MP572

ARKANSAS Discovery Farms

PROGRAM SUMMARY

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

AACD

USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

ARKANSAS DEPARTMENT OF AGRICULTURE

ARKANSAS
Discovery
Farms

Program Summary

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

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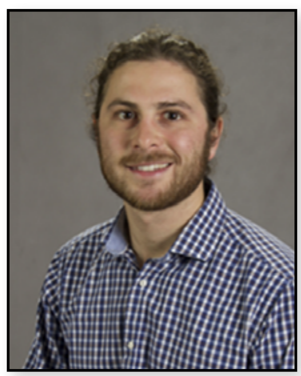

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Foreward

Mike Sullivan
State Conservationist for Arkansas,
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The University of Arkansas System Division of Agriculture Research & Extension has actively worked with partners and producers since the early 1960s. In that time, researchers have tested and developed multiple methods to improve agricultural production in Arkansas. The Discovery Farm Program's work conducted by University of Arkansas staff in partnership with the Natural Resources Conservation Service (NRCS) has proven to be a valuable piece to the ever-growing puzzle of hardships that producers are facing each day.

Edge-of-field monitoring is one of the foundational methods for producers, professionals, and partners of the agriculture industry to further understand how to develop food and fiber equitably and wisely for our country. The use of this voluntary program in Arkansas is a valuable tool because Arkansas farmers work directly with scientists to develop methods that both reduce the impacts to the environment and improve the success of the farmer's operation. Technical and financial assistance from the NRCS Environmental Quality Incentive Program (EQIP) make edge-of-field monitoring a feasible option for producers and partners involved in these endeavors. Edge-of-field monitoring benefits both producers, the University of Arkansas, and the NRCS by validating the science behind conservation practices and helps to document economic and environmental benefits associated with conservation practices and systems.

Arkansas is blessed with productive soils, clean water, and other resources that help make agriculture successful. We at the NRCS and our partners at the University of Arkansas recognize the hardships producers face to increase production and feed the Nation while experiencing increases costs. Together, through programs like Discovery Farms, we are working to help provide information useful for producers in making decisions about their operations. The work we are doing now is just a beginning for a brighter future.

Chapter 1: Introduction

THE ARKANSAS DISCOVERY FARMS PROGRAM

The Discovery Farm Program strives to achieve environmental and agricultural sustainability for farming in Arkansas through monitoring, demonstration, and research to: (1) assess the need for and effectiveness of adopting appropriate Best Management Practices (BMPs) to reduce nutrient and sediment loss and conserve water for major agricultural systems; (2) provide on-farm verification of nutrient and sediment loss reductions and water conservation; (3) mitigate nutrient and sediment losses that may prevent State waters from attaining designated uses; (4) deliver outreach programs to producers in achieving production and environmental goals; and (5) provide information in support of development of the State Water Plan for Arkansas.

OUR PARTNERS

A fundamental and critical aspect of the Discovery Farm program is the partnership between public and private sectors, as well as the agricultural and natural resource communities. These partnerships are essential to program delivery efficiency, mutual ownership, and credibility. The Discovery Farm program and these partnerships help coordinate conservation program delivery from multiple levels of government ranging from local county-based programs to federal financial incentive programs.

Other partners that have provided financial support to date are Arkansas Farm Bureau, Arkansas Rice Promotion Board, Arkansas Soil Test Review Board, Arkansas Soybean Promotion Board, Arkansas Corn and Grain Sorghum Board, Monsanto, Arkansas Natural Resources Commission, and Natural Resources Conservation Service via the (Mississippi River Basin Healthy Watersheds Initiative (MRBI) and National Water Quality Initiative (NWQI)). This funding allowed us to purchase and operate equipment for some of our current farms.

PROGRAM IMPACT

Documenting environmental impacts of Arkansas farming systems, as well as evaluating the cost-effectiveness of alternative practices, will bridge a knowledge gap that now keeps farmers, natural resource managers, and decision-makers from confidently taking effective actions that ensure economic and environmental sustainability. This program, and formation of strong partnerships, has the potential to affect millions of agricultural acres across the state. Program results will also give us the confidence that we are doing our part to maintain safe and affordable food supplies, while protecting our natural resources for future generations of Arkansans.

