Technical Notes

Utilization and Residual Measurements: Tools for Adaptive Rangeland Management

By SRM Rangeland Assessment and Monitoring Committee

On the Ground

- Utilization levels and residual height are tools for adaptive management, not management objectives.
- Utilization/residual measurements are subject to many sources of sampling, procedural and personal errors.
- Season of measurement has a strong influence on interpretation of results.
- Utilization/residual guidelines are not rigid limits to be met every year, but a tool to identify stocking rate or distribution problems over several years.
- Utilization/residual data must be relevant to management objectives.
- Time, location, and protocol for measurement must be documented in plans, reports or management decisions based on the use of the data.

Keywords: utilization, stubble height, residual vegetation, grazing management, monitoring, adaptive management.

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Measurement or estimation of utilization or residual vegetation is a valuable tool in range management when properly used and interpreted. Unfortunately, the use of these annual indicators of grazing use has been and continues to be misapplied and misinterpreted. This situation continues despite extensive and reputable published literature identifying the problems and describing the proper role of utilization measurement. The Rangeland Assessment and Monitoring (RAM) committee wrote this paper to put forth the consensus of the range management profession on the proper application and interpretation of utilization and residue measures, which are expressed in the Society for Range Management's (SRM) position statement quoted below. This paper will cite some relevant publications but does not aim to provide a complete review of all the voluminous literature on this subject, nor does it aim to discuss specific methods in detail. The reader is referred to the publications cited in this paper if additional information is desired.

Background

One of the basic principles of grazing management is that the intensity of grazing should be appropriate for the plant species and site conditions, the timing and frequency of grazing and rest periods, and the response of the grazing animals. Early in the development of scientific range management the utility of a measure of grazing intensity was recognized as a valuable management tool. This was the first organized effort to survey the western rangelands and to estimate its carrying capacity for domestic livestock grazing. The Ocular Reconnaissance Method, developed around 1910 and widely used until after World War II, included the concept of proper use factors (PUFs).[1,2] Although not used much today, the PUF recognized that only a portion of the current growth of forage plants should be removed and that the percentage of removal would vary depending on the growth form of the species, its palatability relative to other species (which is related to the kind of grazing animal and the season of use), and other factors. The key species concept is based on the idea that when the key species is "properly" grazed, the range as a whole will be sustainably grazed (i.e., grazed at an intensity that will maintain or improve the general condition of the range). These concepts led to research to develop techniques by which the degree of grazing could be measured or rated as a guide to grazing management. Research carried out in the 1930s to 1950s developed most of the methods still used today, with some modifications. There has been an evolution in the amount of utilization considered to be "proper"; early estimates of "proper use" (often 75–90%) have been found excessive through experience and research.[3]

Sanders[4] pointed out that early range managers, mainly in the Forest Service, had emphasized forage inventories and

proper use rather than trend monitoring and grazing systems in managing National Forest grazing permits. This approach was also used by the Grazing Service (later the Bureau of Land Management [BLM]). The emphasis may reflect that lack of fences and water on many ranges did not allow good control of the timing of grazing, and the concepts of range condition and trend monitoring were not well developed. Various authors discussed the difficulties of measuring and interpreting utilization in the 1950s and emphasized that utilization should only be considered a tool for management, not a management objective (e.g., Heady,[3] Hedrick,[5] Cook and Stoddart[6]). In the 1950s and 1960s, both the Forest Service and BLM placed more emphasis on trend monitoring and range improvements. However, sometime in the 1970s it appears that both agencies began to again rely on forage inventories (forage allocation) and utilization rather than a stock and monitor approach. Several factors may have contributed to this. Environmental legislation that was passed or implemented in the 1970s produced political and legal pressure on the agencies and may have led to increased reliance on annual indicators of livestock use. In addition, increased emphasis was placed on riparian areas and to extend utilization or stubble height limits (commonly referred to as "standards") for management of these important areas. Guidelines appropriate for upland species to maintain the plants may or may not have been appropriate to address other needs in riparian areas. Finally, some have indicated that agency range specialists became so immersed in the increased office work required under the new legislation that they emphasized utilization and stubble height because it required less field time and training than more comprehensive monitoring and working with permittees and other stake holders on the ground (e.g., Sanders,[4] Cleary et al.[7]). Utilization or stubble height "standards" were written into land-use plans, annual operating instructions, rangeland program summaries, and administrative procedures and policies as rigid limits, which, if exceeded, would be treated as violations of the terms and conditions of grazing permits.

