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SYMPOSIUM

# INVITED REVIEW: The roles of forage management, forage quality, and forage allowance in grazing research[1]

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## ABSTRACT

*Forage-management principles have been structured from small-plot experimentation targeted at evaluating defoliation regimens, fertilization, and other factors on growth and persistence of forage varieties or germplasm. Seasonal and total forage-mass attributes have been the primary benchmark for sustainable grass pastures. Forage mass affects level of grazing intensity and stocking rates to maximize gain per unit land area. Forage nutritive value sets the upper limits on gain per animal. Both forage mass and nutritive value are uniquely linked to animal performance; however, the priority role is different for $C_3$ versus $C_4$ forages because of the substantial differences in percentage of protein and digestible DM. The value of grazing-intensity and stocking-rate experimentation includes identifying ADG × gain per hectare relationships, and the mathematical expressions of other factors including forage allowance. The calculated forage allowance (forage DM:animal BW) has moved past the original point-in-time reference to be more inclusive of the average forage allowance for an entire season. Forage-allowance databases provide management decisions for stocking strategies to affect forage-animal pasture systems. Forage allowance of a pasture may provide management decisions for setting initial grazing intensities, or these calculated values may provide stocking strategy choices to optimize ADG or gain per hectare. The role of forage management is a dynamic, evolving, data-driven process with the inclusion of heuristic approaches to serve as correction factors to optimize forage utilization. Grazing research provides grazing-experiment databases to direct and redirect the role of forage-management decisions to enhance biological-economic efficiencies and sustainable pastures.*

**Key words:** management, forage mass, nutritive value, forage allowance, stocking strategy

## INTRODUCTION

In the design, analyses, and execution of grazing research, the foundational objectives have sought to understand and identify the biological boundaries of the forage–animal interface (Coleman et al., 1989; Forbes and Rouquette, 2007). Grazing research and experimentation may have singular or multiple objectives to define forage growth dynamics and related forage nutritive value as factors controlling gain per animal and gain per unit land area. Rouquette (2015) summarized that researchers design grazing experiments that basically fit a 2-tier objective platform to (1) address and answer research hypotheses related to forage–animal relationships and (2) provide comparative, forage-management principles for educators and stakeholders. The most basic principles of forage management are those affecting forage growth and DM production; harvesting-utilization components related to livestock or mechanical; and factors responsible for forage regrowth dynamics. Within the context of assessing forage growth and regrowth attributes of a species, forage management takes on a dynamic, evolving protocol. With additional knowledge, factors in-

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fluencing forage growth, utilization regimens, and livestock performance, the underlying principles of forage management are defined, recalculated, and transferred into strategies and decisions to establish forage–animal relationship guidelines for efficiency of production. Thus, forage-management principles are constantly evolving and redirecting by scientists, educators, and stakeholders to meet desired goals. Rouquette (2015) defined the objectives of stocking strategies within grazing-systems research to incorporate scientific databases of forage mass, regrowth, nutritive value attributes, and defoliation regimens that were created by grazing intensity, stocking rates, and stocking methods. In addition, these stocking strategies and forage-management guidelines are uniquely identified with climatic conditions and vegetational region. Management success is dependent upon the ability to match livestock nutritive requirements with the dynamics of forage growth and nutritive value and to redirect the utilization strategy to optimize biological and economic endpoints. Hodgson (1990) summarized that the understanding and application of grazing management include implementation of strategies rather than manipulation of stocking rate or rotational schedules. Hodgson (1990) further insisted that the efficiency of grazing-management protocols were inseparately linked to understanding the forage–animal interface and the balancing of forage supply and demand for both the short-term and strategic format to meet production goals.

## GRAZING METHODOLOGY

### *Objectives of Grazing Research*

The objectives of grazing experimentation have been outlined by many researchers (Mott and Lucas, 1952; Bransby, 1989; Burns et al., 1989; Matches, 1992). The primary issues that provide the impetus for grazing research include the need or desire to (a) compare and evaluate a forage variety or cultivar under stocking conditions; (b) define forage–animal relationships at various stocking rates or grazing intensities; (c) evaluate stocking methods; (d) compare systems of use and stocking strategies; (e) assess effect of stocking on nutrient cycling and environmental components; and (f) quantify economic effect of pasture systems.

Although some grazing experimentation may be targeted at a small niche of plant–animal responses to fit a modeling effort (Forbes et al., 1985), most grazing research has been initiated to serve stakeholder needs for biological and economic endpoints (Morley, 1978; Hart and Hoveland, 1989; Sollenberger, 2015). Much of the grazing research has been conducted as "components of the system" wherein short-term, 56-d to 112-d stocking periods are evaluated during a 1- to 3-yr period (Rouquette, 2015). The research, extension, or educator personnel are then responsible for making extrapolations and assumptions for stocking strategies and forage-management guidelines to accommodate a year-long pasture system. Thus, the challenges and applications of grazing research may be in greater demand today than ever before because of changes in grazing-research funding infrastructure, land fragmentation, and emerging novice stakeholders (Rouquette, 2015; Sollenberger, 2015). The state-of-the-state grazing-research concerns are that existing and new landowners seek comparative grazing information from a declining number of research scientists with reduced budgets for stocking experiments (Rouquette et al., 2009). In a review, Sollenberger (2015) provided some insights into the opportunities for researchers and educators to address these challenges and applications of grazing research.

### *Forage Mass and DM Production*

Forage mass and DM production are the benchmarks for sustainable, reliable, perennial-grass pasture systems for livestock production. Forage mass is directly responsible for the degree, extent, and longevity of grazing-intensity and stocking-rate experimentation and application and management principles for stakeholders. Several (Conrad et al., 1981; Bransby, 1991; Sollenberger and Vanzant, 2011) have suggested that stocking rate was the most important factor that affects the soil–plant–animal interface. Stocking rate affects ADG directly or indirectly but is the major management strategy that affects gain per unit land area. In a review of the relationship of forage mass and animal performance in grazing experimentation, Burns et al. (1989) listed 13 different measurements that could be categorized as essential to characterizing pasture, animal, or pasture–animal dynamics. Of the 5 essential measurements for pasture, forage mass was listed first, and forage height was listed fourth. These measurements were critical for estimating forage density and an indexing of sward canopy structure. Forage mass can be measured or estimated directly or indirectly using an array of techniques (Kallenbach, 2015). One of the major decisions facing the forage scientist is that of identifying the forage height at which forage mass should be measured or collected in the pasture. Many scientists have chosen to measure via hand clipping to ground level, whereas others have chosen some height ($\pm$5 cm) above ground level to characterize pasture conditions for the forage–animal interface. For forages such as bermudagrass and cool-season annual forages, a ground level (0 cm) approach may be best because that would measure the forage mass that was potentially available for consumption. A $\pm$5-cm height for measuring forage DM may be more appropriate for bunchgrass or non-sod-forming grasses and for documenting conditions under specific stocking rates and forage mass conditions.

The grazing-research literature has numerous, foundational experiments and citations that have illustrated linear or curvilinear responses to stocking rate and animal performance (Mott and Lucas, 1952; Harlan, 1958; Mott, 1960; Riewe, 1961; Petersen