# Grazing management options for maintaining optimum pasture composition and utilization

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**ABSTRACT**

Global demand for meat and dairy products will continue to increase over the 21$^{st}$ century, however, the global forage-based livestock industry will be challenged in meeting production goals with minimal impact of the environment. Sustainable production of grazing livestock will depend on the use of carefully planned grazing management strategies. Development of a grazing management plan involves making two decisions: determining the livestock density at which pastures are stocked and settling on the method used to graze the pastures. Stocking rate indirectly affects output per animal and per hectare through its direct effect on forage mass and pasture composition. A grazing method should be implemented to maintain the sustainability of a stocking rate that is set to meet a production goal. This review will emphasize the factors to consider in setting a stocking rate and in the selection and design of a grazing method that improves the sustainability of the stocking rate through optimum pasture utilization.

**Key words:** Forages, Forage utilization, Grazing, Grazing management, Grazing systems

## Introduction

Approximately 45% of the earth's land surface is grazing land, which makes the greatest use of land being for the purpose of grazing of livestock and wildlife (Reid *et al.*, 2008). Grazing lands have been a valuable resource for the grazing of ruminant livestock that have provided meat and dairy products to mankind for millennia. Further, grazing lands encompass a wide range of environments, from arid rangelands to improved pastures in humid/wet climates. Grazing lands have a valuable purpose, but population growth, climate change, and urban sprawl are making management of grazing lands increasingly challenged. The U.N. Department of Economic and Social Affairs (2014) projected that world population will reach 9.6 billion by 2050 and populations in developed and developing countries will continue to shift from rural to urban communities. The report stated that percentage of world population in cities and towns was 29.6% in 1950, but is anticipated to reach 66.4% by 2050. Urbanization in developing countries has stimulated income growth, which has enhanced diet variety in these countries (Delgado, 2005). Thus, there has been a trend over the last 40 years of higher consumption of animal products in developing countries, with the greatest increase being of non-ruminants (pigs and poultry) and dairy products (FAO, 2003).

In spite of the increase in consumption of products from non-ruminants, the global numbers of ruminant livestock also have steadily increased over the last 30 years of the twentieth century and the increases are projected to be greater over the first 30 years of the twenty-first century (FAO, 2003; Fig. 1). Cattle and buffalo numbers between 2000 and 2030 were estimated to increase 24% and sheep and goats were estimated to increase by 32%. Global expansion of small and large ruminants are occurring even though ruminants have been identified as major

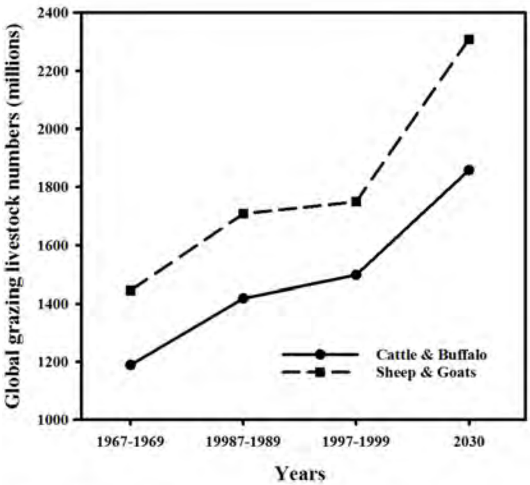


**Fig. 1.** Global changes in grazing livestock numbers over the last 33-yr period in the 20th century and projected values for 2030 (Source: FAO, 2003).

contributors of greenhouse gas emissions (Boadi *et al.*, 2004; Steinfeld and Wassenaar, 2007; Garnett, 2010), reduction in water quality (Galloway *et al.*, 2010), and grassland degradation from erosion and encroachment of noxious weeds (Pimentel *et al.*, 2001). Ruminants will remain as a supplier of high-quality protein in human diets; however, it is imperative that grazing management is implemented to maintain forage production at quantities that meet livestock production goals while minimizing environmental impact. This paper will address grazing management options in setting objectives to sustain pasture utilization and production goals.

## Stocking rate as a management tool

*Animal performance:* Stocking rate controls the forage mass (kg dry matter/ha) available to grazing livestock that has a direct effect on animal performance. The stocking rate, which has impact on per hectare livestock productivity, is the primary management tool for farmers to meet production goals (Aiken, 2015). This is not only the case for commercial farms with confined boundaries for grazing, but also for communal grazing that is linked with animal migrations due to forage mass decline.

