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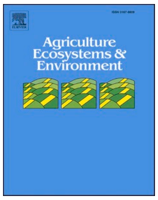

Short communication

A holistic view of Holistic Management: What do farm-scale, carbon, and social studies tell us?

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ABSTRACT

Holistic Management (HM) is claimed to increase production of plants and animals while also increasing soil organic carbon under all conditions in all habitats. Peer-review literature does not support these claims, but several studies report social benefits. Proponents of HM have criticized the small-scale of some studies (less than 2 ha), stating that production and climate benefits only emerge on large working farms (2–66 ha or larger, our size definitions). Here we summarize the conclusions from 22 peer-reviewed studies, focusing on farm-scale studies, and the few social and soil carbon studies from across the globe. Conclusions were synthesized into a diagram showing how grazing pattern (or density), stocking rate and animal type influence biology, climate resilience, and agricultural economics, as well as how HM's management component affects society. This synthesis confirms that HM's intensive grazing approach either has no effect or reduces production, as evidenced by farm-scale studies in United States of America, Argentina and South Africa, thus negating the claim by HM proponents that there is a difference between 'the science and the practice'. Seven peer-reviewed studies show that the potential for increased carbon sequestration with changed grazing management is substantially less (0.13–0.32) than the 2.5–9 t C ha^{-1} yr^{-1} estimated by non-peer-review HM literature. Five studies show that HM provides a social support framework for land users. The social cohesion, learning and networking so prevalent on HM farms could be adopted by any farming community without accepting the unfounded HM rhetoric, and governments could allocate funds to train extension agents accordingly. A future focus on collaborative adaptive farm management and other innovations will be more helpful than any further debate about grazing density.

1. Introduction

Holistic Management (HM) has biological and management components, namely holistic planned grazing (HPG), which is a type of short duration, high intensity rotational grazing approach where animal density (and often stocking rate) is increased with claimed benefits for plant and animal production as well as climate mitigation; and the 'holistic context' that addresses social, environmental and economic aspects of land use (Savory, 2013; Savory and Parsons, 2013). Mechanisms underlying claims are not clearly stated but are often linked to hoof action of animals, increased water infiltration and plant growth (Savory and Parsons, 1980). Scientific studies find no grounds for the claims of increased production or soil organic carbon (SOC). Indeed, claims for the benefits of rotational grazing (including HPG), have been challenged since the 1950's (Sampson, 1951) and more recently by many studies and references therein (O'Reagain and Turner, 1992; Briske et al., 2008, 2011a; Hawkins, 2017; Venter et al., 2019a, 2019b, 2020). However, proponents of HM criticize the small scale of some studies, stating that benefits only emerge on large, working livestock farms / ranches (Teague et al., 2013). 'Small' is relative, but we surmise, and agree, that the study area ideally should be a functional farm regardless of size. Nonetheless, to address this criticism of scale we define small as less than 2 ha and large-scale livestock farms as those between 2 and 66 ha or larger. A 1- or 2-ha threshold is often used to designate farms as small (Lowder et al., 2016). In reality, the size of livestock farms will depend on factors such as the productivity of the area, type of farm (family, corporation) and income to buy land. For example, some of the largest farms in the world (e.g., 3600 ha in Australia) occur in low rainfall areas while highly productive areas can be small (as low as 0.7 ha in Vietnam), and the average farm size

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globally is 66 ha (Lowder et al., 2016). Besides scale, not enough attention has been focused on emergent and possibly unintended social benefits of HM. It has long been recognized that rangelands are complex socio-ecological systems where both the biological and social components should be integrated in an adaptive process (Briske et al., 2011b). These authors suggested that the intensive management of HPG and other rotational approaches likely facilitates additional attention by the land managers, which can be effective for diverse management purposes while not necessarily changing ecological outcomes. Here we summarize the conclusions from 22 peer-reviewed studies, focusing on farm-scale studies, and the few social and soil carbon studies from across the globe that tested the effect of HM, and more broadly, the management of mammalian herbivores, on one or more of biology, climate, agricultural economics, and society.

