Hamilton County Soil and Water Conservation District Cover Crop

Demonstration and Study Project, 2014 – 2018

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Hamilton County Soil and Water Conservation District

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Purpose of Study

The Hamilton County Soil & Water Conservation District Cover Crop Demonstration and Study Project was initiated in September 2014, funded by an Ohio Farm Bureau Grant. The overall goal of the cover crop study was to illustrate the benefits of using cover crops which include:

1. Reducing erosion on fields after harvest through spring.
2. Determine the degree of Nitrogen and micronutrients retention in the soil for the following year's crop.
3. Illustrate the increase in soil health with the addition of extra carbon from the cover crop residue. The Soil Health Calculation indicates soil microbiological activity. Minimum Values of seven are expected with a high value of 50.
4. Demonstrate the increased water holding capacity of soil by adding additional plant residue via cover crops.

Rick Haney, PhD, Soil Scientist, Grassland Soil and Water Research Laboratory, USDA-ARS, Temple, Texas and his staff agreed to perform the Solvita Method (See Appendix A.) for soil fertility testing on all samples from our test fields. Dr. Haney advised that when analyzing the data, the Nitrogen lbs/acre and the Soil Health Calculations were the most telling of soil benefits. These two parameters have been highlighted for each field site for this analysis. (See Appendix B. for the complete nutrient values for each site.)

Initially, four of the County's largest farmers responded to an advertisement looking for volunteer participants. The advertisement appeared in our Winter 2014 Conservation Spotlight District Newsletter. The responding farms were; Heyob Farms, Knollman Farms Inc., Joseph Hoerst Farms and Leonard Minges Farm. All farms are located in Crosby and Harrison Townships, in the Northwest section of Hamilton County, Ohio (See Appendix C. for locations and sampling site maps.)

All four farms agreed to participate in cover crop application for a three year period. They also agreed to allow access to the fields for monitoring and spring soil sampling prior to fertilizer application.

The first year of cover crop application occurred September 19, 2014, by aerial seeding. The seed mix, obtained from Walnut Creek Seed, Carroll, Ohio; contained Daikon Oilseed Radish, Crimson Clover, Winter Cereal Rye and Oats. It was distributed at a rate of 63 lbs/acre.

Unfortunately, five weeks of drought followed the seeding with only spotty rain; germination was minimal. The common thought was that the thick stands of soybeans in all fields prevented the seed from making contact with the soil. Lack of rain complicated the situation.

The second year of cover crop application occurred September 10, 2015, again by aerial seeding. The rainfall pattern replicated our 2014 experience. Germination rate again was minimal. The corn was a worse deterrent for the seed making soil contact than the soybeans. The farmers noted that the one successful seed that re-sprouted in the following spring was the Cereal Rye. They felt the aerial seeding was not worth the cost or the effort. They agreed to continue planting cover crops but only if they could use just Cereal Rye. They refused to include a legume because they felt it would not have enough time to root and fix Nitrogen. Joseph Hoerst decided not to continue his program participation in the fall of 2016.

I expressed concern, to Dr. Haney, that the participants only wanted to plant Cereal Rye for the last two years of the study. I was especially concerned that no legumes were included. He explained that Cereal Rye is a good scavenger of Nitrogen. The issue is that the Nitrogen stored by the Cereal Rye will not become evident until temperature and moisture increases and the rye begins to decompose. That may be in May or later. Because we want to sample the soil before any fertilizer inputs are placed on the fields, we sample in March. His prediction did come to fruition as several of the fields showed lower Nitrogen values in our spring soil testing, but the farmers reported a “greening up”of crops in late May or early June.

Due to the change in seed content and application, the District was able to stretch the grant money an additional year.

In late Sept – early October 2016, Heyob Farms drilled the Cereal Rye seed into their field after harvest. Knollman Farms Inc. and Leonard Minges Farm gently disked the Cereal Rye directly into the soil after harvest. Germination was quite successful on all of the farms and the rainfall cooperated. By March of 2017, all fields had full, thick coverage of rye ranging in height from 12” – 32”. The same processes were used for the fall 2017 planting. The soils were tested on Knollman Farms Inc. and Heyob Farms in March 2018. Unfortunately, Mr. Minges, owner of Leonard Minges Farm, passed away in winter of 2018. When our soil testers went to sample his field in the spring of 2018, they reported they could not access the site.

After conducting the soil sampling, Heyob Farms informed the District that they decided to not plant the 2017 fall cover crops in their test field, but to let the chipped corn stalks lie on the soil. They did plant cover crops in several other fields, totaling over 200 acre. Therefore, the 2018 soil test results from Heyob Farms do not reflect a cover crop planting.

Interpretive Results

Heyob Farms

The field planted by Heyob Farms was 90.4 acres. Soil sampling was done in six areas based on soil types.

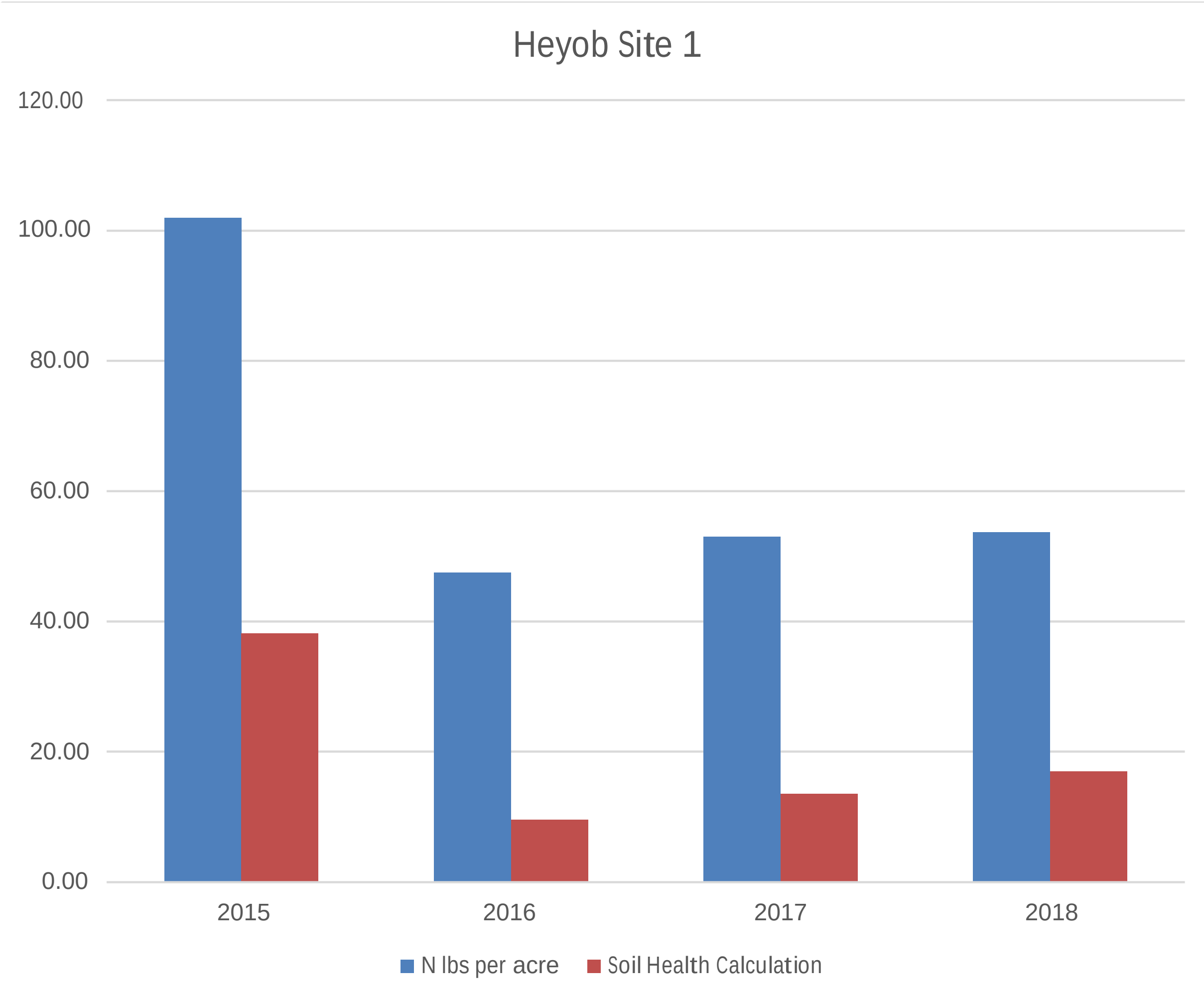
Heyob Testing Sites and Soil Types – See site map in Attachment B.

Heyob	1	RwB
Heyob	2	XeB
Heyob	3	XeB
Heyob	4	RvB2
Heyob	5	RvB2
Heyob	6	WyC2

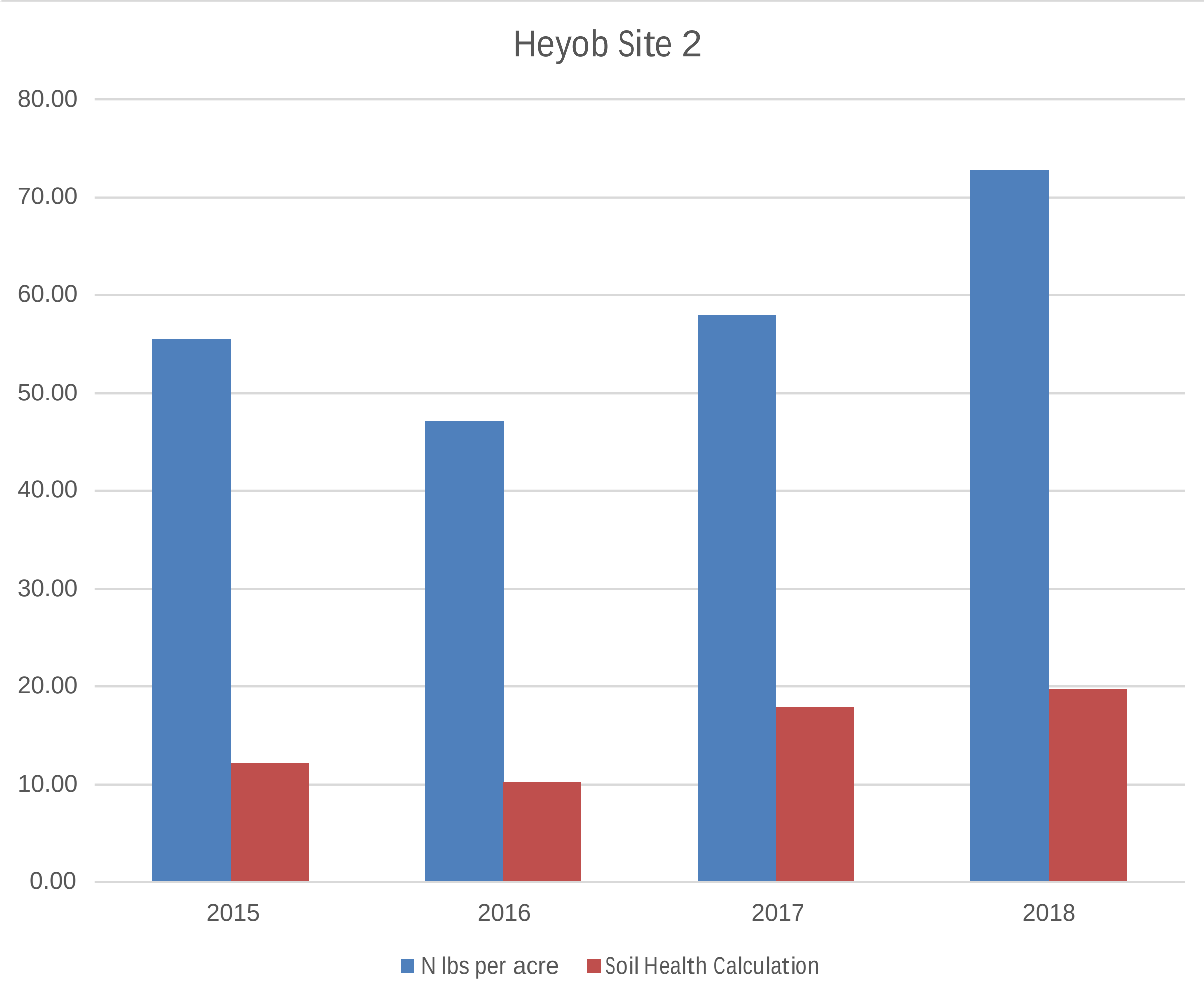
Heyob Farms noted that the 2014 areal seeding resulted in sparse germination and the 2015 flyover resulted in even less germination. In fall 2016, 37 lbs/acre of Cereal Rye was drilled into the soil after harvest. Along with normal moisture they achieved a thick stand of 85 – 100% germination. It was terminated the spring of 2017 at a height ranging from 12" – 18". In 2017, they drilled over 200 acres of Cereal Rye into different fields and achieved a 30" average growth. In 2017, Mike Heyob, co-owner of Heyob Farms, felt the cover crops delayed the corn that was grown in sandy soil. He felt the Cereal Rye had tied up the micro nutrients and Nitrogen. The corn crop was planted April 29, 2017, but the first leaves were streaked, indicating nutrient deficiencies. The new growth of leaves did not green up until late June; once the nutrients were released from the decomposing Rye. The plants were about 2 weeks later in setting ears of corn and Mike noted the ears had 1" – 2" tipping which would potentially cut down on yield. He did note that the Rye does help retain moisture in the soil. Since their fields received low rainfall in June and July 2018, Mike felt the extra water retention might offset the tipping. If they receive additional rain, it could help fill out the ears. Mike also felt that the type of hybrid of corn used makes a difference. He felt he would have to wait until harvest to determine the cost/ benefit of the cover crop.

Mike commented that he would use hybrids that have roots that go straight down when planting in the spring 2019. He felt those hybrids that have horizontal rooting would not respond to cover crops as well. He is also going to cut back to planting 30 lbs. Cereal Rye/acre. as the fall 2017res crop was too dense.

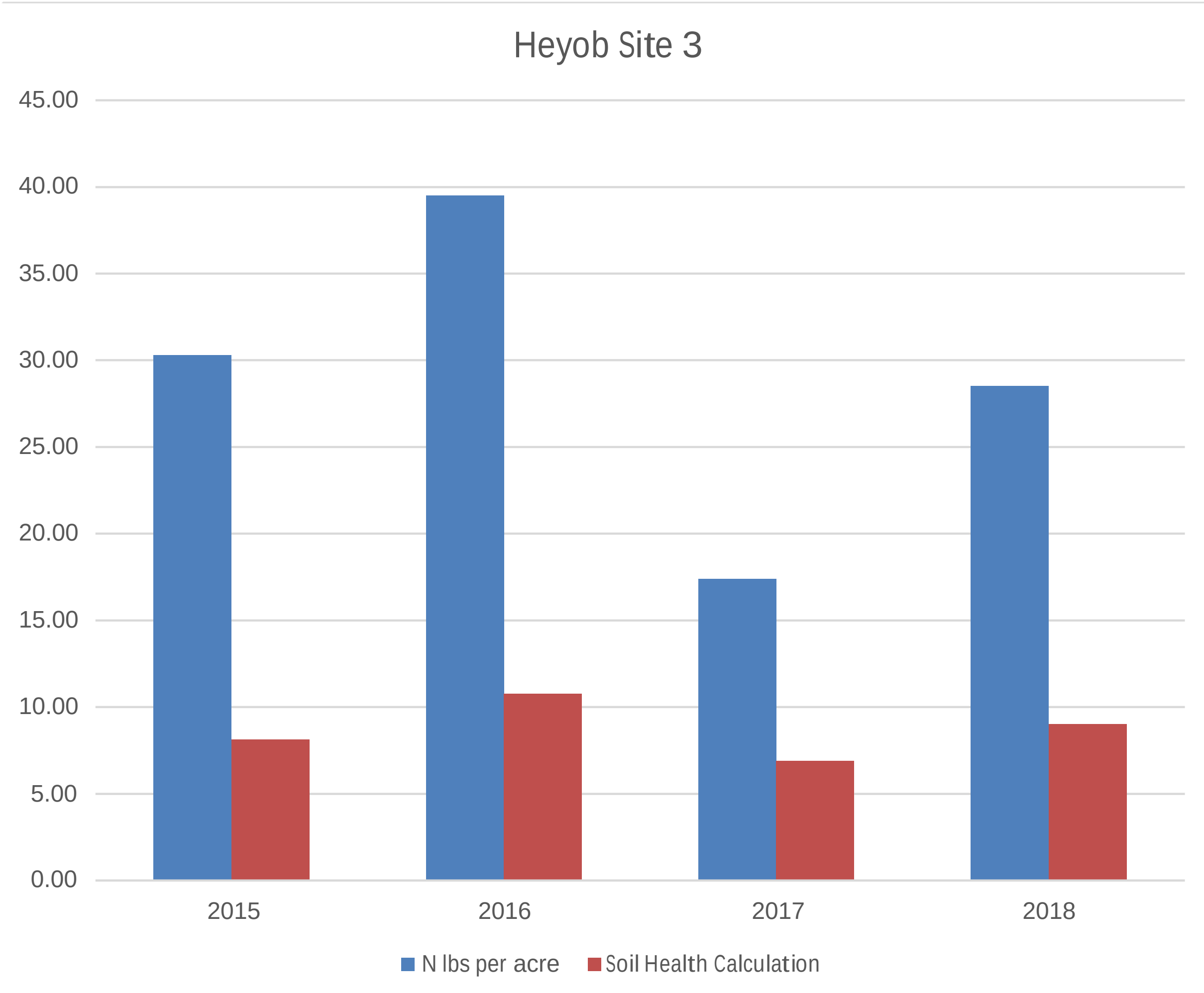
The Nitrogen values were the highest in 2015 following the first areal seeding, except for site 2 and 3, which had the highest rating in 2018 and 2016 respectively. Based on the data for 2015, the Author believes soil samples were taken after the spring fertilizer was applied. If this was the case, the 2015 data is not valid for this study.



