 3, the other plant communities would fall into place as the depth of the bank material increased over the established water table away from the channel itself. Kentucky bluegrass would occupy the driest site of the riparian zone. As vegetation deposits and stabilizes sediment on the lower portions of the bank, it is reasonable to assume that the degraded bank could eventually reach the channel profile shown in Figure 5. The resulting depth to water table may cause sedges and tufted hairgrass to decrease and Kentucky bluegrass to increase.

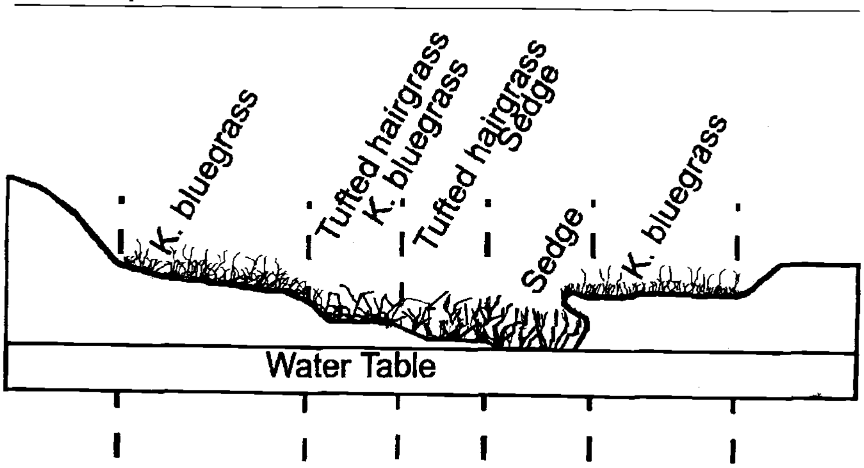
The plant communities that Henszey (1993) studied are typical of many found in the montane zones of the central Rocky Mountains. It is common to find Kentucky bluegrass between the dry uplands and the wetter areas of riparian zones. The argument is made often that the presence of the introduced Kentucky bluegrass in riparian zones, like Henszey (1993) studied, indicates poor grazing practices, and grazing management can influence the expansion or reduction of this bluegrass zone. Common remarks to support this management philosophy suggest that improper grazing may dry out moist area of riparian zones favoring Kentucky bluegrass over other, more mesic grass species. Also, because Kentucky bluegrass is rhizomatous and tufted hairgrass is a bunch grass, tufted hairgrass may not compete well for space while being grazed in the presence of Kentucky bluegrass. Little thought has been given to the arguments that even though Kentucky bluegrass may have been introduced to North America, it is where it should be, and in fact it probably is persistent when riparian zones fill with sediment and soil water dynamics favor its existence. In situations like these, presence of Kentucky bluegrass may not be related in any way to improper grazing but rather to this species' adaptability in competing for soil water with other native species within certain stages in channel succession of riparian zones.

In this paper, the discussion of ecology and management of Kentucky bluegrass verses the presence of native grasses is much less important than the need to recognize that Kentucky bluegrass stubble height should be managed so that other riparian zone values can be maintained or altered if needed.

Henszey's (1993) data provide a strong argument that depth to water table favors one plant community over another, including the Dry Meadow type with Kentucky bluegrass. However, some believe that water's capillary rise from the water table should be sufficient in stream channel configurations like those illustrated in Figures 2, 4, and 5 to support most plants common to the wet and moist areas of riparian zones.

To address this question, Yeager (1996) studied plant growth in sand-filled columns 10 feet tall by 4 inches wide by 1 inch deep. Reverse column flow and outlet reservoir control was used to test response of Nebraska sedge, tufted hairgrass, and Kentucky bluegrass at water table decline rates of 1, 2, 4, and 6 centimeters per day. Average water table decline rates for Henszey's (1993) 8-year field site study were between 2 and 4 centimeters per day. Plants were established in the columns and grew rapidly while water levels were maintained at the surface of the columns before testing began. Sand was used to minimize water's

Figure 4. Hypothetical relationship between channel configuration and plant succession.



capillary rise. Pertinent results are shown in Tables 1 and 2. The length and depth of roots Yeager (1996) could see through the clear plastic front of columns suggest Kentucky bluegrass is more aggressive in growing roots which then may keep up with a declining water table. It is assumed that capillary rise in sand was not sufficient to supply required water for growth because at all decline rates all plants died after 30 days. For all species, the ash free weights (Table 2) confirm observations and again suggest that Kentucky bluegrass may be more adapted than the two other species tested for growing in soils where ground water is deeper or drainage is rapid.

In summary, Yeager's (1996) data suggest that capillary rise from water tables that decline rapidly under riparian zone plant communities may not always be sufficient to provide water required by all plant species. These data also suggest that soil parameters of sediment that builds channel banks and that alters water's capillary rise may be extremely important in explaining where plant species grow and why.

Yeager's (1996) study also helps explain why Henszey (1993) may have found sedge, tufted hairgrass, and Kentucky bluegrass in different locations within riparian zones, and why distinct plant communities may exist away from a stream's edge to uplands. By these arguments, it does appear one can use channel succession to predict plant community. It also appears reasonable to use stubble height data to manage grazing so that one can set an objective to move from one channel configuration to the next as illustrated in Figures 2, 4, and 5. Accomplishing this likely will depend on managers' ability to determine which stubble heights promote sediment deposition and retention so that banks can build while plant vigor is maintained.

Stubble Height and Sediment Deposition

In review, streambank vegetation has been shown to increase channel roughness (Beschta and Platts 1986, Gregory et al. 1991). Increased channel roughness in turn may dissipate stream energy and cause sediment deposition (DeBano and Heede 1987, Debano and Schmidt 1989). Vegetation may sort sediment by size and retain it along riparian zones (Lowrance et al. 1985, Platts and Rinne 1985, Beschta and Platts 1986, Middleton 1993). Established vegetation roots appear to bind soil and stabilize stream channel banks (Gebhardt et al. 1989, Lowrance et al. 1985, Elmore and Beschta 1987, Chaney et al. 1990). Vegetation also has been shown to increase waterway protection by covering banks and slowing down erosion (Chow 1959). However, tall grass may not provide much flow resistance when it lies over in the direction of flow as streamflow velocity and channel depth increase (Haan and Barfield 1978).

There is little doubt that sediment deposition and vegetation are factors in building and stabilizing stream channels. The question is, how can one best manage riparian zones to accomplish the task, and how can stubble height be used to monitor the effort? The flume study of Clary et al. (1996) discussed above and illustrated in Figure 1 suggests that the vegetation should be short and that flexible grass like Kentucky bluegrass is better than longer

Table 1. Maximum visible root depth and length at a water table decline rate of 4 cm per day (Yeager 1996).

Species	Root depth (cm)	Total root length (cm)
Kentucky bluegrass	31	330
Tufted hairgrass	20	183
Nebraska sedge	11	189

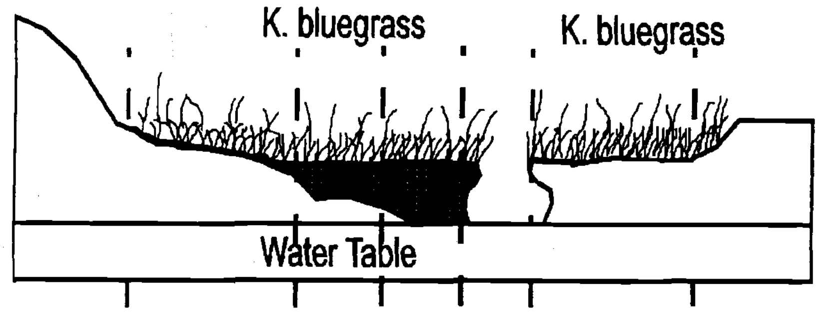
Note: All plants were dead after reaching the maximum root depth after 30 days.

Table 2. Root ash free weight for 10-cm increments at a water table decline rate of 4 cm per day (Yeager 1996).

Depth	Kentucky bluegrass	Tufted hairgrass	Nebraska sedge
	Root ash free weight (g)		
0 - 10	117	43	108
10 - 20	30	27	10
20 - 30	5	2	0
30 - 40	2	0	0

and more rigid grasslike plants for causing sediment deposition. Herbivory, then, at some level should benefit the process of sediment deposition and channel bank building.

Figure 5. Hypothetical change in channel configuration and plant species composition caused by deposited sediment and bank building.



Rumsey's (1996) field study of stubble height and sediment deposition along Spring Creek, WY is a logical step from Clary et al.'s (1996) laboratory flume experiments to learn if what they found applies to a modified stream system. Rumsey was able to maintain some control over direction of flow because the study was in an urban stream that had been channelized in a straight, flumelike configuration, and the low-gradient channel bottom was maintained by permanent structures. Flood plains and vegetation had become established within the channelized reach before the study began in 1994, but she was not able to control streamflow and sediment supply.

Rumsey found no significant difference in sediment deposited over 2 years when stubble heights were maintained unclipped (mean = 24 inches) and at 1-, 3-, and 6-inch heights.

Amount of sediment deposited correlated with and decreased as floodplain elevation increased above the level of low streamflow. The average sediment deposited was 0.2 to 0.4 inch after 2 years. During the third year of the study, sediment deposited increased to about 1 inch deep (Gray et al. 1997). Very few bank-overflows occurred the first 3 years, and none were considered extreme floods. During the fourth year, sediment deposition increased to between 1.2 and 3 inches deep, and several consecutive and extreme floods occurred throughout the summer (Gray 1998, personal communication). The 1-inch stubble height sediment deposition was 1.2 inches deep; the three other treatments were in the range of 3 inches deep. Sediment retained on 1-inch stubble was significantly lower than that deposited on unclipped and on 3- and 6-inch heights, which were not significantly different from each other. In the year of frequent floods, sediment deposited again correlated to floodplain elevation above the level of low streamflow; but unlike what Rumsey (1996) found, sediment increased with bank elevation above low streamflow.

In comparing Rumsey and Gray's work with that of Clary et al. (1996), extreme and repeated floods in Spring Creek were required to separate differences in stubble height's ability to cause sediment deposition. As in Clary et al. (1996), very short stubble height along Spring Creek appeared to cause sediment deposition, especially in years when flooding was not frequent and extreme. During the last year of repeated, strong floods, very short stubble either did not collect sediment as well as longer stubble, or it did not retain deposited sediment during repeated floods. Clary et al. (1996) show that short stubble collects sediment, but they make the strong point that this deposition may be lost it if it is not stabilized by growing or longer plant material (Figure 1).

Rumsey and Gray's work supports Clary et al.'s (1996) results and discussion. Spring Creek field site data also suggests that differences between longer stubble heights may not make a significant difference in the overall process of altering sediment deposition. Again, results from both studies show that moderate grazing of vegetation may not be a significant consideration in managing sediment within riparian zones.

In a naturally meandering and high-sediment-transport stream system (Muddy Creek, WY), Goertler (1992) found that in 6 years the existing vegetation on banks and channel conditions did not cause a reduction in suspended sediment in years of high flow but did in years of low flow. Middleton (1993) found that particle-size classes of sediment changed with distance away from Muddy Creek's active channel, and he related this sorting to decreased streamflow power as flooding receded.

Budd (1994) reported that at least 1 foot of sediment was deposited over 6 years in places like point bars during Muddy Creek floods and that overall change in sediment deposited was not significant among vegetation types, straight-stream study segments, or years. Apparently, amount of sediment deposited on flood plains varies with stream channel configuration, amount of streamflow, and sediment supply. In total, results of Muddy Creek studies suggest that amount of sediment deposited because of the condition of flood plain vegetation may be insignificant compared to sediment deposition caused by the channel and streamflow attributes.

In summary, the examples provided above illustrate that vegetation can filter sediment from streamflow. It may be that shorter stubble can filter more, or at least as much, sediment than taller or ungrazed vegetation. However, very short stubble also may lose sediment deposited from one flood event to the next if it is not stabilized by growing or taller stubble.

There may be differences among plant species' ability to filter sediment depending on their flexibility. However, measure of vegetation attributes may address only a small portion of the forces that shape stream channels. Depending on sediment load and flood flows, stubble height and the grazing that creates it may play only a small role in the sediment deposition phase of bank building. However, because stubble also is responsible for stabilizing any sediment deposited, through the production of root and aboveground biomass, it is important to explore how stubble height relates to the maintenance of plant vigor.

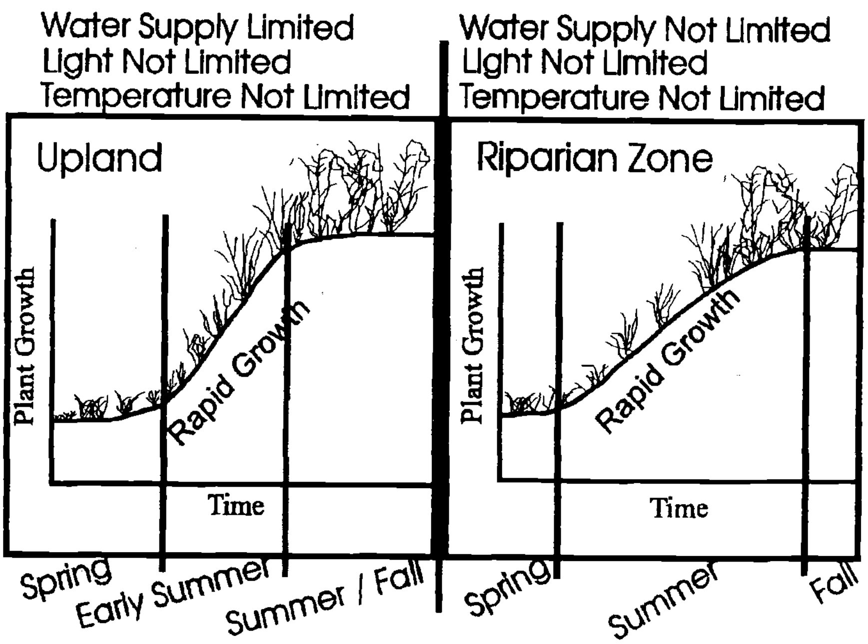
Stubble Height and Plant Vigor

Plant vigor can be measured in many ways. One common measure is the change in the relationship of underground biomass to that produced above ground in any one growing season or in consecutive growing seasons. Roots are assumed important in creating stable streambanks, and any stubble height that depresses root production may affect bank stability and function of riparian zones. It has been shown also that grazing animals can consume aboveground biomass to such an extent that underground biomass can decrease compared to ungrazed controls (Caldwell et al. 1981, Richards and Caldwell 1985, Engle 1993). A reason often provided is that in these grazing situations, the plant uses its excessive carbohydrate root reserves to support growth of aboveground plant parts at the expense of growing roots needed to maintain plant vigor. However, recent literature suggests that photosynthetic material left after defoliation, and greater reallocation of the photosynthates produced from stubble left to the aboveground shoot system, is the likely reason root biomass and carbohydrate storage decrease under long-term, intensive grazing (Detling et al. 1978, Nowak and Caldwell 1984, Richards and Caldwell 1985, Olson and Richards 1988, Briski 1986, Briski and Richards 1994).

