



What can herbaceous forbs tell us about sustainably managing mesic grasslands in South Africa?

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Abstract

High plant diversity maintains ecosystem functioning and delivery of services in response to disturbance through the insurance of functional redundancy. Forbs (herbaceous dicots and non-graminoid monocots), rather than grasses, comprise most of the species in South African mesic grasslands, which receive more than 600 mm of annual rainfall. Research in South Africa's mesic grasslands has shed light on the critical role of forbs in maintaining ecosystem health. Grazing significantly impacts forbs, with overgrazing drastically reducing diversity and replacing native species with hardy, often exotic ones, underscoring the importance of light stocking and judicious grazing management. Certain forb species serve as indicators of grazing intensity, with their relative abundance informing a forb condition score for monitoring and adjusting grazing practices accordingly. High-density, short-duration grazing (HDG) may not immediately affect forb diversity but can damage individual plants, promote unpalatable grasses, and alter forb composition, potentially harming soil health. Forbs exhibit individualistic responses to grazing and competition, highlighting the need for nuanced management strategies. Although forbs regrow after defoliation, their underground storage organs are depleted, affecting future growth and potentially reducing diversity in the long run, emphasizing the importance of lenient grazing pressure. While HDG can increase litter accumulation, it might not effectively replace fire's role in stimulating growth and reducing competition, underlining the significance of fire in maintaining forb diversity. Beyond grazing, certain forbs provide valuable food for herbivores, support pollinator communities, and offer essential resources for human livelihoods, necessitating a deeper understanding of their role in the ecosystem. Managing for forb diversity involves maintaining forb-rich habitats through responsible fire and grazing management practices to sustain biodiversity and the various services these grasslands provide. In conclusion, forbs are an indispensable component of healthy mesic grasslands in South Africa, and understanding their responses to disturbances informs effective land management practices for ensuring long-term ecosystem health.

Introduction

Mesic grasslands, which receive more than 600 mm of annual rainfall, are fire-dependent and consist of a diverse herbaceous plant community (Uys 2006). Forbs, including herbaceous dicots and non-graminoid monocots, contribute more to species richness than grasses in these grasslands (Siebert et al. 2024). High plant diversity ensures functional redundancy and maintains ecosystem functioning and stability when faced with intense disturbance (Hallett et al. 2017), such as by high-density, short-duration grazing. This grazing system, known as high-density grazing (HDG) or regenerative grazing, concentrates livestock in small areas for short periods to create a 'herd effect' that breaks soil crusts, accelerates the recycling of litter and dung, stimulates microbial communities, and boosts rangeland productivity—all while discouraging fire use (Savory and Parsons 1980). The contended benefits of HDG include increased livestock production by increasing the production of key foraging species and improved biodiversity (Savory and Butterfield 2016). Historical research focused on grasses and less was known about the response of forbs to different grazing management systems. This paper reviews the relevant literature to summarize the effects of HDG and heavy continuous grazing on the forb component of mesic grasslands.

Short and long-term effects of HDG and continuous heavy grazing

Long-term studies (over 10 years) in South African mesic grasslands have shown that high grazing pressure and the prolonged exclusion of fire results in the loss of most mesic grassland forbs with a community shift (Chamane et al. 2017a; Morris and Scott-Shaw 2019). Increased grazing pressure leads to changes in forb dynamics, shifts in species composition, life history strategies and growth forms (Nkuna and Morris 2024). Forbs play a critical role in rangeland ecosystems and can serve as indicators of habitat health as studies have shown that heavy grazing shifts perennial forb composition from erect decreaser species to prostrate increaser species (Table 1) (Chamane et al. 2017a; Morris and Scott-Shaw 2019; Morris 2021a). Additionally, annual ruderal and alien invasive forbs are favoured over perennials under intense grazing (Table 1, Table 2). Morris and Scott-Shaw (2019) identified a subset of indigenous mesic grassland forbs that showed a clear negative response to increased grazing pressure (Decreaser species) and other Increaser species that appear to be favoured by heavy grazing (Figure 1).

