DISCOVERY FARMS MINNESOTA

Lessons Learned from Spring Creek Farms

How no-till management influences water quality in East-Central Minnesota

By Warren Formo, Jeremy Geske, Jerome Lensing, Tim Radatz

Is there such thing as zero loss? What practices are effective in reducing soil and nutrient losses? Can data from working farms be useful to policymakers? The Discovery Farms Minnesota Program was founded in 2010 to answer these questions. One of the first sites was Spring Creek Farms in Chisago County. The project provided an excellent location to collect water quality data on a working farm.

2018

WHAT IS DISCOVERY FARMS?

Discovery Farms Minnesota is a farmer-led effort to gather field scale water quality information from different types of farming systems, in landscapes across Minnesota. The mission of the Discovery Farms program is to gather water quality information under real-world conditions. The goal is to provide practical, credible, site-specific information to enable better farm management.

The program is designed to collect accurate measurements of sediment, nitrogen and phosphorus movement over the soil surface and through subsurface drainage tiles. This work leads to a better understanding of the relationship between agricultural management and water quality.

DISCOVERIES AT SPRING CREEK FARMS

Water quality risks are minimized with appropriate use of conservation practices and careful timing of nutrient applications.

- **The no-till planting system was effective** at producing high yielding crops and reducing water quality risks.
- **Surface runoff was similar** to other Discovery Farms Minnesota sites. Annual precipitation amounts were not correlated with surface runoff amount.
- **Low soil loss** was observed throughout the study due to the high residue levels and no-till planting system.
- **Dissolved phosphorus losses** were higher because of stratified soil phosphorus. Spring Creek Farms is taking steps to reduce stratification by banding phosphorus fertilizer below the seed.
- **Timing matters for fertilizer applications**. Avoiding application during high-risk runoff periods reduces losses. (High-risk periods include times when soil is frozen or saturated.)
- **Agricultural management** and water quality complemented (and still complement) each other at Spring Creek Farms because of the thoughtful uses of conservation and nutrient management practices.

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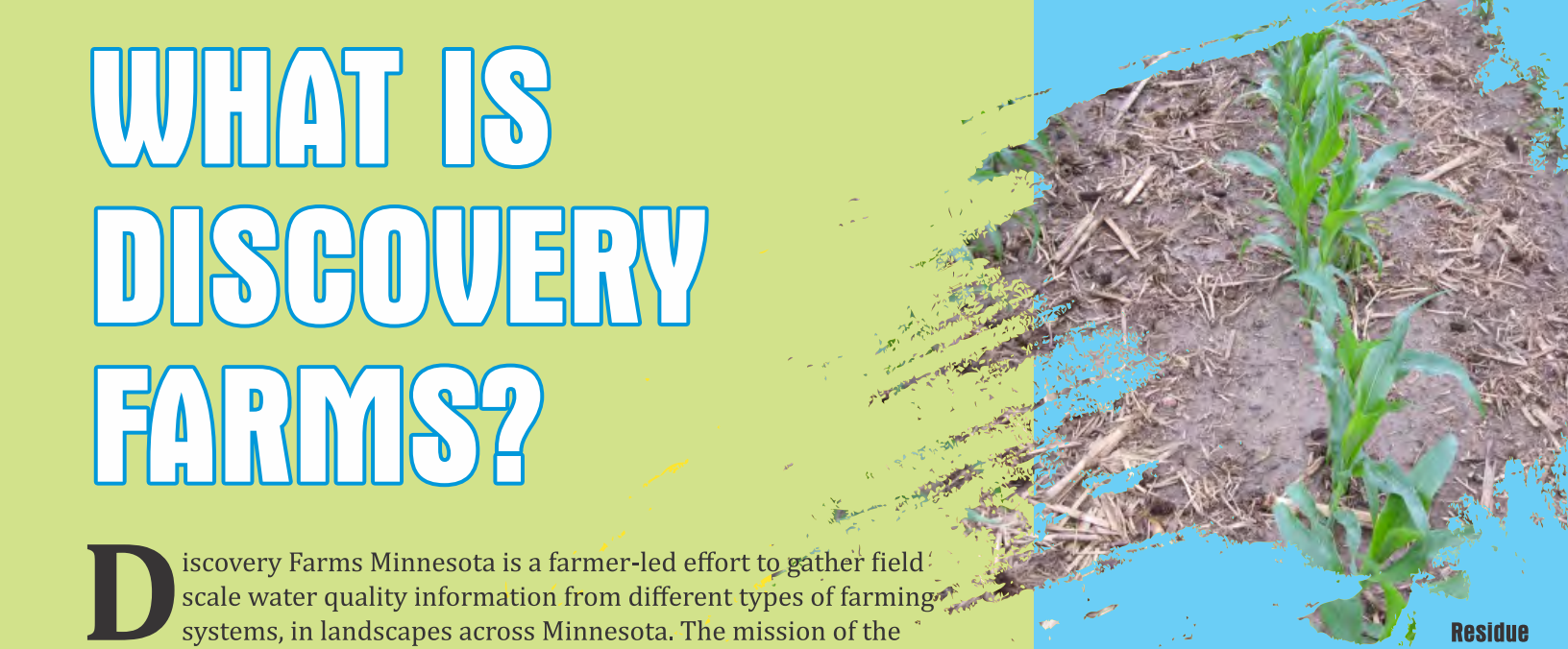

