Comparing grazing treatments on a perennial pasture in central Wisconsin

Brooke Bembeneck[1], Matt Ruark[2], Eric Young[3], Jessica Sherman[3], Jason Cavadini[4], Randall D. Jackson[5]
[1]Agroecology Program, [2]Department of Soil Science, [3]US Dairy Forage Research Center, [4]Division of Extension, [5]Department of Plant & Agroecosystem Sciences; University of Wisconsin-Madison

Methods

Study site

We conducted this study on a somewhat poorly drained Withee silt loam soil (fine-loamy, mixed, superactive, frigid Aquic Glossudalfs; 1 to 3% slope) on the University of Wisconsin-Madison/USDA-ARS Marshfield Agricultural Research Station near Stratford, WI, USA. The 30-year average annual temperature and precipitation are 6.9 °C and 875 mm, respectively. These soils have a compacted layer at ~50 cm depth, which results in high runoff potential due to saturation-excess surface runoff. The site and setup of the paired watershed study was described in Jokela and Casler (2011). The site is comprised of four watersheds separated by berms with drainage ways directing runoff to individual flumes (Figure 1). Each watershed differs slightly in acreage; watershed areas are: M1 1.51, M2 1.39, M3 1.77, and M4 1.67 ha. Watersheds M1, M2, and M4 each have an overall slope of about 2%. Watershed M3 is partially concave; the lower one-third has little to no slope (0.25%) while the upper two-thirds have a 3% slope.

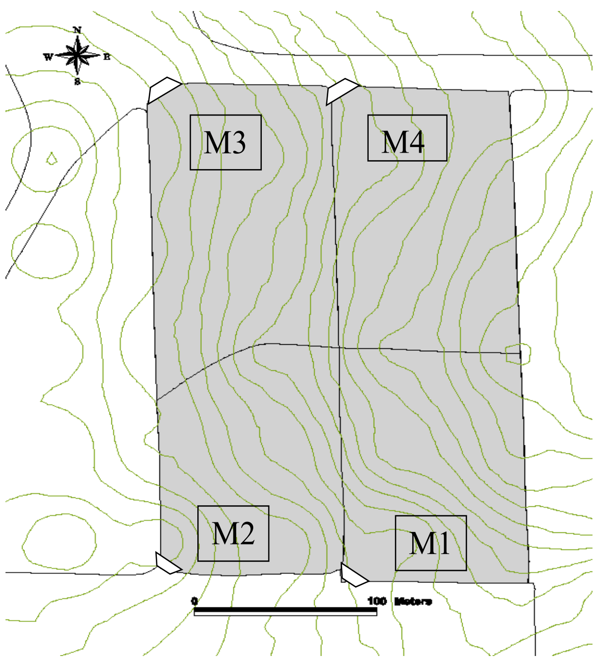

Figure 1. Depiction of watershed treatment sites with contour lines.

The calibration period of the experiment began May 2012 with the sowing of perennial forages. The entire field was planted to alfalfa (*Medicago sativa* L.)(Dairyland 2420/wet) at 6.7 kg ha^{-1}, meadow fescue (*Festuca pratensis* L.) (Pradel) at 11.2 kg ha^{-1}, and oats (*Avena sativa* L.) at 10.8 kg ha^{-1} 16 May 2012 using a grain drill after the seedbed had been prepared by chisel plowing, two passes with a field cultivator, and one pass with a culti-mulcher. Runoff sampling began with snowmelt spring 2013.

Management during the calibration period was typical of perennial forage production on dairy operations in central Wisconsin and the same for all 4 watersheds. Forage was cut and harvested three times a season (twice in 2015) and liquid dairy manure broadcast after harvests. Each watershed received the following manure application:

Date Applied	Application Rate
September 13, 2013	8352 gal/acre (liquid dairy manure)
June 25, 2014	7564 gal/acre (liquid dairy manure)
July 15, 2015	9000 gal/acre (liquid dairy manure)
August 3, 2015	9000 gal/acre (liquid dairy manure)
June 24, 2016	27 tons/acre (heifer bed pack)
July 7, 2017	9000 gal/acre (liquid dairy manure)
October 4, 2017	9000 gal/acre (liquid dairy manure)

The calibration period ended with the establishment of treatments May 2018. Watershed M2 was designated as the control (CTL) treatment, and continues to be managed as it was throughout the calibration period. Watershed M3 had the highest intensity grazing management called Adaptive Multi-paddock Grazing (AMP), watershed M1 had the moderate management intensity grazing treatment applied called Permanent Paddock Grazing (PPG), and watershed M4 had the least management-intensive treatment called Continuous Grazing (CON).

