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# Mob Grazing Results in High Forage Utilization and Reduced Western Snowberry Size

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Additional information is available at the end of the chapter

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## Abstract

Mob-grazing strives to maximize forage utilization and minimize selective grazing by using high stocking densities in small paddocks for short durations (12–24 hr). Rotational-grazing uses low stocking densities for a longer time period, retaining about half of the original available forage; although selective grazing can occur. Three cattle (*Bos taurus* × *Bos indicus*) grazing intensities: mob- (stocking densities from 32,000 to 67,000 kg ha<sup>-1</sup>; duration—24 hr); rotation (stocking density—2500 kg ha<sup>-1</sup>; duration—35 d); and non-grazed systems were compared based on forage utilization and changes to western snowberry (*Symphoricarpos occidentalis*) (WS) patch volume in a 2-year South Dakota study. Pre- and post-grazing forage height was measured every 2.5 m along multiple 50-m transects with WS patch volume measured every 5 m. Forage utilization (consumed and trampled) ranged from 42 to 90% in mob-grazed areas, and harvest efficiency (forage consumed) ranged from 15 to 64%. WS patch volumes decreased by ≥45% in mob-grazed treatments compared with no change in rotational-grazing and increased cover in non-grazed areas. WS pre-graze patch size influenced mob-grazing impact; patches >6500 cm<sup>3</sup> were browsed or trampled to a greater extent than smaller patches.

**Keywords:** pasture management, grazing intensity, shrub control, forage grass production

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## 1. Introduction

Western snowberry (WS) (*Symphoricarpos occidentalis*) (also known as ‘buckbrush’) is a perennial, cool-season shrub, native to the Northern Great Plains (NGP) of the United States [1]. It can grow up to 1 m tall and spreads by seeds and rhizomes. WS can form dense monoculture

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patches ranging from <2 to 200 m in diameter. This woody species can tolerate poor soils, harsh temperatures, flooding, and drought [2].

Some patches of WS are desirable as thickets provide nesting habitat for ground-dwelling birds, as well as some protection for newborn calves (Charlie Totton, rancher, personal communication, June 2013). Therefore, complete elimination of WS plants in most pastures is not the ultimate management goal. But, over time, uncontrolled patches of this less palatable [3], woody groundcover can reduce plant species diversity and amounts of desirable forage; alter nutrient cycling [4]; and result in economic loss [5, 6].

Options for rangeland perennial weed control vary in implementation and effectiveness and require multiple years of maintenance. After WS removal, biomass of grasses and forbs can increase dramatically [7], although WS densities can rebound in less than a year if control measures cease [8]. Herbicides applied in June resulted in good (64%) to excellent (99%) WS control during the growing season, depending on herbicide and application rate [9, 10] with control in subsequent years ranging from none to excellent. Even with excellent control, herbicides often are more expensive than short or mid-term returns justify [11]. However, because WS occurs in patches, uniform treatment of entire pastures may not be necessary, thus reducing costs and environmental impacts.

Physical techniques, based on timing, alone or combined with grazing are other options for WS management. While a single growing season of mowing did not control WS [10], two mowing events over 3 years reduced WS patch size [1], and increased succulent sprout growth, making the plant more palatable to livestock. Grazing WS patches in early season (May) or left untreated had lower WS densities the following year compared to areas grazed in August [12] or burned with late season fire [8]. Prescribed fires from mid- to late-May combined with goat (*Capra aegagrus hircus*) grazing suppressed WS plants, reduced seed production, canopy cover, and stem density [13, 14] in the NGP. However, goats are not commonly reared in the NGP for a variety of reasons [15].

Cattle grazing for weed control is a natural fit for NGP pastures and rangelands. However, weed management using cattle often has limited success. First and foremost, cattle are expensive to raise and replace and, depending on weed species, may result in problems with nutrition [16], reproduction, toxicity, or have other negative impacts (e.g. off flavors of meat) [2, 17]. Since cattle avoid dung-soiled pasture, selective grazing can occur when stocking rates are low or moderate [18, 19]. Thus, only the most palatable plants are grazed, leading to overgrazing desirable species, and ultimately changing the plant community [20]. In addition, cattle hooves break up sod, leaving areas vulnerable to weed invasion, which is counter-productive to control [5].

Deliberately managing and manipulating cattle stocking rate and density, grazing duration, and seasonal timing based on pasture conditions can promote weed management success [16]. Livestock can consume and/or trample plants and improve pasture nutrient condition and competitiveness of desirable plants through incorporation of manure and urine [5], often with fewer adverse effects on non-target species than herbicide applications. Grazing should occur when the weed is most palatable, vulnerable to injury, and not toxic to the animal.