Residue after no-till planting corn

PROJECT BACKGROUND AND STUDY DESIGN

Spring Creek Farms joined the Discovery Farms Minnesota program in the fall of 2010 with the installation of surface runoff monitoring equipment on one of their fields and continued in the program through the fall of 2016. Spring Creek Farms is a grain farm located near North Branch, Minnesota in Chisago County, owned and operated by John and Jewell Peterson. The farm is close to the St. Croix River and the rural/urban interface of the Twin Cities metropolitan area. This location presents unique challenges for production agriculture because of the multiple demands for land use and a heightened interest in the potential effects of agricultural practices on the quality of the surrounding environment.

The site selected for monitoring provided an edge-of-field evaluation of a corn-soybean rotation and no-till management system. The purpose of this study was to measure water

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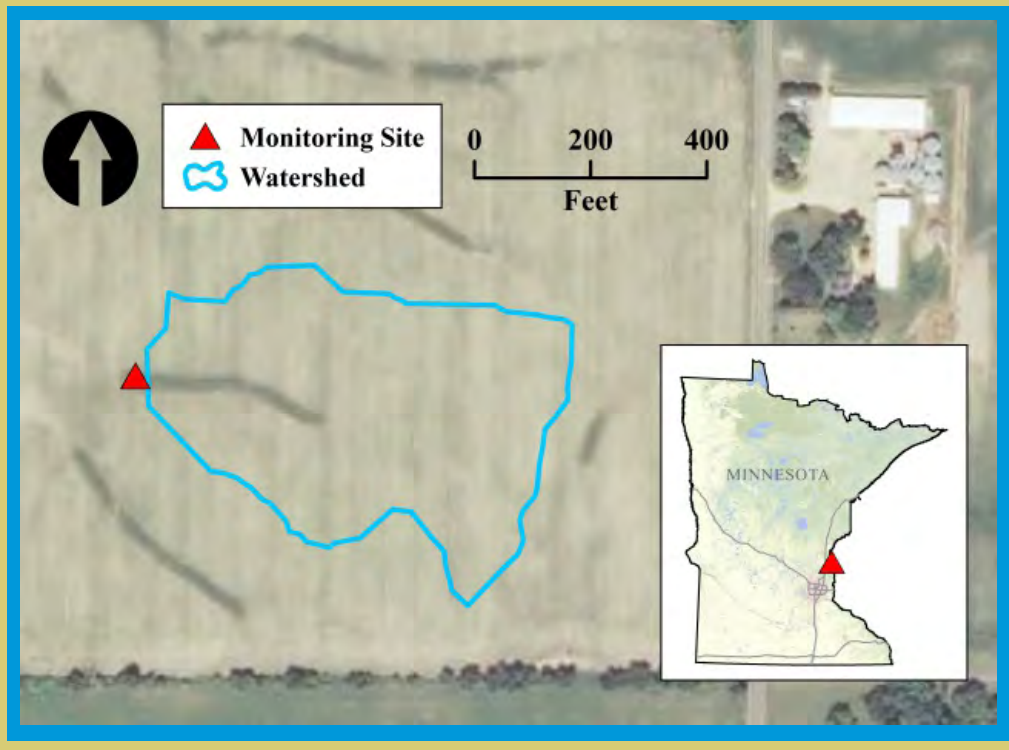
quality from an agricultural field and determine how cropping and management decisions impact soil and nutrient loss. The goal of this research is to provide clear recommendations for ways to minimize soil and nutrient losses during the times of the year when management matters most. Conservation professionals, policymakers, and farmers alike can use this information when making difficult decisions.

