Results:
The goals of this project, in summary, were to demonstrate that grazing immature pastures would stimulate more soil life activity than grazing mature pastures. In addition, it was hoped that we could identify the soil tests that best showed this finding. We also did summer/2nd grazing and fall grazing tests to monitor what was happening to soil health over the entire grazing season. This was accomplished with our herd of 160 stocker steers and 350 ewes with 600 lambs by side during our regular planned grazing program. The paddocks chosen for testing were fields we felt were "typical" of our operation, were as uniform as possible, were not near fence lines, water points or trees and would be close to the grazing stock.

Discussion of the "early" and "late" 1st grazing:
The stock were grazed with the goal of removing 25 ~ 33% of the available forage, one or two days of grazing per paddock. Three pre grazing and 3 post grazing samples were collected, hand clipped to approximately one inch level and dried to 100% dry matter on both the cattle and sheep grazing paddocks. The sheep paddock had 1735# of dry matter available on May 30, 2014 and had 1283# of residual plant material on June 1 after grazing for 26% harvest. The cattle paddock had 1250# of forage on June 1 pre-grazing and 912# of residual forage on June 2 for a 27% harvest. Feed quality analysis was also done on both pre and post grazing samples and support the idea that stock choose the "better" forage. Using crude protein as an indicator of feed quality: In the Early First Grazing treatment - pre grazing steer: 15.8% and sheep: 16.4% as compared to post grazing steer: 13.7% and sheep 14.3% crude protein levels. For the Late First Grazing – Pregrazing steer: 10.0% and sheep: 10.4% and post grazing results of steer: 8.3% and sheep 8.7% crude protein. (these are the only time the results were neat, clean, and as expected – but that's why we do "research", right?)
The Late Grazing forage sampling, pre grazing on 6-25 and post grazing on 6-27, demonstrated significant growth from the first grazing. While the fields were not the same but very similar, the amount of forage available in the Early Grazing was (sheep 1735# & cattle 1250#) to over 5438# in the Late Grazing, (sheep 5408# & cattle 5468#) or a gain of 3945#. That is about 158# of forage growth per day. The forage in the Late Grazing was over 3 foot tall and it was very difficult to "throw" the sample ring and get it to the soil level to collect an accurate plant sample especially after the stock had walked down much of the forage. The sheep post grazing utilization samples showed there was more forage "after" grazing than pre-grazing and the steer site only showed 8% utilization. Visually, it looked like the about 1/3 of the forage had been consumed and the stock were satisfied and full when moved to a fresh paddock.
After the grazing stock exited the paddock, ½ the exclusion area was clipped with a windrower in three alternative strips to provide 3 replications of control, 3 clipped strips inside the exclusion area, and then 3 areas in the grazed area opposite the exclusion were selected for 15 soil samples per replication. Each site; control, clip, graze x 3 per cattle or sheep grazed was sent in for a Haney soil health analysis and a composite of the 3 soil samples per treatment and grazing species were sent in for a PLFA soil microbial community analysis. The Haney soil results were averaged for each treatment over the 3 samples per treatment.
I have limited the data reporting to those indices that I felt provide the most overall representation of the level of soil life under the 3 treatments. The inorganic nitrogen levels were noted because in conversations with Dr. Manske, he felt that if you only had one number and wanted to use a low cost test, the inorganic nitrogen could be an indicator of microbial activity.

Indices Utilized in Measuring Results:
Soil Health: represents overall health of soil system, number will be 0 ~ 50, more is better
Solvita CO2: the CO2 released in 24 hrs. - measures microbial activity, higher number is better
PLFA Biomass: est. of living microbial biomass, less 500 poor, 2000 avg, over 4,000 excellent
Inorganic Nitrogen: Nitrate + Ammonium in ppm N - via H3A extract

Early Graze *Steers*	Control	Graze	Clip	**Late Graze** *Steers*	Control	Graze	Clip
Soil Health	6.04	5.67	7.54		9.80	6.70	10.30
Solvita CO2	46.03	42.47	56		62.23	35.40	61.03
PLFA Biomass	2919	4188	2253		4842	6985	9808
Inorganic N ppm	3.0	4.4	3.7		8.2	9.7	10.3
Sheep				*Sheep*			
Soil Health	10.85	9.07	10.52		14.18	11.30	12.59
Solvita CO2	58.87	52.27	56.5		96.67	66.90	82.30
PLFA Biomass	4492*	6649	3262		12,501	10,916	12,981
Inorganic N ppm	8.0	6.7	8.6		10.6	12.6	13.4

Discussion:

If we average the steers and sheep data - it represents 2 different grazing species and two different paddocks/fields.