Mob grazing (or nonselective grazing) using cattle has been promoted as a system to improve soil health and plant conditions [21–23]. This system attempts to mimic animal/vegetation

interactions of historic prairie ecosystems, where herds of large herbivores move continuously to new areas as forage is depleted [24]. Although not strictly defined, this system uses dense groups of animals (e.g. >28,000 kg cattle ha<sup>-1</sup>) in small paddocks for short time periods (typically ≤24 hr. per paddock). Positive attributes include high vegetation utilization [25]; limited selectivity or avoidance of less desirable and potentially weedy plants [26]; and increased trampling of unconsumed forage, manure, and urine [27], which incorporates nutrients and organic matter into the soil [28] and may ultimately lead to higher forage productivity [21]. Some ranchers have adopted this intense system to reclaim specific pastures, following the recommended guidelines to graze for only a few weeks during the season with movement every 12–24 hr. Grazing return periods are often 1 year or longer, or these pastures may be returned to rotational grazing after recovery.

To date, no studies have compared WS plant response to high cattle stocking intensity (mob grazed areas) with low intensity (rotational grazing) or ungrazed treatments. We quantified the impact of mob grazing on WS populations and compared the response with two less-intensive management systems at South Dakota locations. Due to the expense, need for many animals, and labor and time involved to move cattle frequently, the studies were done in cooperation with ranchers who incorporated mob grazing and rotational grazing techniques into their cattle operations. The objective of this study was to quantify the effect of mob-grazed cattle compared with rotational grazed cattle or no grazing on WS size and forage utilization.

## 2. Methods

### 2.1. Study site description and treatments

Forage utilization and WS (*Symphoricarpos occidentalis*) data were collected at two South Dakota locations, Chamberlain (southcentral SD; 43.8°N, 99.3°W) and Selby (northcentral SD; 45.3°N, 99.8°W). South Dakota, located in the NGP of the United States, has a continental climate, i.e. cold winter temperatures with snow, and moderate to warm summer temperatures. Most annual precipitation occurs in spring and summer.

At Chamberlain, forage and WS response was quantified in mob-grazed pastures (2013 and 2014), ungrazed pastures (2013) and an early (May through mid-June) rotational-grazed pasture (2014). In Selby, treatments were performed in mob-grazed (2013 and 2014), rotational-grazed (2013), and ungrazed pastures (2014). Pasture vegetation and soil types for each site are listed in **Table 1**. Climate, grazing, and sampling information for the two-year period are provided in **Table 2**. Growing degree days (GDD; base 0°C) for the growing season (March through September) were near (±5%) the 30-yr average (1980–2010) at each year and site (**Table 2**). Precipitation (January through September) was 8% lower than their respective 30-yr averages for both sites in 2013, and 4% lower at Chamberlain and 16.5% lower at Selby, in 2014. Specific GDD and precipitation amounts for sampling dates are reported in Myer [29].

Local producers determined stocking intensity, grazing dates, and paddock size, with cattle moved in mob grazed areas after 24-hr (**Table 2**). The rotational and ungrazed treatments differed among years at the locations due to cattle needs and pasture condition. At Chamberlain

Chamberlain		Selby	
Common name	Scientific name	Common name	Scientific name
Western wheatgrass	<i>Pascopyrum smithii</i>	Western wheatgrass	<i>Pascopyrum smithii</i>
Smooth brome	<i>Bromus inermis</i>	Green needlegrass	<i>Nassella viridula</i>
sweet clover	<i>Melilotus officinalis</i>	Western snowberry	<i>Symphoricarpos occidentalis</i>
Western snowberry	<i>Symphoricarpos occidentalis</i>	smooth brome	<i>Bromus inermis</i>
red clover	<i>Trifolium pratense</i>	Kentucky bluegrass	<i>Poa pratensis</i>
Kentucky bluegrass	<i>Poa pratensis</i>	Scurfpea	<i>Psoralidium sp.</i>
dandelion	<i>Taraxacum officinale</i>	Sweet clover	<i>Melilotus officinalis</i>
Common sunflower	<i>Helianthus annuus</i>		
Musk thistle	<i>Carduus nutans</i>		
Common ragweed	<i>Ambrosia artemisiifolia</i>		
Bull thistle	<i>Cirsium vulgare</i>		
Milkweed	<i>Asclepias sp.</i>		
Green needlegrass	<i>Nassella viridula</i>		
Needle and thread	<i>Hesperostipa comata</i>		
Big bluestem	<i>Andropogon gerardii</i>		
Porcupine grass	<i>Schizachyrium scoparium</i>		
Sideoats grama	<i>Bouteloua curtipendula</i>		
Blue grama	<i>Bouteloua gracilis</i>		
<b>Soil types</b>			
Sansarc-Opal clay		Opal-Sansarc clay	
McClure silt loam		Bearpaw-Gettys complex	
Bullcreek clay		Highmore-Bearpaw silt loam/clay loam	
Uly silt loam		Gettys clay loam	

**Table 1.** Plant species and soil types at Chamberlain and Selby, SD in 2013 and 2014.

mob grazed pastures were mob grazed every-other year, so the 2013 mob grazed pasture was ungrazed in 2012, and the 2014 mob grazed pasture was ungrazed in 2013. Meanwhile, the 2013, ungrazed pasture at Chamberlain was rotationally grazed at a stocking density of 250 kg ha<sup>-1</sup> for approximately 30 days on 300 ha in 2012, and this same pasture was rotationally grazed in 2014. At Selby, both the mob grazed and rotationally grazed pastures were managed similarly in previous years as the experimental years, and the 2014 ungrazed pasture was rotationally grazed in 2013.

