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Diverse Adaptive Landscape-Livestock Interaction approach to beneficial grazing management in Canadian prairie rangeland production systems

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Abstract

Rangelands can serve as nature-based solutions to climate and biodiversity crises by sequestering and storing carbon and providing habitat for multiple species. Since rangeland systems are complex, inherently variable, and are facing high rates of change, prescriptive or standardized management practices cannot reliably produce desired benefits. Since 2014, the South of the Divide Conservation Action Program Inc. (SODCAP) has collaborated with rangeland managers in Saskatchewan, Canada, employing a participatory, outcome-based approach to enhance ecosystem health and wildlife benefits in a livestock production context. SODCAP's ongoing Living Lab - Central Prairies (LL-CP) project engages agricultural land managers, researchers, and other stakeholders, using a producer centric approach, to identify characteristics of grazing management systems that can reliably produce needed benefits, including carbon storage and biodiversity. Work to date indicates that a Diverse Adaptive Landscape-Livestock Interaction (DALLI) approach to grazing management is used by local ranchers to ensure that desired benefits are produced over time. DALLI managers dynamically adjust grazing strategies and tools across spatial and temporal scales to distribute livestock impacts throughout landscapes, leveraging techniques like animal herding, strategic water and mineral placement, flexible fencing, and incorporation of diverse perennial and annual land use types within grazing systems. Management responds to and promotes ecosystem heterogeneity, producing a shifting mosaic of impacts, which supports system resilience and biodiversity. Interviews with ranchers who use this approach underscore how diverse factors, such as climate conditions, economic viability, and community well-being, shape management decisions and outcomes. LL-CP's ongoing data collection on soil carbon, greenhouse gas emissions, plant biomass, diversity, nutrient quality, and socioeconomic factors will help to quantify the benefits of DALLI grazing management. This work will help validate the potential of diverse, adaptive grazing strategies to promote sustainable rangeland management amidst dynamic environmental challenges.

Introduction

Rangelands can serve as nature-based solutions – helping curb both the climate and biodiversity crises – but are threatened by conversion, degradation, and climate change (UNCCD 2024). Commonly recommended management practices do not perform reliably in all contexts (Buma et al. 2024) and can negatively affect other important values, like species diversity (Grenke et al. 2020). To better ensure that rangelands provide needed benefits over the long term, solutions must reflect the inherent complexity of rangeland systems

(Walker 2020) and should be defined in collaboration with knowledgeable local rangeland managers (Teague and Kreuter 2020).

Rangelands are complex social-ecological systems, with unpredictable outcomes due to interactions and interdependence of their parts. Grazers interact with variable topography, soils, plants, and other ecosystem features, creating heterogeneity, which in turn influences other ecosystem processes (Fuhlendorf et al. 2017). Managers weigh diverse priorities and select different management approaches depending on their motivations and practical considerations. Conventional rangeland management has sought to reduce this complexity, prescribing practices that discourage or prevent selective grazing, to make ecosystems more efficient and predictable. This approach assumes that livestock production is the primary goal, and that uniform use of homogenized landscapes will maximize livestock production. However, the anticipated benefits do not always materialize (Briske et al. 2008), possibly because heterogeneity is important for the functioning of rangeland ecosystems (Adler et al. 2001).

Beneficial grazing management encompasses more than just production and should support healthy ecological functioning and long-term resilience of rangeland systems. To achieve this, management must be robust to extreme and highly variable climates, including excess moisture and drought; must address enduring impacts of historical land management; and must be capable of adapting to relevant environmental, economic and social changes, all while ensuring the production of multiple benefits. Operations should be financially viable, but short-term economic gains should not hurt long-term sustainability or involve trade-offs with crucial benefits such as biodiversity or carbon storage. Given that there are still many unknowns about the dynamics of rangeland systems, and increasing uncertainty about how these systems will function in the future, there is no one-size-fits-all definition of beneficial grazing management. Certainly, adaptive management is key. Briske (2017) further suggests that collaborative learning and collective action by diverse stakeholders is required to produce knowledge, increase adaptive capacity, and maintain resilience. Similarly, Teague and Kreuter (2020) advocate for researchers working directly with innovative rangeland managers to better understand, quantify and communicate how they secure beneficial outcomes.