Contrary to HDG claims, intense trampling under high stocking density led to more compacted soils, with no significant difference in nitrogen and carbon levels compared to low-density grazing (Table 1). Litter mass was higher under HDG compared to an adjacent ranch that employed a lower stocking density (Table 1). A similar pattern was observed over a shorter time period where HDG resulted in a four-fold increase in (and deeper) litter accumulation (Chamane et al. 2017b). Dense litter can reduce evaporation and increase water availability but soil moisture is not limiting in these mesic grasslands and excessive litter can reduce irradiance received by plants, thereby limiting their growth (Chamane et al. 2017a).

More than 90% of forb species were defoliated by grazing or mechanically damaged by the ripping, shredding and tearing of hooves under HDG over the short-term (<10 years) period (Chamane et al. 2017b). Even low-abundance species do not always escape damage. These impacts may be reversible provided it is over a short period or less frequent with adequate recovery time because several mesic forbs have underground storage organs (USOs) that they can resprout from.

Table 1: Schematic presentation of the long-term effects of high-density grazing (HDG) compared to low-density grazing (LDG) on vegetation and soils (data from Chamane et al. 2017a).

	LOW DENSITY GRAZING	HIGH DENSITY GRAZING
Erect forbs	Wide bar	Narrow bar
Prostrate forbs	Narrow bar	Wide bar
Grass diversity	Wide bar	Narrow bar
Grass richness	Wide bar	Narrow bar
Forb diversity	Wide bar	Narrow bar
Forb richness	Wide bar	Narrow bar
Veld condition	Wide bar	Narrow bar
Litter	Wide bar	Narrow bar
Soil compaction	Narrow bar	Wide bar
Soil nitrogen	Wide bar	Narrow bar
Soil carbon	Wide bar	Narrow bar

Table 2: The life-history strategy and growth form of mesic forbs under different types of grazing pressure. Data are from Chamane et al. (2017a; Morris and Scott-Shaw 2019).

LIGHT GRAZING	HEAVY GRAZING
Perennials	Ruderal annuals & perennials
Native	Mostly non-native
Erect	Prostrate
Leaves on stems	Leaves at base

Response of forbs to repeated defoliation

Recurrent leaf damage due to heavy grazing in the growing season reduced the vigour (Morris and Nkuna 2024) and regrowth in the following spring (Morris 2021b) of *Hypoxis hemerocallidea* and *Thunbergia atriplicifolia*. Regrowth and USOs declined progressively under recurrent leaf damage. For both species, the USOs were more vulnerable to herbivory than the aerial organs; in *H. hemerocallidea*, corms were nearly halved in mass, accompanied by reduced inflorescence production (Morris 2021b; Morris and Nkuna 2024). This indicates that persistent defoliation reduces the USOs under chronic disturbance by overgrazing or frequent mowing which may weaken and eventually kill the plant. That would reduce the overall forb species richness and in turn reduce the resilience of forbs, diminishing their competitiveness against grasses and threatening their long-term survival (Siebert et al. 2024). Interestingly in another study of *Merwillia plumbea*, spring defoliation did not result in lasting impacts on carbohydrate reserves or macronutrients, suggesting that *M. plumbea* may be resilient to infrequent, intense defoliation, including in spring (Morris and Nkuna, unpublished data). Further research is needed on defoliation effects across different seasons.

Ecosystem services provided by forbs

Forbs provide essential services such as forage for livestock, food for humans and habitat for wildlife (Morris 2024; Siebert et al. 2024). The common cultural uses of forbs include spiritual uses and medicine for humans and animals (Siebert et al. 2021). Forbs also play a role to regulatory and support services by contributing more to diversity which ensures ecosystem resilience and stability (Morris and Nkuna 2024).