Site	Climate				Grazing information			Sample date		
	GDD Jan - Sept	30 yr avg <sup>a</sup>	Precip. Jan - Sept	30 yr avg <sup>a</sup>	Treatment	Stocking density	Paddock size	Graze duration	pre	post
	Base 0C		mm			Kg/ha	ha			
Chamb. 2013	3262	3416 (-8%)	468	507 (-8%)	Mob	67,000	5	24-hr	19-Jun	8-Aug
					Ungrazed <sup>b</sup>	---	300	---	19-Jun	8-Aug
2014	3230	3416 (-5.4%)	489	507 (-4%)	Mob	43,800	2	24-hr	9-Jul	17-Jul
					Rotation <sup>c</sup>	250	300	35 days	9-Jul <sup>d</sup>	13-Sep
Selby 2013	2904	3027 (-4%)	366	399 (-8%)	Mob	32,200	2	24-hr	21-Sep	28-Sep
					Rotation	2,600	80	36 days	18-Jun	19-Jul
2014	2852	3027 (-5.7%)	334	399 (-16.5%)	Mob	37,500	2	24-hr	23-Jul	7-Aug
					Ungrazed	----	80	---	20-May	6-Sep

<sup>a</sup>30 yr average is based on 1980 to 2010 data for the nearest weather stations to the study site (Chamberlain and Hoven, SD, respectively).

<sup>b</sup>Rotationally grazed in 2012

<sup>c</sup>Grazed in May – mid June

<sup>d</sup>Both sampling dates occurred after rotational grazing

**Table 2.** Climate, grazing information, and sampling dates for 2013 and 2014 at Chamberlain (Chamb.) and Selby, SD locations.

## 2.2. Vegetative data collection

Three parallel 50-m transects were set up about 10 m apart (pre-graze measurement) immediately prior to the first sampling date (**Table 2; Figure 1A**) with two paddocks of each grazing treatment sampled each year (six transects) per site. Average standing forage height was measured to the nearest cm every 2.5 m along each transect, with GPS points recorded (Garmin eTrex 20, Garmin International, Inc., Olathe, KS). Every 5 m along each transect, the closest WS plant was identified, tagged with a metal loop near the plant base, and height (highest point from soil surface) and two perpendicular widths were measured.

After grazing, or in the fall for the non-summer grazed paddocks, transects were reestablished. Average standing forage height, including WS, at each sampling point was measured again and percentage of newly trampled forage (e.g. vegetation remaining that was  $\leq 45^\circ$  from upright position) was estimated in mob-grazed paddocks only. Tagged WS plants were measured as in pre-grazing, and post-grazing condition (e.g. intact, trampled, browsed) was recorded.



**Figure 1.** Pasture condition before (A) and after (B) a 24-hr mob grazing event at Chamberlain, SD.

Forage productivity can be estimated using the grazing stick method:

$$\text{Forage productivity} = (\text{average standing forage height} - 10 \text{ cm}) \times 79 \text{ kg ha}^{-1} \text{ cm}^{-1}. \quad (1)$$

which is the conversion value for a cool season, mixed species pasture with about 90% cover [30]. The 10 cm is subtracted from the height to account for remaining leaf and stubble after grazing. In preliminary data sets, Myer compared grazing stick method to clipping forage biomass at >40 sampling points and found these two estimates were within 15% of each other [29].

Therefore, due to time and labor constraints, grazing stick measurements that accounted for height and percent cover were used to describe relative forage productivity and grazing impact.

### 2.3. Data analysis

Forage consumption (efficiency) percentage [31] was estimated by:

Forage consumption = [(pre-graze biomass) – (post-graze biomass + trampled)]/(pre-graze biomass) × 100; with biomass estimated using the grazing stick method described above, and assuming the difference in standing forage was consumed by the livestock and not by insects, wildlife, or rodents [32]. Since there was no trampled forage estimate for rotational-grazed paddocks, this was only calculated for the mob-grazed treatment. Additionally, forage utilization (consumed + trampled forage) was estimated at each sampling point and was based on change in biomass (estimated using the grazing stick method), including the trampled forage. Pre- and post-grazing WS relative plant volume was estimated for each tagged plant using the equation:

WS volume = height × width 1 × width 2; with height measured at the highest point on the plant from the soil surface, width 1 as the widest horizontal measure of the WS, and width 2 the width of the WS perpendicular to the width 1 measurement.

Matched paired one-tailed (post-graze < pre-graze) t-tests were used to compare pre- versus post-grazing WS plant volume and estimated forage biomass at each point along the transect at a significance value of  $P \leq 0.10$ . Data were combined when appropriate. Data from ungrazed pastures were examined with a one-tailed matched paired analysis test with the assumption that spring forage < fall forage.