Reports of the relationship between output per animal (body weight gain or milk) and stocking rate have been varied, with some reporting curvilinear declines (Harlan, 1958; Mott 1960; McCartor and Rouquette, 1977) and others detecting linear decreases (Jones and Sandland, 1974; Riewe, 1961) as stocking rate increased. Jones and Sandland (1974) evaluated data combined across stocking rate experiments with various tropical and temperate pastures, and determined there was a linear relationship between body weight gain per calf and stocking rate, and a quadratic relationship between output per hectare and stocking rate (Fig. 2) . Similarly, Mott (1960) combined data from various stocking rate experiments, but fitted exponential models for relationships between both per animal output and output per hectare with stocking rate (Fig. 3).

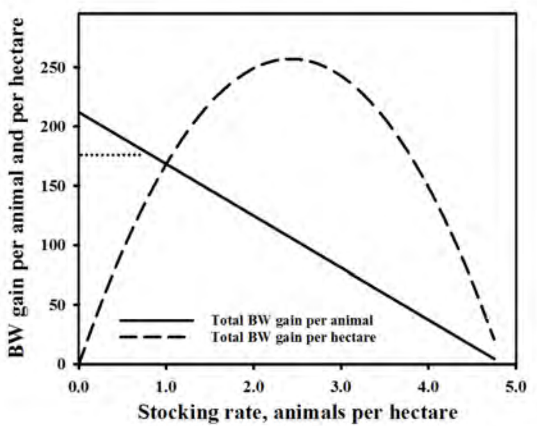


**Fig. 2.** Relationships of per animal and per hectare body weight (BW) gain with stocking rate (SR), as derived by Jones and Sandland (1974) using data from grazing experiments counducted with different environments and forage species (Source of graph: Aiken, 2015).

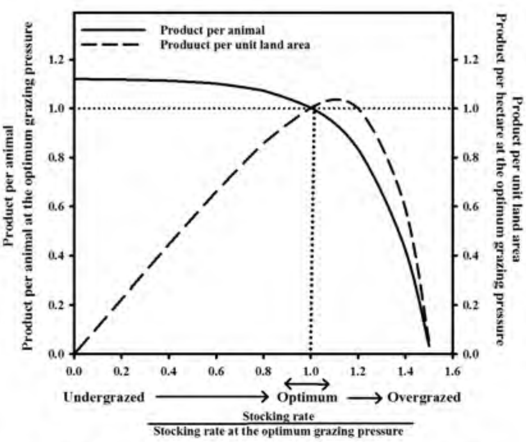


**Fig. 3.** Relationships of per animal and per hectare output with stocking rate (SR), as derived by Mott (1960) using data from grazing experiments conducted under different environments and forage species. Per animal and epr hectare outputs were adjusted to be relative to outputs for the optimum SR, and SR were adjusted to be relative to teh optimum (Source of graph: Aiken, 2015).

Assessments also differed between Mott (1960) and Jones and Sandland (1974) of which stocking rates should be designated as economically optimum. Curvilinear models were calculated by both for the output per hectare x stocking rate relationship, with output per hectare increasing at an exponential rate to a maximum output at a critical stocking rate, with further increases in stocking rate beyond the critical rate resulting in exponential decreases in output per hectare. Jones and Sandland (1974) considered the stocking rate that maximized output per hectare as the economically optimum stocking rate. Mott (1960) cautioned that stocking rates generating maximum output per hectare would be excessive and cause pastures to degrade over time; therefore, he surmised that stocking rates slightly less than the one for maximum output per ha would be more sustainable. It is plausible to use stocking rates to maximize output per hectare when utilizing annual forage species, but these stocking rates may not be sustainable for those perennial species that lack persistence over long-term grazing with these heavier grazing intensities.

A generalized model that accurately describes the relationship between animal outputs and stocking rate for all forages may not be possible because of variation across forages in sward canopy structure and responses to grazing intensity (Coleman *et al.*, 1989). The Mott model accounts for dynamics of dry matter intake and nutritive values as grazing intensity increases, which indicated that these variables do not change proportionately with grazing intensity. Grazing experiments that evaluated weight gain responses to stocking rate have often reported linear declines in average daily weight gain as stocking rate increases (Cowlishaw, 1969; Bransby, 1988; Aiken *et al.*, 2006). However, McCartor and Rouquette (1977) and Aiken (2015) warned that the statistical power of stocking rate experiments are often limiting in providing the precision necessary to accurately detect trends in animal output as stocking rate increases.