No-till planting is implemented for both the corn and soybean crops. No-till planting has been used since the mid-1990s by Spring Creek Farms. Phosphorus and potassium have been surface broadcast prior to the corn crop to meet the nutrient needs since moving to no-till practices. Starting in 2010, Spring Creek Farms modified their phosphorus and potassium application method. Their current application method places the phosphorus and potassium fertilizer in bands directly beneath the row. Corn is planted directly over the band and depth is adjusted so that there is 1.5 inches of soil between the fertilizer and seed. At planting, 5 gallons per acre of 6-18-6 (N-P205-K20) is placed in



Location of monitoring site at Spring Creek Farms

PROJECT BACKGROUND AND STUDY DESIGN

Drainage Area (ac)	Average Slope (%)	Soil Type	Drainage Class	Tile Drainage
6.1	3.40%	Cushing Loam	Well Drained	No

Monitoring site properties at Spring Creek Farms

Monitoring Equipment

contact with the seed with small amounts of micronutrients also applied with this liquid. Soybeans utilize residual fertilizer the following year. The nitrogen management program consists of two side-dress applications for the corn crop. About 40% of the total nitrogen application occurs at the 4 to 6 leaf stage of corn development (early June). The remaining 60% of the nitrogen application occurs at the 10 leaf stage of corn development (late June/early July).

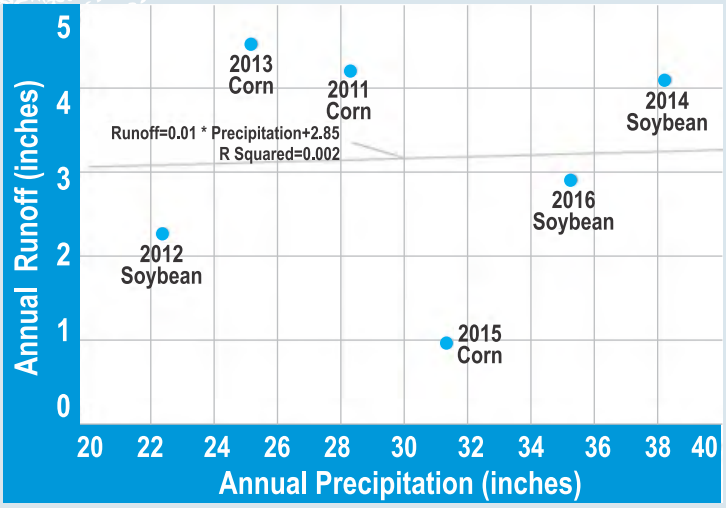
Six years of on-farm, edge-of-field surface runoff data was collected at Spring Creek Farms from a 6.1 acre field. Details of the monitored site are included in the table above. Three forms of nitrogen (nitrate, ammonium, and organic), total phosphorus, dissolved phosphorus, and total suspended solids (a measure of soil loss) were measured along with flow, precipitation, soil moisture, soil temperature, humidity, and air temperature. Field management information is also included in the table below.