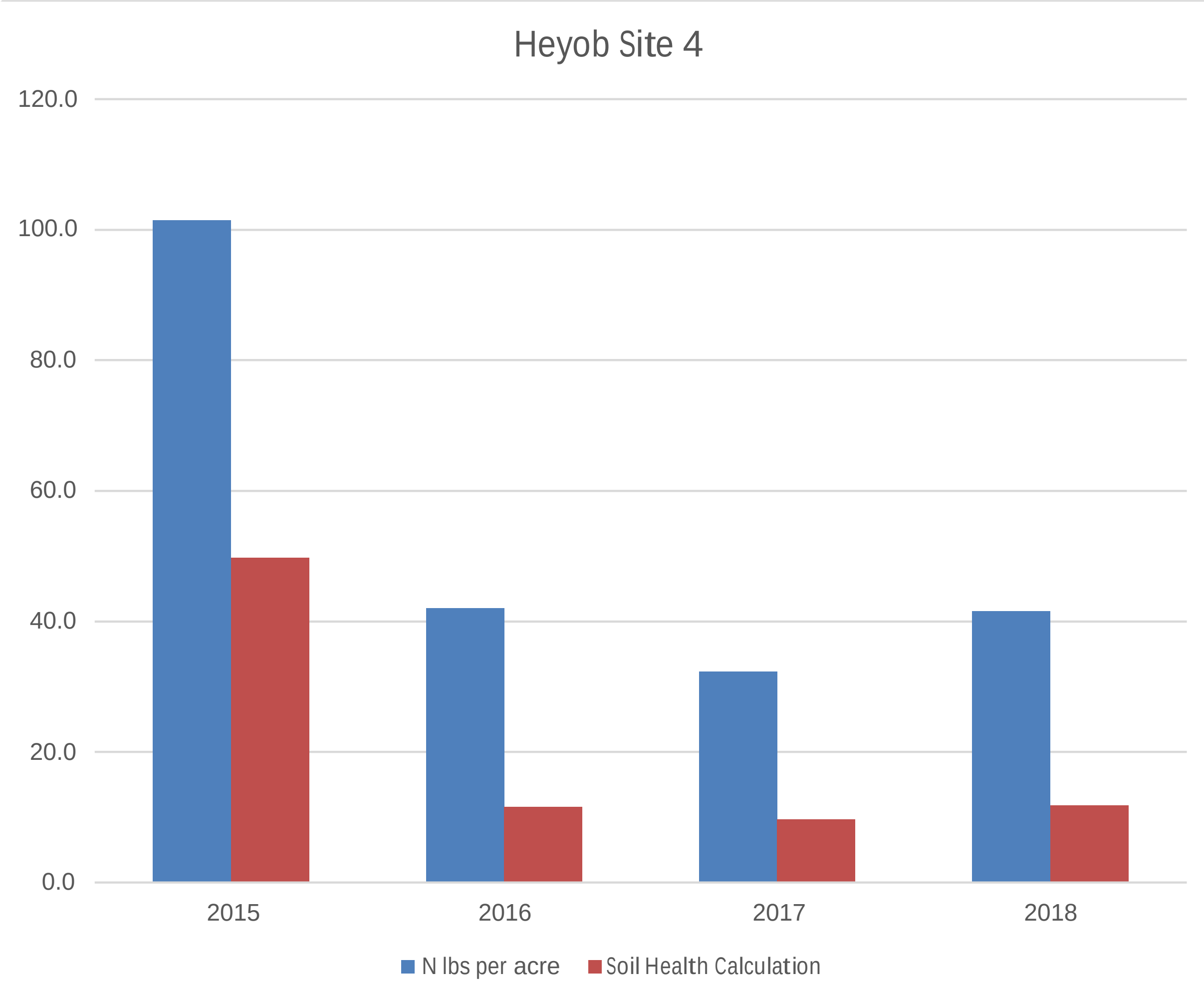
Heyob Site 1- Discounting 2015 data, this site showed a 10 lbs/acre increase in Nitrogen and a 4 point increase in Soil Health Calculation from 2016 – 2017. Fall of 2018 was left in corn stubble with no cover crop planted. The N/Acre was maintained and soil Health increased 3+ points.



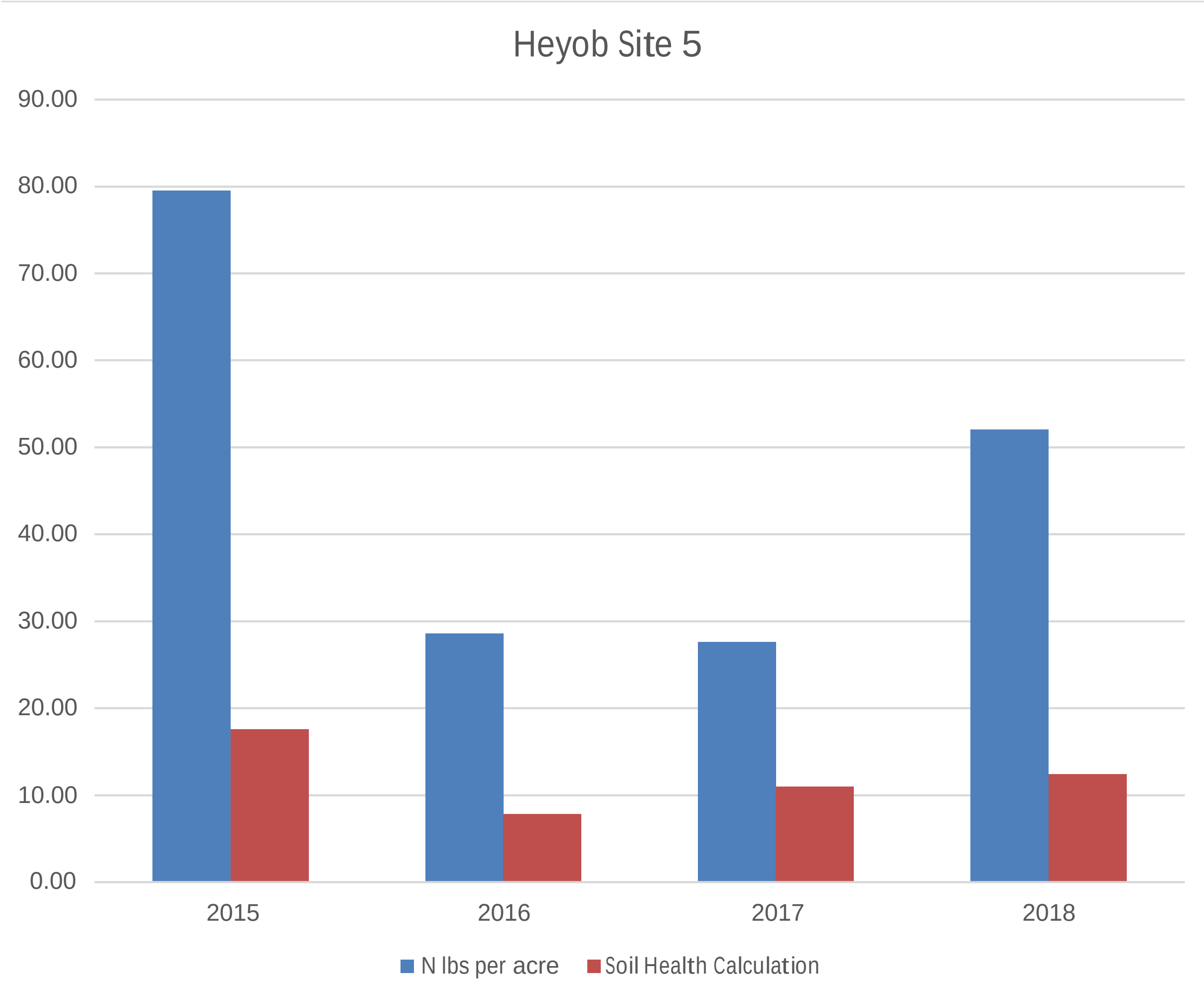
Heyob Site 2 –This site also showed a 9lb. N /acre increase and a 7.5 point increase in Soil Health Calculation. Curiously, the 2018 spring soil testing was the highest in NPK and soil health. This was the year the Heyobs decided to leave the corn stalks and not plant the cover crops.



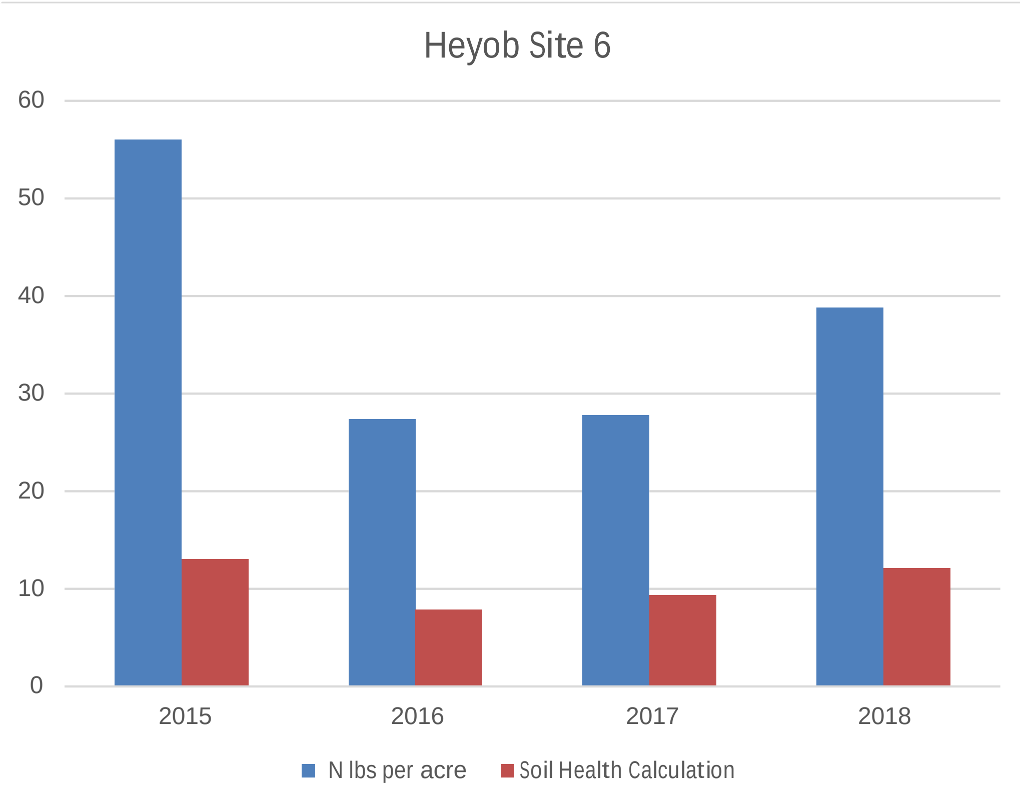
Heyob Site 3 – Had the highest Nitrogen reading in spring of 2016 at almost 40 lbs/acre and 10.8 in Soil Health Calculation followed by a 22 lb. Nitrogen drop in in 2017 and a rebound to 28.5 in 2018. The Soil Health Calculations were also erratic.



Heyob Site 4 – Discounting 2015 stats, Nitrogen lbs/acre varied from 42 lbs/acre in 2016 to 41.5 lbs/acre in 2018. Soil Health mimicked the same pattern from 11.6 in 2016 to 11.7 in 2018.



Heyob Site 5 – Discounting 2015 stats, Nitrogen lbs/acre remained steady in 2016 and 2017 hovering around 28lbs/acre. There was a sharp rise to 52.7 lbs/acre in 2018. Soil Health Calculation rose from 7.8 in 2016 to 11.03 in 2017 and 12.4 in 2018.



Heyob Site 6 – soil testing was much like site 5.

Heyob Fertilizer Inputs and Composite Yields

	Yield Bu.	N lbs.	P lbs.	K lbs.	Spring Soil Health Values Ave.	
2014-Soybeans	51	13.5	34.5	165	Fall 2013 K application/	Spring 2014 NPK
					23	Spring 2015
2015- Corn	169	182	51	120		
					9.7	Spring 2016
2016- Soybeans	60	13.5	25	45		
					11.3	Spring 2017
2017-Corn	136	172	51	120		
					13.6	Spring 2018
2018 -Soybean	49.9	13.5	25	45		

Due to heavy, continuous rainfall the spring of 2018, the Heyobs had to replant the soybeans. The rain continued and cause spotty growth.

Sites 1, 2, 5 and 6 either maintained or increased the Nitrogen lbs/acre while sites 3 and 4 declined in 2017. All sites maintained or at least a 5 lb/acre increase in the spring 2018 soil testing results. No cover crops were planted the fall of 2017; Chopped corn stalks were left to lie on the field.

Dennis Heyob reported that since the cover crop was not well established every year, they didn't alter their fertility program. There was an increase in Soybean yield between year 2014 and 2016 by 9 bu., however, a higher rate of Nitrogen fertilizer was added in 2016. The conclusion is that more years of trial would be needed comparing all the variables of weather, and cover crop. Mike Heyob stated they will be planting Cereal Rye the fall of 2018 following soy beans, but he did not see enough benefit of planting after corn.

Heyob Farm Photos

Photo by Ellen Heyob

Terminating Cereal Rye

Photo by Ellen Heyob

Corn Sprouting Through Rye -2018

Cereal Rye Stubble

Tipping – Immature Kernels

Streaking of lower plant leaves

Solid Green color of upper leaves

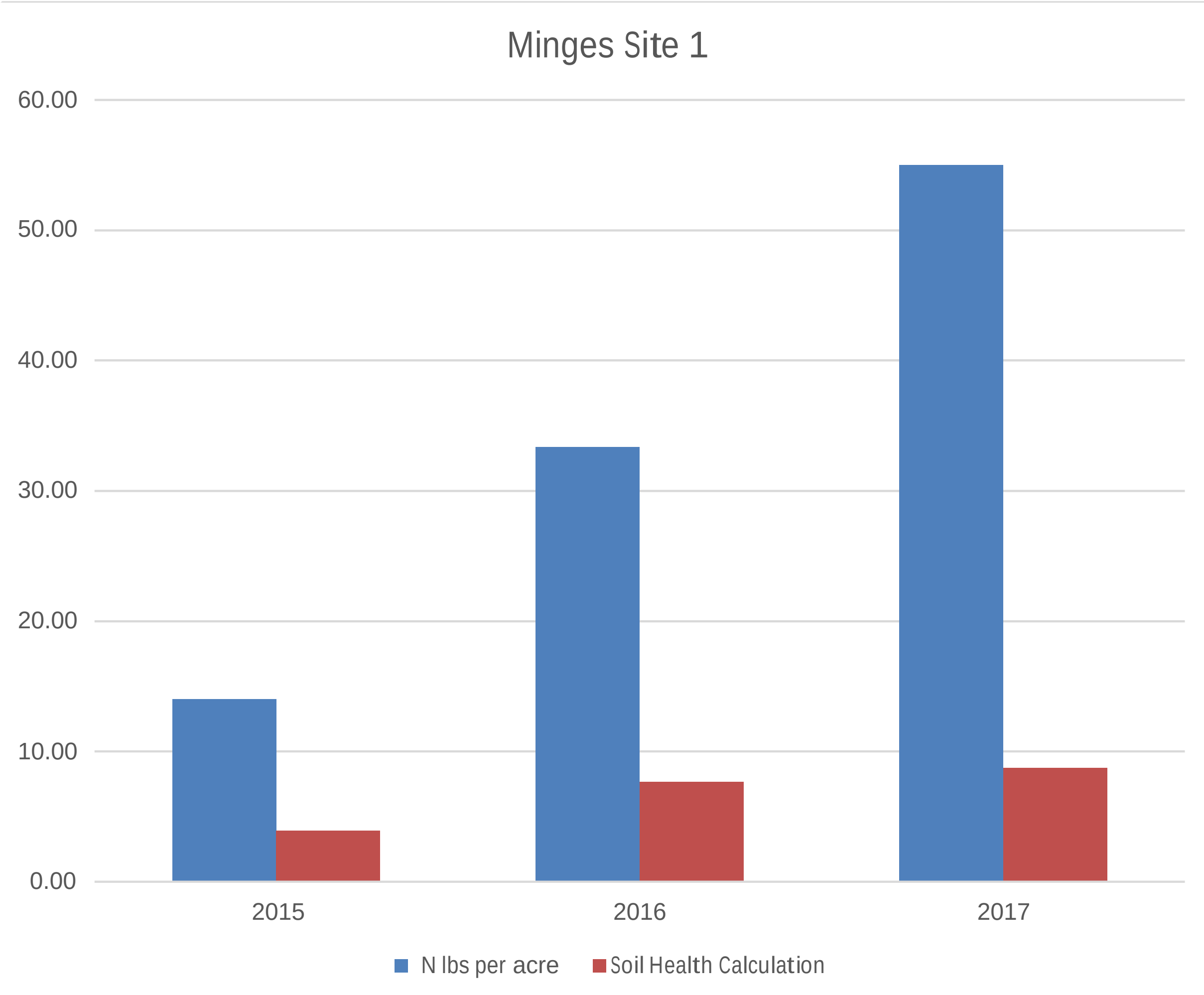
Minges Farm

The Leonard Minges Farm planted 105 acre. in cover crops. Four soil testing sites were selected for testing.