This recent research offers strong support for measuring stubble height to monitor grazing effects on plant vigor in riparian zones. Instead of measuring and estimating the plant parts that have disappeared (utilization), measuring stubble height gives the opportunity to ensure that enough photosynthetic material is left after grazing to promote short- and long-term plant vigor. As important, sediment deposition also may influence the plant's ability to regrow after floods because the photosynthetic material is covered. Therefore, measuring stubble height also provides the opportunity to see how deposited sediment alters plant vigor. In riparian zones, it is reasonable to assume that grazing and flood sediment will alter plants' production potential. However, one must also consider that, in riparian zones, stubble regrowth potential may be greater than in surrounding uplands. If so, there may be more flexibility in managing grazing in riparian zones than on uplands.

Generalized curves showing annual cumulative aboveground biomass for grass plants like those growing in Wyoming are illustrated in Figure 6. In the uplands, grass plants must grow to the mature, flowering stage using limited soil water provided by winter and spring precipitation. In contrast, grasses in riparian zones may have access to sufficient soil water to support growth into late summer and fall. Both upland and riparian grasses must build up photosynthetic leaf material in spring and use it to replenish any root reserves lost in support-

Figure 6. Generalized cumulative aboveground biomass curves for comparing upland and riparian cool season grasses and the relative time a plant may have to regrow after being grazed.



ing the early growing process and, then, to support growth until the plant reaches maturity (Richards and Caldwell 1985). However, because soil water is generally a limited resource for plants growing in uplands, the time they have to reach maturity generally is less than in riparian zones. Most uplands grasses mature by late spring or early summer when their soil water supply generally is depleted and dormancy ensues. Grasses in riparian zones, without the influence of grazing, also follow this generalized upland growth pattern, but the mature grass may stay greener longer than in uplands because of it has an extended soil water supply. However, when riparian grasses are subjecte to defoliation or flood sediment, they appear able to continue growing and able to mature into late summer and early fall. It is this potential for regrowth over an extended period in riparian zones that makes measuring photosynthetic material left after grazing and deposition of flood sediment so important to maintaining plant vigor. It also is a very good reason managers should consider measuring stubble height, not utilization, to evaluate grazing effects on riparian plants.

In using stubble height as an indicator of change in plant vigor, managers must determine what amount of plant material is needed to manufacture sufficient photosynthates so whole-plant needs are met after defoliation. However, accomplishing this task is complicated and part of the historical mystery that inspires the study and profession of range management. Evidence suggests that when plants are defoliated during periods of accelerated growth, they may be stressed more than when grazed during early and late periods, when growth is slower, because during active growth the leaf, sheath, and stem meristems are being elevated and are more susceptible to grazing (Olson and Richards 1988). However, it is important again to point out that in riparian zones the time a plant has to recover after being grazed should be longer than in uplands because of the lasting soil water supply. Therefore, the extent of impact on the plant and its ability to re-grow after being defoliated when it is rapidly growing likely will depend on the amount and distribution of material left (stubble height) and not on what has been consumed (Olson and Richards 1988).

Briske and Richards (1994) stress that we still have much to learn about how grazing modifies plant regrowth. Most research has focused on answering regrowth questions using single plants and individual species. It is clear, from their text, that not all grass species respond in a similar way; growth form and ability to withstand competition may vary between species and environments studied. To work within this problem, rangeland managers generally have followed the "take half, leave half" rule of thumb (Crider 1955) after finding that upland range was ready for grazing. Range readiness usually has been defined as the time at which grass shoots are just ready to flower or in the early stage of flowering. This means grazing on uplands grass at the middle to end of leaf, sheath, and stem meristem elongation and when soil water supply is about gone. Potential for managing upland plants' regrowth is, therefore, poor in reality. In riparian areas, if stubble height is sufficient to provide for photosynthetic activity, then regrowth potential after any grazing or sediment deposition is good, and the "take half, leave half" principle historically used for uplands may not apply. In fact, depending on the riparian plant species measured, stubble height after taking half by weight may underestimate the volume of photosynthetic material left for maintaining plant vigor even when regrowth potential is ignored. Kinney and Clary's (1994) work illustrates this point (Figure 7).

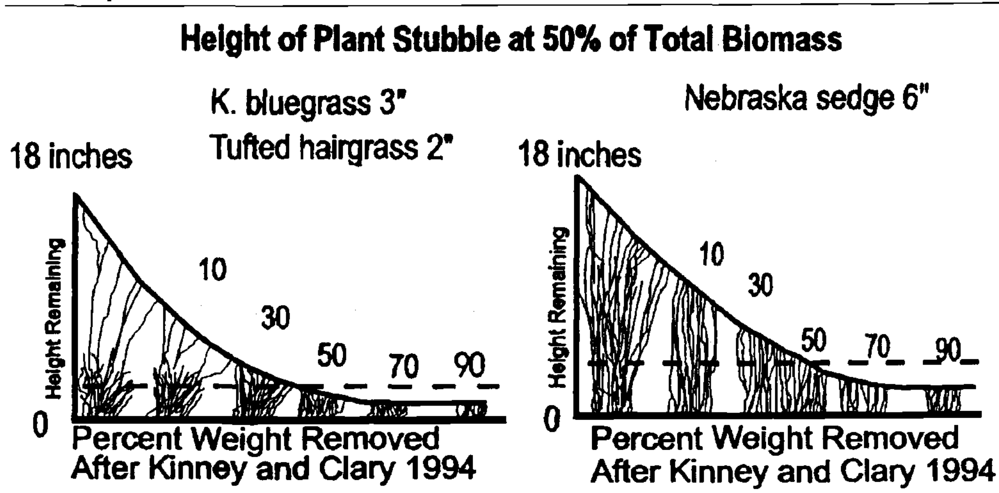
In Figure 7 are Nebraska sedge, Kentucky bluegrass, and tufted hairgrass, three important plants in riparian zones of the West. Sedge and grass have different growth forms. Herbage weight of leaves and shoots of Nebraska sedge is somewhat evenly distributed from the plant's crown to its top. In contrast, most herbage weight of Kentucky bluegrass and tufted hairgrass is near the ground surface as leaves; only a small portion of the overall biomass is elevated as stems and flowers. It appears, then, that grasses with growth forms like Kentucky bluegrass and tufted hairgrass can be grazed much shorter than plants like Nebraska sedge when "take half, leave half" of the total herbage weight is the management criterion for maintaining plant vigor after defoliation. This is because Kentucky bluegrass and tufted hairgrass still have about 50% of their biomass weight (mostly as leaves) when their stubble is between 2 and 3 inches tall, but Nebraska sedge stubble is about 6 inches tall when all mature plants are 18 inches high.

However, this does not mean in either case that stubble height is equivalent to the photosynthetic area needed to support regrowth and to maintain plant vigor. In fact, even if Nebraska sedge were grazed to 2 inches high and Kentucky bluegrass and tufted hairgrass to 1 inch high, it does not mean that stubble would not have enough photosynthetic area to support regrowth. One can only assume that if they were grazed this short they may just need more time to recover to the point that they maintained plant vigor. In all cases mentioned, stubble heights presented for the three plants are likely to cause sediment deposition, but photosynthetic requirements for supporting regrowth after flooding are not known.

There is no reason to believe that less than 50% of the weight of a grass plant is not sufficient to maintain vigor in riparian zones. This may be especially true if we consider how animals graze grass under light to moderate use. Grazing animals usually do not graze plants evenly. They generally use only part of individual plants and, thus, leave parts ungrazed. The combination of defoliated and undefoliated plant parts after grazing may even increase light near the crown, promote greater nutrient uptake in roots, increase photosynthetic rates in defoliated leaves, sheathes, and shoots, and initiate activity of leaf primordial meristems and tillering from auxiliary buds (Olson and Richards 1988, Briske and Richards 1994). This may be especially true if light, temperature, water, and nutrients are not limited. Of all watershed habitat, then, the wet and moist zones of riparian areas should best promote regrowth under light and moderate grazing and maybe even under occasional heavy grazing.

To address the issue of stubble height and plant vigor, Rumsey (1996) used total aboveground and underground biomass as indicators of change when

Figure 7. Illustrated height of remaining vegetation when 50% of the aboveground total weight is removed for three 18-inch-high grasslike cool season plants.



plant heights were maintained at 1, 3, and 6 inches along Spring Creek, WY over a 2-year period. Each treatment was clipped weekly when plants were rapidly growing so that stubble heights did not increase much between clippings. When plants grew slowly toward the end of the growing season, they were clipped biweekly. Each treatment was compared to unclipped controls.

A purpose of the study was to see whether very short stubble heights would cause a decrease in root production and, thus, potentially increase streambank instability; also, whether stubble height differences produced differences in aboveground production compared to unclipped controls.

Rumsey (1996) reported no significant differences in underground biomass between the control and clipping treatments after 2 years. Total aboveground biomass was not significantly different between the unclipped control (mean = 24 inches high) and the 1-inch stubble. However, both of these produced significantly more aboveground biomass than the 3- and 6-inch treatments. The 3- and 6-inch stubble's aboveground biomass was not significantly different from each other. Gray (1998, personal communication) has analyzed Rumsey (1995-96) and Gray et al. (1997-98) data. He found that after 4 years, the unclipped control plots produced significantly more total aboveground biomass than each of individual clipping treatments. However, the 1-inch treatment produced significantly more aboveground biomass than the 3- and 6-inch treatments, which were not different from each other. Gray has not completed analysis of underground biomass production after 4 years.

These data suggest that maintaining all plants at 1, 3, and 6 inches over 4 years will reduce total aboveground production of plants growing along Spring Creek. The data also suggests that grass maintained at shorter stubble heights may produce more total aboveground biomass than the longer stubble when subjected to these extreme clipping treatments. However, caution should be taken in applying Rumsey (1996) and Gray et al. (1998) data. Although production of total aboveground biomass did decrease for all clipping treatments, clipping was extreme compared to how animals generally graze riparian plants under light or moderate use. Generally, under light and moderate use they take only a part of an individual plant, leaving the rest to help provide the photosynthetic needs for regrowth. Also, the response of individual plant species was not studied. Therefore, there is always the possibility that plant species could have been lost and that less aboveground biomass could have been produced by one or a few species more tolerant to clipping. An argument also can be made that aboveground production would be even less if plots used for data collection were subjected to grazing, because simulating grazing by clipping does not account for any physical impact to plants caused by animal activity.

Rumsey's (1996) data do suggest, however, that in wet and moist riparian areas like Spring Creek, sporadic grazing that reduces stubble height to less than 50% by weight of the ungrazed plants may not permanently damage plant vigor as measured by total above- and belowground production. Gray's 4-year data, however, suggest that extreme grazing may reduce production of total aboveground biomass. The answer to the question of how these 4-year clipping treatments alter total belowground biomass and, thus, potential for maintaining streambank stability is nearly complete.

To summarize the discussion of plant vigor, stubble height does represent plant photosynthetic area. Stubble photosynthetic area then can be maintained at levels capable of producing the photosynthates necessary to maintain plant vigor under grazing. If moderate grazing is defined as taking half and leaving half of the plant's capability to produce a total amount of aboveground biomass, then stubble heights after grazing will vary because plants in different riparian plant associations may have different growth forms. Stubble height does not represent the plant's photosynthetic ability to support regrowth and plant vigor. Generally, using 50% of the aboveground biomass as an indicator of maintaining plant vigor likely will underestimate the photosynthetic area remaining to support regrowth.

Much has been said about differences in stubble height of Kentucky bluegrass, tufted hairgrass, and Nebraska sedge. Because of growth form, 50% of the total aboveground production results in a much shorter stubble for Kentucky bluegrass and tufted hairgrass than for Nebraska sedge (Figure 7). Taking it one step farther, the differences in stubble height between these plants and potential for regrowth after grazing or a flood also may be associated with recognized stages in channel and plant succession. Figure 8 combines the concepts discussed earlier for soil water storage potential (Figure 6), total accumulated biomass (Figure 6), and channel and plant succession (Figures 2, 4, and 5). The combination of these concepts may be used to help predict where short stubble height is likely under moderate grazing and how regrowth potential may vary because of available soil water.

Under the protocol of leaving 50% of aboveground plants in place as stubble, the expectation may be that in the Kentucky bluegrass zone aboveground biomass will be short and the potential for regrowth may be limited. This is because it generally occupies the driest zone of the riparian area, and therefore it does not have much time to go through its growth cycle before its water supply is depleted. The expectation may be that tufted hairgrass stubble, like Kentucky bluegrass, also will be short because these plants have like growth forms.