In Canada, where most prairie ecosystems have been converted to annual cropland, rangelands are crucial reservoirs of diverse cultural, social and ecological benefits. Some prairie rangeland managers and institutions have been especially proactive in ensuring these benefits are produced, and that managers are recognized for their efforts. At the same time, policy makers are seeking input on what constitutes beneficial grazing management in various regions across Canada (Government of Canada 2024). This paper, utilizing the existing network of managers and researchers aims to describe a management approach.

Methods

The South of the Divide Conservation Action Program Inc. collaborates with rangeland managers in Canada's Prairie Ecozone, employing a participatory, outcome-based approach to enhance ecosystem health. Since 2014, we have formed dozens of land management agreements aimed at improving outcomes for wildlife, soils and vegetation within a livestock production context. Most agreements define target outcomes that managers aim to achieve, but do not prescribe methods by which to achieve them. In 2022, we engaged producers and other collaborators in a living lab project (McPhee et al. 2021), in which diverse participants work together to identify innovative pathways for creating agri-environmental benefits in working prairie agricultural landscapes. Living Lab – Central Prairies (LL-CP) has undertaken five formal co-development sessions focused on grazing management to date, with 39 producers engaging with researchers and other stakeholders through to facilitated sessions and iterative group discussions. Participants share and discuss observations and preliminary results concerning soil carbon, biodiversity, economics and more, and how these outcomes are affected by management. LL-CP researchers have also conducted semi-structured interviews with core participating producers (n=22) to better understand the practices managers undertake and why. These producers can all be considered rangeland managers.

The rangeland managers contributing to results operate diverse operation types – including ranches, farms, and community pastures – using management units that range from a few hundred hectares to 1000 hectares in size. Their operations are distributed across the three main soil zones of southern Saskatchewan (black, dark brown and brown chernozemic soils). This also represents a moisture gradient from mesic (black) to xeric (brown).

Observations

To address complex intertwined goals and desired outcomes, managers are utilizing a newly defined Diverse Adaptive Landscape-Livestock Interaction (DALLI) approach to grazing management. The approach is so named because managers dynamically adjust grazing strategies and tools across spatial and temporal scales to distribute livestock impacts throughout landscapes, taking advantage of animal behaviours interacting with natural variability to create heterogeneity. Managers monitor and respond to heterogeneous impacts in real time, leveraging diverse tools and techniques like animal herding, strategic water and mineral placement, flexible fencing, and incorporation of diverse perennial and annual land use types within their grazing systems,

Table 1: Comparison of characteristics of conventional grazing management approaches for the Northern Great Plains (NGP) region, Adaptive Multi-Paddock (AMP) and Diverse Adaptive Landscape-Livestock Interaction (DALLI).

Grazing management characteristics	Conventional approaches for NGP region	Adaptive Multi-Paddock (AMP)	Diverse Adaptive Landscape-Livestock Interaction (DALLI)
Paradigm	Homogeneity/ efficiency-based	Homogeneity/ efficiency-based	Heterogeneity/ system-based
Primary goal	Production without degradation of forage resources	Production with enhancement of soil health	Optimization of multiple social-ecological values
Mode of success	Prescribed practices	Prescribed practices	Defined outcomes
Rest periods	Incidental; in avoided areas	Prioritized; planned, post-disturbance (for recovery of desired species)	Prioritized, planned and *ad hoc*; pre- and post-disturbance (for stockpiling and plant community recovery)
Grazing periods	Long; planned based on expected forage supply	Short; planned based on expected forage supply, with some flexibility in response to actual supply	Variable; planned based on expected forage supply, with high flexibility in response to actual supply
Stocking rate	Low-Moderate	Moderate-High	Variable
Stock density	Low	High	Variable
Season of use and rest	Fixed	Fixed-Variable	Variable
Pattern of grazing impacts	Pasture-scale; fixed gradients of use, persisting and being reinforced over time	Operation-scale; uniform impacts, being reached sequentially, paddock by paddock	Patch- to landscape-scale; variable, shifting in space and time