2. Method

A review of scientific literature was conducted using natural language on publisher-neutral citation index platforms (Google Scholar, Web of Science, Science Direct) with no restriction on date. Three separate searches were conducted using key words separated by Boolean operators: (1) "holistic grazing" OR "holistic management" AND "farm-scale" OR "ranch-scale"; (2) "holistic grazing" OR "holistic management" AND carbon OR climate; (3) "holistic grazing" OR "holistic management" AND social OR econom* OR "support framework". Three searches were conducted since combining all keywords into one search resulted in many irrelevant topics. The addition of other terms describing HPG, e.g., multi-paddock, mob or cell grazing, did not yield further studies. Several studies were also obtained by ‘snowballing’, i.e., references within references including reviews. Based on abstracts and full texts, peer-reviewed articles were selected that compared HPG and other patterns of grazing at defined stocking rates, or more broadly assessed management of mammalian herbivores on production, climate and society, with a focus on farm-scale studies. The aim was not to conduct a meta-analysis of agricultural-style trials that tested how HPG influences production as this has been previously conducted (Hawkins, 2017) while too few studies about HPG and climate or social studies exist. The studies encompassed a range of locations globally, livestock and wildlife types, and grazing management types that were adaptive or not (Table 1). Studies that reported a positive, neutral or negative effect of HPG were tallied and summarized in graphical format to show how mammalian herbivory influences biology, climate (using SOC as a proxy), and agricultural economics, as well as how HM’s management component affects collaboration, learning and other features of society. In the diagram, herbivory is divided into grazing pattern (or livestock density where different grazing methods such as continuous season-long, multi-paddock, etc., result in different animal densities at the same stocking rate), animal type (ratio of browsers to grazers including livestock and wildlife), and quantity of animals or stocking rate in livestock units (450 kg) per hectare (LSU ha^{-1}). Livestock units were recalculated from the original citations where needed (Table 1).

3. Results

Large, farm-scale studies in the United States of America (Augustine et al., 2020), Argentina (Oliva et al., 2021) and South Africa (Venter et al., 2019a) concluded that HM has no effect (cattle in USA and South Africa), or reduces animal production (sheep in Argentina; Fig. 1). The lack of difference in cattle weight gain was not surprising given that HM had no effect on foliar production in the same studies, and that animal behaviour did not differ between season-long-, four-camp grazing and HPG (Venter et al., 2019b). Two farm-scale studies in South Africa and the US (Venter et al., 2019b; Windh et al., 2019) found that season-long continuous grazing was more profitable than multi-paddock grazing because the cost of infrastructure (fences, water), labour and time were greater for the latter (Fig. 1). As many studies have found previously, farm-scale studies surveyed here found that stocking rate (Venter et al., 2019a, 2020; Derner et al., 2021) matters more for plant and animal production than grazing pattern/density (Fig. 1). The American farm-scale study found that animal gain and profit increased with adaptive but not nonadaptive multi-paddock grazing, i.e., what mattered was not the grazing intensity but that decisions were adaptive and informed by farmer-scientist and other stakeholder collaboration as well as intensive monitoring (Derner et al., 2021). They concluded that multi-paddock grazing may be more effort than it is worth. Interestingly, the South African farm-scale study found that HM can reduce both external and internal livestock parasites (Rapiya et al., 2019) as well as vegetation patchiness (Venter et al., 2019b) (Fig. 1).

Recent estimates of carbon sequestration on grasslands indicate that SOC can increase if overgrazing is decreased (Conant and Paustian, 2002; Conant et al., 2017) or if herbivores are returned to ungrazed native grassland (Smith et al., 2008) but SOC gains are substantially less at 0.13–0.32 t C ha^{-1} yr^{-1} (Henderson et al., 2015) than the 2.5–9 t C ha^{-1} yr^{-1} calculated to occur with a change to HM in non-peer-review literature (Savory, 2013; Itzkan, 2014). There is no demonstrated effect of HPG on SOC compared to traditional approaches such as season-long grazing (Fig. 1). Interestingly, changing from livestock to wildlife (notably megaherbivores such as elephants that knock over, consume and damage large trees and shrubs) increased soil carbon over decadal timescales in Kenya (Sitters et al., 2020). An increased ratio of browser to grazer livestock types decreased the amount of woody vs grassy plant biomass (Fig. 1) and this was linked to decreased woody plant encroachment (Venter et al., 2018, 2019a).