Binomial analysis of WS plant volume data (yes = less volume post grazing (or in the fall for non-summer grazed treatment); no = same or greater volume) using the equation: [33]

$$[p \pm t_{(0.1)} \text{sqrt}(p(1-p)/n)] \quad (2)$$

was used to determine if grazing intensity treatments impacted individual WS plant volume. In addition, WS plants were separated into two volume classes (<6500 cm<sup>3</sup> and >6500 cm<sup>3</sup>) based on the median WS plant size in grazed pastures and analyzed using two-tailed matched paired t-tests to determine if pre-graze volume impacted cattle interaction with plants.

## 3. Results

### 3.1. Chamberlain

Estimated forage biomass before mob grazing was 6100 and 2840 kg ha<sup>-1</sup> in 2013 and 2014, respectively (Table 3). Stocking density was greater and individual paddock size larger in 2013 (67,200 kg ha<sup>-1</sup> on 5 ha) than 2014 (43,680 kg ha<sup>-1</sup> on 2 ha). Harvest utilization (consumed + trampled) in mob-grazed areas were similar and >90% each year. Harvest efficiency (amount consumed) was also similar and >60% each year.



Site	Year	Treatment	Standing Forage		t test	Trampled forage	Utilization <sup>a</sup>	Efficiency <sup>b</sup>
			Pre-graze	Post-graze		Kg/ha		
Chamb.	2013	Mob	6,100	80	****	2,130	99	64
		Ungrazed <sup>c</sup>	1,190	2,690	****			
	2014	Mob	2,840	160	****	894	94	63
		Rotation <sup>d</sup>	1,980	1,660	*			
Selby	2013	Mob	1,900	1,110	****	505	42	15
		Rotation	2,690	790	****			
	2014	Mob	1,980	240	****	785	88	48
		Ungrazed	470	2,920	****			

\*\*\*Significant at  $p < 0.0001$ , \*significant at  $p < 0.1$

<sup>a</sup>Utilization = forage consumed and trampled, calculated by  $[(\text{pre-graze}) - (\text{post-graze}) / (\text{pre-graze})] \times$

<sup>b</sup>Efficiency = forage consumed, calculated by  $[(\text{pre-graze}) - (\text{post-graze} + \text{trampled forage}) / (\text{pre-graze})]$

<sup>c</sup>Rotationally grazed in 2012

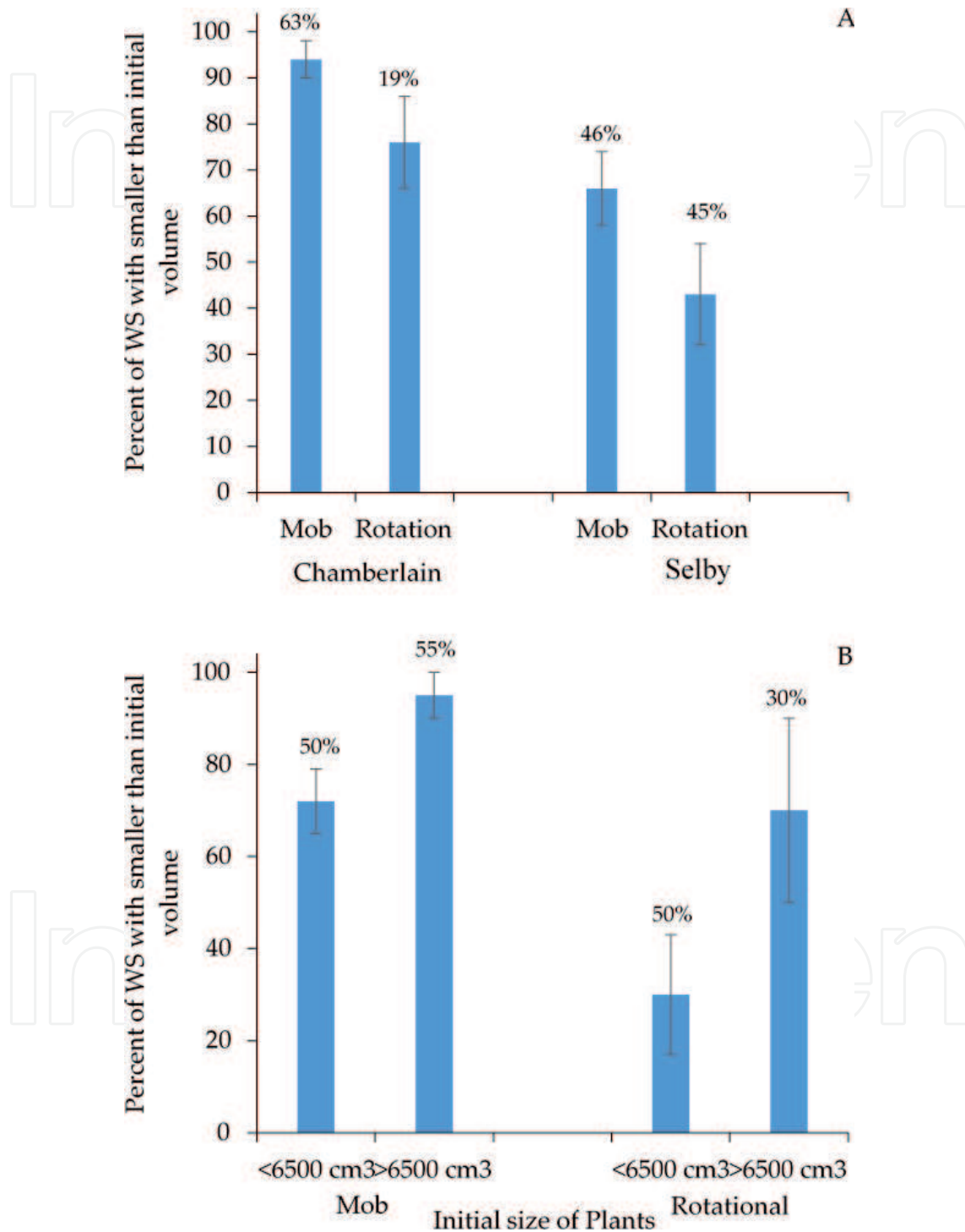
<sup>d</sup>Both sampling dates occurred after rotational grazing