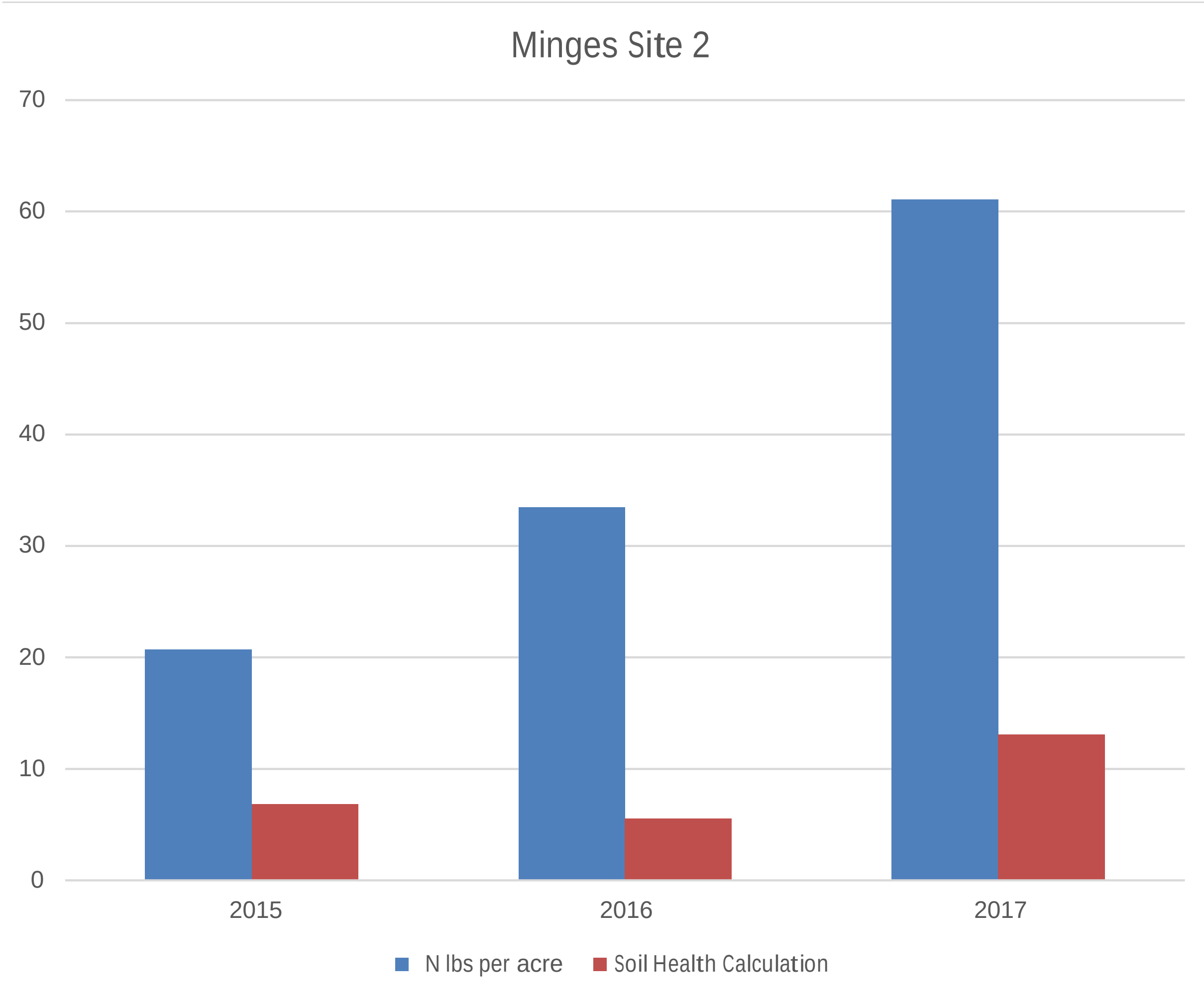
Minges Sites and Soil Types – See Attachment B for site maps

Minges	1	Gn	1
Minges	2	Gn	2
Minges	3	Gn	3
Minges	4	McA	1

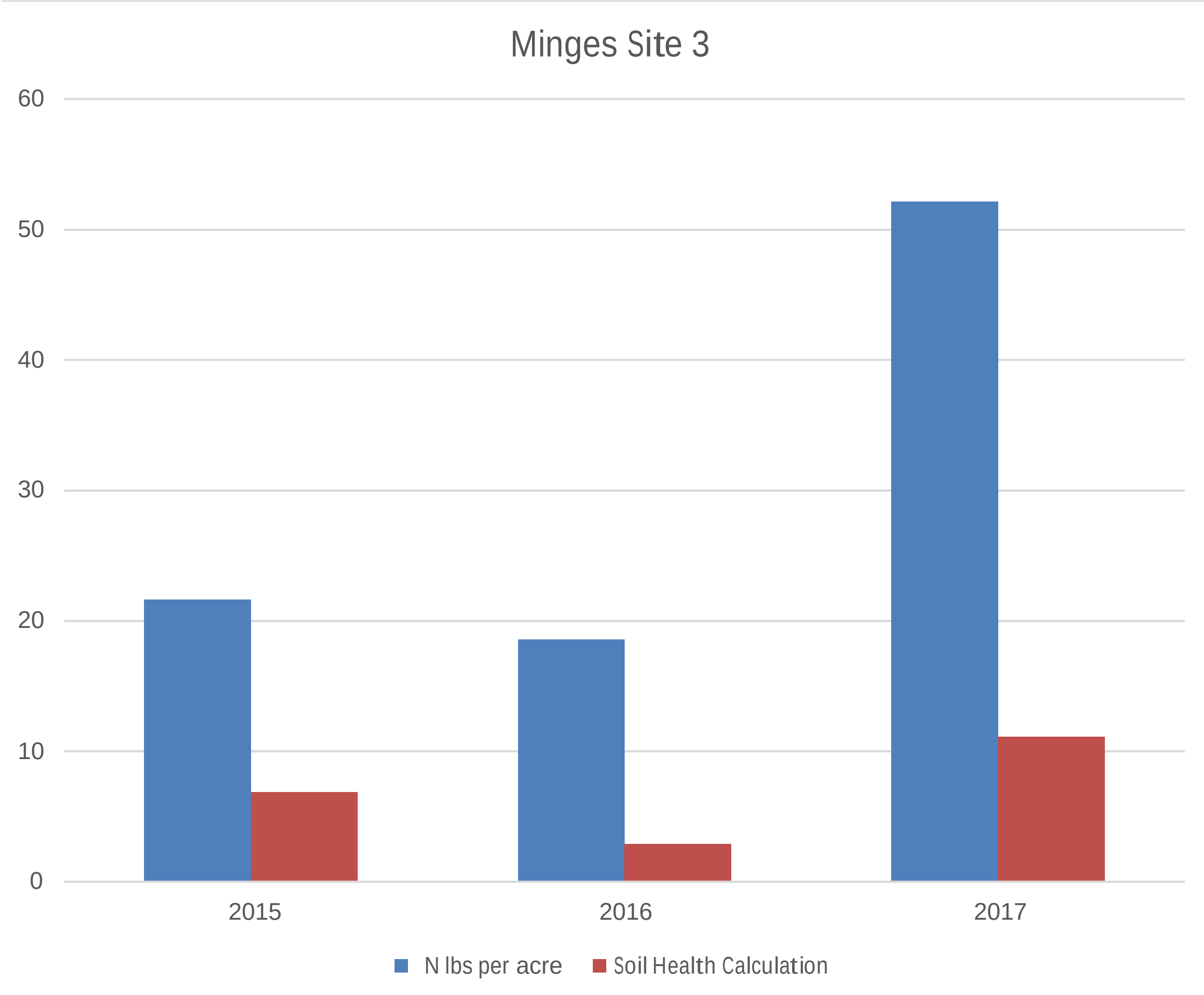
Gary Minges, son of owner, felt the cover crops would be a bonus if they provided any benefit. He felt the 2014 and 2015 aerial application of seed didn't provide much cover. He cited the lack of or timing of rainfall as the biggest barrier. In 2016 and 2017, they gently disked the Cereal Rye seed into the soil after harvest and had good thick growth the following springs. Gary terminated the Rye at least two weeks before planting in the spring. He also turbo tilled the Rye residue into the soil before planting. He did not experience early streaking of corn leaves, excessive tipping or late ear setting on plant.



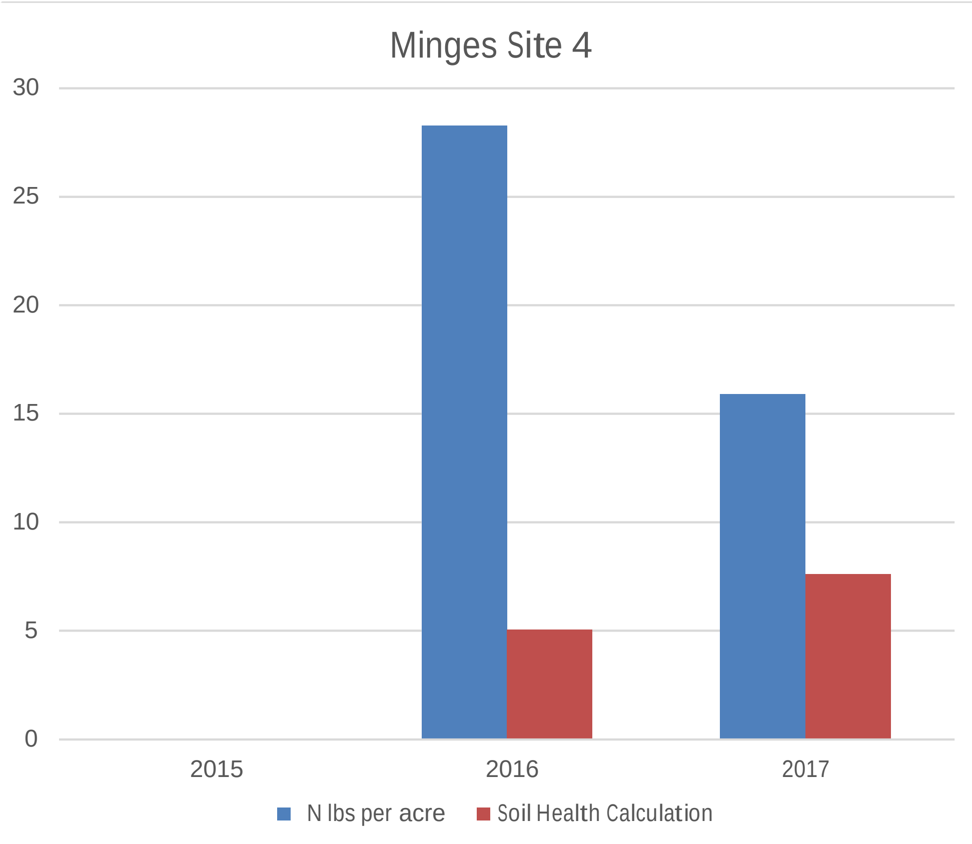
Leonard Minges Farms Site 1. - The Nitrogen increased over the three years of participation. The soil health rating also improved from 2015 – 2018 from 3.9 to 7.75



Minges Site -2. The Nitrogen values tripled over the three year test period. The soil health rating increased from 3.9 in 2015 to 8.75 in 2017.



Minges Site - 3 . Nitrogen/acre dipped 3 lbs from 2015 – 2016, but rebounded to 52 lbs/acre in 2017. Soil Health jumped from 6.9 in 2015 to 11.1 in 2017.



Unfortunately, we did not receive data on this site from the lab in 2015. The sample must have been lost or misplaced. Soil Health increased from 5 in 2016 to 7.6 in 2017.

	Yield Bu/Acre.	N lbs.	P lbs.	K lbs.	Spring Soil Health Ave.
2014-Soybeans	54	0	0	0	
Fall 2014+ MAP 11-52-0				150	
2015- Corn	196	189	78		5.8
At planting					
2016- Soybeans	50	0	0	0	5.3
Fall 2014 – + MAP 11-53-0				150	
2017-Corn	170	189	78		10
2018 -Soybean		0	0	0	

Summary

The Leonard Minges Farms fields showed a definite increase in both Nitrogen and Soil Health, except for site 4 Nitrogen. The results are on target with what our study hoped to show.

Gary Minges is not sure if he will have time to plant cover crops in the fall of 2018.

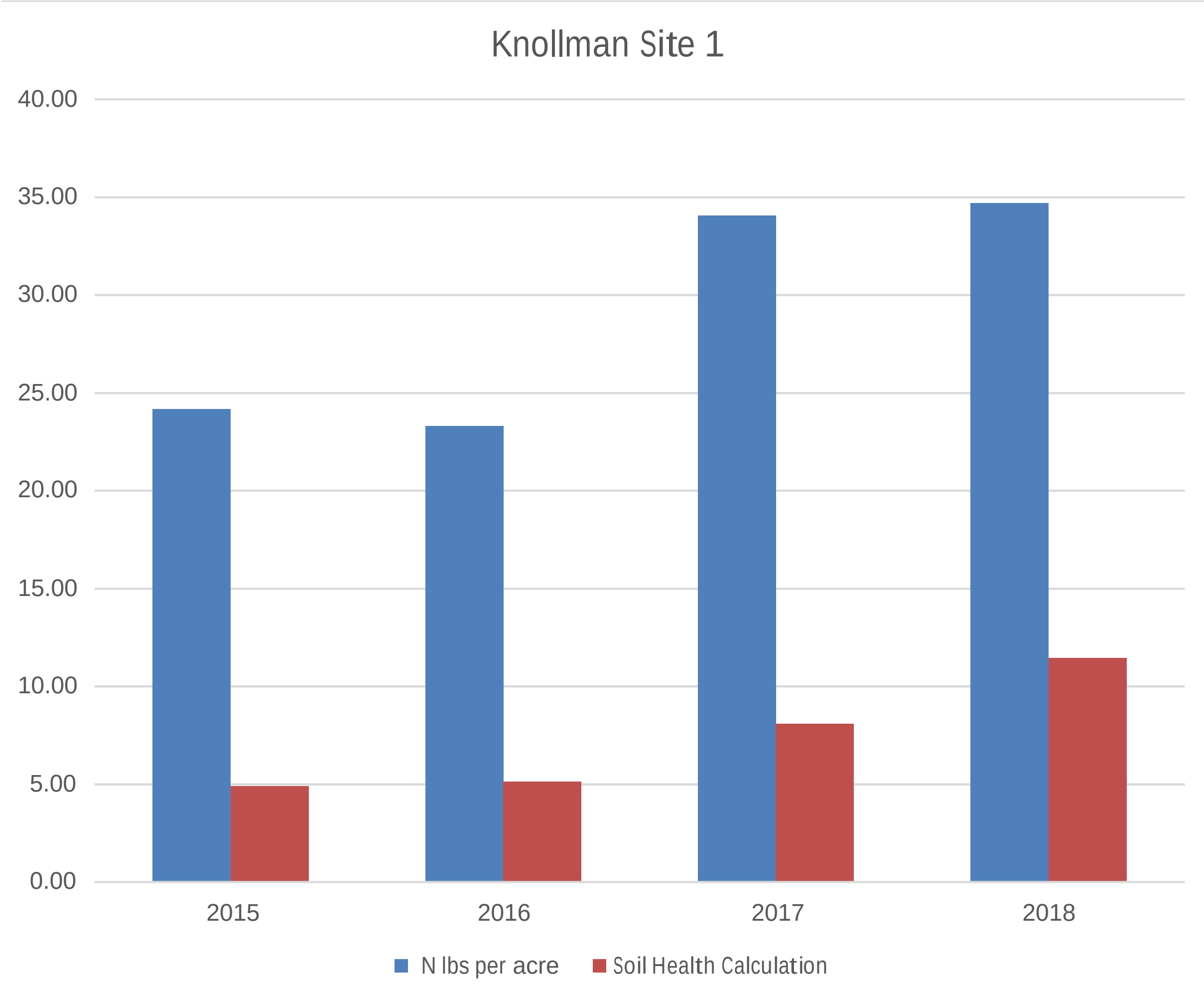
Knollman Farms

Knollman Farms Inc. planted 120 acres of cover crop seed for the study. There were eight soil testing sites on this acreage. See Attachment B for location maps.

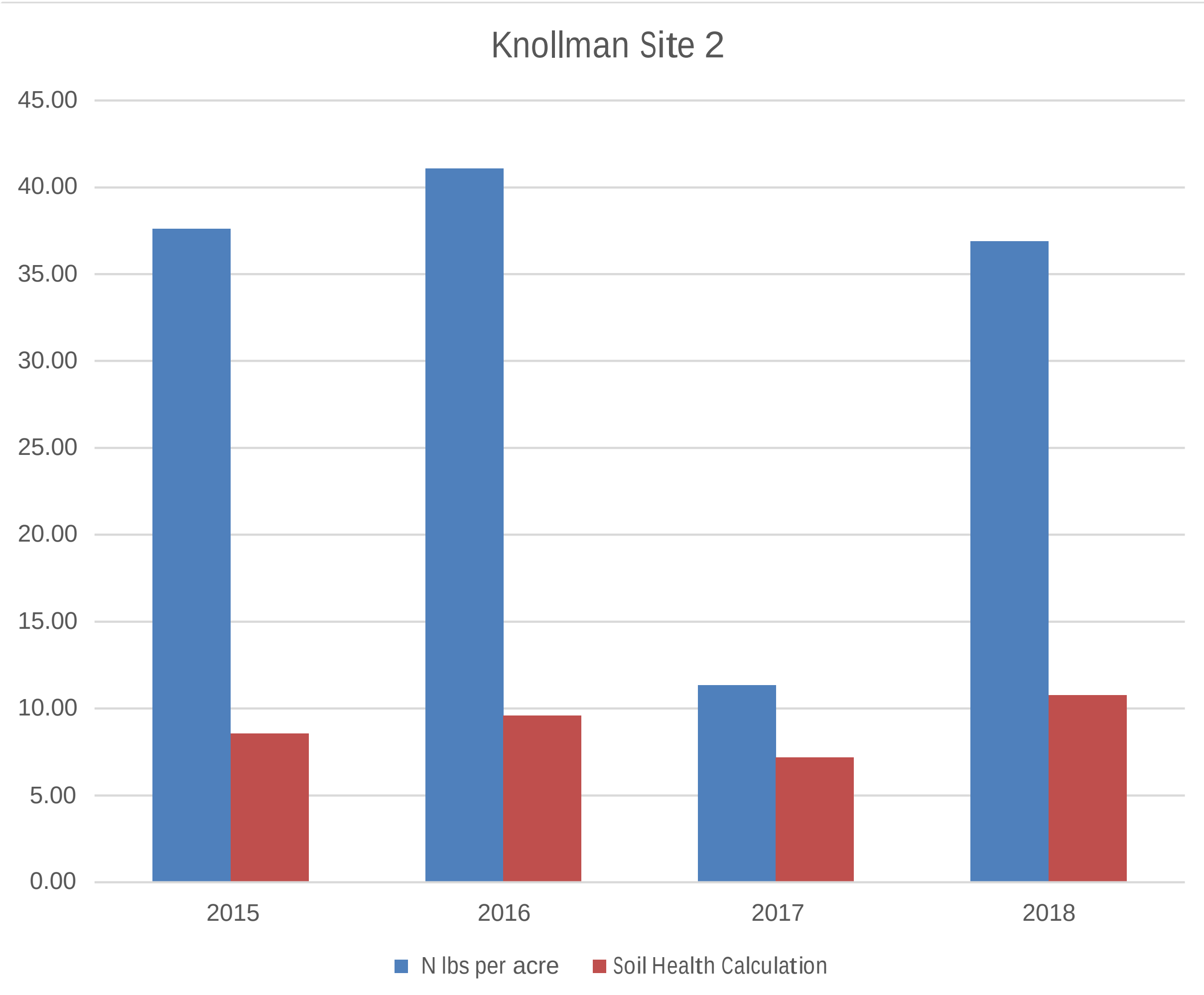
Knollman Sample Sites and Soil Types

Knollman	1	McA1
Knollman	2	HoA
Knollman	3	HoA
Knollman	4	McB
Knollman	5	McB
Knollman	6	RdA
Knollman	7	Pn2
Knollman	8	Pn2