However, regrowth potential for tufted hairgrass should increase because it occupies a wetter area of the riparian zone and therefore, it has more time and soil water to grow. To leave an equivalent amount of biomass weight for Nebraska sedge, the stubble of the tall sedge zone will have to be higher than Kentucky bluegrass and tufted hairgrass. However, expectations should be that the sedge plants of this zone should have the greatest amount of time and soil water to recover losses in photosynthetic area and regrow to maturity.

Evidence presented generally suggests that moderate grazing does leave sufficient photosynthetic area for maintaining plant vigor. Also of interest is how stubble height can be used to monitor animal foraging behavior and the associated impacts to the physical stability of riparian zones or the use of other desirable woody plant species as suggested by Hall and Bryant (1995). Using stubble height to monitor grazing impact on these riparian zone attributes may be more important to the manager than it is for maintaining stubble heights that support plant vigor and sediment deposition.

Stubble Height and Physical Attributes of Riparian Zones

Grasslike vegetation has been shown to be important for maintaining the physical integrity of streambanks (Zonge et al. 1996, Zonge and Swanson 1996). Grazing by large herbivores may cause hoof damage by using these resources (Buckhouse et al. 1981, Kauffman et al. 1983, Marlow and Pogacnik 1985, and Myers and Swanson 1992). Physical damage may vary depending on season of use and soil moisture. More physical damage occurs when soils are wet (Marlow and Pogacnik 1985), but amount of animal use may be less in wet areas when surrounding upland vegetation is green in spring and early summer (Kauffman et al. 1983, Clary and Webster 1989, Clary and Booth 1993, Hall and Bryant 1995). To reduce impact to streambanks and channel characteristics during grazing, Hall and Bryant (1995) recommend managers:

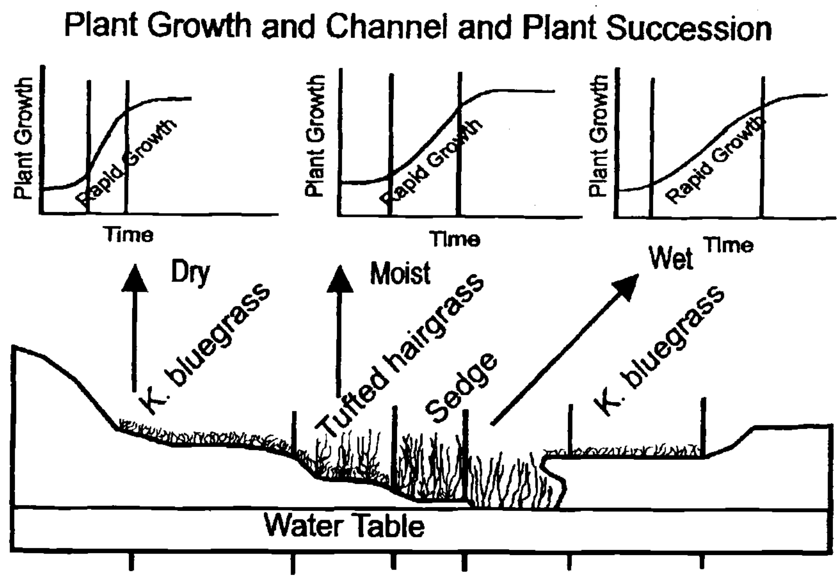
1) Pay attention to the stubble height of the most palatable species as height approaches 3 inches;
2) Note when stubble height moves from 3 inches to less than 1 inch; and
3) Keep track of the greenness of the most palatable species and, when greenness diminishes and the plants appear to dry, look for animals to seek greener vegetation.

Their advice is excellent and illustrates the wisdom and field experience of the authors.

This paper provides evidence that there are two distinct areas in riparian zones where stubble height may differ assuming that a grazing management philosophy of using 50% of available production will be enough to maintain plant vigor. These areas are the tall sedge and rush zone in wet areas and the tufted hairgrass and Kentucky bluegrass zones in the moist to drier areas. It appears that stubble heights also can be used to predict the extent of grazing effects on the physical integrity of riparian zone attributes and the potential for the animal's forage preference to switch to woody plants.

Excluding vegetation–soil surface compaction, physical damage to riparian zones is likely when soils are wet and soft and animals' hoofprints are heavy enough to break through the vegetation–soil surface. Physical impacts also include animals' breaking off or shearing soils of overhanging bank edges along stream channels. Area surrounding ponds, bogs, springs, and lake shores are examples of where soils may be wet and soft all or parts of a year. The greenline—that specific area where a more or less continuous cover of vegetation is encountered when moving away from the center of an observable channel (Cagney 1993)—represents the general area of concern along streams. Figures 2, 4, and 5 illustrate that wet and soft greenline extents vary with channel succession.

Figure 8. A generalized illustration of where Kentucky bluegrass and tufted hairgrass usually grow. Where they grow, one may expect short stubble height after grazing.



The zones occupied by tall sedges and rushes present a clear and concise image of where physical damage may be more than likely. Also, tall sedges and rushes usually are the last grasslike plants to be defoliated to any great extent when livestock graze riparian zones.

Physical impact and grazing vulnerability of these wet areas, however, may fluctuate with season of use and drought in any single season of the year because wet area soils may dry and become firm. Plants like Kentucky bluegrass and tufted hairgrass should be using their soil water supply as upland plants do, which should aid drying and increase the strength of riparian soils above declining water tables at the interface between uplands and wet zones (Figure 8). Therefore, stubble height standards that predict when damage begins may have to be flexible depending on whether soils are wet and soft or dry and firm. By monitoring established standards within the transition zone between the taller grasslike plants of wet soils and those in the rest of the riparian zones, information gathered can provide a first level of protection against physical damage to streambanks and other sources of water. Also, these data can be correlated to hoof imprinting and bank damage that exceed acceptable levels.

The greenlines of stream channels that support tall sedges and rushes generally are easy to define in the early stages of channel succession; therefore, following the stubble height monitoring protocol described above is appropriate. However, when channels reach maturity, the greenline often is difficult to differentiate from the remaining plant communities of the riparian zone, and tall sedges and rushes may be absent along the channel edge for reasons discussed earlier in this paper. Consequently, the lack of a tall sedge and rush zone eliminates the opportunity to use stubble height characteristics of plant species that have contrasting growth forms to achieve an early warning of bank damage.

Also, in smaller and mature stream channels, where the annual flow regime does not include a lot of contribution from other tributary streams during spring runoff, banks may overhang. In contrast, in larger streams the majority of flow is contributed by tributaries during spring runoff. The width and depth of these larger channels may adjust to contain high flows. In situations like these, well-vegetated banks often round off into the larger channels where low flow can be isolated anywhere between banks, and banks generally do not overhang except on the outside curve of meander bends.

A case can be made that a small mature headwater stream with overhanging banks is at great risk of being impacted by animal use and streamflow dynamics. Assuming erosion is cyclic, this channel configuration may be at a point when the stream system is ready to begin unloading its stored sediment. In part, this is because most roots generally are concentrated in the top 6 inches of soil surface because grasslike plants may have taken on more of the growth form of upland plants. As a result, the strength of the bank soil matrix can vary from weak to relatively strong, and the supporting soil columns for overhanging banks generally are exposed to streamflow even in drier months.

These factors appear to set the stage for bank failure under relatively light use even though many managers of riparian zones have identified this channel condition as a standard for what they believe they must achieve (USDI 1993). By grazing livestock along channels like these, one assumes a high risk of bank damage because these same banks can be broken by several classes of animals, streamflow dynamics, and ice. Therefore, measuring stubble height can help minimize risk associated with livestock grazing when measurements are correlated to use of vegetation and bank damage and subsequent measurements are recorded to compare the amount of change caused by livestock with that caused by other animals, streamflow dynamics, and ice.

Because grasslike plants in the riparian zones of many mature streams may have growth forms similar to Kentucky bluegrass and tufted hairgrass, stubble height after grazing likely will be between 3 inches and 0.75 inch at the channel edge (Figures 5 and 7). To minimize risk of physical damage, it is important to follow Hall and Bryant's (1995) warnings. Three inches of stubble can disappear rather quickly, and if tall sedges and rushes are not present there is no early warning as to when animals start using the vegetation along the banks' edges.

In summary, it appears that there are two distinct areas within riparian zones where stubble height may differ assuming that a grazing management philosophy of "take half, leave half" the plant's aboveground production is enough to maintain plant vigor. These are the tall sedge and rush zone occupying wet areas and the tufted hairgrass and Kentucky bluegrass areas of drier sites. Measuring stubble height at the transition zone between these and correlating data to the amount of hoof imprinting in wet areas and bank damage can serve to monitor animal impacts to riparian zones. Because wet riparian areas can dry during summer and in drought, stubble height standards should be flexible when used to predict physical and grazing impacts. Where differences in grasslike growth forms do not exist between uplands and water sources, particular attention should be given to Hall and Bryant's (1995) warning that one must closely monitor stubble height as it moves from about 3 inches to 0.75 inch. This is especially pertinent when monitoring the risk associated with grazing small mature streams and bank damage because: a) overhanging banks are rather easy to break off; b) a tall sedge and rush zone may not be present to give an early warning of grazing pressure increases along banks; and c) bank damage by other large grazing animals, streamflow dynamics, and ice can be extensive.

Stubble Height and Grazing of Woody Plant Species

Shrubs, especially willow, in riparian zones appear to be important for wildlife habitat (Thomas et al. 1978, Platts et al. 1983, Loft et al. 1991, Finch and Marshall 1993) and for stabilization of streambanks (Groeneveld and Griepentrog 1985). Also, willow communities can be altered or even eliminated after extended periods of browsing (Chadde and Kay 1991, Kovalchik and Elmore 1992, Singer et al. 1994). Increases in livestock's willow grazing have been observed when grasslike vegetation matures and turns from green to yellow in summer, and when green grasslike plants in riparian zones are consumed extensively (Kauffman et al. 1983, Clary and Webster 1989, Hall and Bryant 1995).

However, willow use also can be extensive when wildlife graze riparian zones (Gaffney 1941, Chadde and Kay 1988, Chadde and Kay 1991, Singer et al. 1994). Meiman (1996) illustrates that wildlife used willow in all seasons in all willow communities studied. Yet, results from this study indicate that livestock use generally was confined to specific landscapes for allotted periods. Use by both classes of animals generally was low during spring to midsummer.

Stubble height resulting from livestock grazing generally is used to predict when grazing animals shift from mostly herbaceous to woody plants. However, as discussed above, grazing animals also may shift from grasslike plants of dry and moist communities to the tall sedges and rushes of wet riparian zones. The shift may be before woody plants are used extensively; therefore, measuring any animal use of the tall sedge and rush community also may serve as an early warning of when consumption of browse species begins. Hall and Bryant (1995) and Clary and Webster (1989) provide sound reasons for shifts like these. They also provide stubble heights that appear to give warning that grazing animals will use shrubs if grazing continues.

Clary and Webster (1989) suggest that vegetation on riparian zones should be 4 to 6 inches high after grazing. Hall and Bryant (1995) warn managers to watch use of shrubs as grasses' stubble height decreases from 3 inches to 0.75 inch. As stubble moves below 3 inches, chances are shrub use will increase. The authors give sound advice, but their differences illustrate that the height of remaining vegetation and increased use on woody shrubs may depend on: a) the growth form of riparian zone grasslike plants; b) maturity of stream channels; and c) landscape position within individual riparian zones.

The discussion above about stubble height, stream channel stability, and foraging behavior suggests flexibility in management is important. If soils of streambanks or edges of ponds, bogs, springs, or lakeshores are soft, stubble may need to be higher to prevent physical damage. If soils are hard, lower stubble may be acceptable. In either case, animals' shift from using grass to areas supporting growth of tall sedges, rushes, and woody plants probably should be monitored at the same time. Overall, Hall and Bryant's (1995) warning that foraging behavior changes rather rapidly when stubble height goes from 3 inches to 0.75 inch is pertinent to monitoring the dry and stable soil conditions of tall sedge and rush communities as well as in the wet transition area between these and areas where Kentucky bluegrass and tufted hairgrass may dominate grasslike plants.

All large grazing animals may cause physical damage to riparian zones and consume both grasslike and woody plants. Managers of riparian zones therefore should use stubble height to predict potential impacts by animal class. Woody plants in riparian zones provide browse and habitat for elk, moose, and deer (Gaffney 1941, Chadde and Kay 1988, Chadde and Kay 1991, Singer et al. 1994), and use may extend through all seasons (Meiman 1996). To document overall grazing impacts on riparian zones, livestock producers can monitor use of woody plants and stubble height just before and immediately after using riparian areas. Other grazing impacts can be monitored similarly by appropriate management agencies and concerned interest groups. The result of this complete monitoring effort will be an evaluation of management objectives focused towards managing riparian zones in the western United States.

Summary

Riparian zones and their function along stream channels must be related to the cycle of erosion. It has been demonstrated in this paper that as sediment is deposited, channel succession occurs and that this process of bank building may be used to predict change in plant succession. As plant species composition is altered, growth form of grasslike plants may occur, and stubble height after grazing may then function differently in relationship to: a) how sediment is deposited along stream channels; b) how plant vigor responds to grazing action; c) when physical damage occurs to streambanks and wet and soft soils; and d) when and to what degree grazing use occurs on other plants of interest.

Stubble height measurements should predict how managers can best alter desired changes between the different stages of bank building recognized as major components in channel succession. Short stubble may increase sediment deposition and production of aboveground biomass and not damage health attributes of grasslike plants. However, in the process of grazing to short stubble, bank and hoof imprinting on soft and wet soils may occur, and forced use of other desirable plants may increase. Contrasts in the use of stubble height to alter function of riparian zones therefore exist, which require that managers be flexible when applying this monitoring protocol.