**Table 3.** Impact of pasture management on forage at Chamberlain (Chamb.) and Selby, SD experimental sites in 2013 and 2014.

The comparison pasture was not grazed in 2013 but had been rotationally grazed in 2012. On June 19, forage biomass was estimated at  $1190 \text{ kg ha}^{-1}$ , whereas on August 8, biomass increased to  $2690 \text{ kg ha}^{-1}$  (**Table 3**). Between the first and second sampling there was  $>200 \text{ mm}$  of rainfall. In 2014, the comparison pasture was grazed at a stocking rate of  $250 \text{ kg ha}^{-1}$  from May to mid-June, which was prior to the first sampling. Forage biomass on July 9 and September 13 was similar ( $P = 0.1$ ), averaging about  $1800 \text{ kg ha}^{-1}$ . The apparent lack of growth may be explained by dormancy of the dominant cool season species, lack of rainfall ( $<12 \text{ cm}$ ) between sampling dates, and a grasshopper (*Caelifera* sp.) infestation that consumed forage regrowth.

Response of WS plants to mob grazing was similar in both years, with data combined over years. About 95% ( $\pm 4\%$ ) of the measured plants were reduced post-grazing by an average of 63% (**Figure 2A**). Forage near WS plants was consumed (about 75% less biomass present), rather than trampled, and WS appeared to be browsed (stems and leaves removed). WS plant response in the 2013 ungrazed pasture indicated no difference in WS plant volume between the first and

second sampling ( $P = 0.43$ ). In 2014, WS plants were reduced in volume by about 19% (from 8850 to 7050  $\text{cm}^3$ ) between the first and second sampling dates ( $P = 0.01$ ) even though grazing occurred prior to the first sampling. This was due to a large grasshopper infestation in the area.



**Figure 2.** Percent ( $\pm$ SE) of western snowberry with smaller volume post-graze by grazing system (A), and percent ( $\pm$ SE) of western snowberry with small volume post-graze based on initial size (<6500  $\text{cm}^3$  and >6500  $\text{cm}^3$ ) by grazing system (B). Numbers above bars represent the average volume reduction of western snowberry plants in the respective category.

### 3.2. Selby

Forage at Selby averaged about 1940 kg ha<sup>-1</sup> each year prior to mob grazing (**Table 3**). After the 24-hr grazing event, forage remaining was 1110 kg ha<sup>-1</sup> in 2013 and 240 kg ha<sup>-1</sup> in 2014. Forage consumption and utilization were estimated at 15 and 42%, respectively, in 2013. In 2014, efficiency and utilization were estimated at 48 and 88%, respectively. The three-fold increase in forage consumption (efficiency) in 2014 compared to 2013 may have been due to timing of the grazing. Forage was likely more mature and less palatable for cattle in late September (2013) compared to late July (2014). The increase in both consumption and utilization may have also been due to the slightly higher stocking density in 2014 compared to 2013 (**Table 2**). In the 2013 rotation-grazed pasture, the forage biomass averaged 2690 kg ha<sup>-1</sup> pre-graze and about 790 kg ha<sup>-1</sup> post-graze, with an estimated 70% consumption and utilization, as very little newly trampled biomass was present. In 2014, the ungrazed comparison pasture had about 470 and 2920 kg ha<sup>-1</sup> at the first and second sampling, respectively.