Experimental design

For the three grazing treatments, five dairy heifers were assigned to each watershed. In 2018, stocking rates for each watershed were 0.28, 0.33, and 0.29 AU ha^{-1} for AMP, PPG, CON, respectively. Stocking rates in 2019 were 0.28, 0.31, and 0.30 AU ha^{-1}. Grazing began 4 June 2018 and 5 June 2019 for each treatment year.

Grazing management in AMP consisted of ~0.025-ha paddocks delineated with movable polywire creating long rectangular paddocks. Heifers began grazing the south end of the pasture and were moved to the north with each move. The adaptive nature of this management resulted in heifers being moved every 1 to 4 d based on forage availability. Once the forage stand was grazed to ~10 cm residual stubble height, heifers were moved to a new paddock.

Grazing management in the PPG treatment consisted of setting up two polywires to make three equal sized permanent paddocks. Polywire ran north to south creating long rectangular paddocks. Heifers in this pasture, were moved every 10 to 15 d depending on forage availability. Once the available forage in the paddock was grazed down to ~10 cm, heifers were moved into a new paddock.

Grazing management in the CON treatment allowed heifers to have full range of the pasture for the entire grazing season. If needed, a bunker was installed on the northeast end of the pasture to supply supplemental feed. However, within the first two years of the treatment phase of this study, supplemental feed was not needed.

Runoff sampling

Runoff was sampled and monitored at gauge stations located at the low point of each watershed. Flume design and monitoring procedures were based on those used by the US Geological Survey (Stuntebeck et al., 2008) with slight modifications. Each runoff monitoring location consists of a 60-cm fiberglass H-flume (Tracom, Inc., Alpharetta, GA) attached to 1.8-m long plywood approach channels attached to wingwalls. The wingwalls are steel sheet pilings placed 1.2-m deep to minimize the effect of frost heaving. Earthen berms extend out from the ends of the wingwalls to assist in directing flow. The channels and flumes are winterized with plywood and canvas from late fall through early spring, and the housing is heated to avoid freezing of sample tubes. Flow meters and sampling equipment are housed and protected from weather in a commercially available 1.8 x 2.1 x 2-m high shed (Niagara model, Yardmate Series, Royal Outdoor Products, Inc. Middleburg Hts., OH). All equipment, heat tapes, and heaters run on AC power with battery backup.

Runoff volume is determined by measuring stage in the H flumes with an air bubbler/pressure transducer flow meter (ISCO Model 4230, Teledyne Isco, Inc., Lincoln, NE). A bubbler PVC tube (3.175 mm i.d.) is attached to the floor of the flume 40 mm back from the outlet. Staff gauges also were installed in the H flumes to allow simultaneous comparison of stage with that from the flow meter. Flow-based runoff samples are collected by an automated 24-bottle (1 L) refrigerated sampler (ISCO 6712SR, Teledyne Isco, Inc.). A sampling tube (9.3 mm i.d.) was attached to the flume floor near the flume outlet and extends ~2 m to the automated sampler inside the enclosure, protected from freezing by heat tape and foam insulation. A CR1000 datalogger (Campbell Scientific, Inc., Logan, UT) is used to read and store data and control the runoff sampling collection scheme. A weather station was located ~1000 m from the site and measures precipitation with a tipping bucket rain gage, as well as air temperature, humidity, wind, and solar irradiance. Real time, two-way radio telemetry allows remote communication with each runoff monitoring station and the weather station. A Campbell Scientific software program (Loggernet) was used to connect with the modem and communicate remotely with the field stations to read runoff data in real-time and modify the sampling program, if needed.

Runoff samples from individual bottles from each runoff event are combined, subsampled and analyzed for total dissolved solids (TDS) (Method 2540C; APHA, 1995), suspended solids (SS) (Method 3977-97B; ASTM International, 2000), Total N and Total P (acid persulfate/autoclave method; Patton and Kryskalla, 2003). A second sample (60 mL) is passed through a 0.45-µm pore size filter for dissolved reactive P (DRP) (Method 4500-P F; APHA, 1995), nitrate-N (NO_3-N) (Method 4500-NO_3 F; APHA, 1995) and ammonium-N (NH_4-N) (phenolate method; APHA, 1995).

