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Evaluation and Practical Use of Research Results For Developing Grazing Strategies

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EVALUATION AND PRACTICAL USE OF RESEARCH RESULTS FOR DEVELOPING GRAZING STRATIGIES

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ABSTRACT

Given the diversity of potential objectives and production environments there are many types of research beyond grazing studies that can be used to design grazing strategies. Management perception and awareness of information are important factors in the development of creative and efficient grazing strategies. Well thought out and clearly documented goals and objectives will help to identify the kind of information that is needed. Grazing strategies should be financially and ecologically sound in respect to management objectives, but most importantly, they should be as simple and risk free as possible. The relative value of any information must be based upon how well that information can be used to efficiently achieve management objectives. Information must be critically evaluated to avoid the pitfalls of myths that often occur in discussion of grazing management.

OBJECTIVES

The feasibility of current or potential objectives should be checked against all available resources including people. Review the talents, interests, and current time commitments of all individuals involved in the enterprise. All financial assets and obligations should be well documented. The quantity, quality, and productivity of rangeland, seeded pastures, hayland, crops, crop residue, equipment, facilities, fence, water, livestock, wildlife, and timber need to be accurately inventoried. State and federal agencies generally provide range inventories on public land. The Soil Conservation Service will generally provide range inventories on private land when requested.

Projected ownership plans are extremely important in developing grazing strategies. If ownership of calves and yearlings will be retained, less than maximum average daily gains (ADG) could provide compensatory gain and reduce cost of production in the following production phase. If ownership will not be retained, near maximum ADG will be required to maximize net enterprise profit.

INFORMATION

The majority of published research results in the last several decades have been printed in scientific journals which can be acquired from university libraries and some local libraries through inter-library loans. Information from earlier studies, frequently published as research bulletins, can be acquired from the respective university experiment stations. In addition to libraries, university and college faculty on campus and research and extension centers frequently have extensive files of reprint publications. While these individuals may be able to provide you with the current state of knowledge on specific questions, review of key publications can provide valuable insight.

All information that is potentially valuable for the development of grazing strategies is not published. Long-term grazing management experience has provided ranchers and research scientists with valuable knowledge and perception that may never be published. Correspondence or on-site consultation with these individuals should not be overlooked.

It may be helpful to group information into categories. Searching for a specific kind of information can provide the focus needed to improve the efficiency of time invested. Possible categories of information may include the following:

1. Ideas & Concepts: These may be hypothetical (myths) or well documented principles that could stimulate creativity or improve understanding of different grazing management strategies.
2. Response Surfaces: Changes that occur over a wide range of points in a single factor, i.e. the pattern in livestock gains over time from May through October.
3. Critical Points: The level of variables at which dramatic or economically important changes begin to occur, i.e. the grazing pressure at which animal performance will fall below maximum, or the level of defoliation at which significant root biomass reductions will occur in grasses.
4. Interactions: Relationships between two or more variables, i.e. the influence of plant maturity on degree of defoliation over a range of grazing pressures.
5. Technology: These may include methods and procedures for altering plant species composition or for monitoring the physiological, ecological, or economic effects of management decisions on vegetation, livestock, wildlife, or the watershed.
6. Decision Making Guidelines: These guidelines are generally based on the above categories. A growing interest has developed in synthesizing information into graphs or simple computer models that can be used to optimize forage and livestock production. i.e. SMART: a simple model for estimating the influence of changes in grazing pressure, length of grazing season, and beginning and ending date on yearling average daily gain (Hart 1989).

CRITICAL EVALUATION

Published research results are generally correctly interpreted for the conditions specified in the publication. Information on study site(s), environmental conditions, methods, and procedures should be reviewed to determine similarity with your production environment.

It is challenging to conduct field research in range ecosystems because of the large amount of natural variation in vegetation, soils, and environmental conditions. Grazing system studies are especially sensitive to this variation as well as variation in management perception and the performance potential of livestock (Grovum 1984, Winder and Beck 1990). In general, field studies conducted over several locations and/or several years will provide more dependable information than short-term studies on a single location, regardless of the research topic. Considerable variation in treatment effects can occur from year to year because of differences in the pattern and total amount of precipitation. Review as many readily available articles as possible. If inconsistencies occur among published results, confer with research personnel by phone, in person, or in writing to discuss inconsistencies and to determine the reliability or risk of incorporating the information into a grazing strategy.

