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Case Study: Dairies using self-described ultra-high stocking density grazing in Pennsylvania and New York[1]

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ABSTRACT

Proponents of ultra-high stocking density (UHSD) grazing emphasize increased forage-use efficiency and soil improvement by grazing mature forage with stocking densities up to 560,425 kg/ha of beef cattle on small paddocks with rest periods up to 125 d. However, it is unclear whether this management technique is appropriate for dairy farms in the northeastern United States. A case study was conducted to characterize management practices and forage and soil quality on dairy farms using self-described UHSD grazing. Data collected on 4 organic dairy farms in Pennsylvania and New York practicing UHSD grazing included pasture and soil nutrient analyses, stocking density, botanical composition, and pasture stratification. Herds were mixed breed with milk yields ranging from 11.9 to 17.7 kg/d per cow. Stocking density ranged from 49,421 to 377,912 kg/ha with 30 to 49 d of forage rest. Forage consumed was 46 and 45% of total available in 2012 and 2013, respectively. Within the available forage that was eaten, cows consumed 75% of forage from layers 33 cm and higher and 49% from below 33 cm. Across years, forage CP, NDF, and NE_l averaged 24%, 44.7%, and 1.43 Mcal/kg, respectively. The increase in forage quality during 2012 was likely a result of forage being less mature at each successive grazing. Soil mineral content and pH were within recommended levels. Grazing dairies in Pennsylvania and New York have taken a modified approach to UHSD grazing by using forages more mature than recommended in management-intensive grazing systems by allowing longer periods of forage rest.

Key words: ultra-high stocking density, dairy, grazing, forage quality

INTRODUCTION

Management intensive grazing (**MiG**) is a flexible form of rotational grazing where the goal is to maintain the pasture sward in a productive vegetative state throughout the grazing season (Blaser, 1986) while providing optimal forage production and use per unit of area (Heckman et al., 2007). A variation of MiG that has recently gained interest on grazing farms is referred to as ultra-high stocking density (**UHSD**) grazing. This grazing approach uses high stocking density (BW/units area; up to 560,000 kg/ha) to graze small areas of mature forage (Salatin, 2008) for short durations and is characterized with long forage recovery periods (25 to 150 d; Hancock, 2010; Lemus, 2011). Anecdotal observations of increased profitability (via increased carrying capacity), improved animal performance, improved forage species diversity, and increased soil quality (improved soil OM, improved microbial action, greater water-holding capacity; Earl and Jones, 1996; Judy, 2008; Salatin, 2008) have been promoted with the implementation of UHSD grazing using beef cattle. The idea of greater economic sustainability by increasing the number of animals grazing with little fixed cost investments (fencing and water), while simultaneously improving the condition of the land (Savory, 1983), is appealing to all sectors of livestock graziers. However, much of the current information on UHSD grazing systems refers to beef cattle in semi-arid rangeland environments (Savory and Parsons, 1980; Holechek et al., 2000). Several dairy farmers in the northeastern United States have implemented components of UHSD

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grazing systems that were initially promoted for beef cattle. However, nutrient requirements of dairy cattle differ from beef cattle (NRC, 2000; 2001), and grazing management varies widely among farms. As a result, anecdotal outcomes from adopting UHSD grazing on dairy farms have ranged from self-described success to failures with severe losses in milk production, animal health, and farm profitability. Currently, there are no established science-based guidelines to assist dairy farmers and their farm consultants in adopting UHSD grazing. Therefore, the objective of this case study was to characterize management practices and forage and soil quality parameters on grazing dairy farms in Pennsylvania and New York that are using self-described UHSD grazing management.

MATERIALS AND METHODS

Four organically certified dairy farms (3 in Pennsylvania and 1 in New York) participated in this study. The dairy farmers selected were self-described UHSD graziers and were initially surveyed to capture their experience and management practices. In June 2012, one pasture on each farm was identified to be the sample pasture. The pastures selected had been managed under UHSD grazing before this grazing season and were representative of pastureland on each farm. Farm and pasture management information was gathered using a detailed survey given to each farmer to describe intended grazing management practices and animal production.

Farm visits occurred each time the study pastures were grazed from June to November of 2012 and from April to June of 2013. Sampling encompassed 2 yr to capture data from all months throughout the grazing season, because project funding did not become available until June of 2012 and delayed the initiation of sampling early in the grazing season. Data collected during each farm visit, immediately before grazing, included number of cows grazing, measurements of pregrazed forage height, canopy stratification, botanical composition, and samples for forage-quality analyses. Forage samples were plucked by hand to the approximate height the cows were grazing from representative spots within the pasture (n = 20), composited, and frozen before shipment to an independent laboratory for analysis of nutrient content (Dairy One Forage Analysis Laboratory, Ithaca, NY). Forage height was recorded on a diagonal transect of the sample pasture using a meter stick at 25 points. Stratification of the forage canopy was measured by the herbage-gripping stratification method described by Barthram et al. (2000) to estimate the vertical level at which cows were consuming the most forage and to document forage utilization. This method uses rubber-lined, narrow boards (50 × 5 × 1 cm) that are inserted into the sward at ground level and then clamped together capturing a section of forage that is then clipped off at ground level. This section of forage was placed on a template and cut every 7 cm, with the 0- to 5-cm section discarded because of contamination of forage sample with soils. The forage from each vertical level was dried in a forced-air oven at 60°C for 48 h and weighed for DM content. Five stratification clippings were taken from both pregrazed and postgrazed areas within the sampling pasture. Botanical composition was estimated twice during the 2012 grazing seasons for all farms, once for 2 farms in 2013, twice for 1 farm in 2013, and was not recorded for 1 farm in 2013. Botanical compositions of the pastures were estimated visually using the step-point method at 50 points within the sample pasture (Little and Frensham, 1993).

