Grazing Management to Restore Soil Health, Ecosystem Functions and Ecosystem Services

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Abstract: Ruminants, including livestock, have been blamed for causing damage to the environment and human welfare. However, if properly managed, ruminants can play a significant role in efforts to reverse the environmental damage caused by human mishandling and neglect. Worldwide, at least one billion people who live in rangeland ecosystems depend on them for their livelihoods, typically through livestock and other ecosystem services that affect human well-being. To ensure the long-term sustainability of rangelands and environmental sustainability on a global scale, agricultural production strategies are urgently needed to transform current harmful non-inorganic industrial farming practices into resource conservation practices that improve ecosystem functioning.

1 INTRODUCTION

In order for people to live sustainably, land must be used to enhance its self-healing potential and provide essential ecosystem services such as stable and productive soils, air quality, clean water, and biological integrity. However, in most pasture lands of the world, continuous or relatively uncontrolled grazing exceeds the capacity, which is often aggravated by additional feeding, has led to degradation of vegetation and soils, reduced productivity and biodiversity, as well as reduced ecosystem sustainability. Pasture managers and scientists have tried various forms of pasture management to ensure sustainability or restoration, but the results have been mixed. The most promising (and controversial about its effectiveness) is an approach combining integrated or systemic thinking with creative, adaptive management to manage the distribution of grazing over time, across landscapes and plant communities, using planned movement of livestock through a number of pens: strategic or adaptive grazing management with multiple pens (AMP) (Glazyev,2021).

The results of single-subject, small-scale, short-term component scientific studies are useful for mechanistic understanding, but problematic for complex adaptive systems such as agroecosystems, since they often overlook the interactions between different elements and do not seek to identify the unintended consequences of the options they promote, and therefore have limited applicability to managed landscapes. such as pasture lands. To bridge the gap between single-subject, component-based research and adaptive methods for effective resource management, research should have a realistic, appropriate scale and context; thus, it would be useful for scientists to collaborate with financially successful, environmentally-conscious farm managers to conduct research. Skepticism and curiosity are necessary in order to push the boundaries of knowledge, sometimes questioning the apparent consensus until a higher synthesis is achieved. The scientific method requires constant search for deviations from existing hypotheses and constant verification of consistency between field research, modeling and practical experience. In this article, we present what has been published about the advantages and disadvantages of grazing cattle in multiple pens, how it is necessary to manage grazing cattle in multiple pens to achieve the best results, and hypothesize which studies will better understand how managing grazing cattle in multiple pens can improve the provision of ecosystem services and socio-ecological sustainability of pasture ecosystems, while avoiding unintended consequences. We rely on the previous article, which comprehensively examined the dichotomy between the results of the study of rotational grazing and the contradictory results

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obtained by farmers using AMP grazing. Our current paper builds on the points discussed in this previous review and includes AMP grazing results that have been published subsequently (Gorodnitsky, 2019).

2 MATERIALS AND METHODS

Although simple forms of grazing management (for example, postponement of grazing, rotational rest and rotational grazing) have been recommended for more than a hundred years as an important tool for maintaining pasture productivity and improving animal management, they are often applied rigidly, rather than adaptively, and with mixed results.

Most, but not all, studies of cattle grazing in the scientific literature have concluded that rotational grazing is no better than light continuous (seasonal) grazing, which sharply contrasts with the experience of many AMP practitioners. This criticism of grazing in multiple paddocks is based on a subgroup of grazing management studies, which have generally been developed and conducted in a reductionist manner, rather than on methods that were probably applied by representatives of successful grazing farms, and therefore do not reflect successes. Made with AMP on commercial ranches. The plan and organization of experiments, which are often not taken into account, show a great influence on the results obtained (Yulkin, 2019).

Desired results are achieved by achieving specific goals. Most of the rotary pasture treatments in the experiments were not carried out in accordance with management protocols, which, as it was shown, give the desired results and underestimate the potential of multi-pasture grazing to improve the functioning of the ecosystem. In particular, the studies were of a short-term nature and did not take into account the critical factor of scale. The pens were grazed for too long, and the plants were not given enough time to recover from grazing. As conditions changed, research management did not adapt to the changes, but used fixed and predefined protocols. Due to the lack of adaptation to constantly changing conditions, it was not possible to achieve good livestock and improve the use of resources (Bashmakov, 2021). The researchers also focused on differences in productivity without taking into account the negative impact on key elements of ecosystem functioning or the long-term accumulation of negative effects from continuous grazing.