ON SITE RESEARCH AND EVALUATION

Ranchers can also benefit from small scale research on their own ranches. Research is defined as a studious and critical inquiry and examination aimed at discovery and interpretation of new knowledge. Graduate degrees are not required for worthwhile evaluations, but the principles of valid tests should be understood. The primary requirements are simple. Valid tests of treatments or management alternatives require a comparison between control (as is) and treated (altered) experimental units. These units may be individual plants or animals, plots, pastures, or herds as long as the control and treated units are as similar as possible. Whenever possible, replicate the treatments over several locations or years.

Valuable information can also be gained by evaluating the effects of past and current management on vegetation and livestock response. This can be done by using functional grazing records, livestock performance records, precipitation records, field notes, and photographs. Livestock scales are extremely valuable in monitoring the efficiency of grazing strategies. Animal performance is a measurement of the efficiency of management in providing the necessary quantity and quality of forage for production objectives. When consistent weighing conditions are used, on site, pre- and post-grazing season livestock weights are much more reliable than hauling cattle over truck scales.

MYTHS

Despite the enormous amount of published research, widely held myths still present significant hazards to range livestock producers. A myth is an unproven or false collective belief that is used to justify a practice. The origin of myths over the past 90 years can be traced to many sources including academic, agency, and corporate sources as well as the range livestock industry. All of our respective organizations have played a role in the development of one or more myths. Resolution of unfounded myths will require a collective effort.

The following myths are either not true or partially true. Those concepts that are partially true may be sensitive to environmental conditions or they are correct only up to a critical point. Insight on the following myths is provided in the balance of this text.

Myth: Plants on rangeland must be grazed, in order to maintain plant health or vigor.
Myth: Grasses are best able to withstand grazing late vs. early in the growing season.
Myth: Conventional rotationally deferred grazing systems provide all pastures with an equal opportunity to recover.
Myth: Stocking rates (carrying capacity) can be increased when grazing systems are

implemented.

Myth: Dormant vegetation cannot be damaged by overgrazing.

Myth: Reducing the length of time plants are exposed to grazing is more important than the amount of forage removed.

Myth: Unweaned calves gain (bloom) well in September and October on native rangeland.

Myth: Maximum weaning weights will ensure maximum net return to cow-calf enterprises.

Myth: Grazing systems can be used to increase individual animal performance on rangeland beyond levels achieved under moderately stocked season-long continuous grazing.

Myth: Production per head of livestock is less important than production per acre in obtaining maximum enterprise profit.

Myth: Increased stocking rates are necessary to increase total animal production per acre.

Myth: Increasing stocking density (concentration of livestock) and reducing the length of grazing periods improves infiltration rates.

Myth: Season-long continuous grazing is "bad".

Myth: There is one grazing strategy that is best suited for all range ecosystems.

Myth: Net profit of rangeland enterprises increases as harvest efficiency increases in summer grazing programs.

ANIMAL PERFORMANCE

Beyond managerial capabilities, the greatest limits on livestock production are related to the grazing animals' ability to select and consume a diet supplying enough nutrients to meet daily requirements for maintenance and production (Mccollum and Galyean 1985). Maintenance of a diverse plant community, containing not only desirable grasses but also palatable forbs may allow grazers to maintain a higher level of nutrient intake during periods of grass dormancy (Mccollum and Galyean 1985).

Practices that allow livestock to selectively graze during the summer become more important as the growing season progresses. Forage quality declines as plants mature. The profound impact of this process on seasonal declines in animal performance is well documented (Klipple 1964, Burzlaff and Harris 1969).

Diet quality, intake, and animal performance decline as grazing pressure increases beyond a critical level at any time during the growing season (Olsen et al. 1989, Ralphs et al. 1986). Grazing pressure is an animal to forage relationship measured in terms of animal units (AU) per unit weight of forage at any instant (AU/T). Increasing grazing pressure increases the frequency and severity of defoliation and reduces the opportunity for selective grazing (Hodgson and Ollerenshaw 1969).