Several studies (Stinner et al., 1997; Kennedy and Brunson, 2007; de Villiers et al., 2014; Mann et al., 2019) show that HM’s management component provides a support framework for land users by increasing social learning (the ability to learn from one another), peer-peer support and agency or self-determination (Fig. 1, abbreviated as ‘holistic context’). A case study on communal lands of Zimbabwe indicated HM was better than no planning (Gadzirayi et al., 2007). However, the introduction of HM in a form designed for communally owned lands was not successful at Hwange Communal Lands, Zimbabwe, near to the Savory African Centre for Holistic Management. Here Holistic Land and Livestock Management (HLLM, a form of HM) was introduced to 18 communities but adoption was low as it did not address concerns of the community such as lack of labour for the intensive animal movement, cultural misalignment, and lack of attention to livelihoods from livestock (Chatikobo, 2015).

4. Discussion

Claims about increased production and climate resilience with HM are unfounded based on farm-scale studies, which are also supported by many experimental trials and reviews (Briske et al., 2011a; Hawkins, 2017). This is not surprising because Venter et al. (2019b) found that animal behaviour (time spent grazing, walking or resting; proximity to one another, dung trampling, and selectivity at plant scale) did not differ. It is known that frequent, severe defoliation reduces grass production, and one stated aim of HPG is to avoid repeated defoliation. Where defoliation severity and frequency were manipulated in a manipulated plot- and pot-scale study it was indeed found that production decreased (Venter et al., 2020). However, two farm-scale studies that included adaptive management and compared HPG and season-long grazing found defoliation at the plant-scale was similar, i.e., both approaches resulted in a season-long ‘rest’ for grass (Venter et al., 2020; Porensky et al., 2021). Regarding overall profitability, long-term animal weight gain is known to be highly variable within and between grazing approaches and years, and it is probably better for land managers to match the desired animal end weights and time of year to market rather than trying to determine which grazing system is better (Windh et al., 2020).