Volume data from WS plants were combined for the 2013 and 2014 mob grazing treatment, with 66% ( $\pm 8\%$ ) of the tagged plants decreasing in volume by 46% after grazing. In the rotational-grazed area, pre- and post-sampling volumes were similar and averaged 15,000 cm<sup>3</sup>. However, 43% of these sampled plants had a 45% reduction in volume, but the remaining plants increased in volume by about 90%. Basal stem counts (data not shown) indicated that WS plants in mob-grazed areas had fewer stems ( $P = 0.001$ ) after grazing, whereas no difference in stem number was observed in rotational-grazed plots. In the 2014 ungrazed pasture, 74% of the tagged plants increased in volume by an average of 5000 cm<sup>3</sup>, a 3000% increase from the first to the second sampling.

### 3.3. Initial WS plant volume and grazing impact

Initial WS plant volume impacted final volume after mob grazing. Mob grazing data, combined by location, indicated that the median plant size was about 6500 cm<sup>3</sup>. When initial plant volume < 6500 cm<sup>3</sup>, 73% ( $\pm 7\%$ ) of these plants had a 42% reduction in volume. However, about 87% ( $\pm 5\%$ ) of the larger plants were reduced in volume by about 62%.

In the early spring rotationally-grazed paddock at Chamberlain (2014), initial volume did not impact final size ( $P = 0.46$ ). About 66% of all plants increased in size an average of 168% ( $\pm 81\%$ ). In the late-season rotation treatment at Selby in 2013, about 50% ( $\pm 13\%$ ) of the small plants were reduced in volume by about 52% (**Figure 2B**), with the remaining plants increasing in volume an average of 150%. About 44% of the large plants were reduced in volume by about 38%, with the remaining plants increasing an average of 37%. While the plant size reduction in the less intensively grazed rotational treatment was similar between the large and small plant classes ( $P = 0.46$ ), the increase in size of the small plants was greater than the size increase of the large plants ( $P = 0.02$ ). This may be due to smaller plants being trampled and stems spread apart thereby increasing the final volume (i.e. plants lost vertical height but both horizontal lengths increased), whereas larger plants may have been more difficult to trample.

These data indicate that WS plants were more impacted by mob grazing compared with plants in paddocks rotationally-grazed early or later in the season. Larger plants in mob-grazed areas tended to be more damaged than smaller plants.

## 4. Discussion

Cattle in NGP mob-grazed settings were more competitive for available forage, and were less selective in consumption, eating vegetation that would normally be avoided in a less intense grazing. The high stocking densities also resulted in more trampling and greater animal impact (e.g. dung deposition, data not shown) per unit area [29]. Other studies have reported similar results in other intensive-grazing systems although terminology [e.g. ultra-high stocking density [23]; intensive stocking [34]; cell-grazing [35]; high intensity, low frequency grazing [36], stocking rates, grazing duration, and seasonal timing often differ. High stocking densities have been shown to maintain animal performance if carefully managed [36]. Lush regrowth during the rest period following an intense grazing event increased forage crude protein (from 8.9 to 10.2%) and digestibility (from 44.6 to 54.7%) compared with more mature forage in less-intensively grazed areas [36]. Timing of grazing events, both within and among seasons on the same parcels, must be carefully controlled as repeated grazing when grass is at a vulnerable growth stage can result in rangeland degradation [37, 38].

Other studies have reported that cattle graze less palatable, weedy species when grazing intensity is high. For example, cattle have browsed prickly pear (*Opuntia macrorhiza*) [39], absinth wormwood [29], and thistles [40], species that are typically avoided in low-intensity grazing. The least desirable species at Australian sites, purple wiregrass (*Aristida ramosa*) and gray tussock-grass (*Poa sieberiana*), decreased 45% in basal diameter in a cell-grazing treatment with a stocking rate of about 35,000 kg ha<sup>-1</sup> and moved every 1–3 days compared with <5% decreases observed in continuously grazed sites [35]. These results suggest that during mob-grazing events, animals will browse less desirable species. In addition, mob-grazing, or similar high stocking-density, low frequency grazing management, has been suggested to maximize forage use [21], aid in maintaining a balance of desirable and undesirable vegetation [41] and may enhance nutrient cycling in the paddock with minimal to no risk to animal gains if properly managed [42, 43]. However, mob-grazing should be strictly managed with recovery periods for forage regrowth to ensure adequate feed. Returns to management can be low for mob-grazing [45] if high stocking densities for long periods reduce average daily gain per animal [46] and may degrade range resources and resilience.

Size of WS plants influenced the efficacy of mob-grazing for weed management. In contrast to absinth wormwood (*Artemisia absinthium*) (AW) where small patches and plants were most affected by mob-grazing [44], larger WS plants were most impacted. Larger WS plants may have leaves closer to the cattle's face, which may facilitate browsing strictly due to convenience, even though the stems are woody. Smaller AW plants, which have herbaceous rather than stiff woody stems, may be more easily trampled and/or consumed.