The statewide program currently consists of 17 farms in Arkansas (Figure 1). The following is a brief description of the current locations.

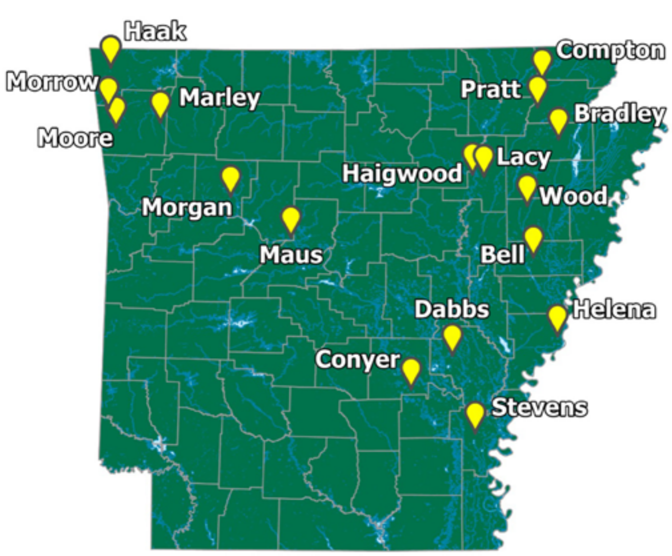


Figure 1. Location of Discovery Farms in Arkansas.

Discovery Farms in Arkansas

Marley Farm | *Poultry and beef operation* (Washington County): A poultry – beef grazing operation in the Beaver Lake – Upper White River Watershed. There are 10 poultry houses, with 1,200 acres of pasture and about 1,000 acres of woodland.

Morrow Farm | *Beef operation* (Washington County): A beef rotational grazing operation in the Illinois River Watershed.

Moore Farm | *Poultry-beef-row crop operation* (Washington County): The operation doubled the number of poultry houses from four to eight on this farm located in the Illinois River Watershed.

Haak Farm | *Dairy operation* (Gentry, Benton County): A 240 acre rotationally grazed dairy operation in the Lower Neosho Watershed, which milks approximately 140 cows. In addition, there are 120 beef cows and 40 stockers on the farm.

Morgan Farm | *Peach orchard operation "Peach Pickin Paradise"* (Johnson County): A peach orchard operation and the first horticulture Discovery Farm.

Maus Farm | *Corn-soybean row-crop operation* (Pope County): A 940-acre row-crop operation in the MRBI focus watershed of Point Remove – Lake Conway, in Pope County. There are about 200 acres of wheat, 240 acres of rice, 200 acres of corn, and 400 acres of soybean.

Wood Farm | *Soybean-wheat-rice operation* (Cross County): A 2,700 acre row-crop operation adopting reduced tillage, cover crop, tailwater recovery, and riparian buffer conservation measures in the L'Anguille Watershed. This farm is in the State's Critical Groundwater Area.

Dabbs Farm | *Rice-soybean-corn operation* (Arkansas County): A 1,500 acre row-crop operation, concentrating on rice, soybean, and corn rotations in the Bayou Meto Watershed. This farm is in the State's Critical Groundwater Area.

Stevens Farm | *Cotton-soybean-corn row-crop operation* (Desha County): A 1,500 acre row-crop operation, concentrating on cotton and corn located in the Bayou Macon Watershed.

Conyer Farm | *Rice-corn-soybean operation* (Jefferson County): A row-crop operation with rice-corn-soybean rotations located in the Bayou Bartholomew Watershed.

Bell Farm | *Rice-corn-soybean with cover crop operation* (Saint Francis County): A row-crop operation located in the L'Anguille River Watershed, which has implemented cover crops conservation measures.

Long Lake Plantation | *Corn-soybean-peanut with cover crop operation* (Phillips County): A row-crop operation in the Lower White Watershed, where land-levelling and irrigation improvements took place prior to adoption of cover crops and use of poultry litter as supplemental fertilizer.

Lacy Farm | *Rice-corn-soybean operation* (Jackson County): A row-crop operation in the Upper White River-Village Creek watershed with waterfowl and deer hunting leases and cover crops conservation measures.