A recent study found 13% more SOC under multi-paddock grazing

Table 1

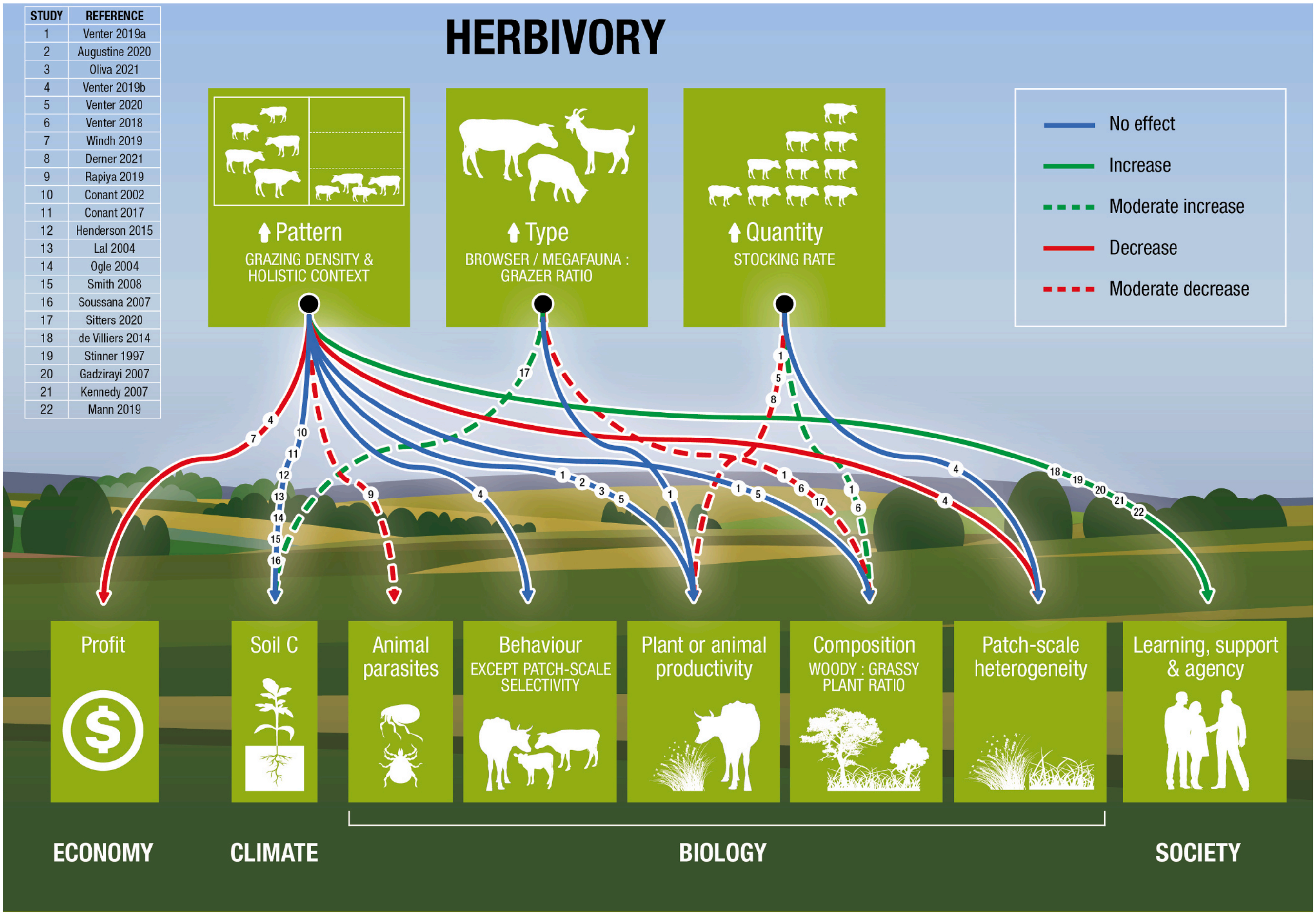
Farm-scale and other peer-reviewed studies comparing the effect of grazing pattern, animal type and stocking rate on biological, climate, agroeconomic and social factors. Conclusions of studies were used to develop Fig. 1. 'Unknown' is used where it is clear from the study or data source that the relevant information is not available (e.g., animal age is not available from a FOA map layer on animal type), and 'Not given' is used where it is uncertain whether the information is available but not reported on, or not available. Abbreviations: DayCent: Daily Century Model; GLEAM: Global Livestock Environment Assessment Model; FAO: Food and Agriculture Organization of the United Nations; LSU: large stock unit defined as 450 kg (data from studies using another weight were converted); MAP: mean annual rainfall.

