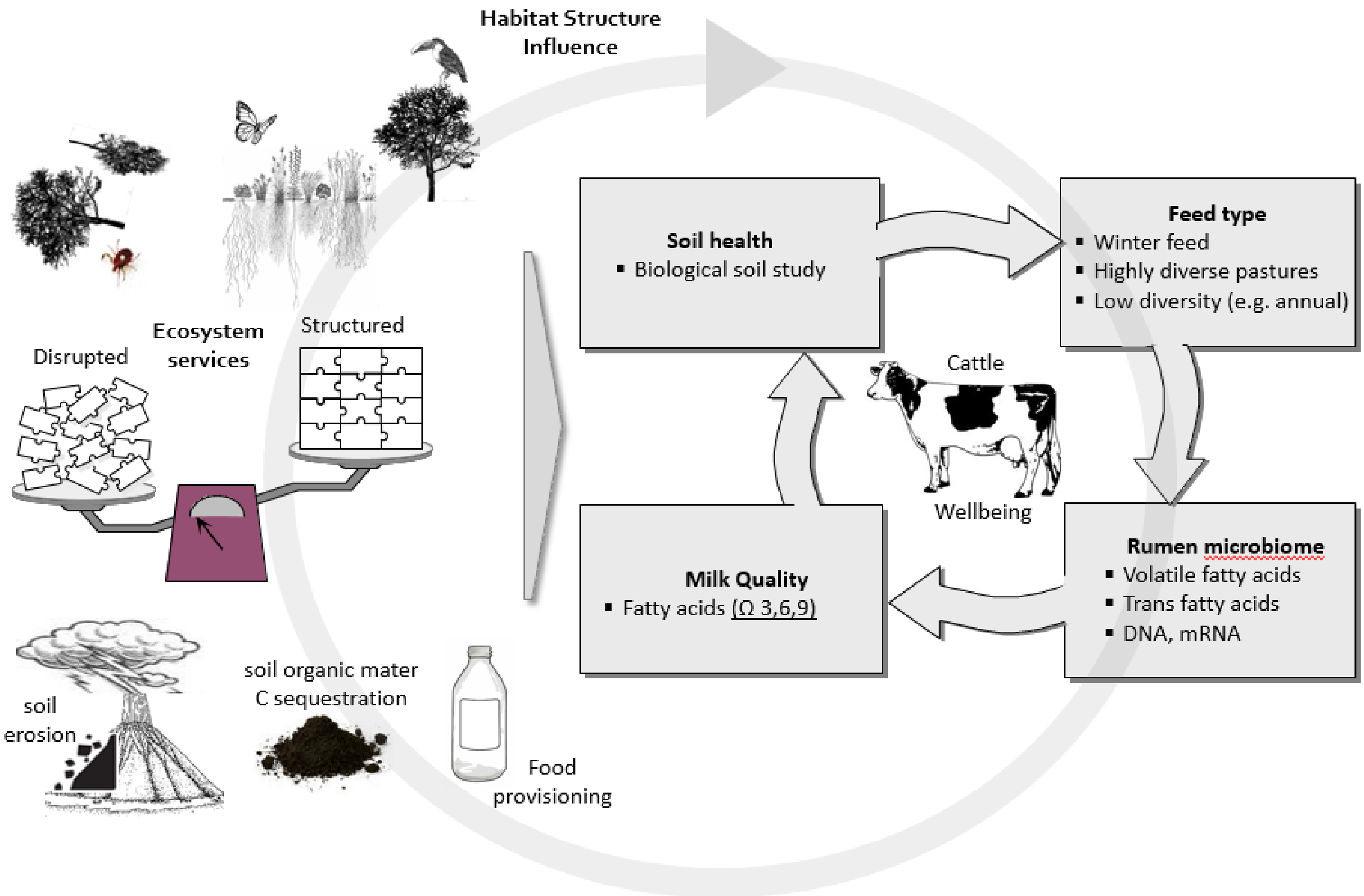

Results from the project

Biodiversity and Livestock Wellbeing

University of Vermont | 2015

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1. Introduction

In 2013, our research team embarked on a collaborative, long-term study focused on assessing how ecologic habitat disruption is associated with livestock wellbeing and health, and how those affect society. It is not only a local issue. With a population growth above 7 billion people, demanding higher living standards, the demand for dairy products is ever increasing. Meeting this demand requires both advancing the agricultural frontier and intensification of the production process, burdening already-degraded ecosystems. This impact habitats, forests, biodiversity, soils, water and rural livelihoods. There exists strong evidence that agriculture both receives and provides a diverse array of benefits from healthy ecosystems, while also imposing dis-services when disrupted.