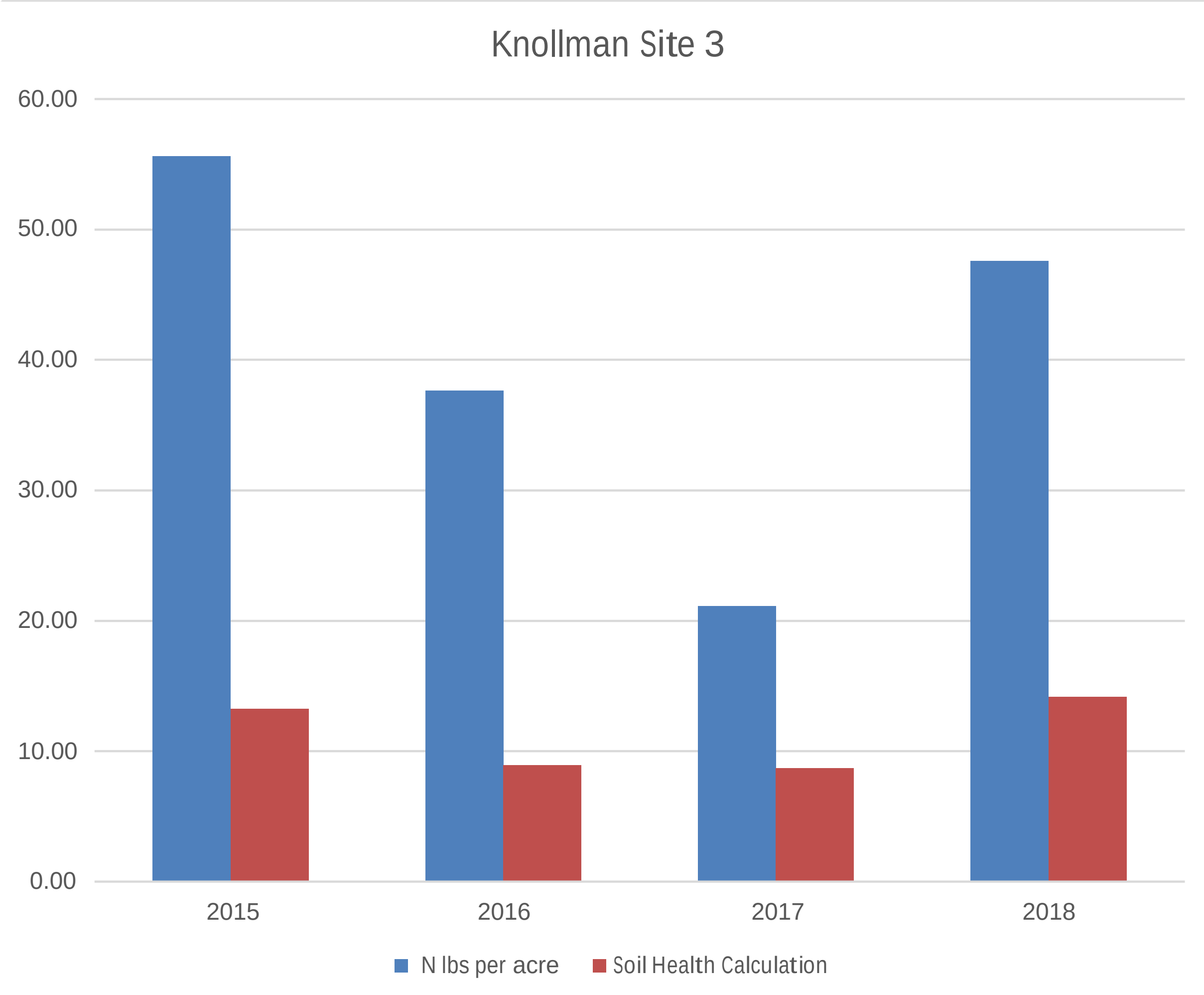
As stated previously, the Knollman's lightly disked in the Cereal Rye seed directly into the soil following fall harvest at a rate of 35 lbs/acre. in the fall of 2016 and 2017. They did not experience the first leaf streaking or the excessive tipping as reported by Mike Heyob. Scott Knollman thought this was because they knifed the fertilizer into the soil below the cover crop root level.



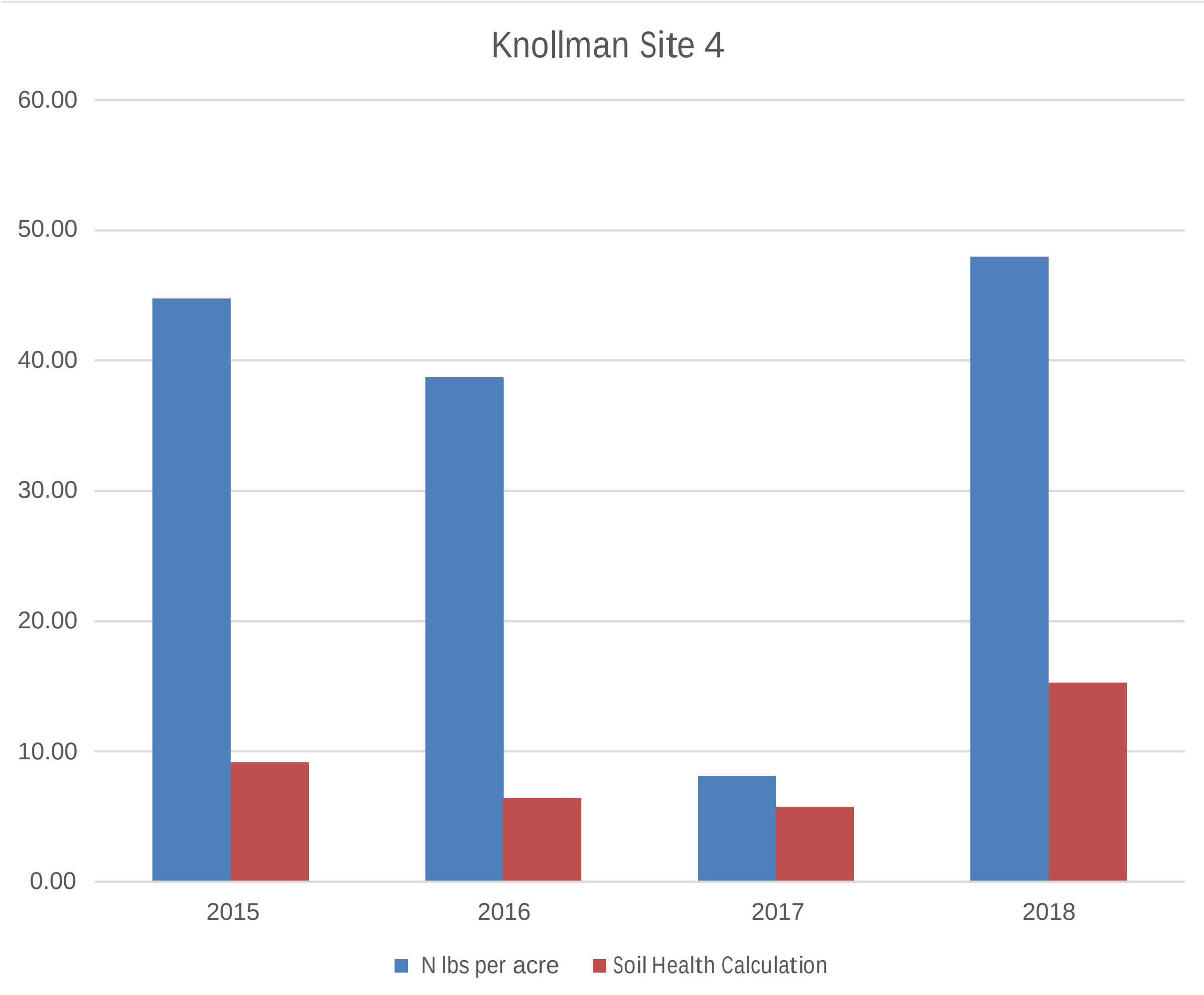
Knollman Site 1 – Nitrogen values increased 10.5 lbs/acre over the four year test period. Soil Health rose from 4.9 in 2015 to 11.5 in 2018.



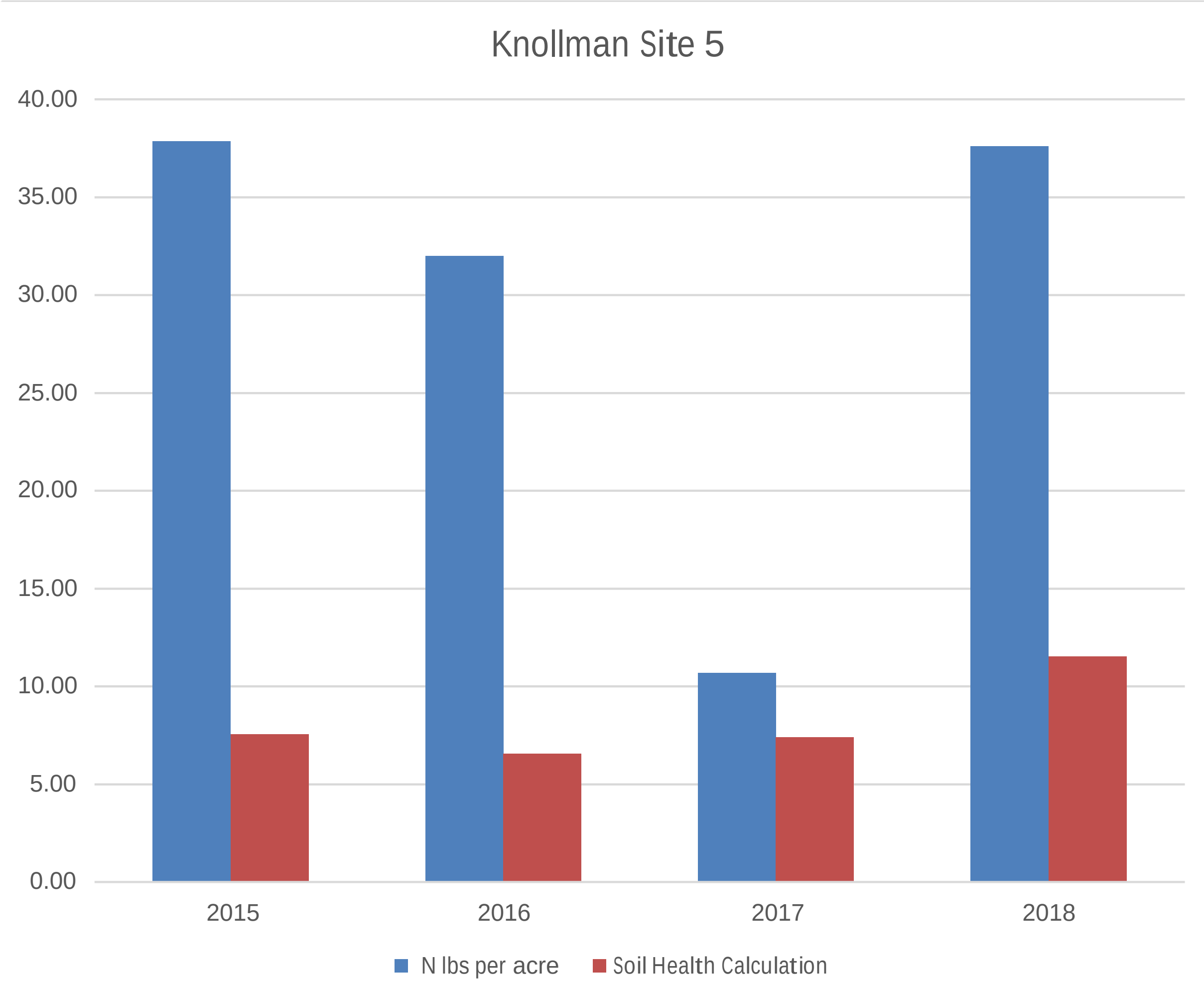
Knollman Site 2 –Nitrogen lbs/Acre rose 41 lbs in 2016 dropping to 11.35 lbs/acre in 2017 and increasing 37 lbs/acre in 2018. Soil Health reflected the same pattern going from 8.5 in 2015 to 9.6 in 2016, declining to 7.2 in 2017 and rebounding to 10.8 in 2018.



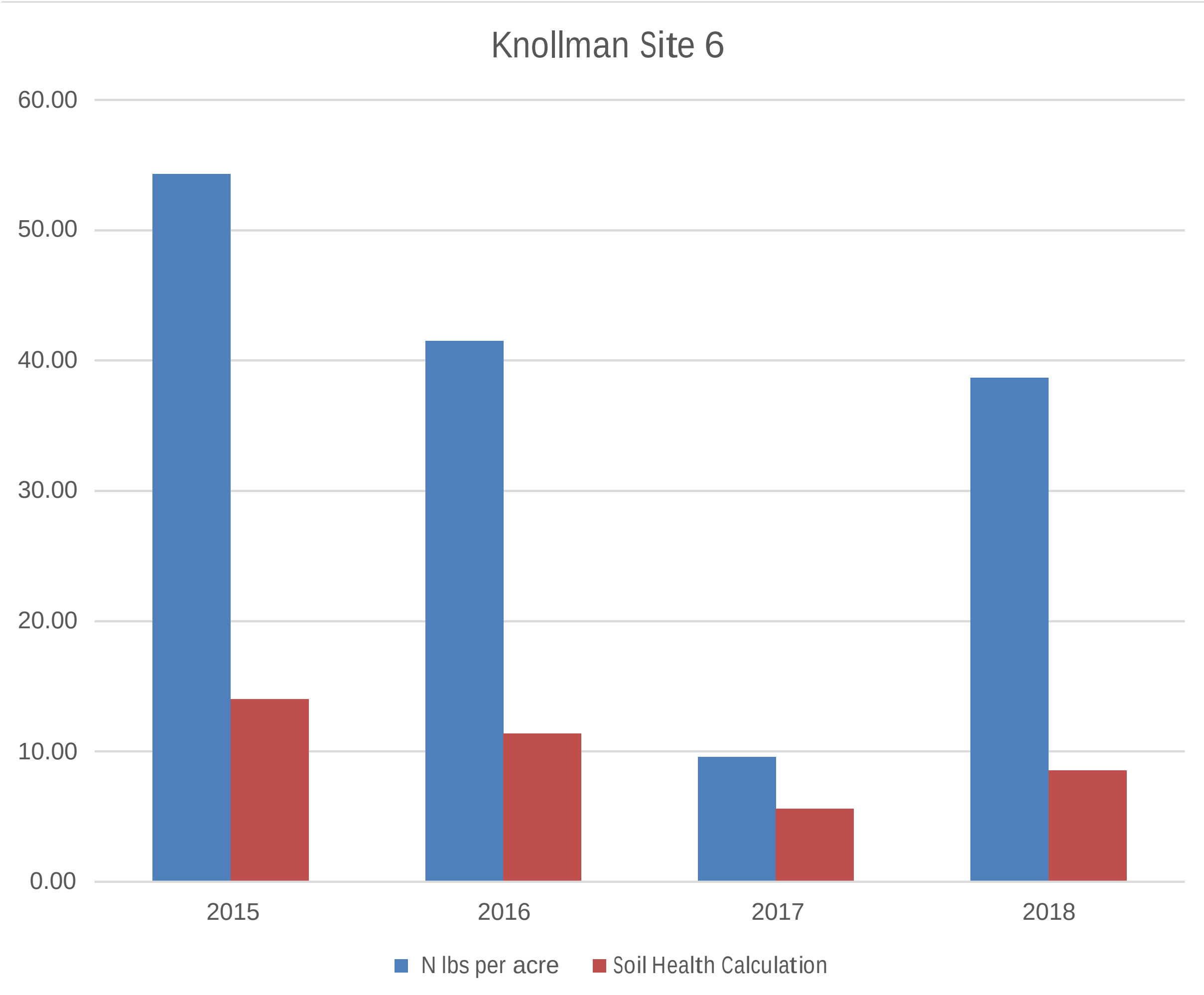
Knollman Site 4 – 2017 saw a severe decline in Nitrogen with a 39 point jump in 2018. Soil Health declined 5 points in 2016 and 2017 increasing to 14 points in 2018.



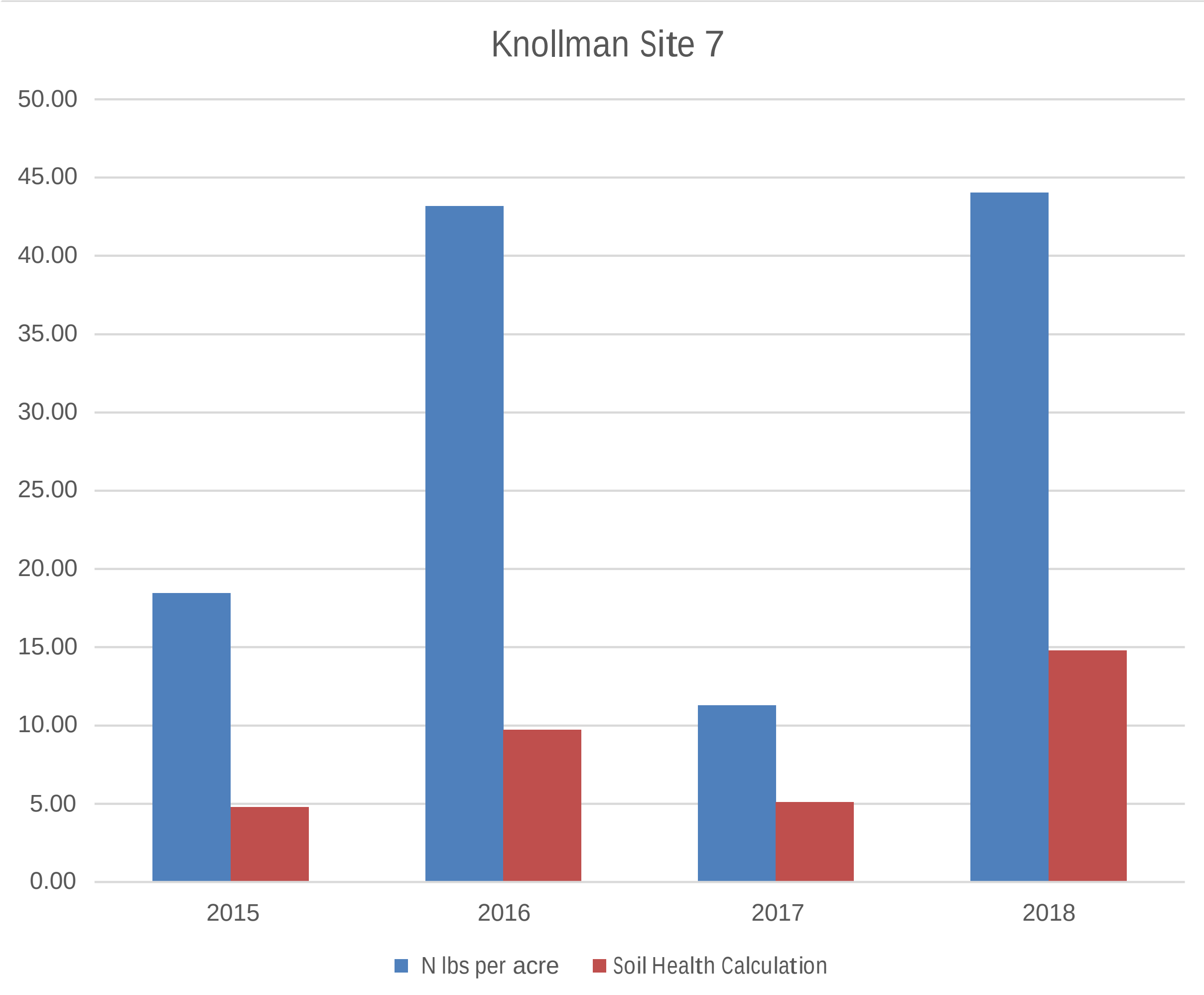
Knollman Site 3 – Followed about the same pattern as Site 2.



