The Comparative Effects of Short Duration, High Density and Conventional, Rotational Grazing on Different Soil, Vegetation and Animal Parameters in Dry and Mesic Grasslands of South Africa

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Abstract

Short duration, high density grazing is a grazing management strategy that incorporates the rotation of large livestock herds, often at double or triple the normal prescribed stocking densities of the specific area. It is claimed that this type of grazing management can improve rangeland health by improving soil and vegetation condition, and subsequently influencing animal performance. Regardless of the scarcity of scientific evidence validating these claims, the change from conventional rotational grazing systems to short duration, high density grazing systems is on the increase in South Africa. This study aims to assess these claims, through the quantification of various rangeland vegetation and soil health, and livestock performance parameters under both conventional rotational and short duration, high density grazing systems. The study will be conducted through fence line contrast studies, whereby neighbouring farms, one practising short duration, high density grazing and the other conventional, rotational grazing, will be assessed. Soil parameters to be investigated will include soil physical (compaction) and chemical (pH, carbon, nitrogen, exchangeable cations) characteristics, whereas vegetation characteristics will include species composition, production, vigour and quality. In addition, animal performance will be measured as body condition and calving rate. This project has the potential to provide objective, scientifically based information regarding some of the controversies revolving around short duration, high density grazing, as well as contribute to the sustainability and economic viability of livestock production in Southern Africa.

Introduction

Grasslands, soils and grazing animals have co-evolved for millions of years. Therefore, it is not surprising that the inter-relationships that exist between these factors are greatly influenced by the manipulation of man through various grazing management strategies. These strategies have two common principal objectives, which are to optimize livestock/wildlife production, and subsequently to restore or maintain healthy rangelands, all whilst enhancing resilience to climate change.

In South Africa, several grazing management strategies exist, namely continuous grazing (i.e. season-long grazing, whereby animals are allowed to graze selectively with minimal disturbance for a year/entire season), deferred-rotation grazing (incorporates periodic deferment, an allocated period whereby there is an absence of grazing during the growing season to all plants to reach reproductive maturity and to set seed), and rotational grazing (a more adaptive management approach compared to continuous and deferred systems that incorporates the rotation of livestock between multiple paddocks).

In South Africa, multi-camp rotational systems are used based on utilization patterns. These systems include the non-selective grazing approach (short grazing periods < 14 days, proceeded by a rest period of a minimum six weeks or longer, and stocking densities adjusted to avoid selective grazing); controlled selective grazing (short grazing periods < 14 days, coupled with short rest periods (<six weeks), with animals being moved when plants are defoliated to a maximum 60% to avoid physiological plant damage and decreased vigor); and short duration grazing.

Short duration grazing, also used interchangeably as rapid rotation, time controlled, high density, ultra-high density, Savory grazing, holistic grazing and holistic resource management, was first introduced by Allan Savory in the 1960's. However, Savory emphasized that holistic grazing management is not short duration grazing, and should not be considered as such. Instead, it is a goal driven management practice that, through its adaptive nature, cannot be quantified or validated experimentally due to its flexibility in animal numbers, length pf grazing periods, number and arrangement of paddocks, and other managerial factors (Holechek, 1999).

However, still today, it is considered as short duration grazing, and will be referred to as such from here onwards. Short duration grazing features a one herd of livestock rotated between eight or more camps. Periods of occupation is short, usually lasting between 1-3 days, followed by a long rest period. Stocking densities are usually double or triple the area norm.

Short duration grazing in relation to soils

In grasslands, soil health is determined by the ability of soil to provide structural support to vegetation, sustain biological diversity and productivity, store water and regulate water movement (infiltration), and cycle nutrients (Mausbach, 1996). It can be measured by the physical and chemical properties of the soil (Doran, 1994). Soil physical properties is commonly measured by soil bulk density. Soils with lower bulk densities have a greater soil structure, and tend to have a greater water holding capacity and higher infiltration rates. Short duration grazing, if implemented correctly, claims to have soils of this nature. However, several studies regarding short duration grazing and the effects thereof have shown that short duration grazing and the hoof action of large number of animals reduces, rather than increases soil water infiltration (McCalla *et al.,* 1984; Thurow *et al.,* 1986; Weltz and Wood, 1986; Warren *et al.,* 1986; Pluhar *et al.,* 1987). Due to this reduction in soil water infiltration, soil erosion tends to increase due to compacted soils, and, in turn, result in increased soil bulk density and reduced fungus biomass (Dormaar *et al.,* 1989).