Average:

Early Graze	Control	Graze	Clip	**Late Graze**	Control	Graze	Clip
Soil Health	8.45	7.37	9.03		11.99	9.00	11.45
Solvita CO2	52.45	47.37	56.25		79.45	51.15	71.67
PLFA Biomass	3706	5419	2758		8672	8951	11,395
Inorganic N ppm	5.5	5.6	6.2		9.4	11.2	11.9

The "**early**" graze treatment did have more PLFA biomass than the control or clipped treatments which would support the idea that grazing was stimulating more microbial activity. However, the other two measurements of soil microbial activity, soil health and solvita indicate less microbial activity. I am not sure I can explain this but a couple of considerations: We did our soil sampling 7 days after the grazing event – was this the best time to capture maximum microbial activity as the result of the grazing? And, is there is no best time because it depends on soil temperature, soil moisture, etc.? The other consideration is that the PLFA test and the solvita test results and soil health number may not represent amount of microbial activity equally, both accurate but not on the same timeline. Another consideration is that the soil health calculation is dependent on the amount of organic C and N, (C - carbon & N- Nitrogen) and an increase in microbial biomass can result in a decrease in soil organic C and N. In the **"Late"** data, all the numbers and especially the soil health and solvita results would indicate that grazing decreases soil microbial activity. The inorganic nitrogen test results do not demonstrate an impacts of grazing or clipping. The levels of inorganic nitrogen (PPM x 2 = #acre) were also low across all treatments for all sampling periods. Bottom line, grazing does impact soil microbial activity, probably, positively when grazing is done on immature plants (Early). The Late grazing data supports the idea that grazing does impact soil life but the results at 7 days post grazing would suggest that soil life activity is decreased.

** the sheep control PLFA biomass data was in error and a calculated number was substituted based on steer PLFA information*

Second Graze *Steers*	Control	Graze	Clip	**Fall Graze** *Steers*	Control	Graze	Clip
Soil Health	9.26	9.90	9.11		14.11	11.02	15.51
Solvita CO2	55.20	48.53	50.67		93.53	65.70	100.13
PLFA Biomass	3947	5870	6550		2803	2200	1926
Inorganic N ppm	7.8	11.0	11.1		8.2	9.0	8.6
Sheep				*Sheep*			
Soil Health	6.27	5.34	7.78		8.59	8.32	7.74
Solvita CO2	40.53	31.67	45.30		56.63	55.50	45.93
PLFA Biomass	6163	3721	5257		2474	2880	1573
Inorganic N ppm	4.0	4.8	4.0		5.8	5.9	6.7

Discussion:

If we average the steers and sheep- it represent 2 different grazing species and two different paddocks/fields.

Average:

Second Graze	Control	Graze	Clip	**Fall Graze**	Control	Graze	Clip
Soil Health	7.76	7.62	8.45		11.35	9.67	11.63
Solvita CO2	47.87	40.10	47.99		75.08	60.60	73.03
PLFA Biomass	5055	4796	5904		2639	2540	1750
Inorganic N ppm	5.9	7.9	7.6		7.0	7.5	7.7

In both the Second and Fall grazing treatments, the grazed samples again were most often demonstrating the lowest soil life results. In this project, it seems that grazing does impact our indicators of soil life and except for the early grazing trial, grazing decreases the indicators of soil life 7 days post grazing.

Other observations from the test results:

Fungi/Bacteria ratio- more fungi is better <.05 poor, .15~.2 average, > .35 excellent
SOM – soil organic matter
Inorganic Nitrogen levels - ideally are 100 pounds per acre –peak of growing season

Early Graze *Steers*	Control	Graze	Clip	**Late Graze** *Steers*	Control	Graze	Clip
Fungi/Bacteria Rario	.34	.30	.32		.15	.23	.29
SOM (Avg. 3.9)	3.6%	4.0%	4.0%	(Avg. 4.1)	4.2%	3.8%	4.4%
Inorganic N ppm (Avg.)	3.7 ppm or 7.4 lbs			9.4 ppm or 18.8 lbs			
Sheep				*Steers*			
Fungi/Bacteria Rario	.19	.29	.24		.18	.27	.26
SOM (Avg. 5.1)	4.9%	5.4%	4.9%	(Avg. 5.0)	5.1%	4.5%	5.4%
Inorganic N ppm (Avg.)	7.8 ppm or 15.6 lbs			12.2 ppm or 24.4 lbs			