Evidence has been presented to suggest that when managers use stubble height to monitor success of moving from one stage in channel succession to the next, they recognize that each stage is independent within a point in space and time. Also, different stages in channel succession can exist along any single drainage net. Therefore, the function of each stage should be evaluated independently based upon its pertinent characteristics for trapping sediment, building banks, supporting plant species, and maintaining a desired channel configuration. This action can provide the data necessary to predict and determine trend toward meeting specific management objectives within all stages of the cycle of erosion and along the full course of a drainage system.

The desirable attributes of using stubble height to predict change in management of riparian zones support this approach. Examples of these are: a) stubble height estimates remaining vegetation and not the amount that has disappeared as consumed forage; b) stubble height monitoring is relatively easy to explain to a varied audience; c) stubble height is relatively easy to measure and therefore serves the wide range of expertise associated with managing riparian zones; and d) a large number of measurements can be taken in a short time which provides for adequate sampling intensity and more precise estimates than conventional utilization methodology.

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Developing and Achieving Management Objectives on National Forest System Lands

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Abstract

To enable the Forest Service to more effectively set and achieve management objectives for the range resource on National Forest System lands, achieving the functionality and desired condition of both aquatic/riparian and upland systems is essential. Setting measurable objectives is a required step before any monitoring can be developed. Monitoring protocols must be workable by grazing permittees and concerned citizens as well as by agency employees. Monitoring for forage utilization, while not a substitute for measuring long-term condition and trend, has its place in the manager's tool box to guide systems on the road to recovery. Monitoring residual vegetation is preferred over methods that estimate amount of herbage removed.

Introduction

The previous papers presented an excellent summary of the determination, interpretation, and use of forage utilization. Two methods to determine utilization were discussed: amount removed, and amount remaining. But most of all the authors illustrated idiosyncrasies and constraints.

Our purpose is to relate aspects of forage utilization to National Forest System (NFS) livestock management. The NFS operates under two of several important congressional laws: the Resources Planning Act (RPA) as amended by the National Forest Management Act (NFMA), both of which require analysis of livestock impacts on the grazing resource. These laws do not require determination of forage utilization, only assessment of the effects of utilization. They also provide for changing Forest Plans when new information becomes available. The NFS has proposed utilization measures as one way to assess livestock impacts. This paper discusses use of utilization in land management and its place in National Forest Plans.

Allotment Management Plans

Management plans dealing with livestock grazing might focus on three important features.

1) Define suitable functioning of ecosystems, both riparian and upland. Those functioning adequately are managed to maintain their function, and those that are not functioning adequately are managed to attain and maintain sustainable function.
2) Define management objectives that specify desired conditions on the ground.
3) Design a management strategy that will ensure the desired outcome based on sustainability. A management strategy is the foundation upon which a monitoring plan is formulated.

We should ask how and where determination of utilization fits in this monitoring plan. Five questions come to mind.

1) **Why** determine utilization? To appraise plant physiology or to appraise animal management? To evaluate grazing effects on vegetation and soil? What management need does it resolve? Does it monitor movement of the vegetation and soil toward or away from the desired condition and suitable functioning?
2) **What** does utilization monitor? Amount of forage removed or amount remaining? Animal distribution? Animal preference?

3) **How** is utilization determined? Percent of forage removed? How is removed forage determined: height/weight curves or percent of plants grazed? Amount of forage remaining? Measured stubble height? Percent of twigs browsed? Measured twig length?

4) **Where** is utilization determined? Critical areas? Key areas? Benchmark areas? What are the criteria for selecting areas?

5) **When** should utilization be determined? Before and after grazing to appraise wildlife use? After livestock move? End of plant growth? End of season? Every year?

Monitoring Objectives

A management plan must define what determination of utilization is supposed to accomplish. How does it monitor maintenance or attainment of a desired condition? For example, how does it relate to monitoring trends in vegetation and soil? How does it relate to animal distribution, allotment carrying capacity, and prescription of a grazing plan? How might it be used to appraise animal damage to soil and vegetation? Can it be used to manipulate livestock (USDI BLM 1996)?

How is determination of utilization used on an allotment without a management plan? Is it used to manage livestock? Should it be used annually or more often to evaluate animal impacts?

There are some monitoring priorities for which determining utilization might be useful if the method is easy to use, quick, and has minimum variability between observers (USDI BLM 1996). In other words, the method should be usable by permittees, the public, and agency employees. The following attributes are particularly important for allotments without a management plan. Determining utilization might be used:

1) As a warning sign to prevent livestock damage to soil or vegetation (Hall and Bryant 1995). We are looking for an indication that there has been enough use and that livestock should be moved. We can measure resource damage after it has happened (U.S. GAO 1988); what we need is a livestock management tool to prevent damage (Hall and Bryant 1995).

2) As a means to develop vegetation structure. Limiting use may provide for an increase in shrub height and crown spread, leave enough stubble to trap sediments in riparian areas, and leave forage for other animals. Vegetation structure is a key element in ecosystem function. These are ways to meet requirements of a biological opinion rendered under the Endangered Species Act (ESA). Annual monitoring typically is required.

3) As a means to prevent soil damage by leaving enough stubble to protect the soil from compaction, soil displacement, and wind or water erosion (Hall and Bryant 1995). Preventing and correcting soil and vegetation damage leads to sustainable function. Annual monitoring might be necessary.

4) As a means to appraise livestock distribution on key or critical areas, appraise allotment carrying capacity, and adjust the grazing management system to avoid vegetation or soil damage (USDI BLM 1996).

Utilization Characteristics

Systems for determinating utilization to meet monitoring needs have several characteristics. One critical factor is recognition that all we have to work with is what remains—stubble height, twigs browsed, or twig length, all of which are directly measurable (USDI BLM 1996, Hall and Bryant 1995). Removed material and total production must be estimated to determine percent use (USDI BLM 1996).

The sampling method must be quick, easy, and reliable with little variation among different observers. This means that when several people sample the same utilization transect, their results show a minimum of difference. Measurements, as opposed to estimates, usually vary less among observers, require less training, and have fewer presumptions about how much is removed (USDI BLM 1996). Focusing attention on what remains seems desirable because it contributes to sustainable function.

What remains directly influences the rate of shrub height and crown growth and the stubble's ability to trap sediment, provide soil cover and protection, and supply forage for other animals; it also affects how animals eat (Hall and Bryant 1995). Cows are an example. A cow reaches her tongue out of the side of her mouth, draws in forage, tastes it, and bites off a mouthful, filling her rumen quickly when forage is plentiful (Hall and Bryant 1995). But as stubble height lowers to 3 to 4 inches, the herbage is too short for the cow's tongue to draw it into her mouth so she starts eating in bites. Bites take in less forage, so more time is required to fill her rumen (Van Soest 1988). As a result, her preference changes to less palatable species in order to fill her rumen. Or she may concentrate her grazing in riparian areas where forage remains plentiful, then damaging vegetation or soil and breaking down stream banks (Hall and Bryant 1995).

The amount of forage remaining directly relates to livestock preference for forage and foraging areas and reveals opportunities to shift livestock distribution from heavily to lightly used locations. When livestock grazing habits change as stubble height approaches 3 to 4 inches, the livestock manager is warned to move animals to avoid damage and maintain trend toward the desired condition and sustainable function (USDI BLM 1996, Hall and Bryant 1995).

What remains can be measured, whereas what was removed must be estimated (USDI BLM 1996). What remains can be sampled with little training, and criteria can be established that are easy to understand, such as a stubble height of 4 inches. What remains can be shown to people: "This is what we want to accomplish" or, "This is when the animals must be moved."

The concept of measuring vegetation remaining is preferred by the authors, who recommend it be adopted as a tool in Forest Plan Standards and Guidelines for both riparian and upland ecosystems while phasing out the estimation of percent use (what was removed).

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Impact of Federal Grazing Reductions on Wyoming Ranches

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Abstract

The study examines the profitability of a ranching operation that adjusted to a reduced stocking rates resulting from a decrease in public land use. A 300-cow case study ranch was developed using input from ranchers grazing on U.S. Forest Service (USFS) allotments in the Big Horn National Forest and adjoining Bureau of Land Management (BLM) allotments.

A linear programming model of production alternatives was developed to assess how the ranch would adjust to a reduction in federal AUMs. The ranch was allowed to adjust cattle numbers and to convert hayland to pasture and/or feed hay. Adjustments to 25, 50, and 100% decreases in federal AUMs were examined. Each scenario then was analyzed to estimate the financial consequences of the reduction using The Farm Level Income Tax and Policy Simulation Model (FLIPSIM).

As total federal AUMs were reduced 25, 50, and 100%, numbers of cows were reduced from 300 head to 261, 221, and 144 head, respectively. Hayland converted to pasture under each reduction scenario was 16, 32, and 64 acres, respectively. These reductions translated into a decline in average annual net cash income of $14,263, $30,689, and $56,554, respectively. The ending equity ratio dropped from the original 0.88 to 0.80, 0.63, and 0.33, respectively, under the 25, 50, and 100% reduction scenarios.

Introduction

Almost 49% of the total acreage in Wyoming is federally owned (USDI BLM 1994). Of this, 60% is under Bureau of Land Management (BLM) jurisdiction (USDI BLM 1994) and 30% is administered by the U.S. Forest Service (USDA FS 1993). More than 2.1 million animal unit months (AUMs) of authorized grazing are provided to livestock ranchers in Wyoming from BLM- and USFS-administered lands.

When federal grazing lands originally were allocated, livestock operators who met the commensurability and prior-use requirements were given preference for receiving available grazing permits. Grazing fees were set below "fair market value," and permits were allocated to encourage settlement and stability of western communities. Public lands were incorporated quickly into the ranchers' forage rotations and became an integral ingredient to successful ranching in the arid West. Public land ranchers contend their economic viability is related to the economies of size achieved from, and seasonal forage demands provided by, grazing federal lands (Torell et al. 1992).

Livestock AUMs on federal lands can be reduced for a number of reasons. For example, the Proposed Action outlined in the Draft Environmental Impact Statement for Rangeland Reform '94 (USDI 1994) projected a 21% reduction from 1993 levels in AUMs on federal lands over a 20-year period. Stocking rate adjustments were predicted to result "from monitoring studies that indicate continuing resource damage and a declining economic feasibility of livestock grazing" (p. 4-38). While not specified, monitoring studies often include the measurement or estimate of utilization. As has been pointed out in previous papers, exceeding arbitrary utilization levels, sometimes for only 1 year, can lead to temporary or permanent reductions in stocking rates on a federal grazing permit.

Several researchers have examined the importance of federal grazing to the economic success of public land ranchers. Torell et al. (1981) used a linear programming model to examine the impact of BLM allotment reductions on Nevada ranchers. As the percentage of AUMs were reduced, a corresponding reduction in ranch net income occurred. Ranchers adjusted by substituting irrigated pastures, deeded rangeland, and USFS grazing for the BLM grazing. Additional hay also was fed and/or cattle numbers were reduced.

Results were similar in Wyoming studies by Olson and Jackson (1975) and Peryam and Olson (1975). Both studies found that reducing the amount of BLM grazing permitted caused a reduction in cow numbers and labor used, along with an increase in off-farm hay sales. Depending on the ranch's dependence on public lands, net income declined from 5.2 to 31.6% as available federal grazing decreased 90%.

This study's objectives were to determine optimal ranch production adjustments to reductions in BLM and USFS grazing reductions for a representative north-central Wyoming ranch. The economic success of the ranching operation, given the optimal ranch production adjustments, was examined under stochastic price and production conditions.

Methods

Analysis was in three steps. First, data for the representative ranch were developed through group interviews. A linear programming (LP) model then was developed to depict the production process of the ranch. Optimal production adjustments to specified reductions in permitted federal grazing were determined using the LP model. Third, ranch resources and production practices under each federal grazing reduction scenario were incorporated into a stochastic simulation model to determine the financial performance of the ranch over a 10-year period.

Representative Ranch

A representative federal land ranching operation was developed for north-central Wyoming, specifically, for Washakie and Big Horn counties. The representative ranch was developed through interviews with a panel comprising four area ranchers selected by the local county agricultural Extension agent. Through consensus, the panel developed the characteristics, resources, costs, and income structure of a representative federal-land ranching operation in the area. The panel also was used to validate the simulated representative ranch to ensure the information gathered was interpreted correctly.

The ranch comprised 2,200 deeded acres and was located at the base of the Big Horn National Forest. Characteristics of the ranch are given in Table 1. The ranch was a typical cow–calf operation, with

Table 1. Characteristics of the representative Wyoming ranch.

	Unit	Value
Land resources owned		
Alfalfa hayland	acre	80
Native hayland	acre	55
Subirrigated pasture	acre	300
Rangeland	acre	1,765
Land resources leased		
Grazing state land	AUM	160
Grazing USFS land	AUM	940
Grazing BLM land	AUM	1,001
Livestock resources		
Cows	head	300
Replacements	head	38
Bulls	head	13
Horses	head	6
Financial resources		
Assets	$	838,719
Liabilities	$	127,855
Debt-to-asset ratio	%	15.2
Efficiency measures		
Calf crop weaned	%	92
Calf sale weight		
Steer	lb	550
Heifer	lb	525

300 head of mother cows and associated replacements and bulls. A 92% weaned calf crop was assumed, with weaning weights of 550 pounds for steers and 525 pounds for heifers. Livestock grazing requirements in the spring, summer, and fall were met by deeded rangeland and subirrigated pasture, along with state, USFS, and BLM grazing permits. State and BLM grazing lands were utilized in the spring (May and June) and fall (October and November). Forest Service grazing lands provided most of the ranch's grazed forage from July through September.

Productivity measurements for the deeded rangeland and subirrigated pasture were obtained from Natural Resource Conservation Service (NRCS) site guides for the areas, assuming land in good condition (Table 2).

Farming operations consisted of an alfalfa growing and haying enterprise, an alfalfa establishment enterprise that used oats harvested as hay for a rotation/cover crop, and a native hay growing and haying enterprise. The alfalfa enterprise yielded 4 tons of hay per acre, the oat enterprise yielded 3 tons per acre, and the native hay enterprise yielded 3 tons per acre (Table 2). The alfalfa and native haying enterprises also contributed 1.7 AUM/acre and 0.6 AUMs/acre, respectively, in aftermath to the livestock operation. All hay crops were flood irrigated or irrigated with side-roll sprinklers.