Natural synchronization of natural grazer reproduction with plant growth cycles and strongly imprinted selective grazing habits apparently increased animal survival (Launchbaugh 1978). These natural patterns cannot be ignored in managing livestock on rangeland. By focusing inordinate energy on achieving maximum weaning weights in the past decade some in the range livestock industry have overlooked the obvious. Maximum net return to the enterprise is rarely achieved when weaning weights are achieved. The costs of early calving, late weaning, and maintaining high breed back percentages in cows with high lactation potential in range livestock enterprises may only be recovered when markets are high. Selecting environmentally compatible livestock characteristics and shifting production schedules to more closely match animal requirements with quality and quantity patterns of feed and forage resources will frequently produce higher net returns.

Dramatic changes in nutritional requirements are associated with environmental factors, reproductive status of cows and heifers and age of growing cattle. Improving the fit of a cow-calf operation to a production environment can increase net enterprise profit at less than maximum weaning weights, because of reduced feed and supplement costs and weather related risk (Adams et al. 1986, Adams and Short 1988, Reece 1991). Weaning calves earlier reduces cow nutrient requirements dramatically. Dry cows can gain weight with forages on which lactating cows would lose condition. Weight of growing cattle influences nutrient requirements. Within a given frame category, 700 lb yearlings require more pounds of total digestible nutrients (TDN) and crude protein per head than 500 lb yearlings. However, average daily gain (ADG) of 700 lb yearlings can be measurably higher than ADG of 500 lb yearlings with equal percentages of TDN and crude protein in their diet (NRC 1984).

The effects of shifting reproduction and weaning schedules or yearling weights must be evaluated with regard to current and projected market and tax conditions. Information on markets, marketing strategies, and ownership decisions is readily available from university, agency, and corporate offices. Direct and auction market data, and feeder and cattle numbers can be acquired from the USDA Grain and Livestock Marketing News office in your state.

The efficiency of animal production on rangeland may be improved by using livestock combinations. When cattle and sheep were grazed together, cattle were more sensitive to grazing pressure than sheep in Texas (Ralphs et al. 1984), but no differences were observed in South Dakota (Volesky et al. 1990). These contrasts may be caused by differences in similarity of plant species preferred by cattle and sheep in different study locations.

PLANT RESPONSE TO GRAZING

Clipping studies provide considerable information about how individual plant species respond to degree and frequency of defoliation in different stages of plant maturity. Differences in response to defoliation may occur among plant species. Information on species in your production environment will be most applicable.

Plant response to defoliation is dependent upon (1) the degree and frequency of defoliation, and (2) stage of plant maturity (Waller et al. 1985). Recovery in a natural ecosystem will depend upon (1) the amount of green leaf and stem area that remains after grazing, (2) suitability of growing conditions, and (3) competition from adjacent plants (Mueggler 1972). If soil moisture and air temperatures are not favorable for plant growth, little or no recovery will occur in the current year. If regrowth goes dormant before carbohydrate reserves are replenished, late season overgrazing reduces plant vigor more than early season over use (Parker 1960). When favorable growing conditions occur, rate of recovery increases as the amount of remaining green tissue increases. Competition from ungrazed adjacent plants may reduce recovery even if favorable growing conditions do occur, especially when grazed plants have been heavily defoliated. While uniformly heavy grazing across all species would reduce competition, the desirable effects of heavy grazing must be balanced against undesirable effects on livestock, site stability, watershed protection, and aesthetic values (Mueggler 1972).

Proper utilization of most range grasses is removal of 50 percent or less of the present, current year leaf and stem tissue by weight (Reece et al. 1991). A simple procedure can be used to develop a visual perception of percentage forage utilization. Clip the current year growth from random bunches or tillers at the ground level. Wrap the samples with string or tape. Balance each sample on your finger. The point of balance is the height at which 50 percent of the leaf and stem tissue would be removed. Clip the sample at this point and balance each half to estimate heights for 25 and 75 percent utilization. Proper utilization will cause little reduction in root growth and plant vigor. Grazing in excess of 60 percent will cause dramatic reduction in amount and depth of root growth.

Heavy grazing is very detrimental under drought conditions. During droughts that occurred in the 1930s and 1950s, drought-induced death losses of grasses in pastures were extreme under heavy grazing and moderate to not different when moderately grazed, compared to ungrazed pastures (Albertson et al. 1957). Heavy defoliation during drought or winter induced dormancy may (1) remove critically needed organic reserves stored in the lower portions of stems, (2) alter the micro environment and make it less favorable for plant growth, or (3) reduce infiltration rates because of reduced plant cover.