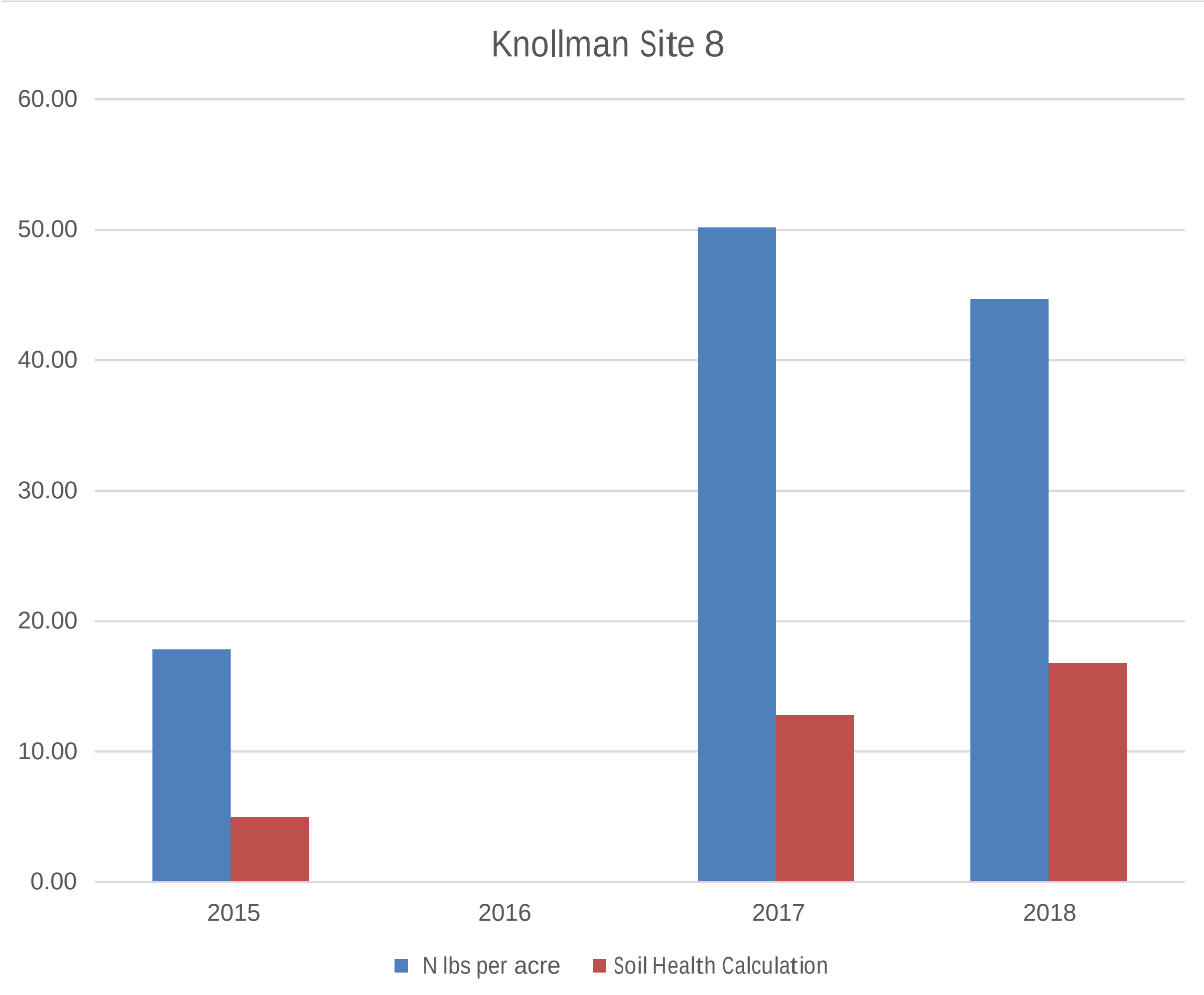
Knollman Site 5 – Nitrogen lbs/acre had a sharp decline in 2017 with a rebound of 27 lbs/acre increase in 2018. This was almost equal to the 2015 Nitrogen lbs/acre. The Soil Health was 7.5 in 2015 to reached 11.5 in 2018.



Knollman Site 6 – Nitrogen lbs/acre decline 44.71 lbs/acre between 2015 and 2017. Rebounding 29 lbs/acre 2018. Soil Health declined 9 points in 2017 and rose 3 points in 2018.



Knollman Site 7 – Nitrogen lbs/acre dramatically climbed and fell between 2015 – 2017 ending on a high of 44 lbs/acre in 2018. The soil health was the lowest at 4.8. In 2015 to a 2018 value at 14.8.



Knollman Site 8 – Nitrogen levels almost tripled from 2015 – 2017, from 18 to 50.2 respectively, and had a small decline to 45 in 2018. Soil Health, however jumped from 4.9 in 2015 to 16.8 in 2018.


March13, 2017


April 14, 2017

Root Mass of Rye

Knollman 2014 -2018 Fertilizer Inputs (lbs.) and Yields (Bushels)

	Yield	N	P	K	Soil Health Ave.	
2014-Soybeans	55.1	13	60	112		
					8.3	Spring 2015
2015- Corn	247.8	195	85	112		
					8.3	Spring 2016
2016- Soybeans	58.1	19	90	80		
					7.6	Spring 2017
2017-Corn	224.4	195	120	60		
					12.9	Spring 2018
2018 -Soybean	64.7		300			

2017 crop had 100 lbs. of potash applied with Rye seed.
After 2017 crop fertilizer applied by soil test. MAP 11-52-0 applied in front of Corn crop.
Potash in front of soybean crop.
Soybean Yields increased during the testing period.

The Knollmans did not lower their fertilizer rates as of September 2018. However, according to Steve and Scott Knollman, the most recent soil testing revealed that they can reduce their spring fertilization in half. They do plan on planting 250 acre. of cover crops in the fall of 2018. They will adjust the seeding rates to 30 lbs/acre on their good soils and use 40 - 45 lb/acre. on their sandier soil. They are very impressed with the extra water retention in the soil which they receive from the cover crops. Another benefit sited by the Knollmans was the reduction of tillage. Steve mentioned that by barely nicking the Rye seed in the soil right after harvest, they already have a good 2" stand of the rye by October 2018. He cited the saving of time and money for fuel due to the reduced tillage. He also noted the better texture of the soil and increased yields regardless of all the variables.

Conclusion

The overall goals of the cover crop study were to illustrate to the farmers the benefits of using cover crops. Establishing four demonstration sites by some of the largest and most respected farmers in the County, surrounding farmers could observe the results and hopefully replicate the use of cover crops.

Goal Attainment

1. **Reducing erosion on fields after harvest through spring.**
Aerial seeding proved to be an expensive and a risky way to spread the seed. Although weather is always a factor, the lack of seed/soil contact proved to be a larger barrier. Direct seeding by drilling or disking was a far more successful method of planting. The dense regrowth of the Cereal Rye in spring 2017 and 2018 definitely succeeded in this goal.

2. **Retaining Nitrogen and other micronutrients in the soil for the following year's crop.** A true sign of success would be to see the farmers Nitrogen inputs reduced in the spring. Results – The results of Nitrogen values were mixed. 59% of the fields saw an overall increase in Nitrogen; 30% saw a decrease and 11% remained about the same. None of the farmers decreased their nitrogen inputs based on the cover crop soil test results; however, the Knollmans said they will adjust their fertilizer rate in 2019 based on their own recent soil fertility test. 2017 and 2018 witnessed a good stand of cereal Rye in the spring. The soil testing was conducted in March prior to fertilizer application. The Nitrogen could have been held by the Rye at this point in the year, releasing it when temperatures and moisture increased. This may have stilted the Nitrogen results.

3. **Illustrate the increase in soil health with the addition of extra carbon from the spent cover crop.**

Both the Heyobs and the Knollmans fields improved overall in soil health. Overall, 94% of the fields had an increase of Soil Health over the 4 year study. 2% had a decrease in Soil Health and 2% remained about the same. These Soil Health results mark the biggest success of this study.

4. **Demonstrate the increased water holding capacity of soil by adding additional plant residue via cover crops.**

The additional plant residue on the soil surface served as a mulch, increasing water holding capacity. This was especially beneficial on sandy soil. Repeated planting of cover crops increased this capacity. The Knollman's in particular felt this increased their overall yields. Results – Both the Heyobs and the Knollmans acknowledged the increase water holding capacity of the soil. Both farmers plan to plant an increased acreage of cover crops in fall 2018. The Knollmans harvested 5 acres of Cereal Rye to save the seeds for planting.

Acknowledgement of Support

In addition to Ohio Farm Bureau for supplying the grant for this project and Hamilton County farm Bureau for holding and distributing these funds, I want to thank the following individuals and organization for assistance and support of this study.

- Rick Haney, PhD, Soil Scientist, Grassland Soil and Water Research Laboratory, USDA-ARS, 808 East Blackland Rd., Temple, TX 76502. Dr. Haney and his staff agreed to perform the Solvita Method for soil fertility testing on all samples from our test fields. Buddy Faulkenberry Engineer Tech/ Lab Manager, Chris Holle, Cart. Tech, and Mike Reed, Physical Science Tech are included in Dr. Haney's outstanding team. Dr. Haney is the pioneer of the Solvita Method using water extraction for nutrient levels as well as organic carbon which is the food for the microbes. Please see Attachment A. for details on this testing method.
- John Williams, District Conservationist, Natural Resource Conservation Service (NRCS) and William Cook, Soil Scientist, (NRCS) were both instrumental in providing aerial photos and maps for this project.
- All of the farmers who participated for their cooperation and time spent on this cover crop project.

Appendix A.

Soil Health Tool (SHT) ver 4.6. An Integrated approach to soil testing

Soil Testing in Nature's Image

Rick Haney USDA-ARS

The soil health tool is an integrated approach to soil testing using chemical and biological soil test data; it is designed to mimic nature's approach to soil nutrient availability as best we can in the lab. This tool is the culmination of nearly 20 years of research in soil fertility and I believe it represents the next step in soil testing for the 21st century.

This tool is designed to answer some simple questions:

1. What is your soil's condition?
2. Is your soil in balance?
3. What can you do to help your soil?

The Soil Health Tool is designed to work with any soil under any management scenario because the program asks simple, universally applicable questions. The methods use nature's biology and chemistry by using a soil microbial activity indicator, a soil water extracted (nature's solvent), and the H3A extractant, which mimics the production of organic acids by living plant roots to temporarily change the soil pH thereby increasing nutrient availability. These organic acids are then broken down by soil microbes since they are an excellent carbon source, which returns the soil pH to its natural, ambient level. The tool uses an integrated approach to soil testing, reflecting the complex ecosystem of the soil, instead of depending upon the narrow measurement of inorganic N, P, and K. The integrated approach is naturally controlled so that N or P will not exceed what is available from the organic N and organic P pools.

Procedure for soil analysis:

Each soil sample received in the lab is dried at 50o C for 24 hr. and ground to pass a 2 mm sieve (Do not grind finer than 2 mm). The dried and ground samples are scooped with the weight recorded using a Sartorius Partum 2102-1S into two 50 ml centrifuge tubes (4 g each) and one 50 ml plastic beaker (40 g) that is perforated and has a Whatman GF/D glass microfiber filters to allow water infiltration. The two 4 g samples are extracted with 40 ml of DI water and 40 ml of H3A for a 10:1 dilution factor. The samples are shaken for 10 minutes, centrifuged for 5 minutes, and filtered through Whatman 2V filter paper. The water and H3A extracts are 2

Analyzed on a Seal Analytical rapid flow analyzer for NO3-N, NH4-N, and PO4-P. The water extract is also analyzed on an Elementary TOC select C: N analyzer for water-extractable organic C and total N. The H3A extract is also analyzed on an Agilent MP-4200 microwave plasma for Al, Fe, P, Ca, and K.

It is critical to use a C: N analyzer designed for water samples, these instruments determine concentrations in ppm whereas C: N analyzers designed for soil are not sensitive enough since they measure C and N in the % range.

The 40 g soil sample is analyzed with a 24 hour incubation test at 25o C., the sample is wetted through capillary accretion by adding 18 ml of DI water to an 8 oz. glass jar (ball jar with a convex bottom) and placed in the jar and then capped. Solvita paddles can be placed in the jar at this time and analyzed after 24 hrs. with a Solvita digital reader. Alternatively, at the end of 24 hour incubation, the CO2 in the jar can be pulled through a LiCor 840A IRGA, which is a non-dispersive infrared (NDIR) gas analyzer based upon a single path, dual wavelength infrared detection system. The peak height is recorded via the Licor software and saved in an Excel file.

We then use an Excel file with a "peak hunter" macro to find the highest peak for each sample at a constant pressure, the macro then corrects for the ideal gas law (thanks to Will Brinton) and converts the result to CO_2-C ppm.
Following lab analysis, the raw data are placed in an Excel file (rawraw) that uses macros for correction by sample weight for each extract as well as various calculations and checks to ensure analytical performance. Once the results pass the checks, they are copied and pasted into the Master Excel file to perform the various calculations that yield available NPK, chemical analysis, and soil health results. The final results are copied and pasted into the "results" file for delivery to the user. In the Excel "results" file you will find the following:
NPK TAB
Fertilizer Recommendations
N, P_2O_5, and K_2O (lbs/acre):
These numbers represent the amount these nutrients presently in your soil in lbs/acre.
Nitrogen: From the water extractable NH_4-N + 70% of NO_3-N + MACRE * WEON *4 where; MACRE = microbial activity retrieve C and WEON = water extractable organic N. The number 4 represent a conservative estimate of the number of significant rainfall events (>1 in.) over the course of a growing season. 3

Phosphate: From the H3A extractable ortho-phosphate and organic P based on microbial respiration and a sliding scale C: N ratio.
Potassium: H3A extractable K.
Nutrient value per acre: Current fertilizer prices are multiplied by the nutrients present in your soil. This is the value in dollars per acre of nutrients currently in your soil.
N, P_2O_5, and K_2O needed calculator (Run button):
In the crop column, type in your crop type. In the yield goal column, type in your yield goal. Click on the Run button and the next three columns will calculate your N, P_2O_5, and K_2O needed in lbs per acre to produce your stated yield goal. You must put a crop and yield goal for each sample or you will get an error.
The method used to calculate fertilizer requirements is based on a simple concept: NPK needed for your yield goal minus NPK you have in the soil. However, it is your money; if you think these numbers are too high or too low adjust them accordingly. We are giving you the best numbers we can based on our current understanding of soil and the limits of technology.
NO_3-N Only (traditional testing) lbs per acre: National 4 year average is 24 lbs per acre
This column represents testing for nitrate-nitrogen in lbs/acre. This is the only form of nitrogen that most soil test labs measure. We only credit 70% of this measurement due to leaching and denitrification over the growing season.
Additional N (SHT) lbs per acre: National 4 year average is 35 lbs. per acre
This column represents the amount of nitrogen present in your soil in addition to the nitrate described above. This number is attained by incorporating contributions from the biological component in the soil plus NH_4-N from the water extract. In other words, this value is the biologically available N value and NH_4-N as compared to the inorganic N measured by most commercial or university labs.
$ Nitrogen saved per acre: National 4 year average is $21 per acre
This column represents the amount of nitrogen saved in dollars per acre by accounting for the biologically available N and ammonium as compared to the nitrate only approach. 4

Soil Health

We have included the national average for some of the measurements based on the mean of 20,000 soil samples from across the country over a four year period (2012-2015).

1-day CO_2-C:

National 4 year average is 52 ppm

This result is one of the most important numbers in the soil test procedure. This value is the amount of CO_2-C (ppm) released in 24 hr. from soil microbes after your soil has been dried and rewetted (as occurs naturally in the field). This is a measurement of the microbial activity in the soil and is highly related to soil fertility. In most cases, the higher the number, the more fertile the soil.

Microbes exist in soil in great abundance. They are highly adaptable to their environment. Their composition, adaptability, and structure are a result of the environment they inhabit. They have adapted to the temperature, moisture levels, soil texture, crop and management inputs, as well as soil nutrient content. In short, they are a product of their environment. If this were not true they most likely would have died out long ago, but they didn't. Since soil microbes are highly adaptive and are driven by their need to reproduce and by their need for acquiring C, N, and P in a ratio of roughly 100: 10: 1 (C: N: P), it is safe to assume that soil microbes are a dependable indicator of soil health. It is clear that C is the driver of the soil nutrient-microbial recycling system. This consistent need sets the stage for a standardized, universal measurement of soil microbial activity. Since soil microbes take in oxygen and release CO_2, we can couple this mechanism to their activity. It follows that soil microbial activity is a response to the level of soil quality/fertility in which they find themselves.

Water extractable organic C (WEOC):

National 4 year average is 225 ppm

This number (in ppm) is the amount of organic C extracted from your soil with water. This C pool is roughly 80 times smaller than the total soil organic C pool (% Organic Matter) and reflects the energy source fueling soil microbes.

A soil with 3 % soil organic matter (SOM) when measured with the combustion method at a 0-3 inch sampling depth produces a 20,000 ppm C concentration. When we analyze the water extract from the same soil, that number typically ranges from 100-300 ppm C. The organic C in the soil water extract reflects the quantity of the C in your soil that is readily available to the microbial population; whereas % SOM is reflective of the entire organic C pool that may become available over the lifetime of the soil. The amount of WEOC reflects the quality of the soil. In other words, % SOM is the house that microbes live in, but what we are measuring is the food they eat (WEOC and WEON).

Water extractable organic N (WEON):

National 4 year average is 20 ppm

This number is the amount of the total water extractable N minus the inorganic N (NH_4-N + NO_3-N). The WEON pool is highly related to the water extractable organic C pool and will be easily broken down by soil microbes and released to the soil in readily plant available inorganic N.