Farming equipment was minimal and included two tractors (100 and 65 horsepower), a 12-foot hay swather, a round baler, a hay rake, a harrow, a disk, and a drill. Most machinery and equipment were 10 to 20 years old and had been purchased from used-equipment auctions around the valley.

Table 2. Productivity measures of harvested and grazed forages.

	Unit	Value
Alfalfa hay	tons/acre	4.0
aftermath	AUM/acre	1.7
Native hay	tons/acre	3.0
aftermath	AUM/acre	0.6
Oat hay	tons/acre	3.0
Graze alfalfa hayland	AUM/acre	11.6
Graze native hayland	AUM/acre	7.7
Graze subirrigated pasture	AUM/acre	1.5
Graze rangeland	AUM/acre	0.3

Livestock typically were fed hay from December through April. Slightly over 1 ton of hay was fed per animal. Concentrate supplements were reserved for replacements.

Ranch assets were valued at $838,719. Liabilities, mostly long-term loans, were $127,855, leaving a debt-to-asset ratio of 15.2%.

Linear Programming Model

The LP model was formulated to account for the representative ranch's seasonal forage and labor requirements. The model's objective function was to maximize profit, subject to the various resource constraints previously described. Forage was accounted for on a monthly basis, and labor was summed by activity. Major activities and their associated cost or return coefficients are in Table 3. Forage resources previously described were designated as activities and entered the objective function as costs of production (Table 3). Hay yields and/or AUMs provided by each activity were made available to livestock enterprises through monthly forage transfer rows to be used in their designated season of use.

Permittees on the Big Horn National Forest were surveyed concerning adjustments they would make if USFS grazing permits were reduced by 25, 50, and 100%. The majority of permittees stated they would adjust their resources at the base ranch and keep ranching until they could no longer stay in business; then, they would sell out. A few stated they could improve some grazing lands (e.g., spray sagebrush), but the majority stated there were not many improvements they could make.

To allow the ranch to adjust to reductions in USFS or BLM grazing, two activities were therefore added to the LP model: graze alfalfa land, and graze native hayland. Stocking rates were figured assuming 780 pounds of forage per AUM and a 90% utilization rate. Costs of grazing the forage included buying and operating electric fences. Leasing pasture from other landowners was not included as an option in the model, for two reasons.

Table 3. Variable costs[1] and prices of major activities in the linear programming model.

Activity	Unit	Value ($)
Grow and harvest alfalfa hay	acre	69.04
Grow and harvest grass hay	acre	27.74
Grow and harvest alfalfa hay establishment	acre	85.64
Grow and harvest oat hay	acre	72.58
Graze alfalfa forage	AUM	3.80
Graze native grass forage	AUM	2.44
Graze subirrigated pasture	AUM	4.00
Graze private rangeland	AUM	3.25
Graze BLM land	AUM	7.19
Graze USFS land	AUM	9.46
Graze state land	AUM	8.59
Purchase alfalfa hay	ton	70.00
Purchase grass hay	ton	60.00
Purchase protein supplement	ton	200.00
Purchase price of bulls	head	1,700.00
Maintenance cost of cows[2,3]	head	37.64
Maintenance cost of replacement heifers[2]	head	21.80
Selling price of steer calves	cwt	88.75
Selling price of heifer calves	cwt	81.50

[1] Excludes labor

[2] Excludes cost of feed stuffs

[3] Includes maintenance of bulls and value of cull animals

First, a surplus of private leases does not exist in the area. Second using private leases to compensate for a reduction in federal AUMs would displace other livestock production in the region and inaccurately reflect the impact that a decrease in available federal grazing would have on the region.

Constraints in the model included the number of AUMs available on USFS and BLM lands. As these numbers were reduced, the model adjusted by reducing the number of cows and rearranging the forage situation in the most profitable manner. As the number of cows were reduced, the associated inputs (e.g., number of bulls required), variable costs, and outputs were adjusted accordingly.

Fixed costs (e.g., legal fees, land taxes, insurance, and depreciation) remained unchanged as USFS and BLM permits were reduced.

Labor requirements were identified separately for each activity in the model. The ranch owner provided 200 hours labor per month. Additional labor requirements could be met by hiring a full-time employee for $18,000 per year (providing 200 hours labor per month) and/or by hiring part-time labor for $5.00 per hour.

Simulation Model

The mathematical description of the representative ranch and the appropriate resource adjustments from the LP optimization were entered in the Farm Level Income Tax and Policy Simulation Model (FLIPSIM). FLIPSIM is a Monte Carlo simulation model developed by Richardson and Nixon (1986). The model has been used for numerous farm level policy and technology analysis (e.g., Anderson et al. 1993; Lemieux and Richardson 1989; Richardson and Smith 1985). FLIPSIM allows the operator to simulate a representative ranch under alternative policy and management scenarios using stochastic prices and yields.

Weaning weights and livestock prices were stochastic in the simulation. The economic activity of the representative ranch was simulated over a 10-year planning horizon for 100 iterations. Each year, weaning weights were generated randomly based on a historical series of weights from panel producers. Livestock and feed prices also were selected randomly for each iteration based on the average annual prices in the 1996 Food and Agricultural Policy Research Institute baseline and associated historical probability distributions of each variable. In the simulation, steer calf prices averaged $79.67 per hundredweight., alfalfa prices averaged $60.94 per ton and intermediate-term debt financing averaged 9.15%.

FLIPSIM allows the user to track several financial variables. Variables of interest in this study were annual net cash income and owner's equity. Results of the 100 iteration analyses constitute an estimate of the probability distribution for each variable.

Using the probability distributions, the probability of negative cash income and the probability of the ranch owner's obtaining a lower real equity can be determined for each federal grazing reduction scenario. A 6% discount rate was used to adjust cash flows for the effects of time.

Federal Grazing Reduction Scenarios

A baseline simulation of the representative ranch without federal grazing reductions was compared with nine reduction scenarios. Scenarios 1 through 3 reflected reductions of 25, 50, and 100% in USFS grazing permits, holding BLM grazing numbers constant. Scenarios 4 through 6 entailed 25, 50, and 100% reductions in BLM grazing permits, holding USFS permits constant. The last three scenarios represented 25, 50, and 100% concurrent reductions in USFS and BLM grazing permits.

Results

Annual net cash income for the representative ranch when USFS and BLM permits were at their full use averaged $31,556 (Table 4). Four percent of the time, the ranch had a negative annual net cash income. Ending equity was reduced to 88% by the end of the 10-year planning horizon, assuming no inflation. Ending equity eroded over the 10-year planning horizon for 75 out of the 100 iterations simulated.

To adjust to the reduction in USFS grazing permits, animal units operated by the ranch declined, some hay acreage was converted to summer grazing pasture, and the amount of labor needed was reduced (Table 4). The panel that developed the representative ranch believed the season of use on BLM lands was fairly rigid and could not be grazed during the summer to make up for lost USFS AUMs. Therefore, adjustments included grazing some private rangeland during the summer and converting hayland to pasture to keep production at a maximum. Because of the seasonal rigidity of grazing BLM forage, adjustments in cow numbers or in hayland to pasture conversion were not the same as the USFS permits were reduced from 25 through 100%.

The loss of all 942 USFS AUMs amounted to a loss of 136 mother cows along with the associated bulls and replacement heifers. The loss of the 942 USFS AUMs amounted to a greater than one-to-one conversion on the ranch, as the USFS AUMs amounted to a reduction in only 78.5 AUs. This was because the conversion of hay acreage to pasture allowed less feed for wintering cows and also because of underutilized BLM AUMs.

Labor also was reduced as the ranch lost USFS AUMs. The reduction was not constant on a per-cow basis because some labor requirements were fixed on the ranch. Labor requirements per mother cow increased from approximately 15 hours per cow to almost 18 hours per cow as the ranch completely lost USFS grazing permits.

Economies of size have been noted as partly responsible for the value attached to federal grazing permits. This was observed in the simulation analysis as average annual net cash income was affected by the rigidity of the BLM grazing season,

Table 4. Adjustments to reductions in U.S. Forest Service AUMs.

	Percent reduction in USFS AUMs			
Adjustments in	0	25	50	100
USFS AUMs	942	707	471	0
BLM AUMs	1,001	1,001	1,001	1,001
Number of cows	300	267	221	164
Acres hayed	135	117	95	79
Hay acres converted to pasture	0	17	40	56
Hours of labor	4,481	3,901	3,688	2,872
Average annual net cash income ($)	31,556	20,489	15,893	(20,522)
Probability of negative cash income (%)	4	13	18	100
Ending equity ratio (%)	88	83	78	38
Probability of lower real equity (%)	75	99	99	100

Table 5. Adjustments to reductions in Bureau of Land Management AUMs.

	Percent reduction in USFS AUMs			
Adjustments in	0	25	50	100
USFS AUMs	942	942	942	942
BLM AUMs	1,001	751	501	0
Number of cows	300	271	237	168
Acres hayed	135	123	109	80
Hay acres converted to pasture	0	12	26	55
Hours of labor	4,481	4,211	3,858	3,152
Average annual net cash income ($)	31,556	19,835	6,697	(23,111)
Probability of negative cash income (%)	4	14	31	100
Ending equity ratio (%)	88	82	70	35
Probability of lower real equity (%)	75	100	100	100

the fixed nature of labor, and the fixed costs that had to be covered no matter how many cows were operated.

The financial condition of the ranch quickly deteriorated as USFS permits were removed. Average net cash income was reduced a total of $52,078 when USFS grazing ceased, and the probability of negative cash income increased from 4% when all grazing permits were intact to 100% when forest grazing no longer was available. Continued ranching after forest grazing was removed was not a wise decision, as rancher equity eroded to 38% of the original value over the 10-year planning horizon.

Patterns were similar for BLM and USFS permit reductions (Table 5). Cow numbers were reduced on a greater than one-to-one basis, though the reduction was not quite as great as when USFS grazing permits were lost. Accordingly, the financial condition of the ranch deteriorated slightly less, though the ranch quickly turned unprofitable without the use of BLM permits.

When USFS and BLM grazing permits were lost concurrently (Table 6), the effect on the ranching operation was not additive because of the unemployed federal grazing resources due to the seasonal rigidity of both USFS and BLM grazing permits. The carrying capacity of the deeded ranchland settled at 144 mother cows when all federal grazing permits were removed. The ranch was not able to cover all variable and fixed costs at this stage, and it rapidly lost equity.

Conclusions

As previous studies have shown, federal grazing permits were important to the success of the representative ranch used in this study. Economies of size, obtained through the additional cows the ranch was able to maintain because of the federal grazing permits, were an important aspect of this success. Costs of buildings, fences, corrals, and equipment were all reduced on a per-cow basis because of federal grazing permits.

Employment issues also appeared to be important considerations as federal grazing permits were relinquished. While some labor fixity was apparent in this study, the ranch was not able to maintain enough work to employ a full-time person when federal permits were lost.

As mentioned, many permitees of the Big Horn National Forest stated if they lost forest grazing privileges, they would make adjustments on their base properties until they could no longer stay in business. The simulation analysis in this study showed that equity rapidly eroded as federal permits were removed. The potential exists, therefore, that without federal grazing permits, much of the land around national forests could change ownership. Because of the price most land around national forests can demand, the danger is those lands would be subdivided into ranchettes or other residences rather than stay in productive agricultural use.

Results of this study are limited to the area studied and to the assumptions made. Further study appears

Table 6. Adjustments to reductions in U.S. Forest Service and Bureau of Land Management AUMs.

	Percent reduction in USFS and BLM AUMs			
Adjustments in	0	25	50	100
USFS AUMs	942	707	471	0
BLM AUMs	1,001	751	501	0
Number of cows	300	261	221	144
Acres hayed	135	119	103	71
Hay acres converted to pasture	0	16	32	64
Hours of labor	4,481	4,090	3,687	2,688
Average annual net cash income ($)	31,556	17,293	867	(24,998)
Probability of negative cash income (%)	4	14	45	100
Ending equity ratio (%)	88	80	63	33
Probability of lower real equity (%)	75	100	100	100

to be warranted to assess positive and negative externalities, such as the impact upon wildlife, associated with viable ranching operations utilizing federal grazing permits.

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Comparison of Economic Impacts from Public-land-based Tourism and Grazing: A Case Study

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Abstract

This paper examines the economic effects of decreases in cattle grazing allowed on the Big Horn National Forest (BHNF) in north-central Wyoming. A 25% reduction of the 105,775 AUMs of grazing allotted to cattle would reduce economic activity in the four-county area surrounding the BHNF by $1.68 million, of which $441,384 would be personal income for local residents. The communities also would lose 30.56 FTE jobs. Eliminating all cattle grazing on the BHNF would reduce economic activity by $6.74 million, personal income by $1.77 million, and employment by 122 FTE.

Tourism often is touted as the economic savior for small local communities facing decreased grazing allotments. To offset the decline in economic activity from eliminating public-land grazing, recreation would have to increase about 104,000 tourism visitor days (TVD). Tourism would need to increase about 127,000 TVD to offset the loss of personal income. Depending on the growth rate of recreational use, 10 to 53 years could be required for the Big Horn Mountain Area (BHMA) economy to recover the loss in income from the reduction in livestock grazing. To maintain the current employment level, recreation would have to increase about 113,000 TVD. If personal income and employment are important to a local community, more than one TVD will be required to replace each AUM of public land grazing. The numbers presented in this paper are for analysis and comparative purposes only. There is no evidence to indicate tourism recreation would increase as a result of decreased livestock grazing.