## Forage mass

Forage mass decreases beyond a critical stocking rate at which the rate of dry matter intake exceeds the rate of forage growth. It is the reductions in forage mass that affects animal performance. As forage mass increases, animal performance increases and stabilizes at a critical forage mass, beyond which diet selection and quality are maximum (Burns *et al.*, 1989; Sollenberger *et al.*, 2005). The critical forage mass for maximum animal performance is also dependent on forage digestibility (Duble *et al.*, 1971; Guerrero *et al.*, 1984); therefore, there is an inter-relationship between forage quantity and quality in effecting animal performance (Fig. 4). These relationships indicated that maximum output per animal is attained at

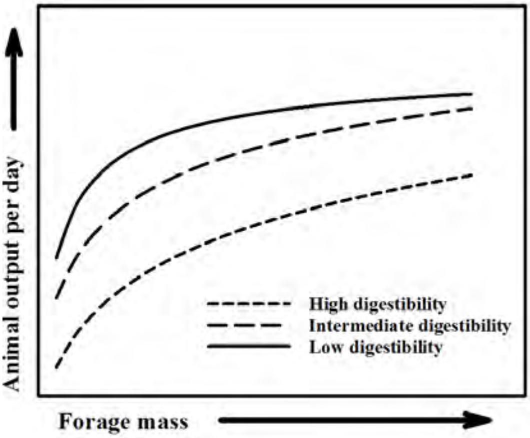


**Fig. 4.** Hypothetical relationships between animal output and forage mass forages with low, intermediate, or high digestibilities.

lower forage masses as digestibility increases.

## Pasture composition

It is this author's opinion that multiple grass and legume species in mixture offer the following advantages over monocultures: 1) provide variety to ruminant diets of different components that meet different animal requirements for protein, energy, minerals, etc., 2) provide variation in plant structures (e.g., leaf to stem ratio and leaf orientation) for improving stand competiveness with weed species, and 3) improve stand resilience to environmental stresses. However, selective grazing, treading, and deposition excreta combined with weather patterns can cause instability in complex botanical mixtures. This is certainly the case with clovers (*Trifolium* sp.) in mixture with grasses that lack persistence when subjected to defoliation in combination with environmental stress (Hoveland, 1989).

High rates of defoliation by grazing can alter the botanical composition of pastures. Heavy grazing pressures sometimes cause botanical shift to more desirable species (Harrington and Pratchett, 1974), but oftentimes they cause encroachment by noxious weeds (Roberts, 1980). Ortega-Santos (1990) reported that encroachment of monoculture perennial peanuts (*Arachis glabrata* Benth.) by bermudagrass [*Cynodon dactylon* L. Pers.] was increased with short grazing cycles (i.e., duration of grazing and rest), and Aiken *et al.* (1995) determined from a clipping experiment with monoculture bermuda grass that encroachment by crabgrass (*Digitaria sanguinalisn* L.) was increased with frequent harvests and taller clipping heights.

For mixtures of grasses and legumes, plant height and growth habit appear to be major factors in plants tolerating heavier grazing intensities. Taller grasses can suppress the lower growing legumes when grazed with light stocking rates (Stobbs, 1970). From a review of the literature, Curll and Jones (1989) surmised that tropical legumes with a trailing or twinning growth habit are less persistent with heavier grazing intensities, and those with a prostate or creeping growth habit are more persistent with heavier intensities. Besides growth characteristics, selective grazing of certain legumes can adversely affect their persistence. High-quality, annual legumes that are selectively grazed by cattle (Aiken *et al.*, 1991a) were recommended by Aiken *et al.* (1991b) for use as pioneer legumes in establishing slower establishing and more persistent perennial legumes.

## Options in grazing methods for targeting sustainable animal production

It has been a matter of considerable debate if the method of grazing pastures can affect per animal or per hectare outputs (Aiken, 2015), but it is likely that any benefits on animal output depend on stocking rate (Bransby, 1988). With heavier grazing intensities, rotational stocking systems designed to provide sufficient pasture rest and regrowth will probably benefit animal output compared to continuous stocking of pastures. Nonetheless, the purpose of grazing methods should be to improve the sustainability of a given stocking rate that is set to target per animal and per hectare outputs.

Grazing systems are developed to account for soil, animal, plant, and social and economic conditions in meeting specific production goals (Allen *et al.*, 2011). For the grazing management aspect of the system, method of grazing is key to minimizing risk of pasture degradation from botanical shifts from desirable forages to noxious weeds, and to maintain pasture condition for optimum recovery from adverse weather patterns and controlling nutrient runoff and leaching. Decisions on which grazing method to implement will be based on the desired stocking rate and the limitations placed on pasture carrying capacities by climate (i.e., arid versus wet), soil fertility, and vegetation (i.e., native versus non-native, improved forages). Grazing methods can be used to increase the number of livestock a pasture can support, but a grazing method must be suitable to the environment and designed to provide flexibility in adjusting to adverse weather patterns.