Organic C: Organic N:

National 4 year average is 12.8

This number is the ratio of organic C from the water extracret to the amount of organic N in the water extract (WEOC: WEON). This C: N ratio is a critical driving factor in the nutrient cycle. Soil organic C and N are highly related to each other as well as the water extractable organic C and N. We assess the organic C: N ratio of the water extract since this relationship reflects the

portion of C and N that are readily available to soil microbes and is a more sensitive indicator of soil health than the total soil C: N ratio. A soil C: N ratio above 20:1 generally indicates that no net N and P mineralization will occur, meaning the N and P are “tied up” within the microbial cell until the ratio drops below 20:1, as the ratio decreases the more N and P are released to the soil solution which can be taken up by growing plants.
Note: water extractable organic C and N are not separate entities in the soil, the C and N are actually from the same molecule, although we separate C and N in analysis because of the nature of the instruments we use to analyze them. 6

Soil Health Calculation:
National 4 year average is 9.3
This number is calculated as 1-day CO_2-C / 10 + WEOC/100 + WEON/10 to include a weighted contribution of microbial activity, water extractable organic C and N. It represents the overall health of your soil system. It combines 5 independent measurements of your soil's biological and chemical properties. The calculation looks at the balance of soil C and N and their relationship to microbial activity. This soil health calculation number can vary from 0 to more than 50. We like to see this number increase over time. This number indicates the current soil health and helps us identify what it needs to reach its highest sustainable state. Keeping track of this Soil Health number will allow you to gauge the effects of your management practices over the years.
Cover Crop Mix:
This is a suggested cover crop planting mix based on your soil test data. This is a recommendation of what you can do to increase your Soil Health number; it is not what you have to do. It is designed to provide your soil with a multi-species cover crop to help you improve soil health and thus improve the fertility of your soil.

Nitrogen

Total N: National 4 year average is 77 lbs. per acre
This number is the total N from the water extract from your soil (in lb/acre). It contains both inorganic N and organic N, which are shown in the next two columns.
Inorganic N: National 4 year average is 38 lbs. per acre
This is the combined amount of plant available forms of inorganic N (NO_3-N (nitrate N) plus NH_4-H (ammonium N) NO_3-N is the form of N that is easily lost from soil through surface runoff, subsurface leaching, erosion, and in water logged conditions, it can revert back to a gas. NH_4-H is usually quickly converted to NO_3-N by soil microbes but is less susceptible to leaching.
Organic N: National 4 year average is 39 lbs. per acre
Organic N is the total water extractable N minus the total water extractable inorganic N in lbs. per acre. This form of N should be easily broken down by soil microbes and released to the growing plant providing minimal chance of loss since the N is bound in large organic molecules. This pool represents the amount of potentially mineralizable N in your soil. 7

Phosphate

This lists the same type of results as nitrogen but for inorganic P and organic P.
Total P: National 4 year average is 97 lbs. P_2O_5 per acre
Inorganic P: National 4 year average is 75 lbs. P_2O_5 per acre
Organic P: National 4 year average is 22 lbs. P_2O_5 per acre

Potassium

National 4 year average is 140 lbs. K_2O per acre

Remaining columns

Columns to the right of the phosphate column on the NPK TAB are used for the GRAPH IT TAB where you can click on a sample, click the Graph it button and see the results from that sample in pie charts and bar graphs.

Al H3A: the amount of H3A extractable aluminum in ppm. National 4 year average is 230
Fe H3A: the amount of H3A extractable iron in ppm. National 4 year average is 126
Ca H3A: the amount of H3A extractable calcium in ppm. National 4 year average is 1231
Organic N release: This is the portion of the water extractable organic N that we credit as plant available based on the microbial activity, WEOC, WEON and the balance of the two (C: N).
Organic N reserve: This is the amount of organic N that is not credited as plant available usually due to lower microbial activity relative to the WEOC and WEON pools. If this number is 0 then the entire WEON pool is considered plant available.
Organic P release and organic P reserve: the same as described above for nitrogen except phosphate uses the H3A extractant.
%P saturation: The amount of H3A extractable P/the amount of H3A extractable Al and Fe expressed as a percentage. This is an index of the P associated with Al and Fe in your soil, a number below 5 usually indicates a need for P fertilizer and a number above 20 usually indicates excess P in soil. These numbers can be misleading if you have high P and low AlFe but high Ca, these numbers are just indicators of some of the chemical properties of the soil but can reflect P fertilizer additions.
8

Ca/AlFe: the H3A extractable calcium/H3A extractable Al and Fe, this ratio is used to indicate the balance of some of the drivers of soil pH. A number less than 1 may indicate a need to add lime, numbers greater than 20 usually indicate a high pH soil (>7.7).
SHC is the soil health calculation and $ saved per acre is nitrogen.

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Appendix B.
Site Nutrient Values

	Heyob Site 1			
	2015	2016	2017	2018
N lbs per acre	101.93	47.52	53.00	53.69
P2O5 lbs per acre	296.42	67.81	85.40	197.26
K2O lbs per acre	192.75	49.23	82.60	190.37
Nutrient value per acre	399.85	83.71	109.90	226.18
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	98.07	0.00	104.48	103.81
lbs P2O5 needed	0.00	0.00	2.13	0.00
lbs K2O needed	0.00	27.77	0.00	0.00
NO3-N Only lbs per acre 70%	22.85	10.40	2.80	7.00
Additional N lbs per acre	79.08	37.12	50.20	46.68
$ nitrogen saved per acre	55.35	25.99	35.10	32.68
Soil Health all ppm				
Solvita 1-day CO2-C	297.14	61.93	67.50	123.53
Organic C	458.93	156.68	216.20	221.95
Organic N	38.51	18.53	25.00	23.11
Organic C:N	11.92	8.45	8.60	9.60
Soil Health Calculation	38.15	9.61	13.60	17.04
Total Nitrogen lbs\acre	111.72	51.98	54.20	56.69
Inorganic N	34.70	14.92	4.20	10.47
Organic N	77.02	37.07	50.00	46.22
Total Phosphate lbs/acre	296.42	67.81	88.40	197.26
Inorganic P	288.85	41.64	40.80	175.10
Organic P	7.57	26.17	47.60	22.16
Al ppm	150.66	88.55	130.90	115.80
Fe ppm	146.20	36.00	123.20	89.52
Ca ppm	1017.61	968.76	572.70	936.31
Organic N release	77.02	37.07	50.00	46.22
Organic N reserve	0.00	0.00	0.00	0.00
Organic P release	7.57	26.17	44.60	22.16
Organic P reserve	0.00	0.00	3.10	0.00
% P sat	43.41	23.67	15.10	41.77
Ca/AlFe	3.43	7.78	2.30	4.56
SHC	38.15	9.61	13.60	17.04
Nitrogen Saved $	$ 55.35	$ 25.99	$ 35.00	$ 32.68

Heyob Site 2

2015		2016	2017	2018
55.52	N lbs per acre	47.07	57.95	72.78
85.74	P2O5 lbs per acre	104.55	191.74	269.99
70.30	K2O lbs per acre	66.50	173.37	218.05
137.82	Nutrient value per acre	115.28	218.07	294.42
Corn	Crop	Soybeans	Corn	Soybeans
200.00	Yield Goal	55.00	175.00	55.00
144.48	lbs N needed	0.00	99.55	84.72
14.26	lbs P2O5 needed	0.00	0.00	0.00
9.70	lbs K2O needed	10.50	0.00	0.00
13.66	NO3-N Only lbs per acre 70%	10.80	1.72	16.31
41.86	Additional N lbs per acre	36.27	56.22	56.47
29.30	$ nitrogen saved per acre	25.39	39.36	39.53
	Soil Health all ppm			
77.96	Solvita 1-day CO2-C	66.99	90.41	131.75
242.57	Organic C	181.14	302.59	295.77
19.83	Organic N	17.92	27.88	28.07
12.23	Organic C:N	10.11	10.85	10.54
12.21	Soil Health Calculation	10.30	17.88	19.70
61.37	Total Nitrogen lbs\acre	51.70	58.68	79.77
21.70	Inorganic N	15.85	2.93	23.62
39.67	Organic N	35.84	55.75	56.14
95.66	Total Phosphate lbs/acre	104.55	195.90	269.99
59.67	Inorganic P	80.70	155.68	257.07
35.99	Organic P	23.85	40.22	12.91
193.65	Al ppm	90.27	118.66	139.94
82.63	Fe ppm	35.92	161.86	157.06
541.48	Ca ppm	1235.99	1247.23	834.03
39.67	Organic N release	35.84	55.75	56.14
0.00	Organic N reserve	0.00	0.00	0.00
26.07	Organic P release	23.85	36.05	12.91
9.92	Organic P reserve	0.00	4.17	0.00
15.05	% P sat	36.02	30.36	39.52
1.96	Ca/AlFe	9.79	4.45	2.81
12.21	SHC	10.30	17.88	19.70
29.30	Nitrogen Saved $	25.39	39.36	39.53

Heyob Site 3

	2015	2016	2017	2018
N lbs per acre	30.30	39.50	17.39	28.53
P2O5 lbs per acre	92.72	30.75	65.61	35.29
K2O lbs per acre	47.77	51.15	88.38	60.78
Nutrient value per acre	118.49	55.23	83.82	57.39
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	169.70	0.00	140.11	128.97
lbs P2O5 needed	7.28	18.75	21.89	52.21
lbs K2O needed	32.23	25.85	0.00	0.47
NO3-N Only lbs per acre 70%	9.10	15.65	3.88	5.70
Additional N lbs per acre	21.20	23.86	13.50	22.83
$ nitrogen saved per acre	14.84	16.70	9.45	15.98
Soil Health all ppm				
Solvita 1-day CO2-C	32.35	83.43	16.81	28.68
Organic C	279.98	127.69	175.89	206.31
Organic N	21.17	11.55	17.08	20.40
Organic C:N	13.22	11.06	10.30	10.11
Soil Health Calculation	8.15	10.77	6.91	9.03
Total Nitrogen lbs\acre	56.98	46.21	40.15	49.09
Inorganic N	14.63	23.11	5.99	8.28
Organic N	42.35	23.10	34.16	40.81
Total Phosphate lbs/acre	108.12	30.75	100.07	35.29
Inorganic P	83.38	19.01	51.76	25.25
Organic P	24.74	11.74	48.31	10.04
Al ppm	134.69	65.04	79.77	152.72
Fe ppm	63.21	31.06	50.76	120.07
Ca ppm	801.67	419.00	2061.91	411.52
Organic N release	19.57	23.10	13.06	22.69
Organic N reserve	22.77	0.00	21.10	18.12
Organic P release	9.34	11.74	13.85	4.19
Organic P reserve	15.40	0.00	34.46	5.85
% P sat	23.75	13.91	33.33	5.62
Ca/AlFe	4.05	4.36	15.80	1.51
SHC	8.15	10.77	6.91	9.03
Nitrogen Saved $	14.84	16.70	9.45	15.98

		Heyob Site 4		
N lbs per acre	101.4	42.01828424	32.363064	41.54989458
P2O5 lbs per acre	289.7	100.0231258	12.5192122	15.47630429
K2O lbs per acre	181.4	67.97211914	53.58182831	62.96014252
Nutrient value per acre	$388.7	110.6137435	40.46231405	49.48942072
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200	55	175	55
lbs N needed	99	0	125.136936	115.9501054
lbs P2O5 needed	0	0	74.9807878	72.02369571
lbs K2O needed	0	9.027880859	7.668171692	0
NO3-N Only lbs per acre 70%	20.2	9.341486168	2.782369089	5.921761703
Additional N lbs per acre	81.2	32.67679808	29.58069491	35.62813288
$ nitrogen saved per acre	$56.8	22.87375865	20.70648644	24.93969302
Soil Health all ppm				
Solvita 1-day CO2-C	407.0	83.58667755	50.15486145	64.55767822
Organic C	522.4	163.4958649	157.2752991	178.4067078
Organic N	38.5	16.15010643	14.58576488	17.59013748
Organic C:N	13.6	10.12351608	10.782794	10.1424284
Soil Health Calculation	49.8	11.60863686	9.619568825	11.78291607
Total Nitrogen lbs\acre	110.1	46.02177811	33.55550766	44.08779144
Inorganic N	33.1	13.72156525	4.38397789	8.907517433
Organic N	77.0	32.30021286	29.17152977	35.18027401
Total Phosphate lbs/acre	289.7	100.0231258	12.5192122	15.47630429
Inorganic P	263.0	67.99536438	10.43267665	8.240780878
Organic P	26.7	32.02776146	2.086535549	7.235523415
Al ppm	121.4	129.9977112	112.1438675	170.5170441
Fe ppm	98.8	41.31710815	69.1006546	96.09784698
Ca ppm	1511.8	1238.337524	307.9490356	225.5225677
Organic N release	77.0	32.30021286	29.17152977	35.18027401
Organic N reserve	0.0	0	0	9.53674E-07
Organic P release	26.7	32.02776146	1.996179354	7.235523415
Organic P reserve	0.0	0	0.090356195	0
% P sat	57.2	25.38502884	3.003200054	2.523800611
Ca/AlFe	6.9	7.228432178	1.699080467	0.845873892
SHC	49.8	11.60863686	9.619568825	11.78291607
Nitrogen Saved $	$57	22.8738	20.7065	24.9397

Heyob Site 5

	2015	2016	2017	2018
N lbs per acre	79.50	28.58	27.64	52.07
P2O5 lbs per acre	228.70	12.69	6.69	22.73
K2O lbs per acre	157.70	53.62	52.55	44.89
Nutrient value per acre	313.10	39.08	34.13	52.45
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	120.00	0.00	129.86	105.43
lbs P2O5 needed	0.00	36.81	80.81	64.77
lbs K2O needed	0.00	23.38	8.70	16.36
NO3-N Only lbs per acre 70%	15.30	5.26	1.54	18.67
Additional N lbs per acre	64.20	23.31	26.10	33.40
$ nitrogen saved per acre	44.90	16.32	18.27	23.38
Soil Health all ppm				
Solvita 1-day CO2-C	99.10	52.36	69.52	77.91
Organic C	430.60	143.34	138.81	148.14
Organic N	33.90	11.61	13.00	16.49
Organic C:N	12.70	12.35	10.67	8.98
Soil Health Calculation	17.60	7.83	11.03	12.40
Total Nitrogen lbs\acre	91.50	30.83	28.30	60.07
Inorganic N	23.70	7.62	2.29	27.09
Organic N	67.80	23.21	26.01	32.98
Total Phosphate lbs/acre	232.30	12.69	6.69	22.73
Inorganic P	197.70	10.57	5.57	14.21
Organic P	34.60	2.11	1.11	8.51
Al ppm	186.60	112.73	102.29	106.49
Fe ppm	124.80	67.84	53.76	43.91
Ca ppm	993.20	301.07	487.05	400.34
Organic N release	62.40	23.21	26.01	32.98
Organic N reserve	5.40	0.00	0.00	0.00
Organic P release	31.00	2.11	1.11	8.51
Organic P reserve	3.60	0.00	0.00	0.00
% P sat	32.40	3.05	1.86	6.57
Ca/AlFe	3.20	1.67	3.12	2.66
SHC	17.60	7.83	11.03	12.40
Nitrogen Saved $	45.00	16.32	18.27	23.38

Heyob Site 6

	2015	2016	2017	2018
N lbs per acre	56	27.36930369	27.74915148	38.80620349
P2O5 lbs per acre	174.1	42.24058743	88.38001413	142.4603737
K2O lbs per acre	120.9	49.53886414	56.61211853	59.20155487
Nutrient value per acre	$235.90	57.85473512	92.77991197	135.9652872
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200	55	175	55
lbs N needed	144	0	129.7508485	118.6937965
lbs P2O5 needed	0	7.259412575	0	0
lbs K2O needed	0	27.46113586	4.63788147	2.048445129
NO3-N Only lbs per acre 70%	13.3	5.084890079	1.613047266	1.965451527
Additional N lbs per acre	42.7	22.28441361	26.13610421	36.84075196
$ nitrogen saved per acre	$29.90	15.59908952	18.29527295	25.78852637
Soil Health all ppm				
Solvita 1-day CO2-C	67.2	55.24446106	36.47296524	66.24445343
Organic C	352.8	118.5207443	196.4857025	182.0986938
Organic N	27.2	11.00743008	17.54404831	18.38052368
Organic C:N	13	10.76734066	11.19956493	9.907155037
Soil Health Calculation	13	7.810396671	9.331415176	12.10447121
Total Nitrogen lbs\acre	74.6	29.54854202	37.47542191	39.6485405
Inorganic N	20.3	7.533682346	2.387326241	2.887492418
Organic N	54.3	22.01485968	35.08809566	36.76104808
Total Phosphate lbs/acre	200	42.24058743	114.4213852	142.4603737
Inorganic P	153.9	21.26914568	55.65321083	122.9677456
Organic P	46.1	20.97144175	58.76817436	19.4926281
Al ppm	185.1	99.0098877	116.6180649	145.3352051
Fe ppm	99.8	41.00409698	51.16959	77.43856812
Ca ppm	945.5	536.3155518	1055.923706	694.2334595
Organic N release	41.4	22.01485968	26.0531311	36.76104736
Organic N reserve	13	4.76837E-07	9.034965515	0
Organic P release	20.1	20.97144175	32.7268033	19.4926281
Organic P reserve	26	-3.55271E-15	26.04137106	-1.42109E-14
% P sat	30.5	13.11688423	29.64963531	27.80367279
Ca/AlFe	3.3	3.830442667	6.293214321	3.116315842
SHC	13	7.810396671	9.331415176	12.10447121
Nitrogen Saved $	$30	15.5991	18.2953	25.7885

	Minges Site 1		
	2015	2016	2017
N lbs per acre	14.01	33.37	55.01
P2O5 lbs per acre	100.87	109.00	90.37
K2O lbs per acre	80.85	60.67	137.85
Nutrient value per acre	130.53	110.88	133.51
Crop	Corn	Soybeans	Corn
Yield Goal	215.00	55.00	175.00
lbs N needed	200.99	0.00	102.49
lbs P2O5 needed	6.63	0.00	0.00
lbs K2O needed	5.15	16.33	0.00
NO3-N Only lbs per acre 70%	8.95	5.17	23.08
Additional N lbs per acre	5.06	28.20	31.93
$ nitrogen saved per acre	3.54	19.74	22.35
Soil Health all ppm			
Solvita 1-day CO2-C	5.07	49.25	34.25
Organic C	187.96	133.21	168.51
Organic N	15.34	14.10	19.56
Organic C:N	12.26	9.45	8.61
Soil Health Calculation	3.92	7.67	8.75
Total Nitrogen lbs\acre	45.21	35.58	72.22
Inorganic N	14.53	7.39	33.09
Organic N	30.67	28.19	39.13
Total Phosphate lbs/acre	109.51	109.00	117.04
Inorganic P	99.18	87.66	48.72
Organic P	10.33	21.34	68.32
Al ppm	131.08	138.96	95.86
Fe ppm	41.16	40.70	33.67
Ca ppm	2804.82	1087.24	633.35
Organic N release	3.31	28.19	31.81
Organic N reserve	27.36	0.00	7.32
Organic P release	1.69	21.34	41.66
Organic P reserve	8.64	0.00	26.66
% P sat	27.64	26.38	39.29
Ca/AlFe	16.28	6.05	4.89
SHC	3.92	7.67	8.75
Nitrogen Saved $	3.54	19.74	22.35