Haigwood Farm | *Rice-soybean operation* (Jackson County): A row-crop operation in the Upper White-Village Creek watershed studying the implementation of poultry litter.

Bradley Farm | *Rice-soybean operation* (Craighead County): A row-crop operation in the Lower St. Francis watershed as part of the Anheuser-Busch Rice Water Sustainability partnership.

Compton Farm | *Rice-soybean operation* (Greene County): A row-crop operation in the Cache watershed as part of the Anheuser-Busch Rice Water Sustainability partnership.

Pratt Farm | *Rice-soybean operation* (Greene County): A row-crop operation in the Cache watershed as part of the Anheuser-Busch Rice Water Sustainability partnership.

ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP)

The Environmental Quality Incentives Program (EQIP), administered by the USDA Natural Resources Conservation Service (NRCS), provides producers with technical and financial assistance to implement conservation practices. Producers can voluntarily seek this assistance from their local NRCS office. Through EQIP, agricultural producers can "address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, improved or created wildlife habitat, and mitigation against drought and increasing weather volatility" (USDA NRCS 2022).

CONSERVATION ACTIVITIES 201 AND 202

In 2013, the NRCS introduced Conservation Activity standards 201 and 202 as edge-of-field monitoring through EQIP. Edge-of-Field Water Quality Monitoring Data Collection and Evaluation (201) and System Installation (202) are standards available to producers in priority impaired watersheds. Many Arkansas Discovery Farmers received funding for edge-of-field monitoring (Conservation Activities 201 and 202) through EQIP, including the Bell, Conyer, Long Lake Plantation, Maus, Stevens, and Wood farms.

The goals of these Conservation Activities are to:

- "Evaluate the effectiveness of a practice or system of practices in reducing concentrations and/or loads of targeted constituents.
- Use evaluation techniques to acquire insight about existing land management and where applicable, institute change to achieve a future desired condition.
- Collect site specific edge-of-field water quality data to calibrate, validate, and verify predictive models" (USDA NRCS 2022).

METHODS

At the lower end of each field, automated, runoff water quality monitoring stations were established to: 1) measure runoff flow volume, 2) collect water quality samples of runoff for water quality analysis, and 3) measure precipitation. The primary measuring device varied from field to field and included either pipes that lead drainage off the field or 60-degree, V-shaped, 8-inch trapezoidal flumes. These primary measuring devices were gauged and installed at the outlet of the field. The ISCO 6712, an automated portable water sampler, was utilized to interface and integrate all the components of the flow station. Each sampler included either an ISCO 720 flow module equipped with a submerged pressure transducer or an ISCO 750 area velocity flow meter equipped with Doppler technology used to measure the height of water in the pipe or flume at a flow-calibrated measurement point. ISCO Flowlink software integrated data collected by the sampler to calculate total discharge volume and flow rate for a single runoff event.

Discharge data were utilized to trigger flow-paced, automated collection of up to 100, 100-mL subsamples that were composited into a single, 10-L sample. A sample was collected on a unit flow basis, such that a composite flow-weighted sample for the whole discharge event was obtained. Runoff water samples were collected from the auto-sampler, placed in clean, acid washed polyethylene bottles with caps, and labeled with site number, date, time, and collector's name. Samples for dissolved P, nitrate-N and ammonium-N were filtered in the field through a 0.45-μm membrane into a sterile glass vial and stored at 4oC in the dark along with unfiltered samples. The samples were then transferred to the certified laboratory to be analyzed. Dissolved P, nitrate-N, and ammonium-N were determined colorimetrically by standard U.S. Environmental Protection Agency methods. Total N and P were determined by the same colorimetric methods after Kjeldahl digestion of an unfiltered water sample. Particulate P was calculated as the difference between total and total dissolved P. The suspended sediment concentration of collected runoff water samples was determined gravimetrically, as the difference in weights between oven-dried (105˚C), unfiltered, and filtered samples.