Nutrient availability and cycling are considered as chemical indicators of soil health (Larson and Pierce, 1991). Nutrient availability is measured as the Cation Exchange Capacity (CEC), otherwise known as the total capacity of soils to hold exchangeable cations, whereas nutrient cycling is measured by soil organic matter. In grassland ecosystems, carbon and nitrogen are the two most important components of soil organic matter, each producing vital pools in soils. In healthy soils, higher concentrations of soil C and N are present, resulting in more efficient cycling of nutrients (i.e., faster decomposition rates of organic matter made available for uptake by plants) (Brady and Weil, 2008). This is claimed to be characteristic of short duration grazing (Savory and Parsons, 1980; Savory, 1983; Savory, 1988). Literature seems to sway towards this claim. According to Manley *et al.,* (1995), grazed land had higher levels of carbon and nitrogen in the topsoil compared to non-grazed areas. Sanjari *et al.,* (2008) found that although short duration grazing showed significantly higher litter accumulation, a significant increase in soil organic carbon and nitrogen was not found. According to Teague *et al.,* (2011), higher content of soil organic matter was observed on lands subjected to short duration grazing compared to those grazed continuously. Higher content of magnesium, calcium sodium and cation exchange capacity were, too, found in soils subjected to short duration grazing.

Short duration grazing in relation to herbaceous vegetation

Primary production refers to the total new vegetation production in a single growing season (Allen *et al.,* 2011), and is determined by the genetic potential of present plant species, availability of essential nutrients and water to plants, as well as the health and condition of the rangeland (Redden, 2014). It is important to grazing animals, as the amount of available forage is directly related to the number of animals the area can sustain. Increased herbage production is one of the most common claims of short duration grazing. However, research conducted on these claims have rendered varied results, with production remaining constant (Pitts and Bryant, 1987; Anderson, 1988; Thurow *et al.,* 1988; Earl and Jones, 1996), increasing (Cassells *et al.,* 1995) and decreased (Demer eta l., 1994) when compared to other grazing systems.

The selectivity of grazing animals can be an important factor in determining the species composition and the stability of the ecosystem in terms of plant succession. It is generally accepted that as stocking density increases, the frequency at which plants are defoliated increases as well (Matches, 1992). This increased frequency of defoliation lowers forage availability, resulting in possible changes in sward morphology and composition (Matches, 1992). Short duration grazing, however, claims to accelerate plant succession, resulting in a climax dominated plant composition. As with the other mentioned claims, varied results exist in literature (Holechek et al.,2000; Teague *et al.,* 2011).

The aim of the study is to test the general claims of the benefits of short duration, high density grazing by investigating its impact on soil, vegetation and animal performance parameters. This will be done by investigating the following objectives: 1. The impact of short duration, high density grazing and conventional rotational grazing on rangeland health in terms of plant composition, plant production, plant litter, forage quality and rangeland condition, and 2. The influence of short duration and conventional rotational grazing on soil health in terms of soil exchangeable cations, soil organic matter, soil moisture and soil pH.

Materials and methods

Study area

The study will be conducted using a fence line contrast approach on eleven short duration, high density farms and neighbouring conventional rotational farms (rendering a total of 22 study sites). All sampling will be conducted during the wet and dry season for three consecutive years on all identified sites. Five survey zones will be identified for each site, and within each, three sampling plots will be used as replications for vegetation and soil sampling.

Surveys of herbaceous layer

Species composition

The species composition of the herbaceous layer of each site will be determined using a point method, according to the nearest plant method (Everson & Clark 1987; Smit & Rethman, 2000). A 300 m line transect will be used for each plot per site, with plants/nearest plant at each 1 m mark being being recorded.

Veld condition assessment

For each plot per site, a veld condition assessment will be done using the Ecological Index Method (Vorster, 1982; Heard *et al.,* 1986). The method is essential to determine the current condition of the site, and serves as a reference for seasonal sampling and to determine the difference in veld condition under the two different grazing management practices.

Dry matter production

The harvest method (Grunow *et al.,* 1980; Catchpole & Wheeler 1992) will be used to determine the above ground dry matter production of each site. A 0.5 x 0.5 m (0.25 m2) quadrat will be placed at every 10 m point on the 300 m line transect (see species composition) at each plot. All rooted herbaceous plants will be harvested to stubble height using hand clippers, separated by species, and placed in separate paper bags. All harvested material will be dried at 70ºC to a constant mass, weighed and expressed kg/dry matter per hectare. Harvesting at species level will express the contribution of all species to total dry matter production.

Determination of soluble sugars

Soluble sugars will be determined in the field using a handheld Brix refractometer. Five samples of each representative grass species in each site will be measured during the growing season. Few drops of the leaves and stems will be squeezed onto the glass prism of the refractometer and sugar content will be measured by reading the numbered scale in Brix units, which is equivalent to percentage. These results will only be used for comparison between the two grazing systems, and not for exact figures.