Controversy about how utilization should be measured and interpreted reached a high point in the 1990s, leading to the publication of an interagency technical reference[8] and a number of papers on this subject by researchers, consultants, and agency range managers (e.g., Burkhardt,[9] Frost, Smith, and Ogden,[10] McKinney,[11] Sharp, Sanders, and Rimbey[12]). Continuing controversy led to a symposium at the SRM annual meeting in 1997, which was peer reviewed and published (Western Coordinating Committees [WCC] 40 and WCC 55[13]). The authors of the Symposium, and those of Technical Reference 1734-3,[8] agreed on the proper role of utilization for grazing management. Although there has been some improvement, it appears that misapplication continues. The SRM[14] adopted a position statement on utilization in about 1998, which represents the range management profession's view of this practice

> *Use of Forage Utilization and Residue Measurements*
> *The Society for Range Management recognizes and endorses forage utilization and residue measurements as useful tools in rangeland monitoring and acknowledges their value in land management. When used with other monitoring information, utilization can be employed to design and evaluate management decisions. These measurements, when properly timed and conducted using appropriate methods and sampling procedures, can be used as an aid in:*
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> 1. *Analyzing distribution of animal use on a management unit.*
> 2. *Interpreting cause and effect relationships for observed changes in resource attributes such as soil cover, species composition, residual cover, etc.*
> 3. *Adjusting stocking rates and/or timing of grazing when used in conjunction with other monitoring information including: long term vegetation or habitat data, current and historical stocking records, precipitation records, etc.*
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> *Utilization and residue measurements are not management objectives. They are tools to be used with other information in evaluating whether desired resource conditions are being achieved.*

The SRM position statement succinctly states how utilization and residual measures should be used. The interagency technical reference on utilization and residual measurement statement is virtually identical:

> *"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."*[15]

Concern over the misuse of stubble height measurement in riparian areas led to the establishment of a Stubble Height Review Team by the University of Idaho at the request of both the BLM and the Forest Service. The committee report[16] outlines how stubble height should be used and interpreted. Cleary et al.[7] and Smith et. al[2] produced additional critiques and guidelines for use of utilization and stubble height as a basis for management decisions. The documents cited above provide ample evidence based on research and experience of the legitimate role of utilization and residue measurements in the management of rangelands from authors representing universities, research agencies, consultants, ranchers, and practicing range professionals in the National Resources Conservation Service, United States Forest Service, BLM, and state land departments.

Inappropriate Uses of Utilization and Stubble Height

Statements cited above demonstrate appropriate uses of utilization and residue measurements. The RAM committee recommends that statements be added to clarify how utilization and residue measurements should not be used, as follows:

1 Management objectives. Specific limits on utilization or residual measurements should not be included as "standards" or objectives to be met in land use plans, resource management plans, annual operating instructions, or as part of the terms and conditions of grazing permits.

2 Automatic trigger to move livestock. Utilization or residue measurements which reach a guideline value should not result in automatic action (trigger—see University of Idaho Stubble Height Review Team[16]) to remove livestock from a pasture or grazing allotment (i.e., as a rigid standard not to be exceeded in any given year or grazing season). This does not mean that utilization or residue measurements should not be used as an annual indicator to help guide grazing use and planning. The action "triggered" should be for the manager to evaluate appropriate action as dictated not only by utilization in one pasture but consideration for the entire management system.
3 Arbitrary guidelines. Utilization or residue measurements should not be used as guidelines without specifying how they relate to the management objective, the method used, the location and species to be measured, the season of measurement, the qualifications of those making the measurements, and how the data will be interpreted as a basis for management decisions and by whom.[2] Without this information, such measurements are of little value and subject to misuse.

Issues Involving Utilization and Residue Measurements

Precision of Estimates is Often Unspecified: Technique and Training Affect Accuracy

In research studies, sample size can be sufficient to estimate utilization with a confidence level (precision), which is known and satisfactory, but large samples are usually necessary, which may be impractical for everyday management. Even in a relatively uniform "key area," variability among plants or plots observed is usually large. Variation is greater on moderately used ranges than on very heavily or very lightly used areas. Confidence levels are often, if not generally, not reported in utilization monitoring. Clipping methods are especially questionable because of the time required and effect of differences in technique and because quadrat sizes are often small (e.g., 0.96 sq ft). Further, if cages are used for comparisons, there are usually only a few. Reporting an average utilization or stubble height should be done with due consideration for significant digits to avoid a false indication of precision (e.g., 45%, not 43.7%, or 4 inches, not 4.1 inches). Taking punitive action based on measured utilization of 55%, when the guideline is 50%, does not seem warranted when the 90% confidence interval ranges from 45% to 65%.