Description	2011	2012	2013	2014	2015	2016
CROP	CORN	SOYBEAN	CORN	SOYBEAN	CORN	SOYBEAN
Fertilizer timing, placement, and source	May 14, banded, 6-16-40; June 10, broadcast, urea & ammonium sulfate; June 23, broadcast, urea	None	May 4, broadcast, 6-16-40; June 4, broadcast, urea & ammonium sulfate; June 13, broadcast, urea	None	June 15, broadcast, urea & ammonium sulfate, July 1, broadcast, super U & ammonium sulfate	None
Nitrogen application rate (lb/ac)	180	None	181	None	207	None
Phosphorus application rate (P_2O_5 lb/ac)	60	None	60	None	13	None
Potassium application rate (K_2O lb/ac)	100	None	128	None	8	None
Tillage	None	None	None	None	None	None
Plant Date	16-May	10-May	15-May	23-May	5-May	4-May
Harvest Date	7-Nov	12-Sep	Apr 15 (2014)	23-Oct	10-Nov	6-Oct
Yield (bu/ac)	200	48	169	52	190	66
Soil Test pH (0-6 in)	6.4	7.3	7.4	7.2	7.1	7
Soil Test Organic Matter (0-6 in; %)	1.6	2	1.1	1.8	1.8	1.9
Soil Test P (Bray; 0-6 in; ppm)	39	57	41	30	36	20
Soil Test K (0-6 in; ppm)	119	102	83	94	97	71

Farm management information for the monitored field at Spring Creek Farms

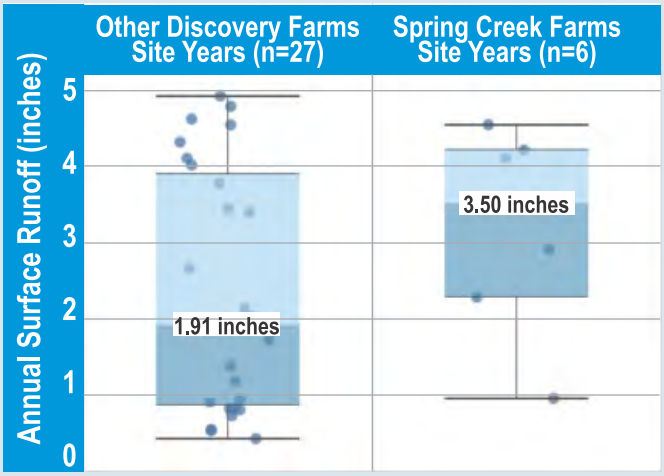
FINDINGS

No-till corn-soybean management works well for this soil and climate.
The loam soils at this site provide high permeability and water movement. No-till management of these soils produces excellent crops as field average yields were always much above county averages. Improved water holding capacity of the no-till system likely contributed to the higher than average yields. Concerns about cold, wet soils limiting productivity are not as significant for these naturally well-drained soils. The no-till system at Spring Creek Farms worked extremely well in these soils and conditions.



Annual precipitation and runoff at Spring Creek Farms

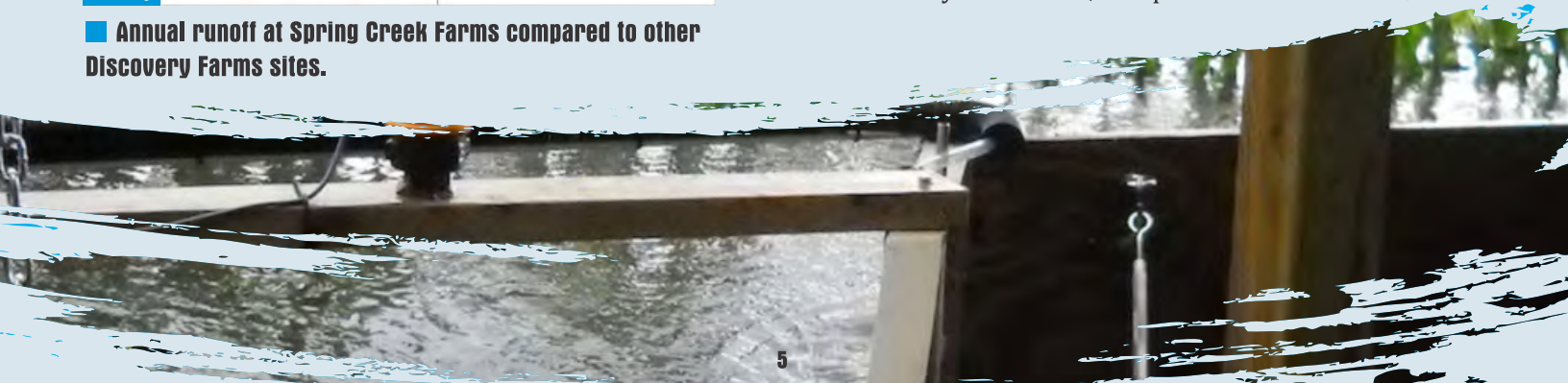
Annual surface runoff amounts were like other locations and farming systems.
On average, 11% of the precipitation that fell at this site left the field as surface runoff. Surface runoff occurred an average of 12 days per year. Median annual surface runoff was higher at Spring Creek Farms compared to other Discovery Farms Minnesota sites (3.50 in compared to 1.91 inches), but there was no statistical difference between the amount of runoff measured at Spring Creek Farms and other Discovery Farms Minnesota sites (Chart below; Mann-Whitney p value = 0.199). Even with the high infiltration rates due to the loam soils and no-till farming system, there were still periods of the year where surface runoff occurred. Fifty-seven percent of the surface runoff at Spring Creek Farms occurred during frozen soil conditions primarily in February, March, and April. Frozen soils infiltrate very little water.