YEAR TO YEAR VARIATIONS

Changes in botanical composition and forage composition are often affected more by yearly climatic differences than by differences in stocking rates (Burzlaff and Harris 1969). Plant species often respond differently to grazing intensity in different years in long-term grazing studies (Launchbaugh 1967). The basal area of native plant species in the Northern Great Plains react to precipitation regimes and grazing pressure in a unique manner (Olson et al. 1985). Continual changes in basal cover can be expected in plant communities as the precipitation regime changes regardless of grazing strategy. While basal cover is not a direct measurement of available forage, it does provide an index to the potential forage production per acre. Rest or growing season deferment may need to be applied to designated pastures in consecutive years in order to produce measurable improvements in total herbage yield or plant vigor (Martin and Ward 1976, Trlica et al. 1977).

ENVIRONMENTAL EFFECTS OF LIVESTOCK

Range ecosystems are circular causal systems: livestock influence vegetation, and vegetation influences livestock performance (Watt 1973). The effects of diverting more nutrients and energy flow into animal products through increased harvest efficiency or increased stocking rates have not been documented on rangeland. Herbage consumption and physical impact of livestock on soil surface and physical conditions can have a measurable effect on the suitability of the environment for plant growth. Extensive removal or reduction of foliar cover will lead to (1) increased temperature extremes and variations, (2) increased air movement near the soil surface, and (3) increased soil moisture evaporation. Excessive removal of foliar cover will also reduce infiltration of precipitation. Soil moisture is the most limiting factor for plant growth in semi-arid range ecosystems.

There is no evidence that any grazing scheme will improve local hydrologic conditions compared to ungrazed conditions (Gifford 1986). Heavy stocking rates decrease infiltration rates and increase erosion regardless of the system used. Plant cover is important in reducing the kinetic energy of falling raindrops. The amount of live and dead plant cover needed to maximize infiltration rates and control erosion ranges from 50 to 70 percent depending on slope and soil porosity. Root systems of range plants also increase soil porosity and soil organic matter. Moderate and light grazing reduce infiltration on porous soils by about 25 percent compared to ungrazed conditions because of soil compaction. Heavy grazing may reduce infiltration by as much as 33 percent (Gifford 1986).

STOCKING RATE

Traditionally rangelands have been stocked on the basis of animals per acre per season. This approach presents problems because of variation in animal age and weight. Weights of different classes of beef cattle have changed dramatically in the last 15 years because of genetic improvement and/or cross breeding. Bigger cows tend to wean heavier calves, but bigger cows and calves also consume more forage. Consequently, range condition has declined on pastures where cattle numbers or days of grazing per pasture have not been reduced.

Animal unit (AU) equivalents are used in research publications. The AU equivalent for beef cattle is easily estimated by dividing the average shrunk weight of the class or herd of animals by 1000. Animal unit equivalents for cattle can be based on their average weight for the grazing season or adjusted at monthly intervals. Cows with an average weight of 1200 lb would be equal to 1.2 AU. Calves begin foraging when about 2 months old. By the time calves are 4 months old they spend as much time grazing as cows (Dwyer 1961). It is generally recommended that the average calf weight should be added to the average cow weight to calculate AU equivalents for pairs when the average age of the calf crop is 3 months.

Yearling cattle with an initial weight of 550 lb and a seasonal gain of 220 lb would be .66 AU [(550 + 110)/1000] for the season. Monthly estimates could be calculated by dividing total gain into monthly increments or by using response surface information for seasonal gains in locations similar to your production environment. About 60 to 70 percent of the total summer gain in growing cattle generally occurs in the first half of the summer grazing season.

Optimum stocking rates for economic returns to land, labor, and management in yearling enterprises increase as the difference between buying and selling prices decreases (Bransby 1989, Hart et el. 1989). However, short-term profits could lead to reduced profits in the long run on rangeland. The most profitable stocking rate for yearling cattle during a 2-year period, near Cheyenne, Wyoming was 60 to 80 percent above Soil Conservation Service (SCS) recommendations, but the increase in net profit over SCS recommendations was small and it was projected that range condition and forage production could not be maintained at the higher rate (Hart et al. 1988). Long-term economically optimum socking rates on rangeland are typically very near levels where animals achieve maximum gain. Grazing trials and surveys conducted over an 11 year period in semi-arid regions in Queensland, Australia showed that exceeding physiologically optimum stocking rates was detrimental to pasture and animal production in the long-run (Beale et al. 1986).