Study	Location	Country	MAP (mm)	Farm size (ha)	Animal	Animal sex and age	Animal density (LSU ha^{-1})	Duration of grazing (d)	Stocking rate (LSU ha^{-1})	Adaptive management	Reference
1	48 locations, see reference	South Africa	150–850	230–110,000	Cattle, sheep, goats	Unknown	0.1–1040	1–80	0.02–3	Yes, varying degrees	Venter et al. (2019a)
2	40°50'N, 104°43'W	US	340	1295	Cattle	Yearling steers	0.18–2.15	21	0.67–0.81	Yes	Augustine et al. (2020)
3	69°19'W, 51°29'S	Argentina	240	26,566	Sheep, lamas	Ewes, rams, wethers, lambs	0.35–0.9	23–68	0.12	Yes	Oliva et al. (2021)
4	30°21′S, 29°30′E	South Africa	760	219	Cattle	Yearling steers	1–36.8	1–180	0.53	Yes	Venter et al. (2019b)
5	30°21′S, 29°30′E	South Africa	760	219	Cattle	Yearling steers	1–36.8	1–180	0.53	Yes	Venter et al. (2020)
6	Sub-Saharan Africa raster map layer	Sub-Saharan Africa	800–1100	n/a	Various	Unknown	0.91–1.1	Unknown	0.91–1.1	Unknown	Venter et al. (2018)
7	40°50'N, 104°43'W	US	340	1295	Cattle	Yearling steers	0.18–2.15	21	0.67–0.81	Yes	Windh et al. (2019)
8	40°50'N, 104°43'W	US	340	1295	Cattle	Yearling steers	0.18–2.15	21	0.67–0.81	Yes and No comparisons	Derner et al. (2021)
9	30°21′S, 29°30′E	South Africa	760	219	Cattle	Yearling steers	1–36.8	1–180	0.53	Yes	Rapiya et al. (2019)
10	Global (review)	Global (review)	n/a	n/a	Various	Various	Various	Various	Various	Yes and No	Conant and Paustian (2002)
11	Global (review)	Global (review)	Not given	Not given	Not given	Not given	Not given	Not given	Not given	Yes and No	Conant et al. (2017)
12	Global (models)	Global (models)	Not given	Various	Mixed livestock from FAO	Unknown	Various as per GLEAM model	Various as per DayCent, Century and GLEAM models	Various as per GLEAM model	Not given	Henderson et al. (2015)
13	Global (review)	Global (review)	n/a	Various	Mixed livestock	Unknown	Not given	Not given	Not given	Not given	Lal (2004)
14	Global (30 locations)	30 countries in boreal, temperate and tropical climates	Not given	Not given	Mixed livestock	Not given	Not given	Not given	Not given	Not given	Ogle et al. (2004)
15	Global (review)	Global (review)	Not given	Various	Mixed livestock	Unknown	Not given	Not given	Not given	Not given	Smith et al. (2008)
16	Multiple locations across Europe (see reference for details)	Hungary, Scotland, Ireland, France, The Netherlands Italy, Switzerland, Denmark	500–1313	Not given	Cattle, sheep	Heifers, bulls, ewes	Not given	15–250	0.09–0.99	No	Soussana et al. (2007)
17	0°17′ N, 36°52′ E	Kenya	550	18,210; 4-ha plots	Elephant, buffalo, cattle, zebra and others	Not given	10–15 cattle per km^2 (LSU not known and often less than 450 in Africa)	36 weeks	10–15 cattle per km^2	Yes	Sitters et al. (2020)

(*continued on next page*)

Table 1 (*continued*)

Study	Location	Country	MAP (mm)	Farm size (ha)	Animal	Animal sex and age	Animal density (LSU ha^{-1})	Duration of grazing (d)	Stocking rate (LSU ha^{-1})	Adaptive management	Reference
18	32°15’ S, 24°32’ E	South Africa	512	5933–8945	Sheep	Not given	Not given	Not given	Not given	Yes	de Villiers et al. (2014)
19	25 locations across US	US	769	7–8800	Cattle, chickens goats, horses, pigs, sheep	Beef and dairy cattle, Heifer cattle, others not given	Not given	Not given	0.05–2.5	Yes	Stinner et al. (1997)
20	19.80° S, 32.87° E	Zimbabwe	1500	881	Cattle	Bulls, oxen, cow, calves, heifers	1.71–3.78	ca. 5–21	0.2	Yes	Gadzirayi et al. (2007)
21	4 counties in Colorado	US	432	23 ranches	Cattle	Not given	Not given	Not given	Not given	Yes	Kennedy et al. (2007)
22	Locations in US, Canada	US, Canada	432–2032	17–20,234	Not given	Not given	Not given	Not given	Not given	Yes and No comparison	Mann et al. (2019)



STUDY	REFERENCE
1	Venter 2019a
2	Augustine 2020
3	Oliva 2021
4	Venter 2019b
5	Venter 2020
6	Venter 2018
7	Windh 2019
8	Derner 2021
9	Rapiya 2019
10	Conant 2002
11	Conant 2017
12	Henderson 2015
13	Lal 2004
14	Ogle 2004
15	Smith 2008
16	Soussana 2007
17	Sitters 2020
18	de Villiers 2014
19	Stinner 1997
20	Gadzirayi 2007
21	Kennedy 2007
22	Mann 2019