Annual runoff at Spring Creek Farms compared to other Discovery Farms sites.

The amount of annual precipitation had little impact on the amount of annual surface runoff.
Thirty year normal precipitation for the area is 32.49 inches. There were three years with below normal precipitation (2011- 2013), one year with near normal precipitation (2015), and two years with above normal precipitation (2014 and 2016) during the study. Annual precipitation did not correlate well with annual surface runoff (chart above). In other words, amount of precipitation was not a good predictor of amount of surface runoff.

Precipitation timing and intensity can explain why the amount of annual precipitation is a poor predictor of surface runoff. There is a discrepancy between the time of most runoff and the time when most of the precipitation occurs. February and March contributed 42% of the annual runoff and only 8% of the annual precipitation. The amount of precipitation has little effect on snowmelt in February and March, compared to other weather



FINDINGS

conditions such as frost depth, snowpack depth, and rate of melt. Almost two-thirds of the annual precipitation occurred from May through September with less than one-third of the annual runoff. During this time runoff is limited because growing crops are using water and protecting the soil by providing a canopy.

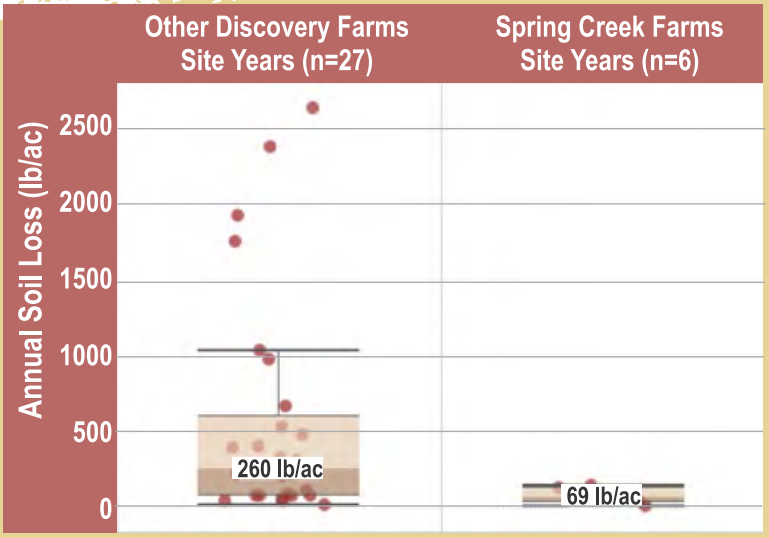
Precipitation intensity influences surface runoff. The table below includes data from 2015 at Spring Creek Farms. The field was planted to corn at the beginning of May. The table highlights two storm events, July 6th and August 22nd, both when the field had a fully canopied corn crop. The July event had a higher amount of precipitation but a much lower intensity while the August event had a lower amount of precipitation with a higher intensity. The August event had much higher runoff because of the increased intensity.