Within the DALLI approach to grazing management, livestock interact with landscape features to create a shifting mosaic of disturbance that responds to, interacts with, and modifies preexisting variability in soil, water, vegetation, and other biotic and abiotic site characteristics, at multiple spatial and temporal scales. Managers desire to maintain actively growing and residual plant cover within an acceptable range of variability (which varies with site and vegetation characteristics) and to avoid livestock use of grazed patches and plant communities until adequate recovery has occurred. To ensure these outcomes are met, they carefully observe

actual conditions, and adjust specific actions as required. A key element is rest, especially of native pastures, as a stockpile for future use and as a means of "drought proofing".

Iterative monitoring and adaptive management are utilized to meet desired management outcomes. Managers' attentiveness and flexibility allows them to layer new values and priorities on existing operational plans; to show leadership in how to achieve desired outcomes; and to seize new opportunities.

Achieving target outcomes often requires management to influence multiple responses – such as plant architecture, plant density, plant community composition – which may vary spatially and temporally, and which in turn influence multiple other ecosystem components (e.g., insect and bird communities; forage and livestock production).

Rangeland managers are spread over many differing landscapes and follow many different business models. As a result, there is no single solution to the desired multilayered environmental and socioeconomic outcomes. Interviews to identify key elements of DALLI with ranchers who use this approach underscore how diverse factors, such as climate conditions, economic viability, and community well-being, shape management decisions and outcomes. DALLI managers generally value long-term – often multi-generational – productivity of the working landscapes.

When compared to conventional approaches, and to Adaptive Multi-Paddock Grazing, a beneficial grazing management practice proposed by Teague et al. (2013), the DALLI management emphasizes heterogeneity and the prioritization of multiple social-ecological values (Table 1). DALLI management aims achieve defined outcomes, using variable grazing and rest periods, stocking rates, stock densities, and season of use to create a pattern of grazing impacts that shifts in space and time.

Discussion

The DALLI approach is a product of complex systems and is well-suited for undertaking management of rangeland systems characterized by high uncertainty. DALLI managers emphasize and enact adaptive management throughout their operations, dynamically adjusting grazing strategies and tools in response to emerging characteristics of the systems in which they operate. Managers are themselves a key component of the grazing system, with actions taken contributing and responding to emerging characteristics of the system. Specifically, management responds to and promotes ecosystem heterogeneity, producing a shifting mosaic of impacts, which supports system resilience and biodiversity. Since the DALLI approach inherently prioritizes multiple benefits, managers are well positioned to layer new values and priorities onto their operations, address challenges, and seize new opportunities when social and environmental conditions change. These features may make DALLI a particularly effective approach to beneficial grazing management in the Canadian prairies and beyond.

Ongoing data collection and analysis on soil carbon, greenhouse gas emissions, plant biomass, diversity, nutrient quality, and socioeconomic factors within the LL-CP project will help to quantify the benefits of DALLI grazing management. This work will help validate the potential of diverse, adaptive grazing strategies to promote sustainable rangeland management amidst dynamic environmental challenges. Together, biophysical and economic findings, qualitative analyses of social science interviews and ongoing co-development with participating rangeland managers will help explain how and why DALLI approaches can help ensure needed benefits are produced over the long term.

Conclusion

Around the world, rangeland managers are helping to ensure long-term productivity of these working landscapes, while recognizing and advocate for recognition of multiple values produced. They are a vital part of rangeland systems, and their attentiveness and flexible approaches are key to ensuring their success. As the production of social and ecological benefits from rangelands grows in profile and importance, and uncertainty about future conditions rises, we must continue to support, learn from, and communicate the successful

approaches of knowledgeable and effective managers – including DALLI managers in the Canadian prairies – to understand and define locally appropriate approaches to beneficial grazing management.

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