In May 2013, 6 soil cores (20 cm deep) were taken along a diagonal transect from within the sample pasture on each farm. The cores were composited, and a subsample was sent for nutrient analyses and OM content (Ag Analytical Lab, University Park, PA). Monthly historic (1981–2010) precipitation averages and total monthly accumulated precipitation were acquired from the closest available National Climatic Center weather stations (www.ncdc.noaa.gov; accessed July 23, 2013), located 8 to 48 km from the Pennsylvania and New York farms that participated in this study.

Forage height, canopy stratification, botanical composition, and forage quality data were transferred to Microsoft Excel files and summarized. Forage quality was analyzed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC), with month as fixed effect, farm as random, and least squares means reported. Differences in forage-quality measures were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

General Farm Information

Descriptions of farms used in this study as reported by the farmers in the survey given at the initiation of data collection in 2012 are presented in Table 1. All farms in this study were certified organic. It is important to note that certified organic dairy farmers may be more apt to adopt a grazing management strategy, such as UHSD, because of certification rules requiring animals to graze and emphasis on soil health. However, there are noncertified organic dairies that also have the same emphases; therefore, this grazing strategy is not limited to organic dairies. Total herd size ranged from 60 to 270 (mean = 178) mixed-breed dairy cows and milk yields ranged from 11.9 to 17.7 kg/d per cow. Cows spent an average of 20 h on pasture daily. Farm 1 milked once daily and farms 2, 3, and 4 milked twice daily. However, farm 2 reported switching to milking once daily when cows were grazed on more distant pastures (up to 2.40 km from parlor). Total pasture area on the farms ranged from 81 to 251 ha. Stored forages produced on the farms included grass and legume hay and grass and legume silages, haylages, and baleages. Three of the 4 farms reported feeding purchased molasses as an energy supplement, and farm

Table 1. Results of farmer survey distributed at the initiation of data collection in 2012 to describe the farms practicing self-defined ultra-high stocking density grazing and to evaluate farmer-intended management goals

Item	Farm 1	Farm 2	Farm 3	Farm 4
Farm description				
Pasture, ha[1]	251	97	105	81
Milking cows, no.	270	60	235	145
Milk yield/cow, kg/d	11.9	17.7	13.5	17.0
Grazing practices				
Grazing cycle, d	28 to 30	When rested[2]	28 to 35	35
Forage remaining	30%	30–50%	30–40%	40%
Moves/d[3]	1	2 to 5	2 to 3	2
Hours on pasture	20	20	20	20
Distance to barn, km	0.31	0.06 to 2.40	0.08 to 0.81	0.06 to 1.21
Supplemental feeding				
Stored feeds, if any[4]	Hay	Silage	Hay + silage	Silage + baleage
Purchased feeds	Salt and mineral	Molasses	Molasses	Molasses
Graze in winter?	Weather dependent	Until Dec.	No	No

[1]Total hectares of pasture on farm, that may be available to all classes and types of livestock, depending on management.

[2]Uses holistic resource management grazing chart.

[3]Times per day cows are given access to fresh pasture.

[4]All hays, silages, and baleages were composed of grasses and legumes. No grain silages were used on these farms.

1 reported purchasing only salt and minerals because they were a forage-only farm. All farms milked during the winter; however, farm 4 dried off all but 60 cows to reduce conserved feed costs. Farms 3 and 4 did not graze in the winter months and fed only conserved feeds. Farm 1 reported that winter grazing was weather dependent but generally fed dry hay from December to March. Farm 2 kept cows outside where they consumed stockpiled forage until December, at which time they were provided with grass and legume silage.

Years of grazing experience ranged from 15 to 27 yr, with 3 of the 4 farmers having ≥20 yr of experience. Generally, the participating farmers reported that they intended grazing cycles to be 28 to 35 d, and one farmer noted using a holistic resource management grazing chart (Holistic Management International, 2014) to determine when to graze. Farmers reported that the goal was to leave behind 30 to 50% of the forage after grazing. These goals fall between recommendations for MiG (Ball et al., 2007) and anecdotal recommendations made for UHSD with beef cattle (Judy, 2008), the latter suggesting 60% of forage be consumed, 20% trampled, and 20% left standing. The participating farms had been using some form of UHSD grazing for 2 to 8 yr. Their reasoning for adopting UHSD grazing included savings of labor and machinery, continuing to provide a forage diet to cows, perception of a natural system, and matching the productivity of the soil to a forage cropping system.