Date	Precipitation (inches)	Intensity (inches per hour)	Runoff (inches)
7/6/2015	2.06	0.17	0.02
8/22/2015	1.56	0.62	0.34

Precipitation and runoff from two events in 2015 at Spring Creek Farms

The no-till planting system was very effective at reducing soil losses.
Median soil loss at Spring Creek Farms was 69 lb/ac and ranged from 12 to 142 lb/ac. This is a low amount of soil loss and would be an equivalent to one 5-gallon pail full of soil lost from an area the size of a football field every year. Annual soil losses were less than other Discovery Farms Minnesota sites (chart above; Mann-Whitney p value = 0.013), indicating the effectiveness of the no-till planting system. Eighty-five percent of the soil loss occurred in April, May, and June at this site.

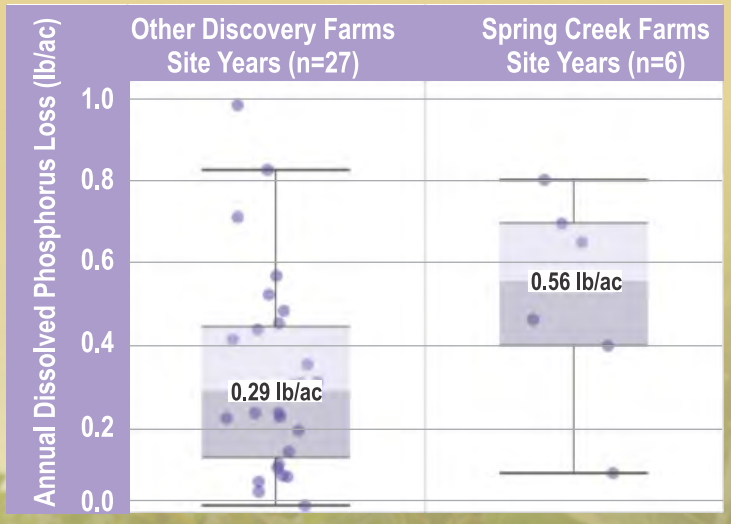
Total phosphorus losses were like other sites because of increased dissolved phosphorus losses.
Traditionally it is assumed that most phosphorus is moved from agricultural fields attached to soil particles. With this assumption, the lower soil losses at Spring Creek Farms should correspond with lower phosphorus losses. However, this is not the case. While there was no statistical difference (Mann-Whitney p value = 0.469), the median



Annual soil loss at Spring Creek Farms compared to other Discovery Farms sites

phosphorus loss at Spring Creek Farms was higher than the other Discovery Farms Minnesota sites (0.96 lb/ac compared to 0.63 lb/ac). Spring Creek Farms had similar range of phosphorus loss as other Discovery Farms Minnesota sites.

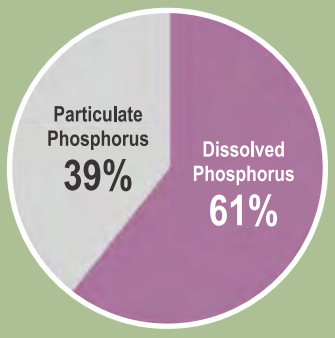
The similarity in total phosphorus losses was due to an increase in dissolved phosphorus loss at Spring Creek Farms. Dissolved phosphorus losses at Spring Creek Farms were higher than other Discovery Farms Minnesota sites (Chart, Mann-Whitney p value = 0.049).



Annual dissolved phosphorus loss at Spring Creek Farms compared to other Discovery Farms sites

FINDINGS

Most of the phosphorus lost in no-till planting systems is in the dissolved form.
Almost two-thirds of the total phosphorus lost at Spring Creek Farms was in the dissolved form (chart below), compared with about one-third at the other Discovery Farm Minnesota sites. This is important when using conservation practices to mitigate phosphorus losses. Solutions are different, and often easier, for mitigating particulate phosphorus losses compared to dissolved phosphorus losses. Conservation practices that minimize soil loss will minimize particulate phosphorus loss. These practices will not impact dissolved phosphorus losses. It is usually most effective to treat the infield sources to reduce dissolved phosphorus losses.



Phosphorus speciation at Spring Creek Farms

Higher residue levels and stratified soil phosphorus in a no-till system leads to higher dissolved phosphorus losses. Detailed soil samples were collected in the fall of 2011 to examine stratified soil phosphorus at Spring Creek Farms. Soil was collected from depths of 0 to 3, 3 to 6, 6 to 9, and 9 to 12 inches. Results of the analysis of these samples are summarized in table below. Highest values for phosphorus and potassium, immobile nutrients, were found at a depth of 0 to 3 inches and the values decreased with depth. This documents stratification in a no-till system.