Introduction

Emotional arguments often are at the center of public-land use issues that involve both commodity users and and individuals advocating a reduction or total elimination of livestock, timber, and mineral production on public lands. Economic considerations have received low priority in the deliberations that result in policy decisions that direct the use of our public lands. As a result, minimal resources have been spent to develop sound scientific methods to estimate the economic impacts of alternative public-land uses on local communities.

Depressed economic conditions prevailed in Wyoming during much of the 1980s. Decline in the energy industry and low prices for agriculture commodities created economic hardships in many Wyoming communities. Economic growth and development opportunities for these rural communities are highly dependent on increasing economic activity in the basic industries, which rely heavily on natural resources located on federal lands.

The Big Horn National Forest in north-central Wyoming is a source of summer grazing for livestock producers and of timber for local sawmills. The Big Horn Mountains and the surrounding area, including forest boundaries, provide visitors the opportunity to enjoy camping, hunting, fishing, sightseeing, geology sites, historic sites, and various other activities in an uncrowded setting.

In 1989, the Big Horn Mountain Coalition formed to explore the possibility of improved tourism marketing for the region. This area had experienced an eroding tax base, by over 50% in one county, and loss of jobs. The executive board of the Coalition was composed of one county commissioner from each of the four counties within the Big Horn Mountain Area: Big Horn, Johnson, Sheridan, and Washakie counties. Their primary objective was to increase economic activity, jobs, and their tax bases from tourism and recreation in the BHMA while mitigating conflicts with other industries and users of the natural resource base. The Coalition's first action was to commission a study through the Wyoming Cooperative Extension Service to develop baseline information on tourism in the area.

The Coalition developed a climate for cooperation and coordination between commodity users, recreationists, federal land management agencies, and local business people in the area. This provided an excellent opportunity to study the economic impact of proposed alternatives for public-land management decisions. Although economics may not be the most critical issue in determining public-lands policy, it should be considered in the final analysis. The consideration should be based on the best data available, which historically have been minimal at best.

This paper is presented in three sections: tourism and recreation, grazing, and economic impact comparisons between tourism and recreation and grazing. Sections one and two—tourism and recreation, and grazing—discuss the purpose, procedures, and impact results for current levels of activity. The third section compares the economic impacts as a result of one activity versus the other.

Tourism and Recreation

Analyses reported in this section are based on survey data collected from visitors to the area during the summers of 1989 and 1990 and the winter of 1989-90 and on a survey of eating, drinking, and lodging establishments during the summer and fall of 1990. The survey data were supplemented with secondary data based on sales tax collections and the census of retail trade and services for the four counties in the study area.

Procedure

Two critical factors had to be quantified to estimate the economic contribution of tourism and recreation in the Big Horn area: first, the number of people visiting the area; second, the level of visitors' expenditures. Two approaches were used to estimate the two factors. An estimate of the number of people visiting the area was developed through interviews with lodging providers in the area to determine occupancy and average daily rates by month. This provided an estimate of the supply of lodging facilities and capacity utilized. Visitor surveys provided the average daily expenditure for each party or each person visiting the area for tourism or recreational purposes. This was used to estimate the demand for goods and services by people residing outside the area. Census data for lodging and eating and drinking establishments for 1987 were analyzed and updated using the latest state sales tax figures to provide a check on the accuracy of the survey results.

Lodging

Three general categories of lodging were used to estimate tourist numbers. U.S. Forest Service figures were used to estimate the number of campers using camp sites on the Big Horn National Forest. Surveys conducted with private campground owners were used to estimate the number of spaces rented per day. An estimate was made of the average number of nights each site was rented per year and the average daily rate. Information collected from motel and other lodging providers was used to determine both the level and type of occupancy. Commercial travelers were separated from tourists because they represent different expenditure patterns and markets. Meetings and conventions were included in the commercial travel. Although they have different expenditure patterns than individual company or government representatives, they are in the area for a specific purpose. Convention centers target this market and are very competitive.

Tourism

Motels and other similar tourist lodging were estimated by subtracting the commercial rooms from the total number of rooms rented. Table 1 shows the total number of rooms occupied by commercial and tourist travelers. Table 2 gives the estimated number of nights Forest Service campsites were occupied. This estimate was based on 429 developed camp sites with an occupancy rate of 62% for approximately 92 days during the summer season. Private campgrounds were estimated to rent each site an average of 48 nights per year. Based on the 969 sites shown in the inventory, this gives an estimate of 46,512 party nights per year.

During the summer season, assumed to be April through November, approximately 17% of the visitors surveyed said the primary purpose of their trip was to visit friends or relatives while they were in the area. It was assumed they stayed with the friend or relatives and did not utilize commercial lodging facilities. These people accounted for 41,769 party days or 142,015 person days. The number of person days was calculated from the average size of party indicated by the survey respondents. Table 2 indicates over 892,000 people spent a night in the Big Horn area for tourism purposes during 1989. This does not count the backcountry campers or day visitors who visited the area, but did not spend a night.

Tourism and Recreation Expenditures

The number of person days is combined with the expenditures per person per day to estimate the total number of dollars tourism brought into the

Table 1. Estimated occupancy rates, Big Horn Mountain area, 1989.

Month	Total rooms occupied	Commercial rooms	Tourist rooms	Summer parties	Winter parties
January	8,410	6,728	1,682		1,682
February	8,760	7,008	1,752		1,752
March	9,790	7,832	1,958		1,958
April	10,216	8,755	1,461	1,461	
May	19,059	10,714	8,345	8,345	
June	35,995	10,618	25,377	25,377	
July	44,871	9,345	35,526	35,526	
August	42,847	10,059	32,788	32,788	
September	25,287	9,619	15,668	15,668	
October	21,786	8,868	12,918	12,918	
November	10,408	7,776	2,632	2,632	
December	9,076	6,686	2,390		2,390
Totals	246,505	104,008	142,497	134,715	7,782

area. Lodging and eating and drinking expenditures are analyzed individually because they represent specific areas that can be cross-referenced with secondary data sources.

Table 2. Estimated number of tourists and recreationists visiting the Big Horn Mountain area, 1989.

Seasons & accommodations	Party days	Number per party	Person days
Summer			
FS Campgrounds	24,470	3.7	90,540
Private campgrounds	46,512	3.4	158,141
Motels, etc.	134,715	3.4	458,031
Friends/relatives	41,769	3.4	142,015
Winter			
Motels, etc.	7,782	4.9	38,132
Friends/relatives	1,194	4.9	5,851
Totals	256,442		892,710

Estimates of lodging expenditures developed using the 1987 U.S. census of services data for Wyoming and the latest sales tax collection figures indicate approximately $7 to $9 million were spent on lodging in the four-county area. Our estimate of $9.3 million (Table 3) is slightly higher but we believe it is justified due to the reporting procedures used for tax purposes. Some tax revenue could find its way into a different industry classification. Also, a small percentage of lodging is tax exempt.

Estimated expenditures at eating and drinking establishments in the area were divided into tourism, commercial travelers, area residents, and day visitors. Tourism expenditures were based on the estimated number of person days visiting the area and their expenditures obtained from the visitor surveys (see Table 3). Using the estimated person days and the daily expenditures given by survey respondents indicates tourists spent $8.6 million in eating and drinking establishments (see Table 4). Commercial travelers are estimated to spend $22 per day per party. This is correlated to each night of lodging. Most, but not all, these travelers are alone. The figures include people attending meetings and conventions who tend to spend more per person, per day on food and beverage.

Local residents are the primary source of income for prepared food and drink establishments. A 1990 study conducted in Park County indicated each individual spends approximately $320 per year in his or her local community for prepared food and beverages. This was the best estimate available and was assumed to apply to the BHMA.

The day visitors' expenditures shown in Table 4 are estimated eating and drinking sales to individuals passing through the area but not staying overnight. The expenditures were calculated as the residual from the $32.1 million total expenditures at eating and drinking establishments in the area. Secondary data sources indicate total eating and drinking revenues are between $27 and $29 million annually. The $32.1 million for total eating and drinking expenditures shown in Table 4 is a gross figure. That is, it contains payments to food and beverage businesses plus tips to employees. Data collected from survey

Table 3. Estimated expenditures for private lodging in the Big Horn Mountain area, 1989.

Tourism/recreation	Person days	Expenditures per day	Total expenditures
Summer			
FS Campgrounds	90,540	0.00	0
Private campgrounds	158,141	3.40	537,679
Motels, etc.	458,031	12.43	5,693,325
Friends/relatives	142,015	0.00	0
Winter			
Motels, etc.	38,132	9.95	379,413
Friends/relatives	5,851	0.00	0
Total tourism	892,710		$6,610,417
Commercial/business units/year	104,008	26.00	$2,704,208
Total lodging	996,718		$9,314,625

Table 4. Estimated expenditures at eating and drinking establishments in the Big Horn Mountain area, 1989.

Tourism/recreation	Person days	Expenditures per day	Total expenditures
Summer			
FS campgrounds	90,540	2.78	251,701
Private campgrounds	158,141	5.33	842,892
Motels, etc.	458,031	11.62	5,322,320
Friends/relatives	142,015	11.62	1,650,214
Winter			
Motels, etc.	38,132	12.97	494,572
Friends/relatives	5,850	12.97	75,875
Total tourism	892,709		8,637,574
Commercial/business units/year	104,008	22.00	2,288,176
Area residents person years	53,600	320.00	17,152,000
Day visitors expenditures			4,000,000
Total eating & drinking			32,077,750

respondents are gross estimates. People indicate how much money they left in the restaurant, not the amount of the check.

Direct expenditures were calculated using total visitor days and expenditures per day data collected from the visitor surveys. Table 5 shows the total in-area expenditures by tourists in the BHMA to be $34.6 million in 1989. The dollar expenditures are heavily weighted toward retail purchases and eating, drinking, and lodging. The low level of expenditures for the recreational services sector may provide some indication of the number of services available. There is a clear indication that many of the businesses in the community benefit from tourism in addition to motels and restaurants.

Total Economic Activity of Tourism and Recreation in the BHMA

Total economic activity is estimated using an input/output model and adjusted primary data. Two major adjustments were made to expenditure data before they were run through the model. First, expenditures made through the trade sector are marginalized at 25.5%. This is due to the large leakage of dollars through the retail sector's purchases of imported items. Only dollars retained in the state can generate new economic activity.

The second adjustment is in the eating, drinking, and lodging sector. Expenditures are assumed to include tips of 10.5% (see Table 6), so this amount is attributed to household income and not as receipts to the providers of the service. This level of tips is substantiated from two sources. Operators of eating establishments estimated tips between 8.5 and 15%. A small, nonscientific survey of employees in the area was made to determine tips as a percentage of total employment income. That varies widely by type of business. Some have virtually no tips, while others have a relatively high percentage. This adjustment also was warranted through use of the 1987 census of retail trade for eating and drinking establishments. Those data were adjusted to reflect more current conditions. That approach indicated the area would have between $27 and $29 million in eating and drinking sales.

Table 6 gives the direct expenditures in column one. These expenditures were calculated from the data in Table 5. Total expenditures from retail stores was $17.4 million, the sum purchased for groceries and liquor through other purchases. Since a high percentage of the dollars from the initial purchases leave the community to replace the items sold, only the gross profit or $4.4 million is left for further expenditures in the area. The remainder, nearly $13 million, is shown as imports in Table 6. Lodging expenditures combined with purchases from eating and drinking establishments gives a total of $15.2 million from Table 5. Most of this amount, or $13.6 million, goes to the eating and drinking establishments while $1.6 million is tips and shown as household income in Table 6. The majority of expenditures for licenses and permits go to the state or federal government and are listed under other final payments. However, the U.S. Forest Service returned $18,667 directly to counties in the area from campground fees collected on the Big Horn National Forest.

Table 5. Estimated total direct expenditures (daily purchases per person) from tourism in the Big Horn Mountain area, 1989.

	Summer			
Category	Campers	Noncampers	Winter visitors	Dollar purchases
Lodging				6,610,417
Eating/drinking				8,632,574
Licenses/permits	1.40	0.68	0.42	660,796
Recreational services	0.30	1.57	1.61	1,288,327
Groceries/liquor	4.50	5.34	3.13	4,593,812
Gas/repairs/maint.	5.50	8.10	8.87	7,029,405
Equipment	0.85	0.47	1.15	483,886
Clothing/other retail	0.59	1.84		1,488,483
Gifts/souvenirs	0.65	3.78	1.08	2,972,298
Other purchases	0.19	1.18		911,863
Number of persons making purchases	90,540	758,187	43,982	
Total purchases				34,631,861

The indirect and induced or secondary effects are shown in Table 6, column 2; the total economic impact of tourism is in the third column. Tourism accounted for $56.3 million of total economic activity in the Big Horn Marketing area in 1989. These figures are not to be confused or compared with the impact of total travel. It is important to segment travel into the proper components to generate accurate estimates of economic impacts.

Income and Employment

Contributions to personal income and number of jobs created are of interest to local leaders in evaluating potential benefits from economic development projects. Tourism does not provide identifiable direct personal income through payrolls. That is, there are no tourism factories with reported personal income statistics that are used to measure economic contribution in many industries. Direct personal income from the $34.6 million of tourism expenditures is only $1.6 million in the form of gratuities. Purchases made from retail outlets and from eating, drinking, and lodging establishments and service providers creates $10 million in indirect personal income in the area through merchant payrolls. This represents a large portion of the impact from the original sale. The retail, food, and other services normally are thought of as supporting the basic sectors in the economy such as agriculture, mining, and manufacturing. However, these become basic sectors for that portion of their product or service sold to tourists. These sales bring new money into the area which fuels the economy in the same manner as exporting oil or agricultural products. The household row in Table 6 shows the direct and indirect components that account for the $11.6 million of total personal income that can be attributed to tourism.

Personal income generated from tourism expenditures can be translated into jobs. Tourism in the BHMA is highly seasonal in nature, and it follows that employment also is seasonal. Employment is estimated on a full-time equivalent (FTE) basis. One FTE is defined as one person working 2,000 hours (full-time) for 50 weeks during the year. The relationship between income and employment was calculated for each sector in the economy and used to estimate direct, indirect, and total employment.