## 5. Conclusions

Mob-grazing with cattle reduced forage selectivity and utilized undesirable plants compared to low stocking density rotational grazing. Long-term benefits of mob-grazing, while difficult to quantify in short-term studies, can be positive and numerous SD ranchers have adopted

this technique to their advantage. In this study, we realize that stricter control of variables such as stocking density, timing, and pasture size, may have resulted in more repeatable and statistically significant results. However, this research was conducted on working ranches and represents actual producer management decisions based on forage pasture conditions, annual climate, and cattle needs. Therefore, the results may be more applicable to NGP ranchers. Ranchers who are interested in using mob grazing should start small to determine how best to employ this system in their operation. Future research that combines mob-grazing at the most vulnerable stages of weed species growth with other management practices (e.g. herbicide application or pasture fertilization) should be considered. We conclude that mob-grazing can decrease forage selectivity and be a useful tool in for integrated weed management of WS, especially for plants larger than 6500 cm<sup>3</sup> in the NGP.

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## References

- [1] Manske LL. Western snowberry biology [Internet]. 2006. Available from: [www.ag.ndsu.edu/archive/dickinso/research/2005/PDF/range05a.pdf](http://www.ag.ndsu.edu/archive/dickinso/research/2005/PDF/range05a.pdf) [Accessed: 2017-07-01]
- [2] DiTomaso JM. Invasive weeds in rangelands: Species, impacts, and management. *Weed Science*. 2000;**48**:255-265
- [3] Pelton J. Studies of the life-history of *Symphoricarpos occidentalis* hook in Minnesota. *Ecological Monographs*. 1953;**23**:17-39

- [4] Pimentel D, Zuniga R, Morrison D. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics*. 2005; **52**:273-288
- [5] Popay I, Field R. Grazing animals as weed control agents. *Weed Technology*. 1996; **10**: 217-231
- [6] Frid L, Hanna D, Korb N, Baver B, Bryan K, Martin B, et al. Evaluating alternative weed management strategies for three Montana landscapes. *Invasive Plant Science and Management*. 2013; **6**:48-59
- [7] Bowes GG, Spurr DT. Improved forage production following Western snowberry (*Symphoricarpos Occidentalis* hook.) control with Metsulfuron methyl. *Canadian Journal of Plant Science*. 1995; **75**:935-940
- [8] Romo JT, Grilz PL, Redmann RE, Driver EA. Standing crop, biomass allocations patterns and soil-plant water relations in *Symphoricarpos occidentalis* hook. Following autumn or spring burning. *American Midland Naturalist*. 1993; **130**:106-115
- [9] Sbatella GM, Wilson RG, Sleugh B. Western snowberry (*Symphoricarpos occidentalis*) control with aminopyralid and metsulfuron. *Weed Technology*. 2011; **25**:616-619
- [10] McCarty MK. Control of Western snowberry in Nebraska. *Weeds*. 1967; **15**:130-133
- [11] Masters RA, Sheley RL. Principles and practices for managing rangeland invasive plants. *Journal of Range Management*. 2001; **54**:502-517
- [12] Bailey AW, Irving BD, Fitzgerald RD. Regeneration of woody species following burning and grazing in Aspen Parkland. *Journal of Range Management*. 1990; **43**:212-215
- [13] Smart AJ, Daniel J, Bruns K, Held J. Browsing of Western snowberry by goats and sheep. *Sheep and Goat Research Journal*. 2006; **21**:1-5
- [14] Smart AJ, Troelstrup NH Jr, Bruns KW, Daniel JA, Held JE. Western snowberry response to fire and goat browsing. *Sheep and Goat Research Journal*. 2007; **22**:20-25
- [15] Sahlu T, Dawson LJ, Gipson TA, Hart SP, Merkel RC, Puchala R, et al. ASAS centennial paper: Impact of animal science research on United States goat production and predictions for the future. *Journal of Animal Science*. 2009; **87**:400-418
- [16] Frost RA, Launchbaugh KL. Prescription grazing for rangeland weed management: A new look at an old tool. *Rangelands*. 2003; **25**:43-47
- [17] Fishel F. Plants poisonous to livestock. Bulletin G-4970 University of Missouri Extension
- [18] MacDiarmid BN. Cattle dung patch 3. Distribution and rate of decay of dung patches and their influence on grazing behavior. *Journal of the British Grassland Society*. 1972; **27**:48-54
- [19] Marten GC, Donker JD. Selective grazing induced by animal excreta I. Evidence of occurrence and superficial remedy. *Journal of Dairy Science*. 1964; **47**:773-776