Determination of crude protein (CP) and neutral detergent fibre (NDF)

Plant samples will be collected by harvesting five 0.25 m^2 quadrats per line transect per plot. Harvested material will be oven dried at 70ºC till a constant mass and milled to pass through a 1 mm sieve. Milled samples will be sent to the Department of Animal, Wildlife and Grassland Sciences (University of the Free State) laboratory for analysis. The NDF analyses will be conducted using an ANKOM Fibre Analyzer. Crude protein and nitrogen analysis will be conducted using a LECO FP-528 N analyser.

Soil sampling

Determination of soil nutrient status, moisture, bulk density and infiltration

Determination of soil nutrient status

The determination of soil pH, soil organic carbon, nitrogen, available phosphorous and exchangeable cations (Ca, Mg, K, Na) will be done for each plot per site. Six topsoil samples will be collected per line transect (see species composition) per plot (one sample at every 50 m point). Samples will be collected at the following depth ranges: 0-5 cm, 5 – 10 cm and 10 – 20 cm using a soil auger. The samples will be bulked and mixed for each depth range, and subsamples will be derived from the bulked mass for laboratory analysis.

Laboratory analysis of soil samples will be conducted at the Soil Science Department laboratory at the University of the Free State. All analyses will be conducted following the standards of the Non-Affiliated Soil Analysis Work Committee (1990). Before analyses, soil samples will be oven dried and funnelled through a 2 mm sieve to remove all debris and larger soil particles.

Soil pH will be determined using the glass electrode method, which involves the mixing of a 1:1 or 1:5 ratio of sieved soil and deionized water. pH glass electrodes are inserted into the soil slurry, and pH is obtained from the displayed pH on the calibrated pH meter.

Total carbon and nitrogen will be determined using the dry oxidation method in a LECO FP 528 analyser. The method entails dry combustion at controlled heating rates and temperatures to release CO_2 and N to determine carbon and nitrogen respectively.

Available phosphorous will be extracted and concentrations determined using the Olsen method and Colorimeter meter respectively. The method involves the mixture of soil samples and chemical reagents until colour development, and absorbencies measured at 850 nm thereafter.

Exchangeable cations will be determined using the 1 M ammonium acetate method using a mechanical vacuum extractor. Extracts will be analysed by atomic absorption spectroscopy. This method allows all exchangeable cations (Ca, Mg, K and Na) to be determined simultaneously.

Determination of soil moisture, bulk density and infiltration

A neutron moisture meter will be used to determine the soil water content. A probe will be lowered into the soil via 10 access tubes on each side to the depth of 1 m. The soil water content will be recorded as displayed on the gauge at six different depths, each representing a different soil layer. These depths are 75 mm (0 -150 mm), 225 mm (151 – 300 mm), 375 mm (301 – 450 mm), 325 mm (451 - 600 mm), 675 mm (601 – 750 mm), 825 mm (751 – 900 mm).

Bulk density of each site will be determined using a penetrometer, with the pressure gauge mounted at the top of a pointed rod, being pushed into the soil until a gauge reading of 300 psi is obtained. The depth of compaction is derived after the penetrometer is removed, and the depth at which 300 psi is measured. Three penetrometer readings will be conducted per 300 m line transect (see species composition), at every 100 m mark.

Soil water infiltration will be determined by means of the falling head test using the double ring infiltrometer (Gregory *et al.,* 2005). The method involves the infiltrometer being placed on the soil surface and water being placed in the outer and inner ring. The time in which water takes to decrease in the inner ring will be measured.

Discussions

It is evident that broad generalizations of the benefits of short duration, high intensity grazing are based on insufficient scientific evidence to support these claims. In addition, these generalizations are often based on the effects of short duration, high intensity grazing over short periods of time. In addition, no clear definitions exist for the terminology used (terms currently used in practice include high pressure grazing, non-selective grazing, ultra-high pressure grazing and ultra-high pressure strip grazing), and studies attempting to compare different methods of the practical application of short duration, high density grazing are few. This complicates the assessment of different studies, as well as complicating the comparison of new studies with existing literature. The management skills also differ between farm managers and this human factor also contributes to the large variability between the successes of different grazing systems. The rainfall in the grassland biome also ranges from below 400 mm to approximately 700 mm, which has a impact on the resilience and reaction of the vegetation to different defoliation methods This complicates the development of scientifically sound and comparable methodologies.

Secondly, broad generalizations and claims in favor of short duration, high intensity grazing is not currently supported by sufficient scientific evidence. Most claims are merely speculation without clear scientific evidence that support the assumed benefits of short duration grazing. The results from the few existing scientific studies do not provide a clear understanding of the complex animal-plant interaction related to short duration grazing. In addition, the results of these studies often differ widely, with positive findings not prevailing over insignificant or negative findings. Therefore, the claim that short duration grazing is superior to traditional rotational practices should be investigated in more detail, and also in different climatic regions to account for differences in the complex animal-plants interactions under different rainfall, vegetation and soil regimes.