Depth (in)	Soil Test P (Bray; ppm)	Soil Test K (ppm)
0 to 3	75	123
3 to 6	39	81
6 to 9	18	71
9 to 12	12	60

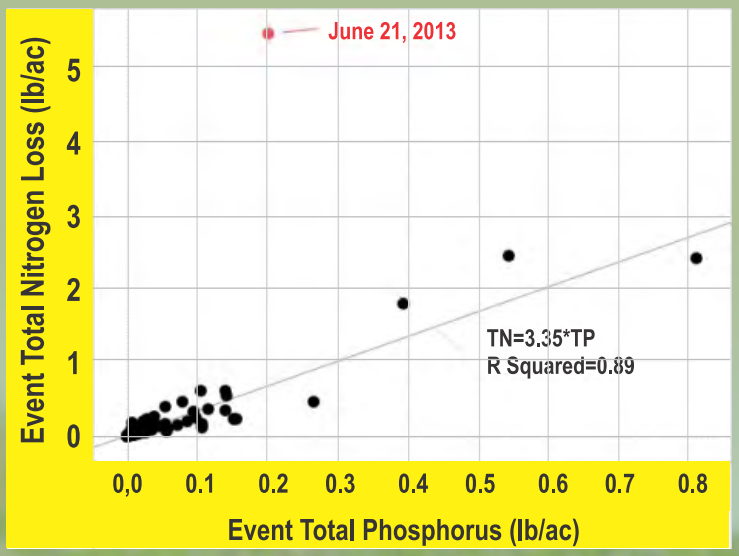
Incremental depth soil samples at Spring Creek Farms

Spring Creek Farms is already taking steps to reduce stratified soil phosphorus. Their new approach of banding phosphorus fertilizer below the seed will lead to less stratification, improving plant access and reducing dissolved phosphorus losses in surface runoff.

Timing of fertilizer applications matters.
When looking at surface runoff events at Spring Creek Farms, phosphorus and nitrogen losses were well correlated (chart below). As phosphorus increased, nitrogen increased at the same rate with one exception. On June 21st, 2013 nitrogen losses were eight times greater. This surface runoff event occurred soon after the second nitrogen split application for the corn crop.

Split applications of nitrogen are a great practice to reduce nitrogen losses when special consideration is given to timing of application. Nitrogen losses in surface runoff at Spring Creek Farms were lower compared to other Discovery Farms locations. However, if a surface runoff event occurs shortly after a fertilizer application, the chance of nutrient losses increases.

Spring Creek Farms made changes to their split application program since the 2013 event to further reduce the risk of nitrogen loss. In-season applications of nitrogen are typically made prior to rain because rain is needed to move the fertilizer into the soil profile to be used by the crop. In 2013, too much rain occurred (about one inch fell in one hour), and more nitrogen was lost than usual. Since that event the timings of the applications have been altered along with the fertilizer product choices. While risks can never be eliminated, Spring Creek Farms is constantly evaluating how to improve productivity and protect water quality with nitrogen management.



Total phosphorus and nitrogen by event at Spring Creek Farms.

John & Jewell Peterson

Why did you choose to participate in the Discovery Farms program?
I was curious to see what the data would be. It was a way to give and learn at the same time. It has been a good learning experience. We are innovative and we like to try different things to become more efficient and more profitable. At the same time, we want to leave our fields in better shape for future generations. Participating in Discovery Farms helps validate what we are doing and identify ways to improve our management practices.

What instilled your conservation ethic?
The desire to leave our land in excellent condition for the next generation. We chose no-till because it was different, it was a challenge, and you could still be profitable. Farming is a constant challenge because every year is different. You take the good that you learn from each year and strive to improve.

What have you taken away from the program?
The amount of water that drops on the land annually is incredible. You don't realize it until you see that flume gathering water from your field. It has changed the way we think about reducing erosion and keeping nutrients on the land for our crops. The data shows we have been doing a good job of minimizing losses, but there is always room for improvement. It has been a good learning experience.

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