It is becoming increasingly clear that the key to sustainable use and recovery after degradation is short-term grazing, moderate grazing during the growing season, leaving sufficient shelter for children, followed by adequate and planned recovery, which is facilitated by effective grazing management protocols in various pens. adjustment of livestock by feed biomass. The livestock factor has a great influence on the productivity of plants, species composition and productivity of animals; Therefore, it has been thoroughly researched and is considered by most scientists as a key management factor necessary to maintain long-term profits while maintaining the functioning of the ecosystem (Glazyev, 2018). However, an adequate diet by itself does not prevent the degradation of pastures, since cattle in large paddocks constantly use preferred plants and places.

This multiple preferred consumption of preferred plants and plots leads to an uneven effect, so that even at low livestock levels, local undesirable changes occur in plants and soils, while these plots are maintained and expanded, and the landscape gradually degrades. Well-planned grazing can mitigate these negative effects of grazing and improve the species composition and functioning of the ecosystem. Many farmers around the world have used AMP pasture management to restore ecosystem services and productivity on degraded pastures in areas with annual rainfall of less than 250-1500 mm.

Many of these farms in more arid areas were initially so devoid of vegetation that they could be classified as diversified. It has been shown that more effective management reverses the mechanisms causing degradation, reduces the amount of desert land, increases the rate of water infiltration, increases the carbon content in the soil, increases soil fertilization, increases soil biodiversity and ecosystem communities, and restores the dominance of the most productive plant species (Nikoláeva, 2018). All these functions are closely related to changes in the composition of soil microbial and biological communities, carbon and nitrogen cycles. In addition to soil microbes, key organisms such as beetles and earthworms have a strong impact on ecological function, and farm management can be adjusted to optimize the benefits they bring.

Farmers using AMP to graze livestock on their pastures have received numerous awards for nature conservation. These farmers work in vast, heterogeneous landscapes where they face the adverse effects of uneven pasture distribution and use their collective environmental and management knowledge to achieve excellent results by practicing adaptive pasture management with multiple paddocks (Porfiriev, 2010). Farmers using MPas with short grazing periods, long recovery periods and adaptively

varying recovery periods and other controls as conditions change. Many pasture conservationists (agency staff and consultants) are in constant contact with farmers, both at the top and at the bottom, and appreciate the positive resources and economic value of well-managed pasture management (Nikoláeva, 2018).

3 RESULTS AND DISCUSSION

For Better governance relies on good science conducted on an appropriate and large scale. Research in all areas of agriculture, including pasture lands and forage ecosystems, must have an ecosystem perspective and a complex system structure that includes adaptability and creativity, and it is this excellent synthesis that resolves the long-standing debate on AMP and rotational grazing. In field studies, it is impossible to control all variables, especially when studying processes rather than events, and this contradicts realistic scales and context (Ministry of Environment, 2017.. Monodisciplinarity studies on small plots and pots do not include the complexity and interactions that occur in managed landscapes, but they are functional elements that need to be understood and studied, as they determine the response to different management at the scale in which the territory is located.

We need to understand more deeply how we can change the management of grazing systems in order to take advantage of the positive ecosystem services provided by soil biota, insects, birds and mammals that affect the functioning of the soil, and minimize management practices that lead to negative consequences. Most of the studies of grasslands were carried out on terrestrial biota, but since soil biota is responsible for more than 90% of the functioning of the soil vegetation system and ecosystem, it is necessary to rely on a broad scientific base that allowed us to understand the functions of soil organisms. Soil biology and biodiversity determine the basic functions of ecosystems that must function well to provide basic services, so research on pasture ecosystems should include key biological factors and test hypotheses about causal mechanisms (Barnes, 2011; Carroll, 2016). These include the accumulation of organic matter in the soil, the capture of solar energy, the infiltration and retention of water, the nutrient cycle and the maintenance of the necessary biodiversity of ecosystems that provide these services (Chiang, 2010; Herrero, 2013).