Botanical composition varied across farms (Figure 1). Sample pastures on farms 1, 3, and 4 were dominated by legumes, with 46, 68, and 47% of the total species composition composed of white clover (*Trifolium repens* L.) and red clover (*Trifolium pretense* L.). Alfalfa (*Medicago sativa* L.) was an important grazing species on farm 3. Cool-season grasses were the dominant species in the sample pasture on farm 2, comprising 48% of the total species composition. Orchard grass (*Dactylis glomerata* L.), reed canary grass (*Phalaris arundinacea* L.), and tall fescue (*Festuca arundinacea* S.) were the dominant grass species on all farms. Plant litter (composed of dead and green material) ranged from 0 to 7% within the sample pastures before each grazing event.

Observed Self-Described UHSD Grazing Practices

Data collected from the forage pastures managed under self-described UHSD grazing in 2012 and 2013 are presented in Table 2. The pastures sampled were 1.05, 0.55, 0.21, and 0.40 ha on farms 1, 2, 3, and 4, respectively. The sample pastures represented a single allotment of fresh pasture, and cows were offered fresh pasture 1 to 5 times daily, depending on the farm. It was difficult to determine how much forage was allotted per movement (within day) because the farmers did not regularly back fence to prevent cows from regrazing areas offered earlier that day. Therefore, the data presented in this study is for a single allotment of pasture, and cows may have had access to previously grazed areas all day, for a few hours, or not at all depending on farm management. Farm 1 only moved cows once daily; however, they also only milked once daily when cows grazed far from the parlor. Recovery time for the sample pastures ranged from 30 to 49 d. The farmers commented that daily pasture allotment was dependent on a visual estimate

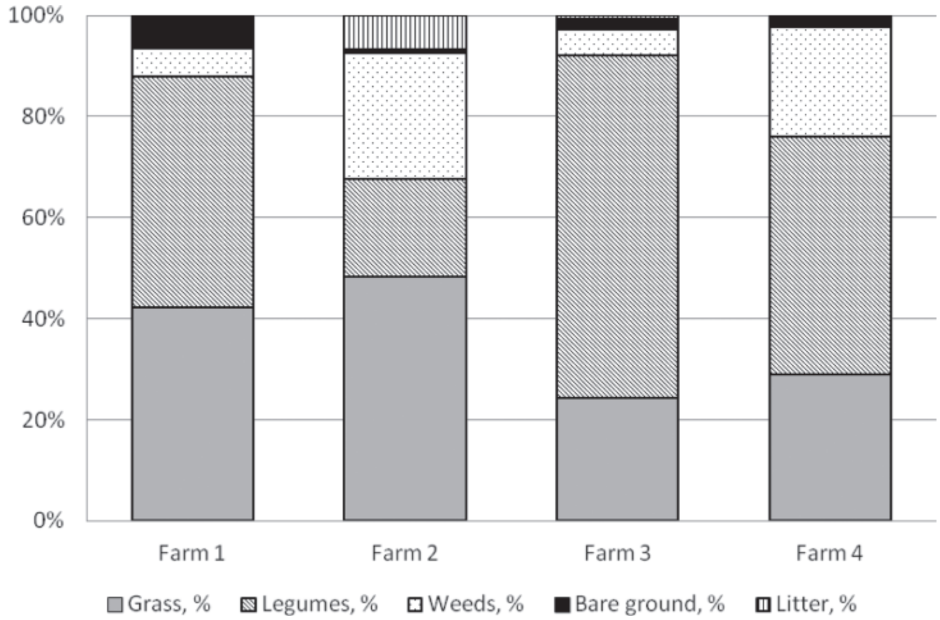

Figure 1. Botanical composition for farms with pastures managed using self-described ultra-high stocking density grazing. Botanical compositions of the pastures were estimated visually using the step-point method at 50 points within the sample pasture (Little and Frensham, 1993). No botanical composition estimates were included for the year of 2013 for farm 2.

of available forage before grazing, the number of cows grazing, and how many animals were stocked on the pasture in previous years. Farmers reported increasing the frequency in which cows were offered fresh forage within a day when forage quality was assumed to be low in an effort to match animal requirements with the nutrients provided by the pasture.

Stocking density ranged from 49,421 to 377,912 kg/ha, across the farms. These stocking densities were generally lower than indicated by proponents of this grazing method with beef cattle (112,085 to 560,425 kg/ha; Judy, 2008). This may be due to several reasons, including slight modification of (but not complete deviation from) traditional MiG practices regarding stocking densities of lactating dairy cows, or less forage available than in some of the beef models where regrowth periods are much longer.