Other sources of variability arise from differences in measurement techniques among individuals such as height of clipping, identification of current growth, height measurement criteria, or lack of adequate training or calibration in estimation procedures. Numerous studies have found variability among observers, especially when they lack experience in the technique. These effects bias the results (affect accuracy) and may not be detected by statistical analysis.

Different Methods Give Different Results

Many utilization and residual vegetation measurement methods have been developed for specific types of vegetation or management objectives. Different methods may provide estimates which can be consistently achieved but which differ from other methods. For example, Halstead et al.[17] found that height–weight measures produced very different results from paired plots. Laycock[18] cited a number of comparisons of methods which showed significant differences among methods used. Using a "standard" as a trigger to move livestock would need to be specific to a particular method, or it is meaningless.

Season of Measurement is Important

The timing of utilization and residue measurement in relation to growing season and grazing season is important for several reasons. First, utilization is defined as the percentage of the current year's growth that is removed by, or disappears during, grazing. Current year's growth can only be observed after the end of the growing season, and even then it is only the standing crop that remains, not the actual current growth. Utilization measured during the growing season does not meet this definition and should be called "seasonal utilization" to avoid confusion.[2] "Utilization guidelines" based on current year's production cannot be applied to seasonal utilization. Early season utilization of growth produced to that point may end the season with very low utilization due to regrowth.[6,10,19] The same is true of stubble height.[16]

Measuring utilization on "key species" as a basis for adjusting stocking rates (i.e., either removing some or all animals from a pasture) or for calculating the "desired" stocking rate for following years, is based on the concept that the use on the key species is gradual throughout the grazing period and correlated with stocking rate.[20] Except for monocultures or very short grazing periods, this is not often the case because animal preferences shift as different plants or locations become more or less attractive to them.[8]

The physiological response of forage grasses has been shown to be more related to the timing and frequency of grazing than the degree of utilization.[21] Also, the growth patterns of any given forage species and of differing life forms may vary significantly from one year to another. This is especially true in warmer regions where growth of some species may occur in almost any season of the year, making it hard to measure current growth or predict regrowth.

The above issues make it unlikely that "utilization limits" have much actual relevance except maybe where the growing season and grazing season are concurrent, and utilization is measured at the end of both.[9] This is not necessarily true of stubble height, which can be measured without reference to current year's growth, and thus can be measured any time during the growing or grazing season. If livestock impact on key species' physiological needs were the desired measure, the appropriate time would be at or after the end of the growing season. However, it might be at other times for other objectives. For example, if bank protection is the objective,

then measuring stubble height before expected bank full runoff would be logical, or if nesting cover for quail is the objective, then measurement should be at or before the start of the nesting period.

Utilization Guidelines Not Meant to be Met Every Year

Utilization and stubble height guidelines are often written into management plans or annual operating instructions as limits, which will not be exceeded during any grazing season. Aside from the obvious questions about how, when, and where such measurements will be done, this approach is entirely at odds with the research studies that underlie such guidelines. Grazing studies are generally conducted over a period of years to compare the effects of different stocking rates on vegetation or animal performance. Although results vary from one region to another and for differences in other factors such as pasture rotation, the general results show that "conservative to moderate" grazing, somewhere around 30% to 60% utilization on key species, is best for both vegetation and animal production.[22] However, except for very intensive studies on small pastures using "put and take" stocking, the desired levels of utilization are not achieved every year.

Laycock[18] described a 10-year stocking rate study done in the Colorado sandhills. The average utilization on needle-and-thread grass (a key species) was 26%, 60%, and 77% for the light, moderate, and heavy grazing treatments, respectively. Yet utilization on this species in the moderate (average 60%) stocking rate ranged from 27% to 85% over the 10 years. The 95% confidence interval on the mean of 60% ranged from 46% to 74%. This was a research study with relatively small pastures, good distribution, and close supervision. If they had been using a "utilization standard" of 60% cattle would have been removed in 5 of the 10 years. This study showed that the key species increased on both the moderate and light grazing treatments despite widely varying utilization levels, and it points out the difficulty in using a rigid utilization limit in a practical situation.