Animal performance in response to a given stocking rate is variable over years because of differences in herbage allowance (Hart et al. 1988). Herbage production on semi-arid rangelands is influenced primarily by precipitation. Even though stocking rates based on AU months (AUM) or AU days (AUD) per acre are practical units for grazing management, it must be remembered that cattle graze forage, not acres. Consequently stocking rates often need to be varied from pasture to pasture and from year to year to provide adequate amounts of forage for livestock.

HERBAGE ALLOWANCE

Availability of forage to livestock can be expressed as herbage allowance, defined as the average weight of palatable herbage per day per animal unit during a specified time period. The actual amount of herbage available for selective grazing declines each day if herbage disappearance (intake, trampling, natural plant breakdown) is greater than daily herbage production. Herbage allowance is calculated by dividing the amount of palatable herbage/acre at the beginning of the grazing period by the planned number of Animal Unit Days/acre.

Rangeland productivity, as measured by saleable livestock products, is a function of forage quantity, forage quality, and efficiency of harvest (Heitschmidt et al. 1982). Harvest efficiency (percent of herbage disappearance accounted for by livestock ingestion) increases as herbage allowance decreases (Allison and Kothmann 1979). However, forage intake, selective grazing, and animal performance were reduced at herbage allowances between 40 to 60 lb/AUD in Texas and Oklahoma during grazing periods of 14 or less days (Allison et al. 1982, Holger et al. 1990).

Harvest efficiency under moderately stocking season-long continuous summer grazing typically ranges from 35 to 50 percent. As harvest efficiency increases, the opportunity for animals to select a high quality diet and maintain high levels of performance declines. Therefore, increased harvest efficiency can increase net enterprise profit only if animal performance is not seriously reduced. Allison et al. (1982) reported that a harvest efficiency of about 70 percent could be achieved without reducing forage intake in Texas by using a mean herbage allowance of about 90 lb/AUD during 14 day grazing periods. Hart et al. (1989) reported that yearling steer ADG during 120 to 150 day summer grazing seasons was reduced below mean herbage allowances of about 110 lb/AUD. Herbage allowances that lead to overgrazing will reduce animal performance and plant vigor. When growth rates were less than maximum in July and August, Hogler et al. (1990) reported mean forage utilization percentages in excess of 50 percent at herbage allowances less than 50 lb/AUD during 10 day grazing periods in north central Oklahoma.

Management of herbage allowance on rangelands under short duration grazing will be challenging because of the need to manipulate days of grazing to account for differences in forage growth rate and standing crop among pastures (Stuth et al. 1981). Critical levels of herbage allowance for animal performance also increase as plants mature and forage quality declines.

SELECTIVE GRAZING

Understanding why domestic livestock select certain plant species or certain plants within a given species is not well understood (Heitschmidt et al. 1990). Plant-animal interactions are complex. Based upon a review of literature from Africa, Europe, and the United States, Holger et al. (1990) stated that defoliation patterns are dependent on factors such as herbage allowance, season of use, tiller morphology and phenology, species and site preferences, and length of the growing season. In a study of tiller defoliation patterns of native range composed of mid and shortgrasses in Texas, Heitschmidt et al. (1990) reported that mid grasses were consistently grazed more intensively than shortgrass species and that intensity of defoliation of individual tillers was a function of pre-defoliation tiller height.

When pastures are grazed two or more times, initially ungrazed tillers are less likely to be grazed in following grazing periods (Briske and Stuth 1982). Preferred plant species are consistently defoliated more intensively and frequently than less preferred species regardless of the grazing schedule or stocking rate (Gillen et al. 1990). The effect of reproductive culms (seed stalks) on tiller selection and severity of defoliation of tillers within a species is inconsistent (Norton and Johnson 1983, Heitschmidt et al. 1990).

Grazing schedules and stocking rates may have little effect on the height at which tillers are defoliated (Gillen et al. 1990). Intensity and frequency of defoliation tend to be greatest when plant growth is most rapid (Owensby et al. 1974, Dwyer et al. 1963, Jameson 1963). The intensity and frequency of defoliation increase linearly as herbage allowance decreases (Hinnant and Kothmann 1986, Briske and Stuth 1982, Hart and Balla 1982).