***Continuous stocking***: This is an extensive type of grazing with one herd or flock having continued access to a single pasture for the year or growing season, and not regarded as a system. Success using perennial species depends on using light to moderately light stocking rates, which can result in seasonal fluctuations in forage mass. Oftentimes used because of the low inputs of labor and capital investment that are required.

***Long-duration rotation systems:*** These are grazing methods that use a small number of paddocks (2 to 7 pasture subdivisions) within a pasture or grazing management area (i.e., the entire area used to support a herd for a year) that are grazed with light to moderate stocking densities (i.e., stocking rate for a given paddock). Grazing periods within paddocks range from 7 to 10 days and rest periods of 30 to 60 days. These systems are not used to maximize utilization, but rather to maintain residual herbage at the end of grazing periods to promote adequate regrowth. Often used in arid climates with native range or with improved pastures subjected to seasonal dry periods.

A 2 or 3 paddock system may be used when pastures are utilized for both grazing and hay production and herd rotations are generally not based on rigid criteria. For a 3 sub-paddock system, 1 paddock can be used in the early or entire growing season for hay production. A single herd can be rotated between the 2 other paddocks and, if needed, the cattle can be rotated to the hay pasture in the late season. The pastures can be stocked at slightly higher rates than with continuous stocking. A 2-paddock system can be used in a switchback type of stocking with similar durations of grazing and rest periods, but can result in seasonally excessive grazing intensities and inadequate regrowth if stocking densities are too high. These systems provide some flexibility in management over continuous stocking, but also is typically done because of lower input of resources.

Four to 7 paddock systems offer more flexibility than 2 or 3 paddock systems. Paddock are grazed for 7 to 10 days, with rotations being based on forage growth patterns. Active growth with adequate rainfall allows for rapid rotations to balance targeted grazing intensities (i.e., pasture canopy heights) and regrowth periods, and less frequent rotations during periods of reduced forage growth, such as during drier weather conditions. This will be accomplished by lowering the stocking density through reducing the number of animals or by expanding the paddock area by allowing 2 paddocks be grazed each time (convert from 4 to 2 paddock rotation or from a 6 to a 3 paddock rotation). Therefore, additional numbers of paddocks provides flexibility in responding to changes in growing conditions and facilitate moderate to moderately heavy stocking densities during periods of active forage growth.

Deferred systems are used primarily in rangelands. In the Merrill System, grazing of 4 pastures are deferred for one pasture for an entire growing season or year. The other pastures in the Merrill System are continuously stocked by separate herds at light stocking rates, but the pastures can also be rotationally stocked if forage growth is adequate to support higher stocking densities. Deferred grazing is alternated between pastures for each year or growing season. The system can also be used with improved pastures, with grazing being deferred in alternating pastures for renovation purposes (weed control or reseeding).

***Short-duration rotation systems:*** A minimum of 8 paddocks are used to provide high stocking densities and rotating cattle based on controlling grazing such that cattle graze only the upper leafy portions of the pasture canopy. Grazing periods are typically 1 to 5 days, depending on stocking density. Residual herbage should also be maintained high to promote root mass and forage regrowth (Gerrish, 2007). Ideally done by using moveable electrified fence to adjust paddock areas as weather patterns and growing conditions change, which allows considerable flexibility in managing pastures to withstand periods of dry weather.

A mob stocking system can be used to maximize utilization. Very high stocking densities can be used for grazing periods of less than 2 days. Animals are forced to graze weedy species which, if done during peak growth periods for the desirable forages, can cause positive botanical shifts. The high stocking densities are also thought to minimize the aversion from dung deposits and encourage rapid accumulation of soil organic matter, but this premise has not be verified or supported by research. Mob stocking could be useful as a management tool, but its successful use will likely depend on climate and soils. Risk could be great for pasture degradation to occur with long-term use of this stocking method.

## Conclusions

Stocking rate is the single most important factor in meeting grazing livestock production goals; however, the types of forages and environmental conditions will place limits on the sustainability of a stocking rate. It is through use of a well-designed grazing system that aggressive production goals can be met, particularly as environmental conditions become more challenging. Rotational stocking systems should be used to manage the land resource, and the use of long- versus short-duration rotation systems will depend on the desired stocking rate and the ability of a given system to provide a balance between grazing intensity and forage regrowth. Also, rotational stocking systems must be flexible in allowing adjustments in rotation cycles with changes in weather patterns.

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