Minges Site 2

	2015	2016	2017
N lbs per acre	20.72409661	33.46948929	61.10862108
P2O5 lbs per acre	130.9811462	144.5566723	33.02288628
K2O lbs per acre	67.52300262	48.43800201	68.72452698
Nutrient value per acre	154.1537834	131.530767	71.61305327
Crop	Corn	Soybeans	Corn
Yield Goal	200	55	175
lbs N needed	179.2759034	0	96.39137892
lbs P2O5 needed	0	0	54.47711372
lbs K2O needed	12.47699738	28.56199799	0
NO3-N Only lbs per acre 70%	4.250628662	5.946855736	19.93093681
Additional N lbs per acre	16.47346795	27.52263355	41.17768426
$ nitrogen saved per acre	11.53142756	19.26584349	28.82437898
Soil Health all ppm			
Solvita 1-day CO2-C	21.95790863	30.11597252	67.07746887
Organic C	254.5516052	120.2839737	217.6691895
Organic N	21.27817917	13.58299446	20.56461525
Organic C:N	11.96303558	8.855483055	10.58464718
Soil Health Calculation	6.869124889	5.572736263	13.11759186
Total Nitrogen lbs\acre	50.41831589	36.0181427	69.65045166
Inorganic N	7.861955643	8.852152824	28.52122116
Organic N	42.55636024	27.16598988	41.1292305
Total Phosphate lbs/acre	173.7012039	144.5566723	33.02288628
Inorganic P	123.3683311	131.1527744	27.51907263
Organic P	50.33287277	13.40389786	5.503813648
Al ppm	82.40826416	127.1238098	146.4942474
Fe ppm	25.99381638	40.09289551	94.88448334
Ca ppm	2312.814941	1107.583618	236.7894745
Organic N release	14.68383884	27.16598892	41.1292305
Organic N reserve	27.87251949	0	0
Organic P release	7.61281507	10.0679595	5.088206244
Organic P reserve	42.7200577	3.335938358	0.415607405
% P sat	69.66864777	37.58639145	5.948235989
Ca/AlFe	21.3355217	6.623641968	0.98098731
SHC	6.869124889	5.572736263	13.11759186
Nitrogen Saved $	11.5314	19.2658	28.8244

Minges Site 3

	2015	2016	2017
N lbs per acre	21.64523994	18.56649897	52.17089737
P2O5 lbs per acre	71.13473499	182.1750642	11.47389245
K2O lbs per acre	70.78775482	42.46412201	54.20991669
Nutrient value per acre	105.3061584	149.8115872	47.8735545
Crop	Corn	Soybeans	Corn
Yield Goal	200	55	175
lbs N needed	178.3547601	0	105.3291026
lbs P2O5 needed	28.86526501	0	76.02610755
lbs K2O needed	9.212245178	34.53587799	7.040083313
NO3-N Only lbs per acre 70%	4.860715055	3.877827072	16.3916729
Additional N lbs per acre	16.78452489	14.68867189	35.77922447
$ nitrogen saved per acre	11.74916742	10.28207033	25.04545713
Soil Health all ppm			
Solvita 1-day CO2-C	26.37377357	13.87234592	57.79489517
Organic C	240.8688507	66.78583527	177.0206451
Organic N	18.61372757	8.803827286	17.84686852
Organic C:N	12.94038773	7.585999966	9.918863297
Soil Health Calculation	6.907438755	2.935475588	11.10458946
Total Nitrogen lbs\acre	44.65107727	23.20666122	59.19589996
Inorganic N	7.423622608	5.599007607	23.50216293
Organic N	37.22745466	17.60765362	35.69373703
Total Phosphate lbs/acre	131.3859119	190.9316383	11.47389245
Inorganic P	63.17665539	167.6959213	9.561577225
Organic P	68.20925655	23.23571701	1.912315226
Al ppm	74.39937592	102.2037506	118.0472183
Fe ppm	22.92811012	33.41276932	45.95588303
Ca ppm	2092.967773	1640.080322	283.062439
Organic N release	16.30478096	14.62941742	35.69373703
Organic N reserve	20.92267418	2.978237152	0
Organic P release	7.9580796	14.47914286	1.873036689
Organic P reserve	60.25117695	8.756574154	0.039278537
% P sat	58.69288635	61.21212769	3.041801453
Ca/AlFe	21.50438499	12.09351444	1.72595787
SHC	6.907438755	2.935475588	11.10458946
Nitrogen Saved $	11.7492	10.2821	25.0455

Minges Site 4

	2015	2016	2017
N lbs per acre	Missing Report	28.27	15.90
P2O5 lbs per acre		132.80	100.40
K2O lbs per acre		60.66	71.60
Nutrient value per acre		125.50	101.70
Crop	Corn	Soybeans	Corn
Yield Goal		55.00	175.00
lbs N needed		0.00	141.58
lbs P2O5 needed		0.00	0.00
lbs K2O needed		16.34	0.00
NO3-N Only lbs per acre 70%		3.97	1.10
Additional N lbs per acre		24.30	14.80
$ nitrogen saved per acre		17.01	10.40
Soil Health all ppm			
Solvita 1-day CO2-C		26.88	17.50
Organic C		111.26	190.70
Organic N		12.45	19.90
Organic C:N		8.94	9.60
Soil Health Calculation		5.05	7.60
Total Nitrogen lbs\acre		30.82	41.50
Inorganic N		5.92	1.80
Organic N		24.90	39.70
Total Phosphate lbs/acre		138.02	146.60
Inorganic P		119.05	82.90
Organic P		18.97	63.80
Al ppm		180.46	60.10
Fe ppm		47.80	22.90
Ca ppm		863.24	2419.00
Organic N release		24.06	14.60
Organic N reserve		0.84	25.10
Organic P release		13.75	17.60
Organic P reserve		5.22	46.20
% P sat		26.29	76.90
Ca/AlFe		3.78	29.20
SHC		5.05	7.60
Nitrogen Saved $		17.01	10.00

Knollman Site 1

	2015	2016	2017	2018
N lbs per acre	24.17	23.31	34.08	34.72
P2O5 lbs per acre	218.21	112.93	109.62	41.18
K2O lbs per acre	108.43	58.14	62.28	98.36
Nutrient value per acre	248.77	108.73	112.17	77.14
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	175.83	0.00	123.42	122.78
lbs P2O5 needed	0.00	0.00	0.00	46.32
lbs K2O needed	0.00	18.86	0.00	0.00
NO3-N Only lbs per acre 70%	9.54	6.18	13.38	3.97
Additional N lbs per acre	14.63	17.13	20.69	30.75
$ nitrogen saved per acre	10.24	11.99	14.49	21.52
Soil Health all ppm				
Solvita 1-day CO2-C	14.18	12.30	25.44	73.18
Organic C	155.03	151.29	184.81	131.65
Organic N	19.22	24.07	18.73	15.20
Organic C:N	8.07	6.28	9.87	8.66
Soil Health Calculation	4.89	5.15	8.11	11.47
Total Nitrogen lbs\acre	52.63	58.45	56.64	36.41
Inorganic N	14.20	10.31	19.19	6.01
Organic N	38.44	48.14	37.45	30.41
Total Phosphate lbs/acre	235.69	116.51	139.02	41.18
Inorganic P	210.76	105.46	88.93	16.51
Organic P	24.94	11.05	50.09	24.67
Al ppm	40.18	69.95	18.01	67.23
Fe ppm	18.50	25.61	11.23	27.40
Ca ppm	1975.90	1548.21	2299.73	513.41
Organic N release	14.06	15.65	20.63	30.41
Organic N reserve	24.37	32.49	16.83	0.00
Organic P release	7.46	2.69	20.69	24.67
Organic P reserve	17.48	8.36	29.40	0.00
% P sat	174.63	53.01	206.71	18.92
Ca/AlFe	33.67	16.20	78.65	5.43
SHC	4.89	5.15	8.11	11.47
Nitrogen Saved $	10.24	11.99	14.49	21.52

Knollman Site 2

	2015	2016	2017	2018
N lbs per acre	37.62	41.09	11.35	36.89
P2O5 lbs per acre	46.20	49.56	108.34	43.08
K2O lbs per acre	53.12	60.81	94.12	53.10
Nutrient value per acre	85.74	72.41	113.32	63.49
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	162.38	0.00	146.15	120.61
lbs P2O5 needed	53.80	0.00	0.00	44.42
lbs K2O needed	26.88	16.19	0.00	8.15
NO3-N Only lbs per acre 70%	8.31	4.61	2.21	2.43
Additional N lbs per acre	29.30	36.47	9.14	34.46
$ nitrogen saved per acre	20.51	25.53	6.40	24.12
Soil Health all ppm				
Solvita 1-day CO2-C	44.29	63.14	11.76	56.29
Organic C	230.32	145.69	202.90	171.48
Organic N	18.31	18.23	19.56	17.22
Organic C:N	12.58	7.99	10.37	9.96
Soil Health Calculation	8.56	9.59	7.19	10.78
Total Nitrogen lbs\acre	49.63	43.06	42.34	37.93
Inorganic N	13.02	6.60	3.22	3.48
Organic N	36.62	36.47	39.12	34.45
Total Phosphate lbs/acre	65.73	49.56	155.43	43.46
Inorganic P	32.10	32.43	98.42	18.14
Organic P	33.63	17.13	57.00	25.33
Al ppm	178.70	290.43	30.23	97.36
Fe ppm	79.92	134.95	17.49	44.15
Ca ppm	378.45	229.28	2125.84	576.80
Organic N release	28.16	36.47	9.07	34.45
Organic N reserve	8.45	0.00	30.05	0.00
Organic P release	14.10	17.13	9.91	24.94
Organic P reserve	19.54	0.00	47.09	0.39
% P sat	11.05	5.07	141.60	13.35
Ca/AlFe	1.46	0.54	44.54	4.08
SHC	8.56	9.59	7.19	10.78
Nitrogen Saved $	20.51	25.53	6.40	24.12

Knollman Site 3

	2015	2016	2017	2018
N lbs per acre	55.59	37.66	21.13	47.61
P2O5 lbs per acre	130.55	25.03	162.67	6.45
K2O lbs per acre	83.40	46.84	122.97	51.10
Nutrient value per acre	181.85	48.98	165.36	41.45
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	144.41	0.00	136.37	109.89
lbs P2O5 needed	0.00	24.47	0.00	81.05
lbs K2O needed	0.00	30.16	0.00	10.15
NO3-N Only lbs per acre 70%	5.65	8.01	7.88	16.03
Additional N lbs per acre	49.94	29.65	13.25	31.57
$ nitrogen saved per acre	34.96	20.76	9.27	22.10
Soil Health all ppm				
Solvita 1-day CO2-C	67.77	62.34	16.45	93.58
Organic C	337.12	124.46	237.55	162.52
Organic N	30.85	14.56	23.25	15.78
Organic C:N	10.93	8.55	10.22	10.30
Soil Health Calculation	13.23	8.93	8.72	14.19
Total Nitrogen lbs\acre	70.09	41.09	58.12	54.48
Inorganic N	8.39	11.98	11.63	22.92
Organic N	61.70	29.12	46.49	31.56
Total Phosphate lbs/acre	145.72	25.03	198.13	6.45
Inorganic P	103.83	14.62	153.36	5.38
Organic P	41.90	10.41	44.77	1.08
Al ppm	174.09	253.82	36.92	88.29
Fe ppm	129.08	73.08	19.89	32.77
Ca ppm	882.51	280.25	1828.22	459.11
Organic N release	49.61	29.12	12.88	31.56
Organic N reserve	12.09	0.00	33.61	0.00
Organic P release	26.72	10.41	9.30	1.08
Organic P reserve	15.17	0.00	35.47	0.00
% P sat	20.90	3.33	151.64	2.32
Ca/AlFe	2.91	0.86	32.18	3.79
SHC	13.23	8.93	8.72	14.19
Nitrogen Saved $	34.96	20.76	9.27	22.10

Knollman Site 4

	2015	2016	2017	2018
N lbs per acre	44.77	38.71	8.15	47.96
P2O5 lbs per acre	138.85	37.73	145.55	107.80
K2O lbs per acre	118.89	66.95	98.63	152.84
Nutrient value per acre	198.38	65.33	139.66	148.14
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	155.23	0.00	149.35	109.54
lbs P2O5 needed	0.00	11.77	0.00	0.00
lbs K2O needed	0.00	10.05	0.00	0.00
NO3-N Only lbs per acre 70%	6.73	14.75	1.15	8.85
Additional N lbs per acre	38.04	23.96	7.00	39.11
$ nitrogen saved per acre	26.63	16.78	4.90	27.38
Soil Health all ppm				
Solvita 1-day CO2-C	44.12	41.43	8.01	111.68
Organic C	233.14	110.03	166.50	201.35
Organic N	24.11	11.79	16.28	19.28
Organic C:N	9.67	9.33	10.23	10.44
Soil Health Calculation	9.15	6.42	5.76	15.26
Total Nitrogen lbs\acre	59.38	45.03	34.93	51.76
Inorganic N	11.15	21.45	2.37	13.20
Organic N	48.23	23.58	32.55	38.55
Total Phosphate lbs/acre	169.60	37.73	185.16	107.80
Inorganic P	118.89	26.98	138.87	69.45
Organic P	50.70	10.75	46.29	38.35
Al ppm	157.43	231.27	32.98	127.48
Fe ppm	77.66	82.38	17.89	68.72
Ca ppm	754.95	402.20	2035.22	530.31
Organic N release	36.51	23.58	6.26	38.55
Organic N reserve	11.72	0.00	26.29	0.00
Organic P release	19.95	10.75	6.68	38.35
Organic P reserve	30.75	0.00	39.61	0.00
% P sat	31.37	5.23	158.25	23.89
Ca/AlFe	3.21	1.28	40.01	2.70
SHC	9.15	6.42	5.76	15.26
Nitrogen Saved $	26.63	16.78	4.90	27.38

Knollman Site 5

	2015	2016	2017	2018
N lbs per acre	37.86	32.00	10.70	37.62
P2O5 lbs per acre	111.86	27.46	169.70	15.53
K2O lbs per acre	75.58	53.75	112.40	55.86
Nutrient value per acre	151.81	50.83	162.40	45.47
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	162.14	0.00	146.78	119.88
lbs P2O5 needed	0.00	22.04	0.00	71.97
lbs K2O needed	4.42	23.25	0.00	5.39
NO3-N Only lbs per acre 70%	9.21	11.41	1.30	6.85
Additional N lbs per acre	28.65	20.59	9.40	30.77
$ nitrogen saved per acre	20.05	14.41	6.60	21.54
Soil Health all ppm				
Solvita 1-day CO2-C	34.93	45.26	12.00	70.50
Organic C	203.63	101.02	210.30	147.15
Organic N	20.20	10.27	20.30	15.35
Organic C:N	10.08	9.84	10.40	9.58
Soil Health Calculation	7.55	6.56	7.40	11.53
Total Nitrogen lbs\acre	54.48	36.89	42.50	40.56
Inorganic N	14.08	16.36	2.00	9.85
Organic N	40.41	20.53	40.50	30.71
Total Phosphate lbs/acre	141.52	27.46	201.30	15.53
Inorganic P	96.72	19.98	163.20	12.94
Organic P	44.79	7.47	38.20	2.59
Al ppm	109.56	244.02	39.60	81.95
Fe ppm	42.12	76.01	22.80	47.72
Ca ppm	1191.50	319.87	1794.00	337.07
Organic N release	27.73	20.53	9.20	30.71
Organic N reserve	12.68	0.00	31.30	0.00
Organic P release	15.14	7.47	6.50	2.59
Organic P reserve	29.65	0.00	31.60	0.00
% P sat	40.56	3.73	140.30	5.21
Ca/AlFe	7.86	1.00	28.70	2.60
SHC	7.55	6.56	7.40	11.53
Nitrogen Saved $	20.05	14.41	7.00	21.54

Knollman Site 6

	2015	2016	2017	2018
N lbs per acre	54.31	41.51	9.60	38.70
P2O5 lbs per acre	103.56	121.54	205.00	6.74
K2O lbs per acre	63.65	78.13	113.00	56.42
Nutrient value per acre	149.25	129.03	186.90	39.95
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	145.69	0.00	147.88	118.80
lbs P2O5 needed	0.00	0.00	0.00	80.76
lbs K2O needed	16.35	0.00	0.00	4.83
NO3-N Only lbs per acre 70%	8.26	6.04	0.50	7.05
Additional N lbs per acre	46.05	35.47	9.10	31.65
$ nitrogen saved per acre	32.24	24.83	6.40	22.15
Soil Health all ppm				
Solvita 1-day CO2-C	92.01	76.71	11.20	42.66
Organic C	251.32	194.93	153.90	138.38
Organic N	22.97	17.62	14.40	15.35
Organic C:N	10.94	11.06	10.70	9.01
Soil Health Calculation	14.01	11.38	5.60	8.57
Total Nitrogen lbs\acre	57.85	44.09	30.30	41.72
Inorganic N	11.91	8.85	1.40	11.02
Organic N	45.94	35.24	28.90	30.70
Total Phosphate lbs/acre	105.55	121.54	229.40	6.74
Inorganic P	67.33	100.22	198.10	5.62
Organic P	38.21	21.32	31.30	1.12
Al ppm	157.44	234.11	63.60	50.59
Fe ppm	72.50	126.81	43.30	23.13
Ca ppm	869.35	670.89	1695.60	240.65
Organic N release	45.94	35.24	8.40	30.70
Organic N reserve	0.00	0.00	20.40	0.00
Organic P release	36.22	21.32	6.90	1.04
Organic P reserve	1.99	0.00	24.50	0.08
% P sat	19.96	14.64	93.30	3.98
Ca/AlFe	3.78	1.86	15.90	3.26
SHC	14.01	11.38	5.60	8.57
Nitrogen Saved $	32.24	24.83	6.00	22.15