GRAZING STRATEGIES

Comprehensive reviews of grazing strategies are uncommon, but extremely valuable (Launchbaugh et al. 1978, Heitschmidt 1986, Hart et al. 1988). When grazing pressure is similar, animal performance under different grazing systems is generally unchanged at moderate stocking rates on mountain rangeland (Holechek et al. 1987). In a comparison of short-duration rotation, rotationally deferred and season-long continuous grazing systems over several stocking rates near Cheyenne, Wyoming, Hart et al. (1989) concluded that stocking rate and livestock distribution were much more important than rotation in determining the success of grazing systems.

Regardless of the grazing strategy, research and long-term observations in semi-arid range ecosystems suggest that sustained animal and vegetation productivity will best be maintained by stocking rates that achieve not more than moderate utilization (40-50 percent) during the growing season every year.

Livestock distribution is critical in avoiding differences in ADG between grazing systems at comparable levels of grazing pressure (Laycock and Conrad 1981). The distribution of grazing over an area is as important as distribution over the season. Unequal distribution of grazing on preferred species or preferred sites can cause seasonal overuse while other species or sites are under utilized (Hyder and Bement 1977).

When stocking rate and livestock distribution are properly controlled, season-long continuous grazing improves or maintains desirable range and meets livestock nutritional needs better than most specialized rest-rotation systems (Lewis 1969). Continuous grazing can be especially appropriate for the special growth requirements of replacement heifers that must reach puberty at 12 to 13 months of age if they are to calve as two-year-olds. A different pasture could be used for replacement heifers each year.

The potential for livestock distribution problems to occur under season-long continuous grazing increases as the diversity of plant species, plant communities, and topography increase within the pasture. If significant diversity in these factors occurs, alternate grazing strategies may provide an efficient solution. Full advantage should be taken of all improvements and capabilities that currently exist. Therefore a complete inventory and assessment of resources is essential for critical consideration of alternate strategies.

Seasonal suitability of forage resources should always be considered when developing grazing strategies. This concept involves grazing forage resources at appropriate levels of utilization when nutritional qualities are highest (Reece et al. 1991). The concept may apply to capitalizing on cool-season annuals, seeded pastures, utilizing perennial cool- or warm-season forages in mixed native pastures or natural transitions in plant maturity over elevation gradients in foothill or mountain pastures.

Where favorable plant growing conditions frequently occur for extended periods of time, intensive-early stocked grazing programs have produced increases in production per acre with no change in ADG compared to season-long summer continuous grazing (Launchbaugh 1957). Under this method a pasture would be stocked with twice as many animal units, but grazed only during the first half of the growing season.

Clearly, no one system of management is likely to be superior to all others (Spedding 1965). In fact, the integration of a number of different grazing methods, each appropriate for a given class of livestock, type of forage resource, and/or time of year will be uniquely different and most efficient on an individual ranch basis.

When multiple pastures are involved in a strategy, the best approach appears to be the use of flexible scheduling. Base the time of use on the availability and quality of forage, frequency or level of utilization on key species or sites, and/or residual plant cover as determined by management objectives for individual pastures.

If intensive rotational grazing strategies are used, the potential for the effects of management decisions to depress animal or vegetation performance increases because more decisions must be made and decisions are more time sensitive. Digestibility and crude protein content of cattle diets decline as short periods of grazing progress (Allison and Kothmann 1979). Energetic costs of grazing are high. Deteriorating pasture conditions at the end of short grazing periods can dramatically increase energy expenditures at the expense of animal performance (Sahlu et al. 1989).

When evaluating the suitability of available forage for animal performance consider the relative amount of herbage in leaf vs. stem tissue. This unsophisticated estimate will provide an indication of forage quality (Bransby and Tainton 1986).

FUTURE NEEDS

There will always be unanswered questions in the search to optimize livestock production in range ecosystems. Resources available for the quest of answers need to be used efficiently. Range livestock producers and research scientists need to work together. Based upon our current understanding, the following issues are of critical importance:

1. Practical decision making guidelines for economically and ecologically efficient grazing management decisions.
2. Critical periods and intensity of grazing for individual species as well as plant communities.
3. Documenting seasonal shifts in plant species most preferred by livestock on native rangeland.
4. Critical forage allowances and/or remaining amounts of standing herbage for optimum animal performance and long-term sustainability of forage resources.
5. Comparative grazing studies of performance in different weight/age categories of livestock on rangeland.
6. Periodic summaries of practical information from research and long-term observations for major range ecosystems.

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