Thus, some think we are facing the "land sparing vs land sharing dilemma". "Land sparing" suggests sustainably intensification of high-yielding agriculture on some lands, setting aside large areas for conservation; on the other hand, "land sharing" recommends keeping ag. and conservation together through a patchwork of multifunctional, low input, intensive agriculture, incorporating hedgerows and ponds.

Generally, minimally disturbed soils, adequate access to a diverse, high quality forage mix, and clean water has a robust correlation with cows' wellbeing and milk quality. We suggest that managing for increased biological diversity in pasture-based dairy production systems, positively contributes to improved livestock well-being, health and productivity, and creates a positive feedback ecological service loop.

Dairy farms support numerous microbial communities, including mutually beneficial relationships between dairy cattle and their microbial symbionts (rumen microbiota). These cellulolytic bacteria break down plant materials providing cows' a source of energy and nutrients. Thereby, understanding the response of ruminant and environmental microbial communities to specific management practices is critical both, to optimizing farm productivity and enhancing ecosystem-based management.

Overarching questions...

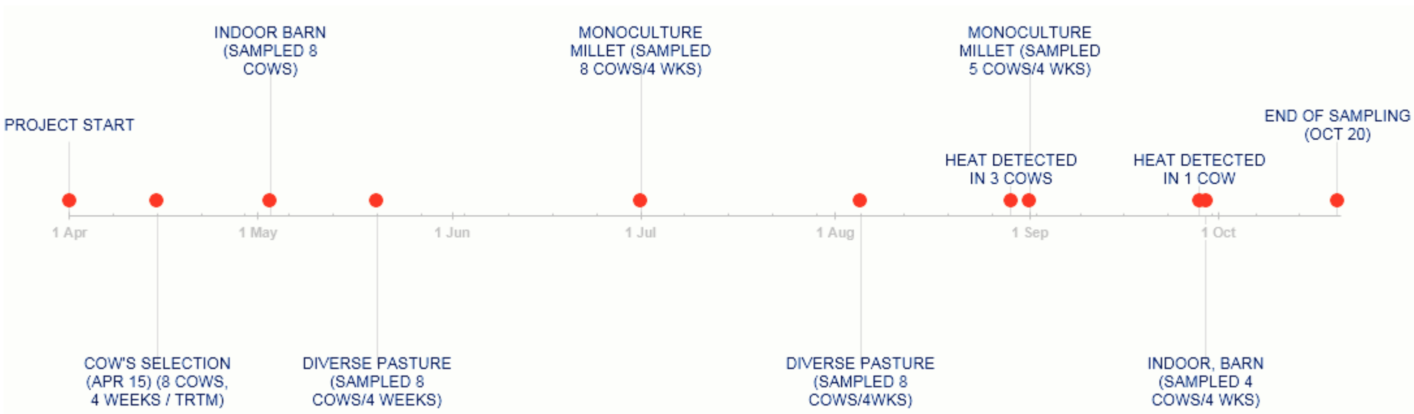
- ***how biodiversity affects livestock well-being, health, and productivity?***
- ***how different diets affect grazing behavior?***
- ***how the relationship between grazing time and diet alters rumination activity, rumen pH and health, milk composition and productivity.***

We studied an integral approach to soils, forage and diet, rumen microbiology, grazing activity and milk quality, to assess how cows are affected. We identified and demonstrated methods for grass-based livestock farmers to: 1) demonstrate how real-time monitoring of grazing behavior and forage intakes allows farmers to optimize forage utilization, rumen activity, and milk composition; 2) improve productivity, milk quality, reduce costs, and increase net farm income; and 3) improve soil health and water quality.

By optimizing these production parameters, pasture-based dairy farmers may simultaneously, advance the health and well-being of their cattle, reduce operational costs and environmental impacts and produce the healthy dairy products society is demanding. We hope that this work can explain the importance of maintaining a healthy ecosystem for Vermont farms.