Vegetation sampling

We collected forage samples to determine forage quantity and quality for each pasture. Sample timing varied for each treatment, but we used the plate meter and ring-clip methods in all four. When making a ring-clip measurement, a plate meter reading was taken first to measure forage height. In the AMP and PPG watersheds, before heifers were moved into a new paddock a total of 30 plate meter measurements were made to estimate average stand height. At the time of the 10th, 20th, and 30th plate reading, the individual stand height was recorded and the forage was clipped in the corresponding spot in the pre-grazed paddock. Likewise, in the paddock that had just been grazed, 30 plate meter measurements were taken to measure the post-graze forage height. However, no forage clippings were taken in the post-grazed paddocks. Plate meter readings were made by recording the plate height when placed on the vegetation canopy with similar force. Ring-clip measurements were made by clipping and bagging the area inside a 1017.88-cm^2 diameter x 7.62-cm tall ring. Forage was sampled by placing the ring at ground level and ensure all forage falling inside the ring (i.e., not just stems rooted within the ring, but all plant biomass in a cylinder projected up from ground level) was cut to the height of the ring and placed in a labeled bag, which was immediately dried at 40 °C for 48 h. Once dried, biomass was weighed and recorded, then returned to the bag for grinding to a 2-mm mesh size. Once ground, biomass was ready for near-infrared (NIR) spectroscopy forage quality determination. For the CON watershed, three ~1-m^2 cages were randomly placed throughout the pasture. Prior to cage placement, a plate meter reading of the individual stand height and ring-clip were taken where the cage was being placed. After 30 d, we measured forage within the cage with the plate meter and a ring-clip. Average stand height was measured in the watershed by taking 30 plate meter readings throughout the pasture. Cages are then moved to a new location in the pasture and the same process repeated. For the CTL watershed, prior to harvest average forage stand was measured by taking 30 plate meter measurements. On the 10th, 20th, and 30th plate meter measurement, the individual stand height was recorded and the forage was sampled using the ring used in all other treatments. Forage samples were weighted wet and dry and then ground and analyzed using NIR.

Stem density

In July and September of 2019, stem density was measured in each watershed. Using a zig zag pattern, all individual tillers (i.e., each grass stem) within a 266 squared centimeters (0.0266 squared meter) were be counted. Ten stem density data points were collected per watershed.

Species composition

Plant species observations began September 2014 and continued throughout the treatment phase of this study. Step-point sampling was done one time per growing season. Approximately 100 points were observed per watershed to assess alfalfa, grass, clover, and broadleaf weed cover. By walking in a zig zag pattern the data collector lowers a pointer toward the ground every 5 paces and records whether the pointer “hits” or “misses” a plant and then categorized the closest plant to the pointer.

Soil sampling

Twenty samples were collected from each watershed and divided into 0 to 10 and 10 to 20-cm depth increments. Samples were air dried, ground (2 mm), and analyzed for organic matter by loss on ignition (Schulte and Hopkins 1996), pH by electrometric method (1:1, soil:water) (Thomas 1996), Bray-1 P (Bray and Kurtz 1945), potassium (K) (Munter 1988) and total C and N by high temperature combustion (Elementar VarioMax CN analyzer). This sampling regime continued on all watersheds during the treatment phase. Additional samples (10 cores each) at depths of 0 to 5, 5 to 10, 10 to 20 cm, and 20 to 30-cm were analyzed for NO^3-N using a 2M KCl extract (Lachat Instruments 1992) in Aug 2017.

Other soil quality samples were collected August 2017. Aggregate stability was measured utilizing an 80-0g subsample (wet method) (Cambardella and Elliot 1993) to determine mean weight diameter (MWD) and percent composition of large and small macroaggregates and microaggregates. Soil bulk density was estimated with three 48-mm diam. x 0.1-m deep cores per watershed. Soil respiration was estimated on subsamples of three 48-mm diam. x 0.1-m deep cores per watershed using Solvita CO_2 respiration testing (Woods End Laboratories, Mt Vernon, ME).