Fig. 1. A schematic summary of how mammalian herbivory (upper boxes) influences aspects of agricultural economics, climate, biology and society (lower boxes). Coloured arrows indicate the nature of the influence (increase, no effect or decrease) and numbers along the arrows indicate studies providing supporting evidence for these relationships, shown as first authors and year at left. Upper boxes comprise aspects of herbivory (pattern or animal density, type of herbivore and stocking rate). Here, ‘holistic context’ is included with pattern/grazing density for ease of layout and refers only to the societal influences. ‘Behaviour’ in the lower boxes refers to livestock grazing, walking or resting; proximity to other livestock, dung trampling, and selectivity at the plant (but not patch) scale.

compared to ‘conventional grazing’ (Mosier et al., 2021). We did not include the results of this study in our survey because stocking rates differed between management types and ‘conventional grazing’ was year-long continuous grazing (three of five cases), which is a known poor management practice. Another study found that adaptive multi-paddock grazing resulted in higher CO_2 but lower N_2O and CH_4 emissions from soil compared to nonadaptive moderate or heavy continuous grazing (Dowhower et al., 2020) but was excluded for the same reasons as above. While SOC gain on restored grasslands has been identified as one of several ‘natural climate solutions’ pathways (Griscom et al., 2017, 2020), the proposed increases in SOC with HM remains high and unsubstantiated, being 19–28 times that of any other estimates of increased SOC on well-managed grasslands compared to overgrazed or ungrazed areas (Lal, 2004; Ogle et al., 2004; Smith et al., 2008; Henderson et al., 2015). Also HM estimates of SOC do not account for increases in other greenhouse gases with increased livestock numbers (Soussana et al., 2007). Critically, the grassland area and duration of sequestration used in non-peer reviewed literature have been overestimated (Henderson et al., 2015; Nordborg, 2016). The capacity of soil to indefinitely sequester C from organic residue inputs (vegetation or animal decomposition products (Lal, 2004; Ritchie, 2014)) is limited by its physicochemical characteristics, i.e., the soil C saturation concept (Six et al., 2002). Depending on climate and topo-edaphic differences, lost ecosystem carbon may be recovered over ca. 205 years in montane grasslands but only over ca. 19–35 years in tropical and temperate grasslands (Goldstein et al., 2020). Interestingly, SOC gains that occur with addition of herbivores to ungrazed grasslands appears to be more likely in arid rangelands (Sanderson et al., 2020). Increased grass cover and SOC with a change from cropping to intensive grazing (Machmuller et al., 2015) is sometimes used to promote HM. However, any change from crop to grassland land use could be expected to result in these increases, and clearly does not demonstrate additionality of intensive grazing over other livestock management approaches.

As complex socioecological systems, rangelands harbour much of our remaining native fauna and flora. As human populations grow, the recreation of temporal and spatial heterogeneity in rangelands will be increasingly important in maintaining not only agricultural productivity but also biodiversity (Fuhlendorf et al., 2009, 2017; Briske et al., 2011a). Many HM practitioners perceive an increase in biodiversity (Stinner et al., 1997; Kennedy and Brunson, 2007) and other desired outcomes on their farms but as we have seen, these are associated with adaptive management and not the number of camps (Derner et al., 2021). Wilmer et al. (2018a) found that plant species composition did not differ between intensive and other grazing management approaches on 17 working ranches in the US. However, intensive grazing has been shown to damage bunch grasses and forbs in high altitude grasslands in South Africa (Chamane et al., 2017b, 2017a) and to destroy habitat for fauna such as ground nesting birds (Little et al., 2015). Livestock production can be balanced with conservation of avian habitat if one considers the ecology of the area, the preferred habitat of a particular bird and the grazing approach (Wilmer et al., 2018b; Davis et al., 2020). The goal of maintaining a productive farm while providing habitat for wildlife can also be accomplished by creating patch mosaics in the landscape via pyric-herbivory (Fuhlendorf et al., 2017). Patch-mosaics and cycling of carbon from above- to belowground may both be facilitated by re-wilding of rangelands with native megafauna from browser and other feeding guilds (Cromsigt et al., 2018). Since an increase in the browser to grazer livestock ratio reduces woody plant encroachment (Venter et al., 2018), we can speculate that inclusion of large browser livestock may cycle relatively more aboveground carbon to SOC while maintaining habitat for biodiversity.