2. Methodology

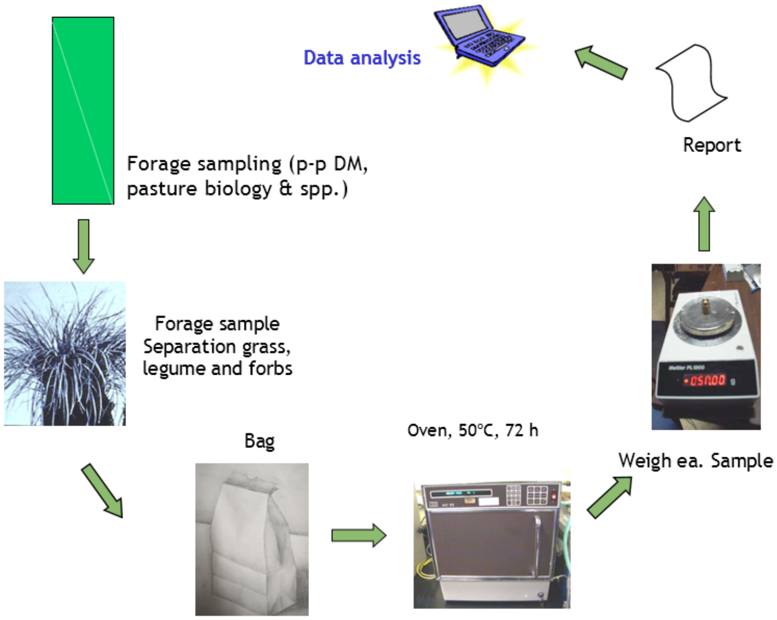
2.1. Timeline



2.2. Location: Choiniere Family Farm

2.3. Soils and Forages

We carried out soil samples where dairy cows grazed, using the Earthfort method for determining soil life (bacteria, fungi, protozoa and nematodes) rations. Forage samples were taken in three stages. First, preceding forage sampling, we randomly threw a 0.1 m2 quadrant 25 to 35 times within each plot to rank the three most predominant forage species using the Dry Weight Rank Method. Second, each time the quadrant was on the ground, we monitored pasture and site ecology by using a pasture monitoring technique to help quantifying soil-pasture ecosystem functions related to mineral and water cycle and community dynamics by randomly recording data from 25 to 100 points. These data points can provide insights for management improvements by evaluating environmental indicators.



Pre- and post- grazing plate meter measurements were taken via Filip's folding plate meter, to estimated herd DM intake. The third stage includes harvesting pre-grazing forages to estimate forage yield (DM/A), quality and botanical composition. The technique requires clipping the forage within the quadrant at soil surface with an electric clipper. Samples were bagged, identified and separated into grass, legume, and forb components (botanical composition) and quality. Later, they are dried at 63C for 72 h, and weighed to determine forage yield.

2.4. Animals

We randomly selected eight-second and third lactation cows in relatively close milk production levels, with days in milk ranging from 50 to 90 days and milk fat between 2.8 and 3.6%, to three different diet treatments: (1) winter feed (hay + total mixed ration TMR), (2) diverse New England cool season pastures, and (3) pearl millet, warm annual pasture. Cows remained four weeks in each treatment, grazing on a diverse pasture, and subsequently on Pearl Millet for 4 weeks. Every week of the grazing season we sampled, forages, bacteriological swabs of udder skin, rumen fluid, feces and milk samples. Milk weights and samples were taken weekly, and tested for butterfat, protein, organic solid and fatty acid. In addition, we collected data on lying time and lying frequency using accelerometers as a potential proxy for grazing activity to estimate forage intakes grazing behavior and rumen health for pasture-based dairy cattle to demonstrate how real-time monitoring of grazing behavior and forage intakes allow farmers' to optimize forage utilization, rumen activity, and milk composition.

2.5. Grazing Behavior & Activity Monitoring

Activity monitors have been used in dairy production for decades, most commonly as a reproductive management tool for cows housed in confinement systems. Electronic continuous activity monitoring systems include pedometers and accelerometers, which record data on behavior and identify changes in activity by monitoring walking activity or lying time events. Changes in walking and resting behavior are associated with either estrus (heat), calving or health problems so these tools have had primary application for heat, calving or sick-cow detection. These electronic monitoring devises are typically attached to either a lower leg, a neck collar, or a halter, and data recorded by these devises are typically transferred by radiofrequency to a data collection unit located in the barn, which may then transfers the data to a micro-computer. In the commercially available systems, data management and analysis occurs through a user-friendly computer software interface. Some commercially available systems are able to integrate with dairy herd management software programs such as DairyComp or PCDart.

A number of research studies have been conducted using Hobo Pendant® accelerometer data loggers (Onset Computer Corporation, Bourne, MA) to monitor cow behavior. These data loggers collect positional information which can be converted to assess walking and lying behavior. Most past research using this tool has focused on cattle in confinement housing.

We were interested to learn if activity monitors could be easily used in pasture-based dairy systems and to evaluate the data obtained by these tools. We had prior experience using Hobo data loggers in cattle housed in tie-stalls to evaluate changes in behavior during mastitis challenge experiments, and noted the data loggers successfully identified changes in activity (increased lying time) prior to the observation of clinical signs among cows with clinical mastitis.