Savory and Parsons (1980) suggested that animal effect through hoof action of dense populations of animals improves water penetration of the soil and increases plant succession in Africa. However, a review of the literature by Holechek et al. (2000) examined various studies conducted with short duration grazing on semiarid rangeland conditions with beef cattle and sheep in the Great Plains and concluded that the hoof action of livestock grazing in high-animal-density situations may actually lower water infiltration (increase bulk density of soils) and increase erosion of rangeland soils. Soil characteristics in the Great Plains differ from the temperate northeastern United States, which often contain clay and shale soils that may have increased compaction issues with high levels of hoof action (Ball et al., 2007). Additionally, the greater

Table 2. Observed grazing strategies of dairy farmers in Pennsylvania and New York practicing self-defined ultra-high stocking density in 2012 and 2013

	Dairy farms in PA and NY			
Item	**Farm 1**	**Farm 2[1]**	**Farm 3**	**Farm 4**
Sample pasture size,[2] ha	1.05	0.55	0.21	0.40
Cows grazing,[3] no.	100 to 145	50	135 to 149	200
Fresh pasture allotment, ha/cow	0.01	0.01	<0.01	<0.01
Stocking density,[4] kg/ha	51,902 to 75,257	49,421	342,404 to 377,912	268,850
Average days between grazing	39	49	30	39
Forage height at grazing 2012, cm	22	20	26	24
Forage height at grazing 2013, cm	44	—	43	24
Forage consumed 2012,[5] % DM	55	—	24	59
Forage consumed 2013,[5] % DM	100	—	25	9

[1]No stratifications collected on farm 2. No forage height on farm 2 in 2013.

[2]Estimated hectares for each offer of fresh pasture.

[3]Cow numbers varied across the 2 yr of the study.

[4]Estimated assuming 544-kg cows.

[5]Estimated using pre- and postgrazed stratifications. Total % DM consumed for farm 1 in 2013 was considered 100%, because the small amount of residue left was old plant material.

levels of precipitation found in the northeastern United States compared with the above studies may result in pugging and mudding of pastures with high levels of hoof action.

Descriptions of UHSD grazing under midwestern United States beef grazing systems have indicated periods of forage rest ranging from 25 to 150 d (Judy, 2008), with short rotations occurring early in the growing season when forage regrowth is rapid and the long rotations occurring later in the season, as ensuring that the plants are fully “rested” and the roots fully regrown is the ultimate goal. The farmers participating in the current study all noted that unusually dry conditions in 2012 (Figure 2), coupled with the summer slump, or seasonal decrease in forage growth, required them to return to the sample pastures sooner than anticipated. As all farms in this study were certified organic, they were required to maintain 30% DMI from pasture to comply with organic certification standards (USDA-National Organic Program). Traditional recommended forage rest periods (dependent on environment) to maximize forage yield and quality for some species under MiG systems during periods of rapid growth include 15 to 30 d for orchardgrass, fescue, and grazing alfalfas and 7 to 20 d for clovers (Ball et al., 2007). Longer rest periods between grazing will allow greater amounts of available forage to accumulate through regrowth; however, as forage becomes more mature, increased lignin and cellulose content limit intake and digestibility (Van Soest, 1994). Furthermore, forage leaves have an approximate lifespan of 30 to 60 d, and over time the rate of leaf tissue loss to aging and decomposition increases, resulting in a high proportion of dead leaves in an ungrazed pasture (Ball et al., 2007).

Forage height at grazing averaged 23 cm across the farms in 2012 and 37 cm across 3 farms in 2013. The shorter grazing height observed in 2012 is likely related to less total forage availability due to below-normal precipitation in Pennsylvania and New York, especially early in the grazing season (Figure 2). The forage heights at grazing observed in this study were slightly taller than those recommended for MiG systems for dairy herds in the northeastern United States (15 to 20 cm; Sullivan et al., 2000) to maintain high forage quality and optimize utilization. As plants mature, the leaf-to-stem ratio changes, favoring more stems and less leaves (Ball et al., 2007). Leaves provide higher-quality feed compared with stems, and young green leaves have greater forage quality compared with old dead stems; therefore, current MiG recommendations are to keep available forage in a leafy state throughout the grazing season to ensure optimal nutritional quality of forage. Current recommendations for UHSD grazing management with beef cattle promote grazing tall, mature pasture, where the resulting ratio of leaves to stems will shift to favor more stems and more mature leaves, thereby decreasing overall forage quality. Although this may be beneficial to a certain degree in binding soluble protein into a more slowly degraded protein form (Van Soest, 1994), allowing forages to become too mature will result in lactating dairy cows filling up on fiber before meeting nutrient needs, particularly energy, which in turn may result in impaired milk production (Kolver and Muller, 1998). Graziers using any grazing management practice must establish a balance between total available forage and forage quality to ensure optimum milk production. The UHSD grazing strategy results in greater forage availability, but forage quality may be reduced. Matching the nutrient requirements of the animals with nutrients available from the forage may be where some dairy farmers have fallen short with UHSD grazing as they learn the art of this grazing system to balance available nutrients without negatively affecting productivity in any aspect of the system (animal, forage, soil).