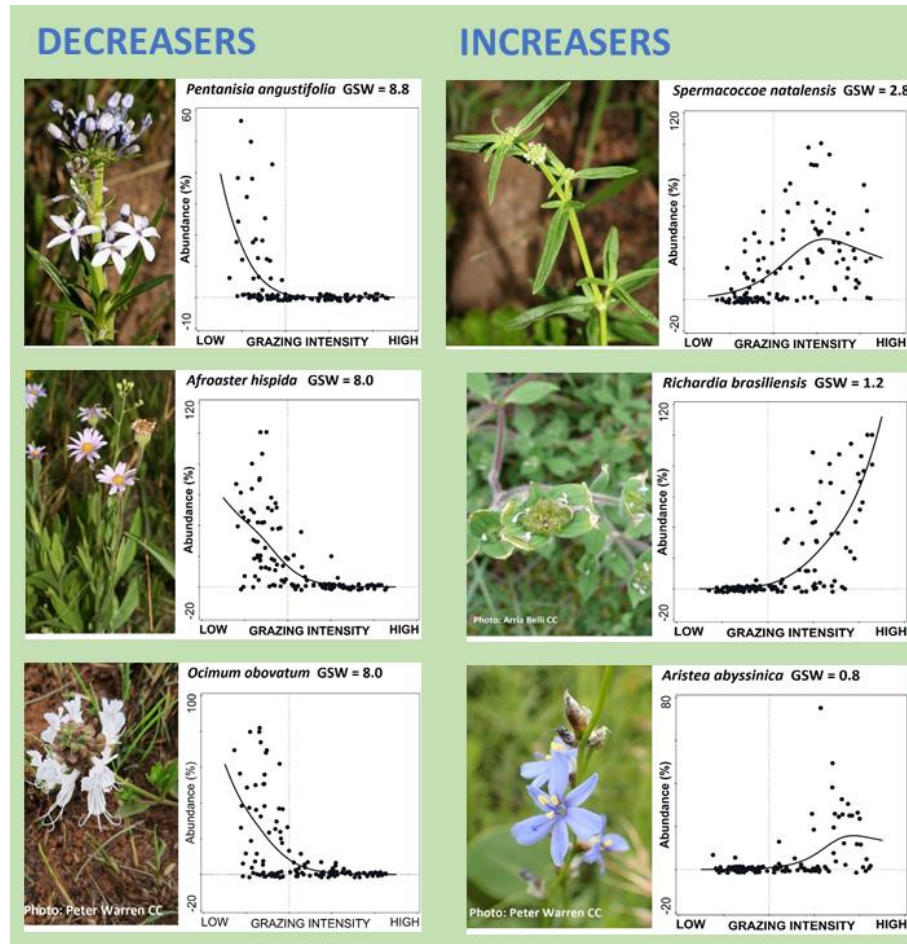


Figure 1: Examples of Decreaser and Increaser mesic grassland forbs that respond negatively or positively, respectively, to increased grazing pressure (Morris and Scott-Shaw 2019). GSW is a grazing score weight indicating a higher sensitivity to grazing. Reproduced from Morris (2019).

Managing for forb diversity in mesic grasslands

Grazing management tools for livestock production can be adapted to maintain forbs in mesic grasslands (Morris and Nkuna 2024). Strategies include adjusting stocking rates, selecting livestock types and managing movements (Kirkman et al. 2023). The combinations of management actions which include the frequency, intensity, duration and timing of grazing and trampling will affect the defoliation regime experienced by forbs and thereby, should influence their vigour and long-term survival (Morris and Nkuna 2024). The response of forbs can be explained by the intermediate disturbance hypothesis, which suggests that moderate disturbance is important while too little or excessive disturbance can reduce their abundance (Fynn et al. 2004). Complete protection from defoliation may favour shade-tolerant forbs and alter community structure (Fynn et al. 2005). Although it is known that forbs require some disturbance, the optimal frequency and intensity for maintaining forbs as well as the effects of disturbance timing are not well known (Morris and Nkuna 2024). Given the insufficient empirical data for managing perennial forbs, a precautionary approach is recommended. To help forbs recover from intense grazing and trampling or cumulative defoliation, it is important to provide periodic, year-long rest from grazing. Such extended rests will allow forbs to regain their vigour, develop bud banks, replenish underground storage reserves, and reproduce vegetatively or by flowering. Controlled burning is also important for removing excess litter and

for stimulating the growth of some mesic forbs. Regularly assessing the abundance of key indicator forb species and monitoring reduced flowering or stem growth can help managers to adjust grazing practices to prevent long-term degradation and maintain species-rich grasslands (Morris and Nkuna 2024).