If utilization levels consistently exceed desired levels, even during years of average or better forage production, a change in management practices may be warranted. Holechek and Galt[23] stated, "…attainment of specific use levels is nearly impossible on a year-to-year basis due to variation in climate. Instead, we believe they should be a target across 5-10-year time periods." Holechek et al.[22] also observed that "management changes may be needed if utilization guidelines are exceeded on over 30% of the pasture or allotment for two consecutive years or in any two years out of five." These recommendations are just rules of thumb based on professional experience, but they recognize the yearly variability to be expected in utilization. Holechek et al.[22] further encourages ranchers to avoid exceeding residue or stubble height guidelines year after year on the same key areas and to make every effort to keep individual key areas from being severely grazed in any year. Livestock utilization at the end of the grazing year that consistently exceeds utilization guidelines over a significant part of the pasture over a period of several years can indicate the need to make management corrections, or re-evaluate the guidelines, before undesirable long-term trends are identified by monitoring.[2]

The concept of key areas is often used to assess utilization. The SRM[1] defines key area as "[a] relatively small portion of a range selected because of its location, use or grazing value as a monitoring point for grazing." Coulloudon et al.[15] stated that key areas should be indicative of the response that is occurring on the stratum. Stratum was defined in the publication as "pasture, grazing allotment, wildlife habitat area, herd management area, watershed area, etc." Key areas should be located within a single ecological site or plant community, be responsive to management actions, and be indicative of the ecological site or plant community they are intended to represent.[5] More than one key area may be selected and monitored within a pasture or other management unit depending on the size of the unit, number of ecological sites, or management objectives. In that case, all should be considered when making management decisions. Each key area is selected because it is representative of use in a large portion of the pasture. Key areas can demonstrate patterns of utilization by grazing animals. Utilization may vary among key areas in any given year due to differences in livestock distribution caused by weather, water availability, season of use, class of livestock, or other factors. Use of pattern mapping or documentation of small impact areas may be useful for addressing these issues. If one key area consistently receives substantially heavier use than the others over several years, then it may be in an inappropriate location (e.g., in a concentration area where use is not typical of any substantial part of the pasture). If, however, the location of the key area receiving consistently heavier use is found to be representative of use in a significant part of the pasture, this may indicate a distribution problem requiring some management change. Therefore, when there are several key areas in a pasture or other unit, selecting the key area receiving the heaviest use in the pasture each year should not limit grazing in the pasture in any given year.[11]

Using Triggers Not Consistent with Coordinated Resource Management Planning

The SRM has long had a policy of supporting the concept of Coordinated Resource Management Planning and adaptive management. Many ranches in the West have mixtures of private land, state leases, or BLM or Forest Service allotments. Different landowners may have different objectives and rules, which makes it challenging to operate a ranch unit. Coordinated Resource Management Planning involves a cooperative effort among the various landowners and other interests (such as state game agencies or Fish and Wildlife Service) to develop plans that are compatible with different agendas but allow the ranch to be rationally and flexibly managed as a unit. Pasture moves should be planned with due consideration to the conditions and effects on the entire ranch unit and all land ownerships. Automatically forcing the

removal of livestock from a pasture or allotment without consideration for the welfare of the animals and the other portions of the landscape under diverse jurisdictions is not prudent. All jurisdictions of land management should work together to address the landscape needs within their individual agency constraints and responsibilities. Without this type of coordinated management decisions made on one land ownership may have undesirable and, perhaps unintended, consequences on another, or on the viability of the operation.

Guidelines: Sometimes Based on Clipping Studies That May Not Reflect Grazing Effects

Utilization guidelines are derived from two types of studies—stocking rate studies and clipping studies. The stocking rate studies are generally aimed at the effects of different stocking rates on vegetation, soils, and animal performance. Clipping studies are aimed at evaluating the effects of utilization levels on individual plant productivity, reproduction, or longevity. Many of the concepts of proper use when applied to key forage plants are based on clipping studies. For example, the rule of thumb of "take half–leave half" probably derives initially from the clipping studies of Crider[24] with respect to root growth in response to top removal. Many subsequent studies have produced somewhat different results and paid more attention to carbohydrate reserves, but the rule is still more or less accepted except in more arid conditions.[22] Some more recent research has discounted the role of percent utilization and placed greater emphasis on time of defoliation with respect to phenology.[25] Regardless, these clipping studies reflect a situation that is not actually encountered on grazed plants. Livestock and other grazers do not merely "clip" the entire plant at a uniform level when they graze. They may graze only part of the plant or select only the leaves, fruits, or seedheads. They may come back and graze the same plants again later in the season or in the next season, and they may trample or pull on the plants, which does not occur in clipping trials. These facts have led some to question whether the effects of grazing are as comparable to clipping effects as has been accepted in use of utilization guidelines.[6,11]