- [20] Anderson VJ, Briske DD. Herbivore-induced species replacement in grasslands: Is it driven by herbivory tolerance or avoidance? *Ecological Applications*. 1995;**5**:1014-1024
- [21] Savory A, Butterfield J. *Holistic Management: A Commonsense Revolution to Restore our Environment*. 3rd ed. Washington, DC: Island Press; 2016. 552 p. ISBN: 9781610917438
- [22] Gordon, K. Mob Grazing 101 [Internet]. 2011. Available from: [hereford.org/static/files/0111\\_MobGrazing.pdf](http://hereford.org/static/files/0111_MobGrazing.pdf) [Accessed 2017-05-01]
- [23] Hafla AN, Soder KJ, Hautau M, Rubano MD, Mayer B, Stout R. Case study: Dairies using self-described ultra-high stocking density grazing in Pennsylvania and New York. *The Professional Animal Scientists*. 2014;**30**:366-374
- [24] Fuhlendorf SD, Engle DM. Restoring heterogeneity on rangelands: Ecosystem management based on evolutionary grazing patterns. *Bio Science*. 2001;**51**:625-632
- [25] Barnes MK, Norton BE, Maeno M, Malechek JC. Paddock size and stocking density affect spatial heterogeneity of grazing. *Rangeland Ecology and Management*. 2008;**61**:380-388. DOI: 10.2111/06-155.1
- [26] Bailey DW, Brown JR. Rotational grazing systems and livestock grazing behavior in shrub-dominated semi-arid and arid rangelands. *Rangeland Ecology and Management*. 2011;**64**:1-9
- [27] Pleasants AB, Shorten PR, Wake GC. The distribution of urine deposited on a pasture from grazing animals. *Journal Agricultural Science*. 2006;**145**:81-86
- [28] Frank DA, McNaughton SJ. Evidence for the promotion of aboveground grassland production by native large herbivores in Yellowstone National Park. *Oecologia*. 1993;**96**:157-161
- [29] Myer H. Mob grazing as a perennial weed management tool in South Dakota grazing lands [thesis]. Brookings, SD: South Dakota State University; 2015
- [30] NRCS Grazing or Pasture Stick: Instructions for Using [Internet]. 2013. Available from: [file:///C:/Users/hxm5183/Downloads/PASTURE\\_STICK4.pdf](file:///C:/Users/hxm5183/Downloads/PASTURE_STICK4.pdf) [Accessed: 2018-04-01]
- [31] Heady HF, Child RD. *Rangeland Ecology and Management*. Boulder, CO: Westview Press; 1994. p. 544
- [32] Hewitt GB, Burleson WH, Onsager JA. Forage losses caused by the grasshopper *Aulocara ellotti* on shortgrass rangeland. *Journal of Range Management*. 1976;**29**:376-380
- [33] Steel RGD, Torrie JH. *Principles and Procedures of Statistics*. 2nd ed. New York: McGraw-Hill, Inc.; 1980. ISBN 0-07-060926-8
- [34] Brock BL, Evans L, Owensby CE. Spatial and temporal grazing patterns on intensive-early stocked and season-long stocked pastures. *Crop Forage and Turfgrass Management*. 2017;**3**. DOI: 10.2134/cftm2016.00016
- [35] Earl JM, Jones CE. The need for a new approach to grazing management—Is cell grazing the answer? *Rangeland Journal*. 1996;**18**:327-350

- [36] Taylor JCA, Kothmann MM, Merrill LB, Elledge D. Selection by cattle under high-intensity low-frequency, short duration, and Merrill grazing systems. *Journal of Range Management*. 1980;**33**:428-434
- [37] Ellison L. Influence of grazing on plant succession of rangelands. *The Botanical Review*. 1960;**26**:1-78
- [38] Manske LL. General description of grass growth and development and defoliation resistance mechanisms. NDSU Dickinson Research & Extension Center: Range Management Report DREC. 1998;**98-1022**:12
- [39] DeLoach CJ. Past successes and current prospects in biological control of weeds in the United States and Canada. *Natural Areas Journal*. 1991;**11**:129-142
- [40] DeBrujin SL, Bork EW. Biological control of Canada thistle in temperate pastures using high density rotational cattle grazing. *Biological Control*. 2006;**36**:305-315
- [41] Taylor JCA, Brooks TD, Garza NE. Effects of short duration and high intensity, low-frequency grazing systems on forage production and consumption. *Journal of Range Management*. 1993;**46**:118-121
- [42] Biondini ME, Manske L. Grazing frequency and ecosystem processes in a Northern Mixed Prairie, USA. *Ecological Applications*. 1996;**6**:239-256
- [43] Taylor CA, Kothmann MM, Merrill LB, Elledge D. Selection by cattle under high-intensity low frequency, short duration, and Merrill grazing systems. *Journal of Range Management*. 1980;**33**:428-434
- [44] Myer H, Smart A, Ohrtman M, Clay D, Clay SA. Mob vs rotational grazing: Impact on forage use and absinth wormwood (*Artemisia absinthium*). In: *Forages*. InTech; 2018. (in review)
- [45] Janssen L, McMurtry B, Stockton M, Smart A, Clay S. An economic analysis of high-intensity, short-duration grazing systems in South Dakota and Nebraska. In: *Proceedings of the Agricultural & Applied Economics Association*; 26-28 July 2015; San Francisco. 2015. pp. 2-28
- [46] Smart AJ, Derner JD, Hendrickson JR, Gillen RL, Dunn BH, Mousel EM, et al. Effect of grazing pressure on efficiency of grazing on North American Great Plains rangelands. *Rangeland Ecology and Management*. 2010;**63**:397-406