Averaged across all farms, cows consumed 46 and 45% of total available DM in 2012 and 2013, respectively. Farm 1 was considered to have 100% of total available DM consumed in 2013 (Table 2), as the small amount of postgrazing residual was dead plant material. This was due to heavy grazing on this farm early in the spring because this farmer was experiencing a shortage of stored forage at the time. This management contrasts with the limited UHSD grazing recommendations available for

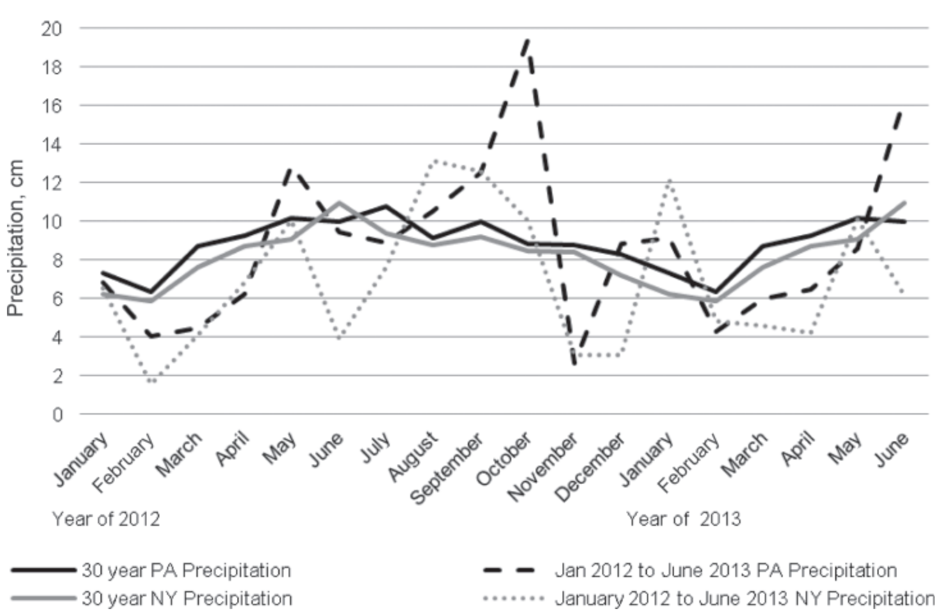

Figure 2. Monthly historic (1981–2010) precipitation averages and total monthly accumulated precipitation in 2012. Weather data were acquired from the closest National Climatic Data Center (www.ncdc.noaa.gov) weather stations available, located 8 to 48 km from Pennsylvania and New York farms that participated in this study.