Rasmussen[21] studied long-term monitoring data on species frequencies and utilization collected by BLM in western Utah. Using regression analysis, he reported no significant relationships between the level of utilization and the observed changes in species frequency. He also found no relation to average utilization on key species and observed changes in species frequencies. Although he did not say so, these conclusions do not imply that utilization has no effect on species abundance, but that other factors, such as weather, may mask those effects under modern conditions of mostly light to moderate utilization on a majority of federal rangelands (except in a certain concentration areas).

Utilization and Residue Measurements Must Have a Documented Relevance to Their Interpretation

The above statement would appear to be so obvious as to not require explanation, yet it is often ignored because of lack of understanding or a specific agenda or both. Utilization as a basis for livestock grazing management is usually based on the key species and key area concepts and aims to assess whether utilization on the key forage species (usually the most preferred and abundant) are being grazed at a level that will maintain or improve their productivity and abundance. It is assumed that, if the key areas are well chosen, "proper use" on the key species in key areas will result in that amount of use or less in the rest of the pasture or allotment—the exception being in certain concentration areas near water or in riparian areas where changes in stocking rates will usually not be the answer to the problem. When we say that the guideline is, for example, 50% utilization, inexperienced people will probably think of a range where all or most of the plants are grazed to 50% and half of all the biomass produced is removed—analogous to a hayfield mowed to a certain height. (Stubble height is even more misleading because some plants are not grazed and therefore no "stubble" is present.) Nothing could be farther from reality because many parts of the rangeland will be used less than 50%, and many of the plant species will also be grazed less than 50% or not at all. Insects, termites, rabbits, and decay may remove more biomass than grazing animals, and to an untrained eye the range may hardly appear to have been grazed at all if it weren't for cow pies and trails near concentration areas. The key species and key areas were selected specifically, or should have been, to serve as an indicator of the impact of livestock grazing to help identify need for changes in management or to help explain observed changes in vegetation. The point is that both key species and key areas are chosen to represent the effects of grazing for a particular kind of livestock—they would not be the same for a sheep operation as for a cattle operation. Key species and key areas are specific to a particular kind of animal or resource value. For example, if the concern is for adequate nesting cover for quail, then measuring utilization on key species for cattle may not provide any useful information because there may be adequate cover of other species that will not be grazed and can provide such cover. Likewise, in riparian areas the location and species measured, the method used, the time of measurement, and the guidelines employed may depend on the objectives (i.e., effects on growth of key forage species, on sediment trapping, on use of other species, on soil compaction or bank stability, etc.).[26]

Conclusions and Recommendations

The RAM Committee is composed of a diverse group of rangeland management professionals from various agencies, educational institutions, private entities, and backgrounds. The paper does not provide any new information—most of the statements here have been stated and restated for over a half century. The Committee recognizes that utilization and residue measurements are useful tools in adaptive range management. However, misuse of both concepts continues to be the cause of disagreement, controversy, litigation, and economic penalties for livestock operators. This paper provides all practitioners of the art and science of range management a foundation to bring the concepts and

procedures of using utilization and stubble height in line with scientific understanding and professional principles for adaptive grazing management, including:

- Recommended utilization levels and residual height or weight are tools for adaptive management, not management objectives.
- Utilization or residual measurements can be subject to many sources of sampling, procedural, and personal errors.
- Season of measurement has a strong influence on interpretation of results.
- Utilization/residual guidelines are not rigid limits to be met every year, but a tool to identify stocking rate or distribution problems over several years, to guide annual management, and to explain long-term trends.
- Utilization or residual data must be relevant to management objectives.
- Time, location, and protocol for measurement must be documented in plans, reports, or management decisions based on the use of the data.

SRM members are encouraged to work collaboratively at the local level to foster greater understanding of these principles for the measurement of utilization and residue and use of the information obtained.

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Authors are Rangeland Assessment and Monitoring Committee, 4505 Private Road 4910, Del Rio, TX 78840, USA (lamarsmithCRC@gmail.com).