The trade sector provides 145 FTE of employment from tourism expenditures. Added to the 525 FTE from the eating, drinking, and lodging sector and 57 FTE from the services sector, tourism accounts for 727 FTE of employment through direct transactions. Most income associated with the direct employment is from merchant payrolls and is included in the indirect/induced income effects in Table 6. The multiplier effect will create an additional 304 FTE of employment annually. This would provide an additional 87 FTE in trade, 200 FTE in eating, drinking, and lodging, and 17 FTE in the services sector. Tourism accounts for a total of 1,031 FTE of employment in the area on an

Table 6. Direct, indirect and total economic impact from tourist visitations to the Big Horn Mountain area, 1989.

Sectors	Total direct	Indirect induced	Total impact
Other businesses	0	3,051,409	3,051,409
Transportation/communications	0	889,291	889,291
Utilities	0	1,185,380	1,185,380
Trade	4,447,135	2,634,321	7,081,456
Eating/drinking/lodging	13,642,477	275,827	13,918,304
Finance, insurance, real estate	0	1,717,130	1,717,130
Services	1,288,327	1,044,534	2,332,861
Health	0	191,850	191,850
Local government	18,667	698,651	717,318
Households	1,600,514	9,969,505	11,570,019
Other final payments	642,129	0	642,129
Imports	12,992,612	0	12,992,612
Totals	34,631,861	21,657,898	56,289,759

annual basis. This represents over 4,000 jobs during the peak summer season.

Potential for Tourism Expansion

There has been considerable discussion on the need to market tourism and recreation in the Big Horn Mountain area as well as in other parts of Wyoming. Some indication of the capacity to handle increased numbers of travelers is needed to aid in marketing efforts. Our data year, 1989, was not one of the better years for tourism in the area. Table 7 indicates excess capacity in the lodging sector at least 9 months of the year. Any efforts to increase the number of visitors during the winter would be very beneficial to the entire service and retail business community. Extending the shoulder seasons into April and May in the spring and into September and October in the fall would be most beneficial. Each of these efforts would require a very specific, narrowly targeted marketing effort.

There was excess capacity in the lodging sector during the summer in 1989. This may not have been the case in 1990, or at least not at the same level. Total rooms available would have accommodated one-third more travelers in June. This translates into a potential to increase tourism by approximately 71% assuming the same level of commercial travel. July had almost 20% excess capacity with potential for 31% more tourists. These figures can become significant when considering increased occupancy rates.

We had unconfirmed reports of a 10 to 20% increase in occupancy rates during the summer of 1990 over 1989. If this is the case, it probably represents a 15 to 30% increase in tourism. Overall, lodging will not be a long-run deterrent to increased tourism in the area. However, lodging may be a deterrent for specific locations or peak periods, such as winter lodging on the Big Horn Mountains or summer lodging during peak weekdays, special events, and holidays. Thus, total utilization of the current excess capacity likely will never be fully attained. The private sector will respond to meet any increase in demand for lodging facilities. Businesses can operate more efficiently with a longer season and higher annual occupancy.

It also should be noted that commercial travel tends to be higher in the summer when more field crews are in the area. Any major construction project or increased activity in the energy sector could require up to 20% of the total lodging facilities available. These activities are good for business and the local economy but should be recognized as potential competition with tourism marketing efforts.

Grazing

In January 1992, members of the Coalition requested a second study to estimate the economic and fiscal impacts of both commodity and recreational uses on federal lands in the BHMA. The Coalition specifically requested that livestock grazing, timber harvest, petroleum and mineral extraction, water storage, and tourism and recreation activities be evaluated. This study was requested about the same time the USFS was considering a 50% reduction in a grazing allotment being transferred in the Paintrock Grazing District in Big Horn County. The results of the grazing component of that study are reported below.

Recently, there has been an ongoing debate over the economic importance to local communities of livestock grazing, timber harvest, and recreation on the BHNF. It has been suggested that jobs lost from decreased grazing can be replaced by expanding tourism in the BHMA. The purpose of this section is to evaluate the economic impact of reduced livestock grazing on the BHNF in the four-county BHMA in terms of economic activity, personal income, and employment.

Procedures

An accurate assessment of the economic impact on adjacent communities from reducing livestock grazing required estimating the structural change in individual ranching operations that would result from reducing the number of animals allowed to graze on the BHNF. This information was provided through preliminary results of a research project by Larry Van Tassell et al., Department of Agricultural Economics, University of Wyoming. Study objectives for the BHMA grazing study were:

1) To use Van Tassell's preliminary estimates of the structural change in individual ranching operations due to a reduction in the number of animals allowed to graze on the BHNF.
2) To estimate the economic impact of an animal unit month (AUM) of cattle grazing on the BHNF in terms of economic activity, personal income, and employment supported or generated in the local economy.
3) To estimate the economic impact caused by a reduction in range cows in the BHMA due to 25, 50, and 100% reductions in AUMs of grazing on the BHNF.
4) To estimate the number of tourism visitor days (TVD) required to offset the economic loss from grazing in terms of economic activity, personal income, and employment (see Economic Impact Comparison between Tourism and Grazing, below).

The impact of one AUM grazing on the BHNF required information on the total dollar sales per

Table 7. Estimated tourism lodging capacity, Big Horn Mountain area, 1989.

Month	Total rooms occupied	Commercial rooms	Tourist rooms	Rooms open	Percent rooms available	Increased tourism capacity
January	8,410	6,728	1,682	*	na	na
February	8,760	7,008	1,752	*	na	na
March	9,790	7,832	1,958	*	na	na
April	10,216	8,755	1,461	*	na	na
May	19,059	10,714	8,345	*	na	na
June	35,995	10,618	25,377	54,000	0.333	0.7095
July	44,871	9,345	35,526	55,800	0.196	0.3076
August	42,847	10,059	32,788	55,800	0.232	0.3951
September	25,287	9,619	15,668	*	na	na
October	21,786	8,868	12,918	*	na	na
November	10,408	7,776	2,632	*	na	na
December	9,076	6,686	2,390	*	na	na
Total	246,505	104,008	142,497			

* Lodging capacity is not a concern most of the year, so room availability was considered only during peak demand months of June, July, and August. Some properties in the area are operated seasonally, due to low occupancy rates, in order to reduce costs.

AUM under typical economic conditions in the BHMA and the decline in range cow units (CU) the area would experience for each AUM of grazing lost on the BHNF. An input/output model, developed for the BHMA, was used to estimate the loss in total economic activity, personal income, and employment (Moline 1991, Moline et al. 1992). Assumptions were as follows.

1) There are 120,828 AUMs of allotted grazing for cattle and sheep on the BHNF.
2) Only the 105,775 AUMs allocated to cattle are considered in this paper.
3) Loss of one AUM of grazing on the BHNF will reduce the cattle herd in the BHMA by 0.069 CU.
4) Based on 1990 prices, the value of total output per range CU was $456.98 in the BHMA.
5) Loss of each AUM of grazing on the BHNF reduces total area output for the range livestock sector by $31.53.
6) Markets will be available for all other agricultural commodities.
7) Recreational use will continue to rise at 2.8% per year with or without livestock grazing.
8) Tourism visitor days increase in proportion to the growth rate of total recreational visitor days.

Table 8. Economic impact from the loss of one animal unit month of grazing on the Big Horn National Forest.

	Dollar flows			Employment
Sectors	Direct	Indirect	Total	FTE
Range cattle	31.53	0.00	31.53	0.000824
Ag services	0.00	0.63	0.63	0.000017
Timber	0.00	0.01	0.01	0.000000
Oil & gas	0.00	0.16	0.16	0.000000
Mining	0.00	0.09	0.09	0.000001
Construction	0.00	0.38	0.38	0.000004
Manufacturing	0.00	1.00	1.00	0.000003
Transportation & communications	0.00	1.00	1.00	0.000016
Utilities	0.00	1.05	1.05	0.000004
Trade	0.00	4.23	4.23	0.000154
Eating, drinking, lodging	0.00	0.54	0.54	0.000021
Finance, insurance, real estate	0.00	2.57	2.57	0.000020
Services	0.00	0.79	0.79	0.000025
Health	0.00	0.76	0.76	0.000014
Local government	0.00	2.23	2.23	0.000053
Households	0.00	16.69	16.69	0.000000
Totals	31.53	32.14	63.67	0.001156

The bases for assumptions 1 and 2, the number of AUMs of grazing allotted on the BHNF, were data obtained directly from the district office of the BHNF. Assumption 3 is based on a linear programming model for a typical ranch in the BHMA. This model estimated that the loss of one AUM of grazing on the BHNF will reduce the herd by 0.069 cows after allowing for reallocation of alternative sources of forage. Assumption 4 was calculated by dividing the model ranch's total receipts by the number of its range cows. The total amount, $456.98, includes each cow's share of calf, yearling, cull cow, and cull bull sales as well as beef produced and consumed by range cattle producers.

It was assumed that production per cow for the model ranch is comparable to the average for the region. Output per cow was used for several reasons. Within the linear programming model, the number of cows is the dependent variable; i.e., all activities depend on the number of cows on the ranch. Also, most producers utilize information based on per-cow figures. An additional reason for using output per cow is the general public can understand what a cow is but may have difficulty understanding the concept of animal units.

Assumption 5 was calculated by multiplying the per-AUM reduction of range cows (0.069) by the total output of each range cow ($456.98). Assumption 6 allows the other agricultural commodities such as hay and grain consumed by range cattle to move to other markets.

Assumption 7 is based on the actual increase in recreation on the BHNF for the most recent 5-year period. Assumption 8 implies recreational used by residents also will increase by 2.8%.

Economic Impact of Grazing in the BHMA

The $31.53 shown in column 1 of Table 8 is the direct financial loss to the range livestock sector from the loss of each AUM of grazing on the BHNF. The second column indicates the distribution of the indirect and induced effects; the third column is the total economic impact of one AUM of grazing on the BHMA. Column 4 provides the distribution effect of changes in employment associated with each AUM of grazing.

Information in Table 8 shows the total economic activity, personal income, and employment associated with 1,000 AUMs of grazing. Each 1,000 AUMs of grazing would generate $63,667 of total economic activity, $16,689 of which is personal income. Each 1,000 AUMs also will support 1.16 FTE jobs.

Two adjustments were made in the input/output model to more accurately reflect the impact of a reduction in AUMs of grazing that would result in a reduction in total range cow units produced in the BHMA. First, the total requirements matrix was adjusted to consider a change in output and to remove the need to estimate deliveries to final demand. Second, interactions between range cattle and other agricultural sectors were removed to allow products that had been consumed by range cattle to be sold in other markets. A 25% reduction in grazing allowed on the BHNF was arbitrarily selected to represent the total impact that would result if a forestwide grazing policy was implemented at that level. A 25% AUM reduction would reduce grazing on the BHNF by 26,444 AUMs which would reduce the cow herd by about 1,825 in the BHMA.

Table 9 shows the direct loss to cattle producers to be $833,814. This direct effect translates into a loss throughout the area's economy of $1.68 million in total economic activity, $441,384 in personal income, and 30.56 FTE of employment.

A 50% reduction in AUMs permitted on the BHNF would double the impact of the 25% reduction, resulting in a reduction of 52,888 AUMs grazed on the BHNF with 3,649 fewer cows in area range herds. This would reduce economic activity by $3.37 million, personal income by $882,767, and employment by 61.13 FTE. The most drastic policy would be to eliminate all cattle grazing from the forest. This action would reduce the cow herd by approximately 7,298 cows, about $3.34 million of output. This would translate into $6.74 million in

Table 9. Economic impact of a 25-percent loss of animal unit months (AUMs) of grazing on the Big Horn National Forest.

Sectors	Dollar flows: Direct	Dollar flows: Indirect	Dollar flows: Total	Employment FTE
Range cattle	833,814	0	833,814	21.78
Ag services	0	16,585	16,585	0.46
Timber	0	395	395	0.01
Oil & gas	0	4,257	4,257	0.01
Mining	0	2,416	2,416	0.02
Construction	0	10,059	10,059	0.10
Manufacturing	0	26,548	26,548	0.08
Transportation & communications	0	26,367	26,367	0.41
Utilities	0	27,655	27,655	0.11
Trade	0	111,929	111,929	4.08
Eating, drinking, lodging	0	14,414	14,414	0.55
Finance, insurance, real estate	0	68,064	68,064	0.54
Services	0	20,826	20,826	0.65
Health	0	20,143	20,143	0.37
Local government	0	58,912	58,912	1.41
Households	0	441,384	441,384	0.00
Totals	833,814	849,952	1,683,767	30.56

economic activity, $1.77 million in personal income, and 122 FTE of employment.

Economic Impact Comparison between Tourism and Grazing

The third objective of this paper is to estimate the number of tourism visitor days required to replace the economic activity, personal income, and employment lost through decreased grazing on federal lands. A tourism visitor day (TVD) represents a visitor from outside BHMA spending 1 day in the local area. Table 10 shows the impact of one tourism visitor day to the BHMA. Direct expenditures of $38.79 per day were reported in an earlier study of tourism in the BHMA (Taylor et al. 1991).

Table 10. Total economic impact of one tourism visitor day (TVD) associated with the Big Horn Mountain area.