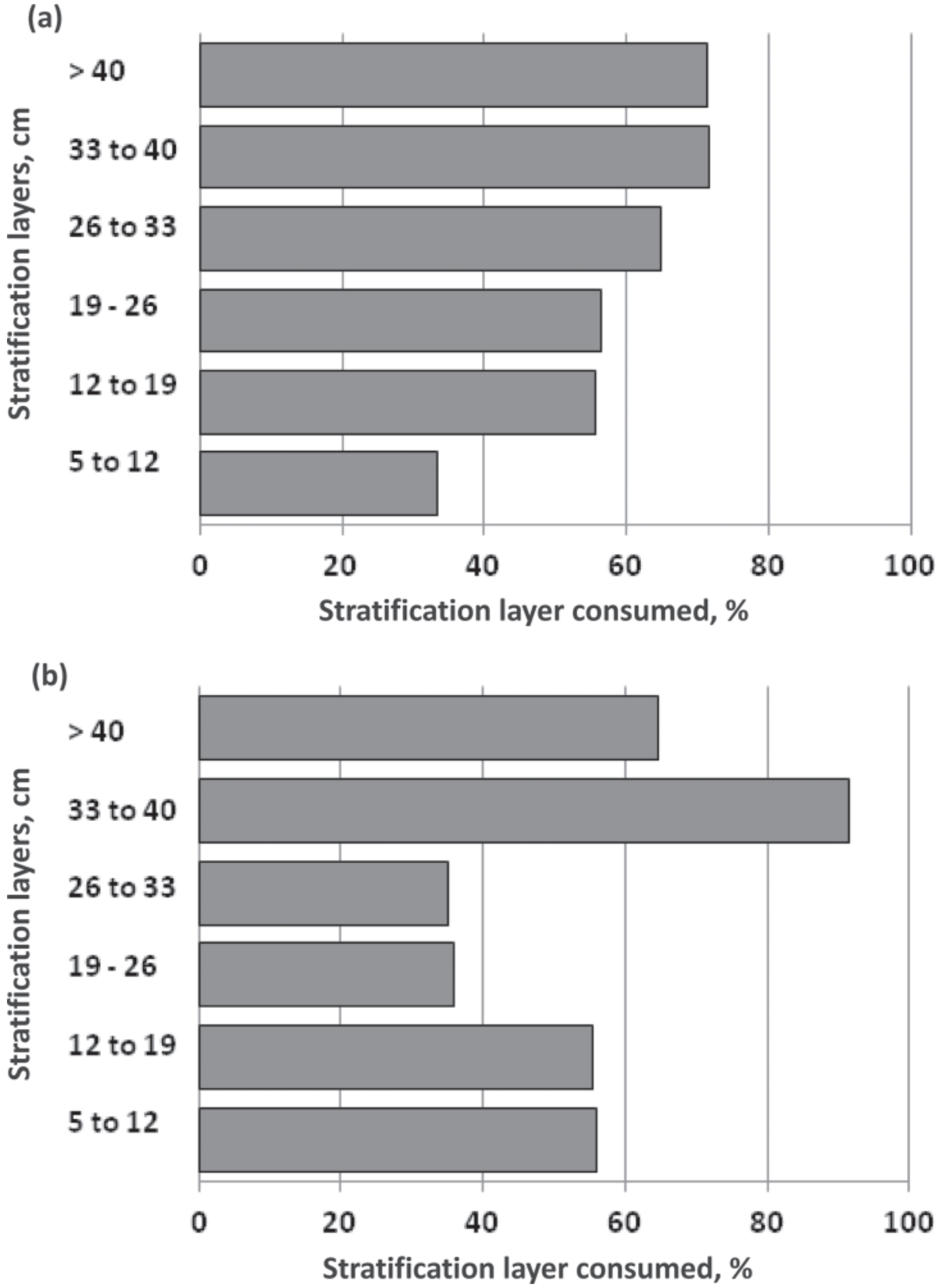

Figure 3. Percentage of each stratification layer consumed during self-described ultra-high stocking density grazing in 2012 (left) and 2013 (right), respectively. Yearly data were averaged across 3 farms and 4 samplings. Total DM% consumed was 45 and 46%, respectively. Stratification samples were unavailable for farm 2 in both years.

beef systems (e.g., Judy, 2008) that promote greater levels of residual to be trampled into the soil to provide nutrients for the invertebrate population, to hold moisture in the soil, and to provide litter to improve the OM of the soil.

Percent of stratified layers consumed during 2012 and 2013 are shown in Figure 3. As expected, the most forage was consumed from the upper layers of the forage canopy where there would be a greater proportion of vegetative leaves, as opposed to the layers closer to the ground that would contain older leaves, dead material, and stem. Cows consumed an average 75% of forage from layers 33 cm and higher and an average of 49% from layers below 33 cm, averaged across farms.

Sanderson et al. (2006) reported that total percentage of forage consumed ranged from 42 to 49% in orchardgrass–white clover pastures grazed by lactating dairy cows in a MiG system, which was comparable to forage disappearance in the current study. Sanderson et al. (2006) also reported a comparatively greater level of defoliation in the upper layers of pasture swards, such that the top 2 to 3 layers (19 to 33 cm) were almost completely removed. Because CP increased from 14.4% of DM in the basal layer to 26.6% of DM in the >33-cm layer, whereas NDF correspondingly decreased from 66.0 to 55.6% of DM between those same layers (Sanderson et al., 2006), it would seem reasonable that cows would actively select for those upper canopy layers (Forbes and Hodgson, 1985). In a companion study to Sanderson et al. (2006), total forage CP and NDF were reported to be 22.5 and 38.7% of DM, respectively (Soder et al., 2006). Whereas total forage CP was similar between the study by Soder et al. (2006) and the current study, total forage NDF was slightly higher in the current study, which could suggest slightly more mature forage. Despite different grazing styles, forage heights as well as nutrient content were fairly similar between MiG reported by Sanderson et al. (2006) and the current study. This would suggest that UHSD grazing systems adopted by dairy graziers in Pennsylvania and New York are not drastically different from MiG; rather, they are slight modifications of the MiG system adapted to their individual farms.

Nutrient Composition of Pastures

A summary of nutrient composition, averaged by farm, of pastures managed with self-described UHSD grazing in Pennsylvania and New York is presented in Table 3. Overall, pasture quality was high; however, there was wide variation in pasture quality across the farms and throughout the grazing season. Pasture CP ranged from 14.2 to 32.2% and NDF ranged from 33.6 to 60.0% across all farms and throughout the grazing seasons. These variations likely reflect differences in botanical composition and seasonal effects on forage quality and emphasize the importance of regular forage-quality testing of pastures. Phosphorus, Ca, K, and Mg concentrations of forages were within the range typical for forages in this region (Soder and Stout, 2003), and all were adequate or in excess of requirements for lactating dairy cows producing 25 kg of milk (NRC, 2001). Forage K was observed to be greater than NRC recommendations (NRC, 2001) on farm 4. High dietary K concentrations in the diet of late prepartum dairy cows, with the potential for high milk production, can predispose the animal to milk fever (Goff and Horst, 1997). Forage K has been found to increase with increasing levels of dairy slurry application, which is a common fertilization practice on pastures in the northeastern US (Soder and Stout, 2003).