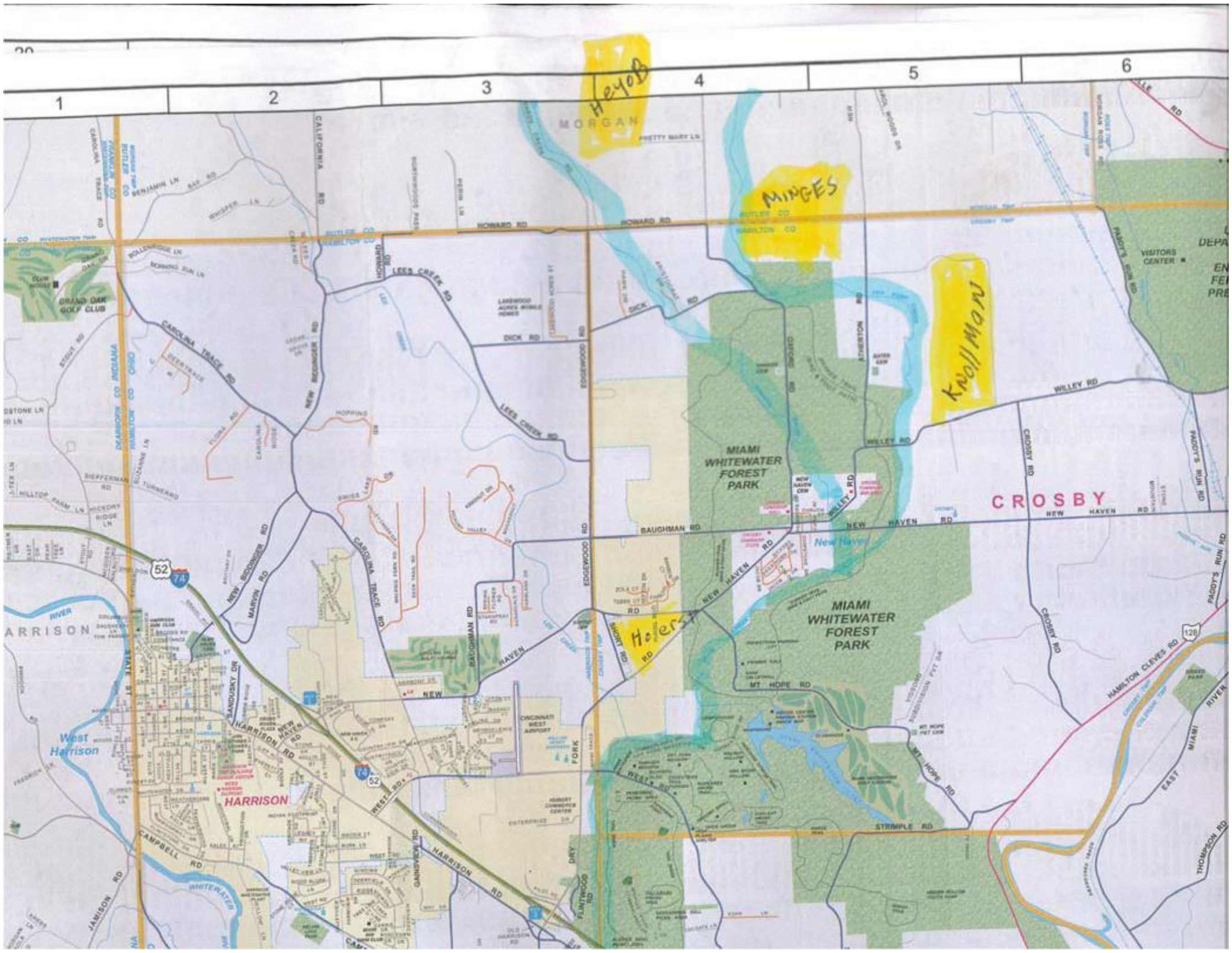
Knollman Site 7

	2015	2016	2017	2018
N lbs per acre	18.47	43.19	11.30	44.06
P2O5 lbs per acre	248.80	115.08	142.95	88.78
K2O lbs per acre	121.72	64.61	102.35	66.40
Nutrient value per acre	277.34	120.44	140.41	103.01
Crop	Corn	Soybeans	Corn	Soybeans
Yield Goal	200.00	55.00	175.00	55.00
lbs N needed	181.53	0.00	146.20	113.44
lbs P2O5 needed	0.00	0.00	0.00	0.00
lbs K2O needed	0.00	12.39	0.00	0.00
NO3-N Only lbs per acre 70%	4.75	5.67	0.96	4.16
Additional N lbs per acre	13.73	37.52	10.34	39.91
$ nitrogen saved per acre	9.61	26.27	7.24	27.93
Soil Health all ppm				
Solvita 1-day CO2-C	12.75	60.51	12.71	84.07
Organic C	159.71	183.28	128.63	222.23
Organic N	19.43	18.61	12.71	19.61
Organic C:N	8.22	9.85	10.12	11.33
Soil Health Calculation	4.82	9.74	5.11	14.81
Total Nitrogen lbs\acre	46.95	45.62	27.08	45.84
Inorganic N	8.09	8.40	1.66	6.62
Organic N	38.86	37.22	25.42	39.22
Total Phosphate lbs/acre	263.84	115.08	172.93	88.78
Inorganic P	242.18	96.86	130.31	52.21
Organic P	21.66	18.22	42.62	36.57
Al ppm	74.63	253.00	57.14	103.81
Fe ppm	35.28	116.77	39.58	90.67
Ca ppm	1212.66	693.81	1065.68	567.65
Organic N release	12.41	37.22	10.05	39.22
Organic N reserve	26.45	0.00	15.37	0.00
Organic P release	6.62	18.05	12.63	36.57
Organic P reserve	15.04	0.17	29.99	0.00
% P sat	104.37	13.53	77.73	19.85
Ca/AlFe	11.03	1.88	11.02	2.92
SHC	4.82	9.74	5.11	14.81
Nitrogen Saved $	9.61	26.27	7.24	27.93

Knollman Site 8

	2015	2016	2017	2018
N lbs per acre	17.83		50.20	44.67
P2O5 lbs per acre	236.94		98.50	86.26
K2O lbs per acre	124.58		55.30	76.35
Nutrient value per acre	268.16		108.40	104.98
Crop	Corn		Corn	Soybeans
Yield Goal	200.00		175.00	55.00
lbs N needed	182.17		107.30	112.83
lbs P2O5 needed	0.00		0.00	1.24
lbs K2O needed	0.00		5.96	0.00
NO3-N Only lbs per acre 70%	5.47		8.40	2.14
Additional N lbs per acre	12.36		41.80	42.53
$ nitrogen saved per acre	8.65		29.30	29.77
Soil Health all ppm				
Solvita 1-day CO2-C	11.64		62.30	98.56
Organic C	168.86		223.90	242.00
Organic N	21.32		20.70	20.81
Organic C:N	7.92		10.80	11.63
Soil Health Calculation	4.98		12.80	16.78
Total Nitrogen lbs\acre	51.07		53.80	45.59
Inorganic N	8.42		12.50	3.96
Organic N	42.65		41.30	41.63
Total Phosphate lbs/acre	251.10		107.20	86.26
Inorganic P	230.74		54.00	51.78
Organic P	20.36		53.20	34.48
Al ppm	49.00		112.20	116.13
Fe ppm	19.34		90.60	93.48
Ca ppm	2027.97		690.20	628.43
Organic N release	11.76		41.30	41.63
Organic N reserve	30.89		0.00	0.00
Organic P release	6.20		44.40	34.48
Organic P reserve	14.16		8.80	0.00
% P sat	159.73		23.00	17.89
Ca/AlFe	29.67		3.40	3.00
SHC	4.98		12.80	16.78
Nitrogen Saved $	8.65		29.00	29.77

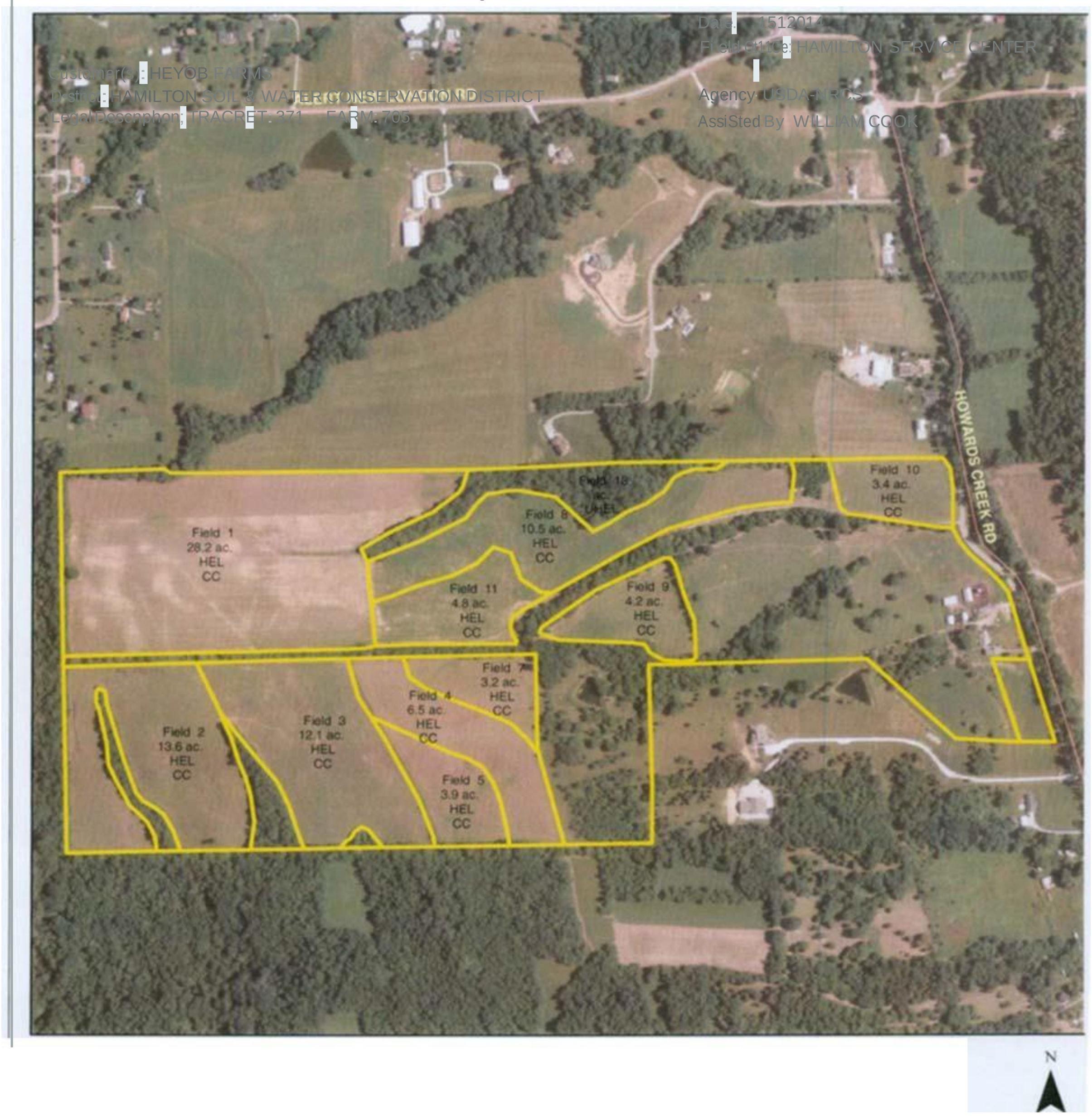
Appendix C.
Site and Soil Maps



Location Proximity of Cover Crop Field Sites

Heyob

EQIP PLAN MAP



Legend

A Land Unit D Legacrey

r:2J Plan Draft

r:2J Locked (ZI Sketch

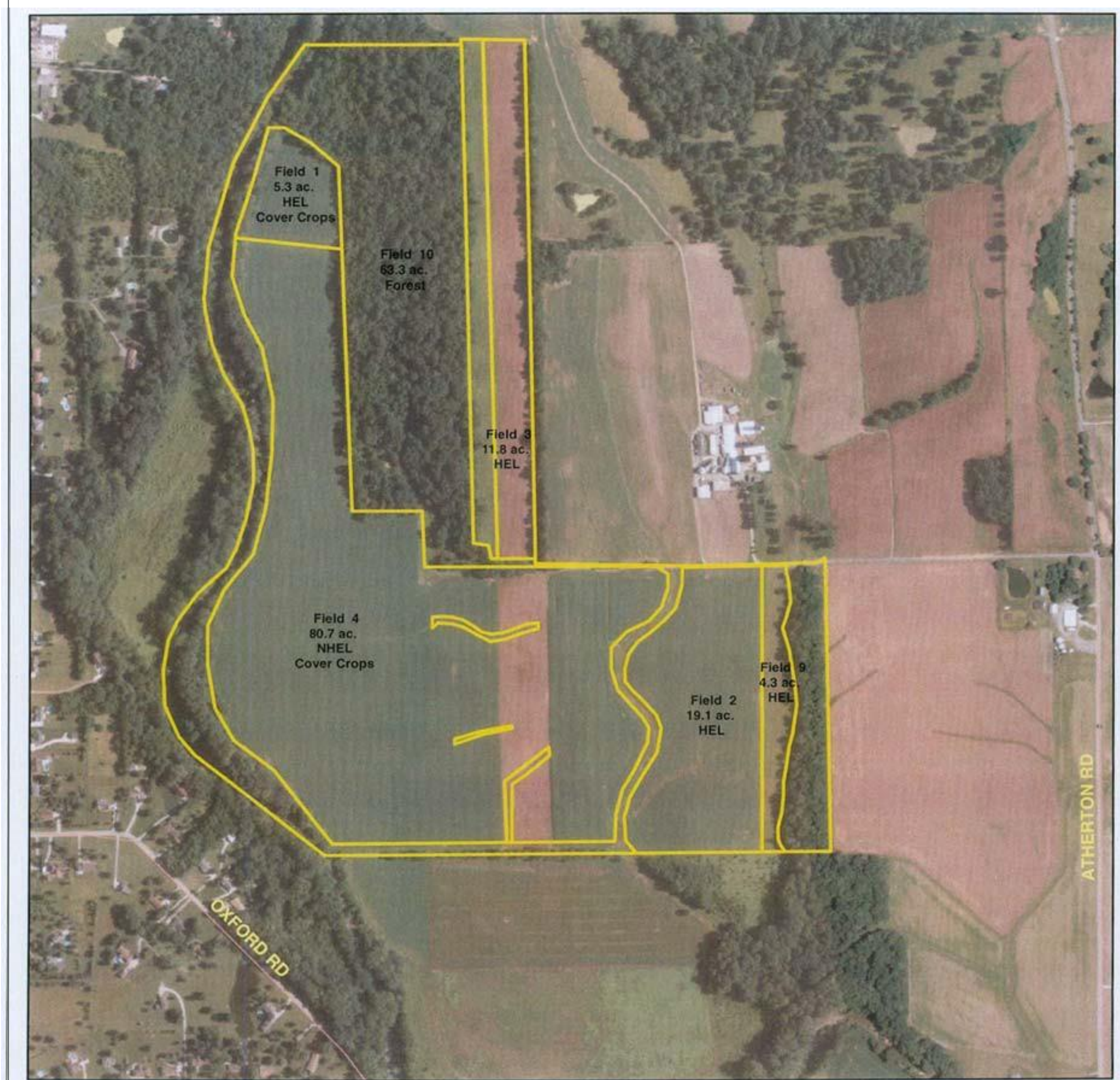
Minges

EQIP Plan Map

Date: 4/9/2014

Customer(s): LEONARD R MINGES
District: HAMILTON SOIL & WATER CONSERVATION DISTRICT
Legal Description: TRACRET: 214 FARM: 462

Field Office: HAMILTON SERVICE CENTER
Agency: USDA-NRCS
Assisted By: WILLIAM COOK



Legend

T-214 EQIP2014

700 1,400 Feet

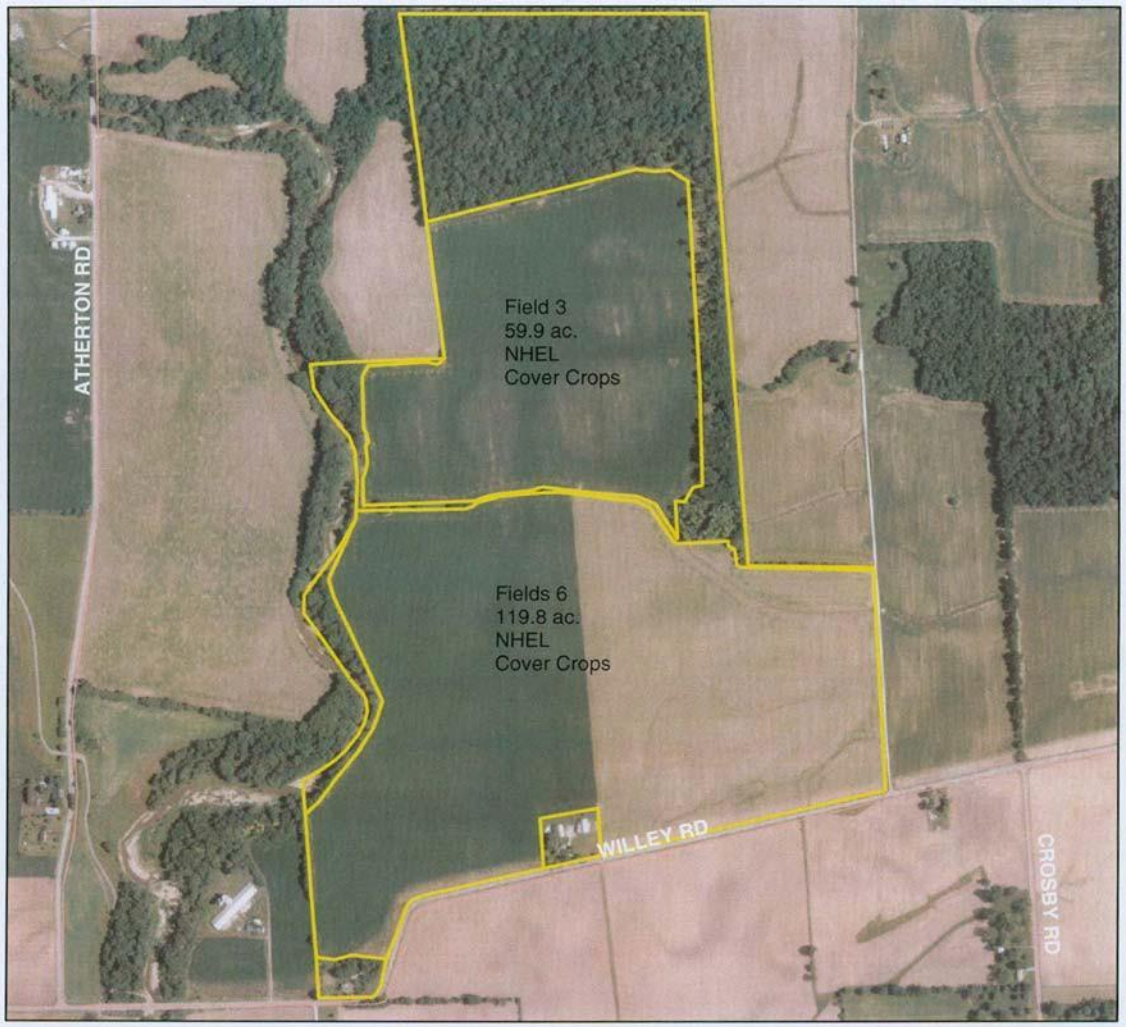
N

Knollman

EOIP PLAN MAP

Customer(s}: KNOLLMAN FARMS INC
District: HAMILTON SOIL & WATER CONSERVATION DISTRICT
Legal Description: TRACRET: 251 FARM:60

Field Office: HAMILTON SERVICE CENTER
Agency: USDA-NRCS
Assisted By: JOHN WILLIAMS



Legend

T-219_Cover Crop 2014

800 1,600 Feet