Based on the published research results we have reviewed, our published studies and intelligence samples in many pastoral settings, we have concluded that only research at the scale of commercial ranches and on properly managed ranches can combine the effects of scale, quality management and adaptation. management protocols to achieve the desired results. We recommend including the following elements in the study of biological components of grazing management:

- increasing heterogeneity of livestock exposure with increasing scale
- sufficient time for treatments affecting biology and soil carbon, from 5 years in areas with high annual precipitation and a long growing season to 15 years in areas with less than 900 mm of precipitation and a shorter growing season
- adaptive management to achieve the best possible results
- parameters related to ecosystem functions as well as production
- several trophic levels and disciplines: soil, fungi, bacteria, plants, insects, wildlife, spatial hydrology and socio-economic
- sufficient soil depth and spatial sampling
- Detailed assessments of the CO2 and 13CO2 fluxes in the static GHG chamber in the context of each treatment to determine the current carbon sequestration; this should be done in the context of the control under study and only after this treatment has been carried out long enough to bring it into line with this particular control.
- Regular life cycle analysis and cost calculation to calculate the total cost of grazing methods on farms and inputs such as fertilizers, pesticides and pharmaceuticals to society.
- practice-tested modeling to provide mathematical hypotheses to support our scientific understanding and to assess which combinations of management decisions provide the best results in different locations and contexts (Lugato, 2014; Martin, 2014).

4 CONCLUSIONS

Grazing in multiple pens provides measurable and significant advantages over continuous grazing if it is well planned and adaptively managed. However, it's about complexity and creativity, not the handles themselves: more handles make adaptive control easier. This is the key to conserving resources and restoring pasture ecosystem services to increase farmers' incomes. Encouraging easy continuous

grazing in the hope that this will minimize the negative consequences, at best, will only support or slightly improve the degraded state of pasture resources, limiting the ability of farmers to earn decent, sustainable livelihoods. Why do so many studies seem to challenge logic and experience? When evaluating the results of the study, it is necessary to take into account how the implementation affected the results obtained and whether it is possible to generalize the results beyond the scope of the study.

In almost all "classical" pastoral studies, there are two main problems, both of which are the choice between simplicity and complexity, control and reproduction in a realistic context. Most grazing studies, for reasons of scientific rigor, have considered widely used treatment methods that exclude adaptive management, and together they show that all forms of grazing management ("systems") without purposeful, creative and adaptive management, they are limited in their effectiveness. The vast majority of these studies have also been conducted on too small a scale to account for the diversity and unevenness of grazing (the process by which degradation occurs), which together show that small paddocks tend to graze more evenly.

This type of study is a larger landscape, but divided into many small paddocks, which provides the inherent advantage of MP (reduced paddock size) even with continuous grazing. Thus, the problem is not that the studies were poorly conducted, but that their design excluded a realistic context, and the result (usually without visible differences between treatment methods) cannot be extrapolated to a large and complex landscape. In contrast, a relatively small number of studies that have a realistic context of scale and complexity combined with well-designed adaptive treatment have demonstrated numerous benefits of grazing.

The approach to agricultural production should be based on regenerative management protocols to ensure the long-term economic and environmental sustainability of agroecosystems. Environmentally sound management of pasture ecosystems can make a positive contribution to basic ecosystem services, in contrast to the disadvantages of many existing agricultural production systems. The philosophy of restoration can be adopted by learning how to restore the provision of ecosystem services in commercial-scale landscapes. Many farmers using grazing principles have improved ecosystem functions, productivity, carbon and soil fertility, water retention capacity and profitability. Their method consists in using several pens per herd with short grazing periods, adequate recovery periods and adaptively changing recovery periods, residual biomass, animal numbers and other controls as growing conditions change.

On the contrary, many grazing management studies did not take into account spatial effects, did not follow adaptive research protocols, provided adequate recovery periods after grazing, provided a sufficient number of years to assess resource improvement after grazing, and ensured sustainable livestock production to increase net profit. economic returns with constant changes in grazing conditions. An ecosystem perspective and system structure can be achieved by combining studies of small-scale components within whole agricultural and landscape systems. Many disciplines should focus on determining how different management strategies affect the causal mechanisms governing biological functions on a local and landscape scale.

It will be important to supplement these studies with modeling experiments in order to provide a solid theoretical basis that can be applied not only in research centers. Simulation models can not only address these complex and interrelated issues at the farm level, but can also be expanded to include the assessment of production, resources and the economic consequences of adopting various management strategies.

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