Forage quality increased ($P <$ 0.05) from June to September 2012, as characterized by an increase in CP and NE_l and a decrease in NDF (Figure 4). The increase in forage quality may be a result of the pasture being in a less mature stage of growth at each successive grazing. From April to June of 2013 forage quality decreased ($P < 0.05$) and coincided with the increase in environmental temperature, typical for that time of year. The increase in forage quality throughout the grazing season is favorable for meeting the nutritional requirements of lactating dairy cows; however, altering forage quality and maturity through repeated grazing may also be achieved through MiG, where the goal is to maintain forage in the vegetative state. It is important to note that CP and NDF values of forage from pastures managed with self-described UHSD grazing were within range of previously published values from MiG-managed pastures in Pennsylvania and New York (Kolver and Muller, 1998; Soder and Muller, 2007). However, NE_l values were observed to be slightly lower in this study compared with those reported by Soder and Muller (2007) and Kolver and Muller (1998).

Much of the current information available on UHSD grazing refers to beef cattle grazing rangeland (Savory and Parsons, 1980; Judy, 2008) in contrast to pastures in the northeastern United States where soils, climate, and forages are much different. Additionally, forgiveness in the system for making mistakes in nutrient intake is much different between beef and dairy systems. Daily requirements for consistent, high-quality forage may be more flexible in beef cattle systems (especially stocker systems) where the goal is ADG over a period of time. In comparison, the goal in grazing dairy systems is to optimize daily milk production. If forage quality or forage availability is inadequate, this effect is quickly reflected in the bulk tank and resulting milk check. For these reasons, maintaining consistent nutrient intake on a daily basis is critical, albeit challenging, in grazing dairy systems. With UHSD grazing where more mature forages are fed, overestimating nutrient intake can quickly affect profitability in grazing dairy systems; therefore, a high level of management is needed to successfully transition to a UHSD grazing system. Furthermore, when adapting new management techniques to a region, farmer training for field diagnosis, monitoring, and control are necessary, and the learning curve and adjustment to intensive management may result in reduced animal performance during the learning period (Savory, 1983).

Soil Parameters

Soil parameters of pastures managed with self-described UHSD grazing are presented in Table 4. Soil mineral content and pH of all farms were within recommended levels for this region (Penn State Agricultural Analytical Services Laboratory, University Park, PA). Organic matter values were as expected for pastures in the northeastern United States but did not exceed values typical for this region (Sanderson and Goslee, 2005), despite claims that UHSD grazing contributes to the rapid accumulation of soil OM, within just a few years (Earl and Jones, 1996; Judy, 2008; Salatin, 2008). Farm 4 noted that soil has historically been high in pH and K, and that boron, gypsum, and Ca is applied each year. Soil K was high on

Table 3. Summary of nutrient composition (as % of DM) of pastures managed with self-described ultra-high stocking density grazing in Pennsylvania and New York[1]

Item	Farm 1	Farm 2	Farm 3	Farm 4	Mean[2]	SD	Min[2]	Max[2]
CP, %	21.9	19.9	25.6	26.6	24.0	4.49	14.2	32.2
NDF, %	47.2	53.6	43.0	44.7	46.2	7.39	33.6	60.0
NE_l, Mcal/kg	1.42	1.31	1.47	1.46	1.43	0.11	2.21	1.61
Ca, %	0.75	0.76	0.93	0.76	0.81	0.19	0.38	1.26
P, %	0.40	0.46	0.39	0.39	0.40	0.05	0.32	0.49
K, %	2.71	2.22	2.93	3.69	2.98	0.64	2.07	4.88
Mg, %	0.24	0.35	0.22	0.27	0.26	0.06	0.18	0.38

[1]Forage samples were plucked by hand to the approximate height the cows were grazing from representative spots within the pasture (n = 20 per pasture) and composited for nutrient analysis.

[2]Mean, Min, and Max = mean, minimum, and maximum values across all farms and all months sampled in 2012 and 2013.