Sectors	Dollar flows: Direct	Indirect	Total	Employment FTE
Agriculture	0.00	0.28	0.28	0.000005
Ag services	0.00	0.04	0.04	0.000001
Timber	0.00	0.02	0.02	0.000000
Oil & gas	0.00	0.23	0.23	0.000000
Mining	0.00	0.13	0.13	0.000001
Construction	0.00	0.39	0.39	0.000004
Manufacturing	0.00	1.63	1.63	0.000005
Transportation & communications	0.00	1.14	1.14	0.000018
Utilities	0.00	1.51	1.51	0.000006
Trade	4.98	3.02	8.00	0.000291
Eating, drinking, lodging	16.06	0.45	16.51	0.000625
Finance, insurance, real estate	0.00	2.05	2.05	0.000016
Services	1.44	1.09	2.53	0.000079
Health	0.00	0.63	0.63	0.000012
Local government	0.02	0.82	0.84	0.000020
Households	1.02	12.83	13.85	0.000000
Other final payments	0.72	0.00	0.72	0.000000
Imports	14.55	0.00	14.55	0.000000
Totals	38.79	26.26	65.05	0.001083

For comparison, the impact of 1,000 TVDs was estimated at $65,052 total economic activity, $13,852 personal income, and 1.08 FTE jobs. A tourism sector is not included in the input/output model, so nonlocal visitors' expenditures were specified as changes in final demand for the appropriate sectors.

Table 4 compares the economic impact of 1,000 AUMs of grazing and 1,000 TVDs to the BHMA. In order to replace the economic activity lost from a 1,000-AUM reduction in cattle grazing, tourism in the area would have to increase by 979 TVDs. More than 1,200 TVDs would be required to replace the $16,691 of lost personal income from grazing. Replacing the 1.16 FTE of employment lost with the reduced grazing would require 1,074 TVDs. Tourism-related employment tends to pay approximately 11% less than employment generated from grazing (Fletcher and Taylor 1992).

The level of total economic activity generated in the area also can be compared, as shown in Table 12. If all cattle grazing was eliminated on the BHNF, there would be 105,775 fewer AUMs of public grazing in the area which translates to 7,298 fewer cow units of production. Column 2 of Table 12 shows the increase in TVDs above the current growth rate required to replace the loss in economic activity that would result from eliminating 25% of cattle grazing on the BHNF.

Column 3 shows the TVDs required to offset the impact of a 50% reduction of grazing. The fourth column shows the increase in TVDs required to replace the impact of totally eliminating cattle grazing on the BHNF. The last column in Table 5 shows the impact of TVDs on the BHMA in 1990.

With current levels of livestock grazing, recreation on the BHNF has been increasing at about 2.8% per year from 1986 through 1990 (USDA 1992). It is assumed that this level of growth can continue with or without livestock grazing. It is further assumed that TVDs will increase in proportion to the growth rate in total recreational visitor days. Given these assumptions, a tourism growth rate above 2.8% would be required to replace the loss in personal income from reduced grazing. However, depending on the grazing reduction and recreation use increase, it could take several years in terms of net present value for the income stream generated by additional tourism visitor days to offset the lost income stream associated with reduced grazing on the BHNF.

Table 11. Economic impact and comparison of grazing and tourism on the Big Horn National Forest.

Type of impact	1,000 Animal Unit Months (AUM)	1,000 Tourism Visitor Days (TVD)	TVD equal 1,000 AUM
Total economic activity	$63,670	$65,052	979
Total personal income	$16,691	$13,852	1,205
Total employment (FTE)	1.16	1.08	1,074

Table 13 shows the timeframe needed for the increased income generated by additional TVDs to offset the loss in income associated with reduced grazing on the BHNF. A 4.0 social discount rate was used to estimate these breakeven points. Three potential growth rates are considered: 3.5, 4.2, and 5.6%. These growth rates represent a 25, 50, and 100% increase in recreational growth beyond the present rate of 2.8%. If grazing on the BHNF were reduced 25% and recreation increased to 3.5%, it would take 10 years for the local economy to recover the loss in income. At a 4.2% increase, it would take 5 years; at a 5.6% increase, it would take 2 years for income generated by recreation to offset the income lost by a grazing reduction.

If grazing on the BHNF decreased 50%, 22 years would be required to offset lost income if recreation increased 3.5% per year, 10 years at a 4.2% growth rate, and 5 years at a 5.6% growth rate. If cattle grazing were eliminated on the BHNF, the local economy would need 53 years at a 3.5% growth rate for recreation to offset the loss from grazing, 22 years at a 4.2% recreation growth rate, and 10 years at a 5.6% recreation growth rate.

This paper does not intend to imply any relationship between grazing levels and increased tourism. It is the intent of this paper to point out the number of tourism visitor days required to offset economic losses if grazing on the BHNF is reduced or eliminated. It is not certain that tourism visitor days can increase at a rate necessary to offset the loss in employment and income caused by reductions in cattle grazing on the BHNF. As Cordell et al. (1990) note, American leisure activity has changed drastically in recent years. Leisure time has decreased by 37% in the last 15 years. In addition, leisure activities are close to home due to an aging population, childbearing in the "baby boom" generation, home-video entertainment, reduced leisure time, and energy costs. Typical American families now plan for shorter, but more frequent, vacations.

These changes have affected the type of recreation use at national forest sites. Total recreation use at national forest sites increased by over 16% from 1977 to 1987, an average annual increase of 1.6%. However, the proportion of all trips that were 2 hours or less in travel time increased from 43% in 1977 to 72% in 1986. By comparison, the proportion of all trips that were 8 hours or more in travel time decreased from 23% in 1977 to 6% in 1986.

Similarly, the proportion of all trips that were 1 day or less in length increased from 30 to 79%, while the proportion of all trips that were more than 1 day in length decreased from 70 to 21%. Thus, at the national level there appears to have been a substantial shift in recreation activity on national forests toward greater use by regional residents. This shift in national trends for recreation has important

Table 12. Number of tourism visitor days (TVD) required to replace grazing animal unit months (AUM) on the Big Horn National Forest.

	Assumed levels of reduced grazing		
Type of impact	25%	50%	100%
Total economic activity	25,884 TVD	51,768 TVD	103,537 TVD
Total personal income	31,869 TVD	63,738 TVD	127,476 TVD
Total employment (FTE)	28,223 TVD	56,445 TVD	112,891 TVD

implications for increasing the growth rate of BHNF-related tourism in the BHMA. In particular, the shift in demand toward more regional recreational use at national forest sites may increase the time required to generate the future increases in visitation to the area necessary to expand the local economy sufficiently to offset the loss from reduced livestock grazing. For example, based on a profile of current summer visitors to the area (Taylor et al. 1991), at least 80% of these visits involve driving time of 8 hours or more, almost the opposite of the national trend. In light of this, the area may be doing well to sustain the current average annual growth rate of 2.8% in tourism visitor days, and a considerably lower growth rate may not be overly pessimistic.

Summary

Wyoming continues to depend on federally owned land for economic activity. Livestock grazing and recreation are two activities on public lands that are extremely important to Wyoming's economy. This paper examines the economic effects of decreases in cattle grazing allowed on the Bighorn National Forest located in north-central Wyoming. A 25% reduction of the 105,775 AUMs of grazing allotted to cattle would cause the economy of the four-county area surrounding the BHNF to decrease its activity by $1.68 million, $441,384 of which would be personal income. The local economy also would lose about 30.56 FTE. A reduction of 50% would cause economic activity to decline $3.37 million, personal income to decline $882,767, and employment to decline about 61 FTE. Eliminating all cattle grazing on the BHNF would cause economic activity to decline $6.74 million, personal income to decline $1.77 million, and employment to decline 122 FTE.

An increase in the growth rate for recreation could help offset the negatives associated with eliminating cattle grazing on the BHNF. To offset the decline in economic activity, recreation would have to increase about 104,000 TVDs. Recreation would need to increase about 127,000 TVDs to offset the loss of personal income. Depending on the growth rate of recreational use, 10 to 53 years could be

Table 13. Years for breakeven income from reduced grazing and increased recreation.

	Assumed annual recreation and tourism growth rate		
Grazing reduction	3.5%	4.2%	5.6%
25%	10 years	5 years	2 years
50%	22 years	10 years	5 years
100%	53 years	22 years	10 years

required for the BHMA economy to recover the loss in income from reduced livestock grazing. To maintain the current employment level, recreation would have to increase about 113,000 TVDs.

The shift in demand toward more regional recreational use at national forest sites may increase the time required to generate the future increases in visitation to the area necessary to expand the local economy sufficiently to offset the loss from reduced livestock grazing. At least 80% of the TVDs in the BHNF involve driving time of 8 hours or more, almost the opposite of the national trend. Therefore, the area may be doing well to sustain the current average annual growth rate of 2.8% in TVDs, and a considerably lower growth rate may not be overly pessimistic.

Despite these concerns, increasing tourism remains a viable strategy for revitalizing the BHMA economy. Currently, it is one of the few uses of public lands with the potential to expand. However, it becomes a less attractive strategy if it can be increased only at the expense of other industries in the BHMA. Given the potential trade-offs and the uncertainty involved, a balanced approach that considers all alternatives is needed to sustain and revitalize the area's economy.

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Integrating Utilization Measurements into Monitoring Programs

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Abstract

Utilization has been controversial for 50 years. The solution is to use the methods properly and in context of a total land-use program. Utilization should never be used as an objective but rather in support of clear ecological objectives. Successful grazing management must be ecologically and economically sound. Utilization measurements can contribute to making proper decisions to help attain objectives.

Introduction

This series of papers illustrates the history of the use of utilization measurements in monitoring rangelands. The papers clearly show the benefits and liabilities in applying utilization concepts in range management. The historical review points out the concerns of scientists about applying utilization methodologies in inappropriate ways, either in the context of management objectives or by misapplication of the methods. This dialogue has been conducted irregularly over the last 50 years. The reasons for historical and current debates over utilization are imbedded in the scientific and management cultures. Managers need tools that help them make defensible decisions. They naturally are drawn to a concept as intuitively attractive as utilization. The concept is simple: A given amount of forage can tolerate a given amount of herbage removal; when that point is reached, quit grazing that area. The scientists are concerned that what is simple in concept is immensely complex in details. Translation of the concept through rapidly collected field data or observations is exceedingly difficult. So the controversy ebbs and flows over time. Large-scale programs over time have focused heavily on utilization for monitoring. After consideration, the emphasis declines, and utilization is reduced in importance.

Throughout the presentations of the scientists and managers in the symposium, a few central ideas were accepted generally. The most prominent area of agreement was that **utilization is a land management tool, not a land management objective.** The current controvery about utilization on rangelands is based primarily on the perception that, in practice, a utilization standard frequently is used as a management objective with no context of the ecological goal for the site being managed. All the scientists found significant fault with this misuse of the utilization concept, as did the Forest Service land managers.

The contributors to this report point out in detail that each technique has its own specific strengths and weaknesses. Consequently, the land manager needs a good understanding of how and when to use each utilization technique so an appropriate technique that gives reliable and accurate results is implemented.

The authors explain many of these details in their papers. Reliability is the repeatability of measurements. The relationship of year and season, as well as the knowledge of field workers, has great effect on reliability. Accuracy refers to the actual correctness of the measurement. This often is affected by the knowledge of the technique, specific ability of the technique to measure the vegetation under the monitoring circumstances present, and the care in implementing the checks and balances of each technique. Both reliability and accuracy are important and must be considered if the monitoring program is to yield useful background information for decision makers.

All the authors indicated the complexity of this concept. An effort to reduce the complex to rules of thumb or to simplistic practice simply will not work. The effect of seasonal changes in vegetation makes measurement difficult under the best of circumstances. The relationship of timing of grazing related to vegetation response suggests a need for a gradient of standards, not a single site-specific standard. Most of the techniques do not yield exact measurement of forage removed. They are not inherently accurate. The concensus is that any utilization method is useful when used in reference to an ecological objective and when integrated with other appropriate data that allow the manager to infer long-term trend in rangeland condition.

The most universally accepted use of utilization techniques is to develop large-scale utilization maps. These maps will highlight areas of livestock concentration and low use. When combined with other pasture information, they can help lead the manager to incorporate management strategies to encourage livestock to graze some areas more and other areas less. Yearly maps are useful when interpreted with other yearly information such as weather patterns, grazing system, and herd history.

The Forest Service contributors suggested the land management objectives include uplands and riparian zones and stressed ecological function and desired land conditions. With these decisions made, the manager can determine what needs to be monitored and how utilization fits into a monitoring strategy to evaluate progress toward objectives. In addition, the Forest Service authors say that monitoring should be based on techniques that federal grazing permittees or concerned citizens can readily implement. They agree that utilization has a place in yearly monitoring programs.

The complex needs for information naturally require a wide variety of approaches to collect acceptable data. If detailed measurements are needed and if statistical reliability is important, then very detailed and expensive monitoring approaches are necessary. It is not responsible to sample inadequately and then make important management decisions based on faulty data. If numbers are collected as part of the monitoring program, they always should be statistically analyzed so the decision maker knows the quality of the information. This at least allows a confidence interval to be established. With that, the value of the information for the manager is clear. For example, utilization of 35%, ±5%, does not mean the same as utilization of 35%, ±30%. If it is not possible to collect sufficiently reliable utilization data, then monitor with a qualitative technique. For most management needs, photo points are fully adequate.

Researchers are testing the use of photographic techniques using geographic information systems technology for quantification. These tools show promise for future objective evaluation of residual standing crop of shrubs. However, the technology is several years away from being practical.

What do we in WCC-40 suggest in using utilization methods for monitoring grazing use?

1) Develop clear ecological objectives.
2) Use site-specific objectives and techniques.
3) Monitor parameters that relate to the objectives. If you are interested in plant vigor, utilization could be a good choice to monitor. If you are interested in plant community change, soil moisture and timing of grazing could be good choices to monitor.
4) Understand the quality of your data so you can interpret them effectively.
5) Select a monitoring tool you can interpret.
6) Use feedback to adjust management.

If the tool—utilization—is used right, it will work.

Finally, remember that decisions that result from monitoring programs can influence the number of animals grazing an area. Whether the land is public or private, there is an economic result from the decision. The stocking rate on rangelands must be sustainable. If not, it will decline due to deterioration. Reductions in grazing that are not required to sustain the resource can cause real economic hardship to the ranch family and consequently to the community. Economic impacts are important and need full consideration in making land-use decisions.