The objectives of this research were to: 1) evaluate the use of Hobo pendant data loggers in pasture-based cattle, and 2) identify potential differences in activity (lying behavior) among cattle grazing different forages.

Eight cows were enrolled from May to October 2014 in a study of the impact of pasture species diversity on milk composition and quality. A Hobo Pendant data logger was attached above the right hind ankle (metatarsus) to each cow for 5 different 2 week periods during the course of this study. The loggers were attached using flexible bandage material and white medical tape. The loggers were removed after 2 weeks and cows were given at least one week before reattaching a data logger. Data was downloaded from the loggers using the Hobo USB Base Station data port connected to a personal computer and data was managed using Hoboware Pro software (Onset Computer Corporation). Data was exported to Microsoft Excel spreadsheets and lying behavior was summarized by day for each cow using SAS software (SAS v9.4, SAS Institute Inc., Cary, NC) and a set of previously published algorithms (Ledgerwood et al., 2010). Outputs from the activity data for each cow included daily lying and standing time, number of lying and standing bouts, and average duration of the daily lying and standing bouts. These data were then used to create averages for periods of time the cows were grazed on either a diverse pasture of a monoculture of millet. A minimum of 3 days data was compiled into the average for each feed source, and during 2 monitoring periods activity was recorded during a transition from one forage source to another forage source. Pre- and post-transition periods were defined, respectively, as the last 4 days grazing one type of pasture and the first 4 days grazing another pasture source.

3. Results

3.1. Forage assessment

Botanical Composition

Grasses (67.3%)

Orchard grass, Timothy, Ryegrass, June grass, Meadow fescue, Brome grass, Bent grass, Quackgrass, Kentucky Blue grass and Millet (treatment monoculture)

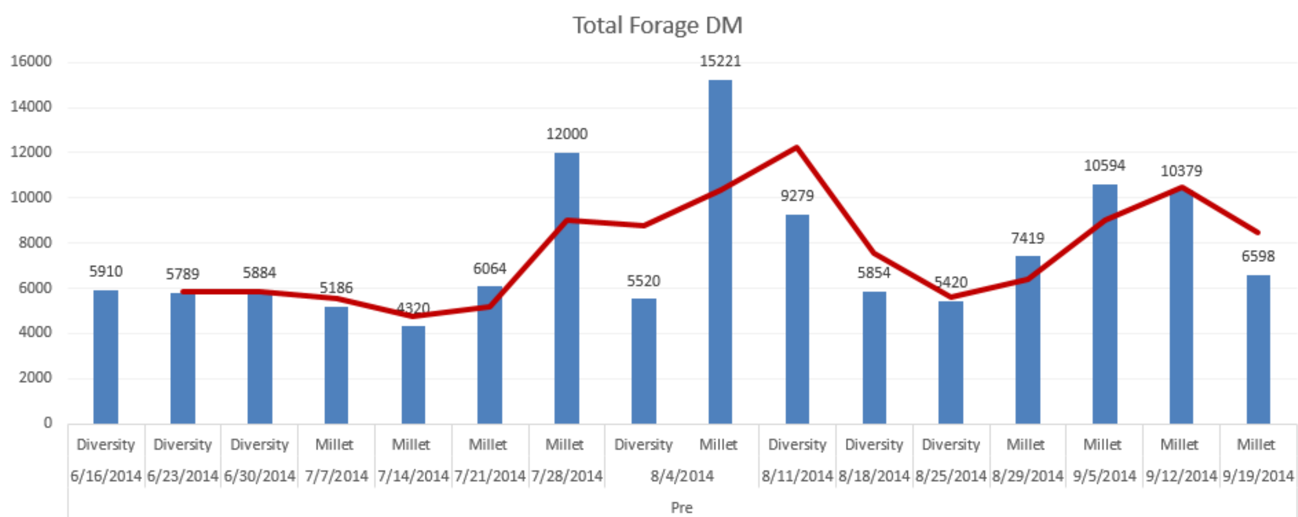
Forbs (10.8%)

Platain, Dandelion, Burdock, Milkweed, Bull Thistle

Legumes (14.8%)

White clover, Red clover, Common Vetch.

Millet DM (ave): 8,531 Kg/ha (7,618 lbs/A) **Diverse DM (ave): 6,227 Kg/ha (5,561 lbs/A)**



Forage production demonstrtates optimal management levels. Soils were well covered and protected in most of the diverse pastures ($p<0.01$), showing adequate manure and trampling ($p<0.01$), moisute distribution ($p<0.01$), presence of earthworms and insects ($p<0.01$), and grazing height.

We did not find differences in the soils between diverse cool season pastures and Millet.