Conclusions

Studies in mesic grasslands have shown that forbs are sensitive to chronic disturbances from HDG or heavy continuous grazing. While the importance of grassland forbs is increasingly recognized (Siebert et al. 2024), the optimal timing and intensity of management practices for forbs are still not well understood. Therefore, to support diverse forb populations, a precautionary approach is recommended: avoid intense and frequent grazing, provide year-long rest periods for grazed areas, use controlled burning, and implement adaptive management through regular monitoring of forb vigour and abundance.

References

- Chamane S, Kirkman KP, Morris C, O'Connor T (2017a) What are the long-term effects of high-density, short-duration stocking on the soils and vegetation of mesic grassland in South Africa? *African Journal of Range & Forage Science* 34, 111-121.
- Chamane S, Kirkman KP, Morris C, O'Connor T (2017b) Does high-density stocking affect perennial forbs in mesic grassland? *African Journal of Range & Forage Science* 34, 133-142.
- Fynn RW, Morris CD, Edwards TJ (2004) Effect of burning and mowing on grass and forb diversity in a long-term grassland experiment. *Applied Vegetation Science* 7, 1-10.
- Fynn RW, Morris CD, Edwards TJ (2005) Long-term compositional responses of a South African mesic grassland to burning and mowing. *Applied Vegetation Science* 8, 5-12.
- Hallett LM, Stein C, Suding KN (2017) Functional diversity increases ecological stability in a grazed grassland. *Oecologia* 183, 831-840.
- Kirkman KP, Fynn RW, McGranahan D, O'Reagain PJ, Dugmore T (2023) Future-proofing extensive livestock production in subtropical grasslands and savannas. *Animal Frontiers* 13, 23-32.
- Morris C (2024) From forage to multifunctionality: shifting perceptions of rangeland ecosystem services in the journals of the Grassland Society of Southern Africa. *African Journal of Range & Forage Science* Accepted.
- Morris C, Nkuna S (2024) Frequent defoliation rapidly and progressively reduces the vigour of a perennial mesic grassland forb, *Thunbergia atriplicifolia*. *African Journal of Range & Forage Science* Accepted.
- Morris CD (2021a) How Biodiversity-Friendly is regenerative grazing? *Frontiers in Ecology and Evolution* 9, 816374.
- Morris CD (2021b) Buried but unsafe – defoliation depletes the underground storage organ (USO) of the mesic grassland geophyte, *Hypoxis hemerocallidea*. *South African Journal of Botany* 141, 265-272.
- Morris CD (2019) Key forbs indicate the condition of mesic grassland. *Grassroots* November 2019, 19(4), 7-8.
- Morris CD, Scott-Shaw R (2019) Potential grazing indicator forbs for two mesic grasslands in South Africa. *Ecological Indicators* 107, 105611.
- Nkuna S, Morris C (2024) Overlooked forbs – implications for rangeland biodiversity and function in Southern Africa. *African Journal of Range & Forage Science* Accepted.
- Savory A, Butterfield J (2016) *Holistic management: a commonsense revolution to restore our environment*. Washington, DC: Island Press.
- Savory A, Parsons SD (1980) The Savory grazing method. *Rangelands Archives* 2, 234-237.
- Siebert F, Morris C, Chamane S, Ntuli N, Siebert S (2021) The functional importance of forbs in grassland ecosystems, 25 - 29 October, *Virtual*. pp. 175 - 179.
- Siebert F, te Beest M, Fynn R, Klimešová J, Morris C, Nkuna S, Siebert S, Fidelis A (2024) Past, present, and future of forbs in old-growth tropical and subtropical grasslands. *Annual Review of Ecology, Evolution, and Systematics* 55, 395-421.
- Uys RG (2006) Patterns of plant diversity and their management across South African rangelands. PhD thesis, University of Cape Town, South Africa.