Second Graze *Steers*	Control	Graze	Clip	**Fall Graze** *Steers*	Control	Graze	Clip
Fungi/Bacteria Rario	.17	.28	.24		.08	.20	.11
SOM (Avg. 4.4)	4.2%	4.3%	4.6%	(Avg. 4.36)	4.4%	4.1%	4.3%
Inorganic N ppm (Avg.)	10 ppm or 20 lbs.			8.6 ppm or 17.2 lbs			
Sheep				*Steers*			
Fungi/Bacteria Rario	.37	.36	.32		.26	.22	.05
SOM (Avg. 3.6)	3.8%	3.5%	3.6%	(Avg. 3.5)	3.6%	3.7%	3.3%
Inorganic N ppm (Avg.)	4.3 ppm or 8.6 lbs.			6.1 ppm or 12.2 lbs.			

I compared the fungi/bacteria ratios across all 4 harvest periods by the different treatments:

Control fungi/bacteria ratios: steers .185, sheep .250 Average = .2175
Graze fungi/bacteria ratios: steers .253, sheep .285 Average = .2688
Clip fungi/bacteria ratios: steers .240, sheep .217 Average = .2288

I am not sure the difference is statistically different but the trend does favor the paddocks that were grazed.

I don't expect the SOM to be influenced in one year by the treatments but it is interesting to look at the history of the paddocks and compare it to the SOM levels. The inorganic nitrogen numbers closely paralleled the SOM values.

The Early Graze *sheep*, SOM - 5.07; the Second Graze *steers,* SOM - 4.36, and the Fall Graze *steers*, SOM - 4.26 were all the same paddock. This paddock has been in pasture for over 30 years and has not been hayed.

The Early Graze *steers*, SOM - 3.86 and the Second Graze *sheep*, SOM -3.63 were the same paddock, pasture the last 3 years and was cut for hay the previous 20 years with minimal added fertility.
The Fall Graze *sheep*, is the lowest SOM, 3.53 and has only been in pasture the last 4 years and was tilled for the prior 2 years.
The Late Graze *steers*, SOM -4.13 and Late Graze *sheep*, SOM -5.0 was the same field that has always been managed as one field and was divided by temporary fence into two 4 acre paddocks for this trial. I would have expected to see very similar SOM. This was a reminder of the inherent variability in soils and the importance of replications and cautions when making conclusions.

What did I learn (so far)? Grazing as compared to control and clipping treatments did impact indicators of soil health. Our pasture paddocks appear to have an excellent level of soil life, with peak PLFA biomass data being over 10,000ng/g. PLFA biomass data seems to be time of the year dependent, but it is not certain if that is due to plant physiology, soil temperature, or amount of daylight or a combination of factors.

Discussion:

The primary finding in this one year, on-farm, grazing- soil health project is that soil health is a very complicated system! While we did demonstrate that grazing did impact indicators of soil health within 7 days of treatment, the initial interpretation of the results were that in most cases the impact was to "decrease" indicators of soil health and not to increase the soil biomass, soil health index, and Solvita score. This was contrary to our hypothesis that grazing "early" would have a more beneficial impact on soil health than late or mature plant grazing.

We have been contacting various soil health experts: Drs. Haney, Manske, and Ward Laboratories and unfortunately have not gotten a good explanation of why we saw the unexpected results. The most common response was that we needed to repeat the project for another 2 years. We are continuing to study previous research even though some of the grazing impact on soil health/ nutrient cycling work was done about 30 years ago, before the current more sophisticated soil tests were available. We are also working on finding assistance to do a statistical analysis of the results to improve the confidence of the results.

I think one of the major issues that should be clarified is the need to include **time** in the discussion of soil health. We are looking for those indicators that could tell us what kind of impact on soil health a single grazing event would generate. We are looking for short term impacts, changes in soil life indicators that obviously could lead to long term impacts, such as soil organic matter levels, fertility levels, etc. Having the ability to measure the impact of a single grazing event would allow us to quantitatively measure the impact of different kinds of grazing management. For example, what is the difference between grazing an immature plant vs a mature plant, or grazing 33% of the available forage vs 90% of the available forage, or the difference between a 4-hour mob grazing event vs a 2-day, less intense grazing?