3.2. Activity Monitoring For Pasture-Based Dairy Cattle

1. The Hobo Pendant data loggers were well tolerated by the cows for up to 14 days of attachment. We observed no adverse effects of attaching the loggers to the lower legs of the cattle when bandages were applied appropriately. There is the risk of restricting blood flow when applying flexible self-adhesive bandage material (too tight) or bandages falling off (too loose) so experience or training is required to avoid these potential complications.

2. The Hobo Pendant data loggers generated the expected data on lying and standing times for the full 14 day periods of attachment in pasture-based conditions. We experienced no loss of data during recording or transfer during this study, although in the past we have experienced logger failures possibly due to moisture exposure.

3. Average Lying time, number of lying bouts, and duration of bouts did not differ for the different types of grazed forage. Cow activity was the same during the periods when grazed on diverse pastures, the monoculture of millet, or when housed indoors. Cow activity was the same during the pre- and post-transition periods when moving to a new pasture type.

4. Cows differed in their activity. There was a range of lying times, lying bouts, and duration of lying bouts among the cows, and average activity was greater in some cows compared to others.

5. Milk production differed among the cows and was influenced by days-in-milk and standing/lying times. Increasing lying time was associated with increased milk production, while as would be expected given the length of this study and the stage of lactation of the cows in this study, increasing days-in-milk was associated with decreasing milk production.

3.3. The link between diet and health (and how this can mean extra cash)

Kraft Lab (Emily Egolf, Class of 2015; Melissa Bainbridge, Ph.D. student; Jana Kraft, Ph.D.)

Greater consumer awareness of the relationship between diet and health is fueling a niche market for foods that promote optimal health and wellness as well as reducing the risk of chronic disease. Such a niche market can be rewarding to small and medium-sized producers to better compete in the marketplace. For example, demand for dairy and meat products from pasture-fed cattle is increasing as consumers become more aware of the link between diet and health and dairy farmers are being offered premiums for milk produced without grain supplementation (i.e., Grassmilk from Organic Valley). Dairy co-op and beef producers are increasingly using the content of beneficial, so-called bioactive, fatty acids as a marketing tool. Moreover, it is conceivable that in the future the farmer may receive a premium for their milk or meat containing higher contents of bioactive fatty acids. Thus, improving pasture management and feeding strategies to increase and maintain the levels of bioactive fatty acids in dairy and meat products will help to ensure consumer demand and improve the sustainability and profitability of the dairy farmer.

Grass-fed organic milk average has ratio of (ω-6) fatty acid to (ω-3) fatty acid of 2.3, whereas conventional milk had an average ratio of 5.8.

Benbrook, et al. (2013) PLoS1

Cattle cannot produce certain unsaturated fatty acids, such as omega-3 fatty acids; therefore, to increase the amount of these bioactive fatty acids in milk and meat you must increase the supply of these fatty acids in the cattle's diet. The main fatty acids that is needed in forage to increase bioactive fatty acids in milk are linoleic acid and alpha-linolenic acid. These fatty acids either escape the rumen intact to be incorporated into milk and meat or are modified by rumen bacteria or the cattle's body to become CLA (conjugated linoleic acids). Milk and meat products from cattle are a unique source of these fatty acids.

> *“organic milk healthier, because it has a more favorable balance of (ω-6 & ω-6) fatty acids”*

As Vermont summers have become increasingly unpredictable, interest has been growing in using summer annual forages to fill the gap provided by the “summer slump” when perennial pastures experience less growth. The recent work of UVM researchers has examined the effects of pearl millet vs. a diverse pasture (>15 species) on milk fatty acids, milk production, and rumen function.

4. Final Considerations

We did not observe any differences in lying time among the different types of pasture forage sources, however the system used in this study only monitored lying and standing behavior. We hypothesize that activity monitoring that includes rumination monitoring has the potential to provide data that can be used to evaluate forage intakes. We did observe a positive association between increased lying time and increased milk production. Additional research is needed to develop guidelines for lying time activity and rumination rates using activity monitoring systems so that producers might use these systems to optimize management of grazing dairy cattle.

There was no effect by the pasture type on milk weight or fat and protein percentage. The content of saturated fatty acids in milk was lower when feeding pearl millet while the content of CLA in milk was higher when compared to the diverse pasture treatment. Contrary, the content of omega-3 fatty acids in milk was almost twice as much when cows grazed on a diverse pasture comparison to grazing on pearl millet. In conclusion, grazing pearl millet has no effect on milk production but modifies the fatty acid profile of milk fat. We are currently investigating the effect of the two grazing systems on the rumen microorganisms to delineate specific changes in the microbial eco-system and its function.