Thus, if HM claims are unfounded, why does this approach continue to find considerable support from practitioners? Social studies make clear that social cohesion, learning, support, increased social agency, and a care for the environment often unite HM farmers (Mann et al., 2019). These are important benefits in the complex decision-making environment of a farmer, and HM apparently provides a much-needed supportive framework. A key finding is that it was the collaborative adaptive approach to managing animal and other resources in space and time that mattered, not the number of paddocks (Derner et al., 2021). It is particularly enlightening that these authors found adaptive, multi-paddock grazing to have production benefits while nonadaptive multi-paddock grazing did not. Studies on the socio-ecological complexity of rangelands with multiple stakeholders has indicated that a spiral vs traditional circular adaptive management cycle applies, with iterative learning loops, pathway dependencies, and traded-offs (Fernández-Giménez et al., 2019). The co-development of goals and social learning only occurs with considerable effort but the approach is thought to lead to improved communities, learning and solutions, according to these authors.

It is fully recognized that various grazing management approaches besides the proven traditional approaches, such as season-long grazing, may serve the goals of a farm at any one time. Land managers in the US Western Great Plains tended to be flexible and use a diversity of grazing management options in response to local climatic as well as broader social, economic and political dynamics (Wilmer et al., 2018a). Interestingly, in whole-farm adaptively managed studies, intensive grazing resulted in homogeneity at the patch-scale in African grasslands (Venter et al., 2020) but heterogeneity in American grasslands (Porensky et al., 2021). A four-year study found that rotational grazing increased annual plants and litter while decreasing forbs compared to continuous grazing (Jacobo et al., 2006). These studies are useful illustrations of how, given this information, a manager may decide to use high rotation as a tool. Equally, quick rotations can be used to reduce tick infestations (Rapiya et al., 2019). Advances in technology that allow quick feedback of information should become increasingly valuable in the adaptive management process. For example, remote sensing of vegetation and GPS-collaring of livestock showed that animals preferentially grazed lowlands and flat plains in arid US rangelands but avoided uplands and sloped areas in more mesic areas where lowlands often flood (Raynor et al., 2021). Rapid feedback can help practitioners develop land use plans that are specific in space and time.

What are the implications of these findings? Firstly, scientists who are producing research contrary to HM claims are failing to convey the message to farmers. Maybe because there is no “Unsavory institute” to promote the contrasting evidence and a clear message. Such a message was put forward as early as 1992: “Simple grazing systems using adaptive and opportunistic management are recommended” (O’Reagain and Turner, 1992). Potentially, the social cohesion, learning and networking so prevalent on HM farms can be adopted by any farming community without accepting the unfounded HM rhetoric. Considerable funding and training services have helped HM become popular and we suggest agricultural services can learn from this by allocating funding to training of extension agents, who in turn work with land users, including pastoralists and communal landowners, to develop scientifically sound and supportive management frameworks. More broadly, collaborative adaptive rangeland management involving scientists, land managers, pastoralists and others forges science-management partnerships and can help practitioners solve complex problems within rangelands (Wilmer et al., 2018b; Reid et al., 2021). Reid et al. (2021) showcase six cases studies where collaborative teams have integrated knowledge from diverse stakeholders, including marginalized groups, to co-produce solutions that are generically useful at scale. For example, a pastoralist-research collaboration led to action networks with subsequent social learning and policy change. Success in farming continues to be dependent on clear management decisions about farm goals, concomitant land use plans, appropriate stocking rates for the area, forage inventories and animal care, followed by adaptive management based on regular monitoring. A future focus on collaborative adaptive farm management and other innovations such as patch-mosaics and re-wilding will be more helpful in creating productive and biodiverse rangelands than any further debate about grazing density.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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