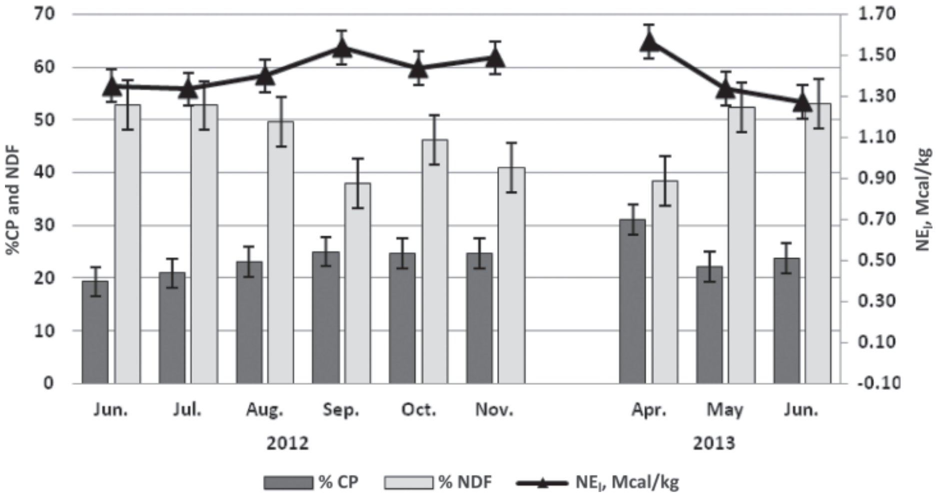

Figure 4. Crude protein, NDF, and NE$_l$ of pastures managed with self-described ultra-high stocking density grazing throughout the grazing season. Forage samples were plucked by hand to the approximate height the cows were grazing from representative spots within the pasture (n = 20 per pasture) and composited for nutrient analysis. Least squares means of forage quality measures are reported, with standard error bars indicating differences ($P < 0.05$).

farm 4, which coincides with the high K levels observed in the forage. Soil in pastures with a history of heavy manure application may have an accumulation of nutrients such as K and P, and it is not unusual for pasture soils in the northeastern United States to have K levels in excess of 300 mg/kg (Soder and Holden, 1999). Farm 3 reported applying lime to pastures, which explains high soil pH and Ca.

Definition of UHSD Grazing

Perhaps one fundamental issue is that the definition of UHSD grazing (sometimes dubbed "mob" or "tall" grazing by adopters of similar practices) is quite ambiguous. Motivated by livestock farmers in dry or low-quality soil environments, some farmers have been trying to improve soil and forage quality through residue management. They allow pasture forages to grow taller than the traditional 15 to 20 cm and allow animals to consume and trample the sward. In farm press and trade publications, farmers report greater animal productivity (primarily beef cattle), including increased weight gain, lower feed costs, and improved soils. Unfortunately, there has been little research-based information to provide dairy farmers in the northeastern United States regarding the practice of UHSD grazing.

In a UHSD grazing field day the authors conducted as part of the current study, attendees (primarily farmers along with a few agency personnel) were asked to write their definition of UHSD grazing on a card at the beginning of the day. The responses were variable and are included in Table 5. These divergent responses emphasize the lack of uniformity in definition and interpretation of UHSD grazing, emphasizing a need to better describe these grazing management practices. Furthermore, the farms used in this study had above-average pasture management skills. Over the years they have improved pasture quality through rotation grazing strategies that have likely improved soil health and forage quantity and quality. Therefore, the transition to a UHSD system was more of a slight shift in grazing management rather than an abrupt change in overall management for these farmers.

Table 4. Soil parameters of pastures managed with self-described ultra-high stocking density grazing in 2013[1]

Item	Farm 1	Farm 3	Farm 4
OM, %	4.1	4.0	3.2
pH	6.5	7.6	7.0
P, mg/kg	65	79	93
K, mg/kg	276	280	511
Mg, mg/kg	305	184	277
Ca, mg/kg	1,516	1,869	1,201
Zn, mg/kg	3.40	4.30	3.10
Cu, mg/kg	3.50	4.50	3.10
S, mg/kg	11.0	12.3	11.4

[1]Soil samples were measured within the sample pasture at each farm. Soil samples were unavailable for farm 2.

IMPLICATIONS

Based on observations of this case study, grazing dairies in Pennsylvania and New York have taken a modified approach to current UHSD grazing definitions by grazing forages slightly more mature than recommended in MiG systems and slowing the rotation slightly to allow plants to mature. Longer grazing rotations may increase forage DM available; however, farmers must be conscious of maintaining forage quality to meet the high nutritional requirements of lactating dairy cows. Ultra-high stocking density grazing is a modification of MiG that has been successfully adopted on these farms, all of whom are long-time graziers with high levels of management. Grazing dairy farmers who are interested in adopting UHSD grazing should proceed slowly and observe animals, forages, and soils before making further grazing management modifications. Further research is needed to examine the effects of transitioning to UHSD grazing on animal performance

Table 5. Results of an ultra-high stocking density grazing (UHSD) field day survey asking participants for their definition of UHSD[1]

Farmer response
Large number of animals on fenced small paddock grazing down tall “stored” growing plants for short periods
A lot of cows on a small area for a short time
Cattle grazing headed grass on the verge of rank
Wait until grass is very tall, let cows eat the top 1/3 of plants and trample the rest of the plant to feed the soil
High-density, short-duration grazing
Group of cows moving from pasture to pasture devouring grass or plants growing in the field
Grazing cows at >100,000 kg/ha
7+ cm regrowth with a herd of 200+ animals with frequent moves
Grazing at a height that is close to high-quality dairy hay or haylage using very high stocking rates
Grazing grass past ideal maturity so there is lower quality but higher quantity
Grazing patterns to maximize pasture rotations and nutrition for well-balanced nutrition

[1]Field day attended by 20 farmers on June 11, 2013.

and farm profitability as well as on soil and forage characteristics.

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