For row-crop situations where irrigation was utilized, irrigation inflow was measured with turbine-based, inline flow meters outfitted with data loggers to determine application rates and cumulative irrigation volume. Pipe Planner and PHAUCET are computer-assisted hole sizing programs that can improve furrow-irrigation efficiency. It is thought that by integrating a surge valve into the design that irrigation efficiency can be further increased, and this was studied on many of our row-crop Discovery Farms. Surge irrigation is the intermittent application of water used to improve distribution uniformity along a furrow, and it works on the principle that dry soil infiltrates water faster than wet soil (Henry et al., 2021). When soil is wet, a seal is formed because the soil particles at the surface consolidate. When water is re-introduced in a furrow that has been wet, the wetting front moves quickly past the wetting zone to dry soil. At the wetting interface, dry soil slows the advance. This phenomenon allows for a faster advance through the field with less deep percolation and better application uniformity. The end result, therefore, is a more even distribution of water in the rooting zone from the polytubing to the tail ditch and reduced nutrient loss from deep percolation near the polytubing. Surge irrigation is performed through a program of cycle times set by the user that accounts for the advance of the furrow.

Chapter 2: Results by Farm

2-1 – Jeff and Marsha Marley Farm: Poultry-Beef

(Washington County) Elkins, Beaver Lake Watershed

The Marley Farm is located in eastern Washington County. The farm has 10 poultry houses, 1,200 acres of pasture, and 1,000 acres of woodland. The focus at the Marley Discovery Farm includes monitoring runoff from four poultry houses flowing into a 3-acre pond as well as runoff from two poultry houses flowing through a hayed pasture (i.e., grassed waterway) into an ephemeral creek, before entering the main stem of the White River. Conservation practices evaluated are "Farm Pond" (CP 378) and "Grassed Waterway" (CP 412). Monitoring stations quantify nutrient and sediment loadings before water enters the pond and grassed waterway and again before runoff exits the pond and pastures and reaches the creek.

Over the 11-year project, nutrient concentration of water exiting the pond were 86% lower for dissolved P, 67% lower for total P, 92% lower for nitrate-N, and 66% lower for total N, compared to runoff concentration prior to entering the pond (Figure 8). Over a 7-year period from 2013 to 2019, the grassed waterway resulted in an average reduction in runoff volume of 28%, and imparted nutrient load (lbs ac^{-1} yr^{-1}) reductions that amounted to about 24% of the dissolved and total P, 72% of the nitrate-N, and 54% of the total N (Figure 7). This study is important as it demonstrates the effectiveness of conservation practices at decreasing nutrient runoff from poultry production areas.

Figure 2. Jeff Marley standing next to a water quality station that samples the water leaving his broiler houses before entering a pond.

Figure 3. The Discovery Farm monitors the runoff from six broiler houses at the Marley Farm pictured behind the pond.

Marley Farm, cont.

Figure 4. Jeff and Marsha Marley sitting on their front porch with their five children behind them.

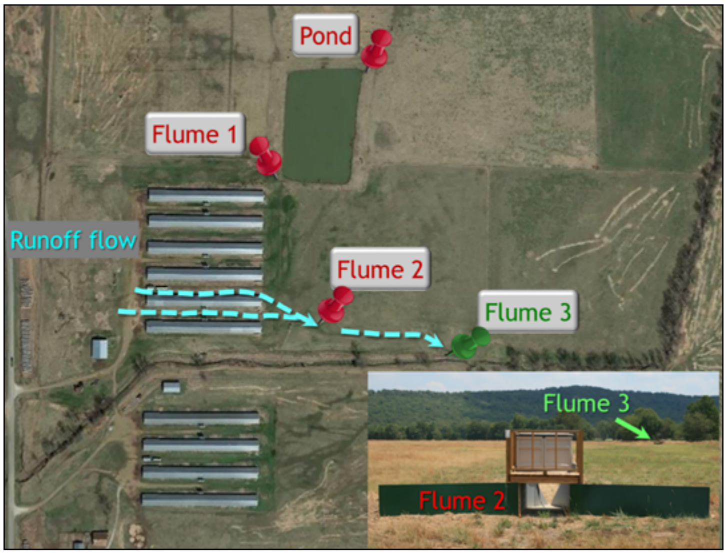


Figure 5. Imagery of the Marley Farm depicting the location of the four sample locations where runoff is measured leaving six broiler houses and again after passing through a grassed waterway and pond.

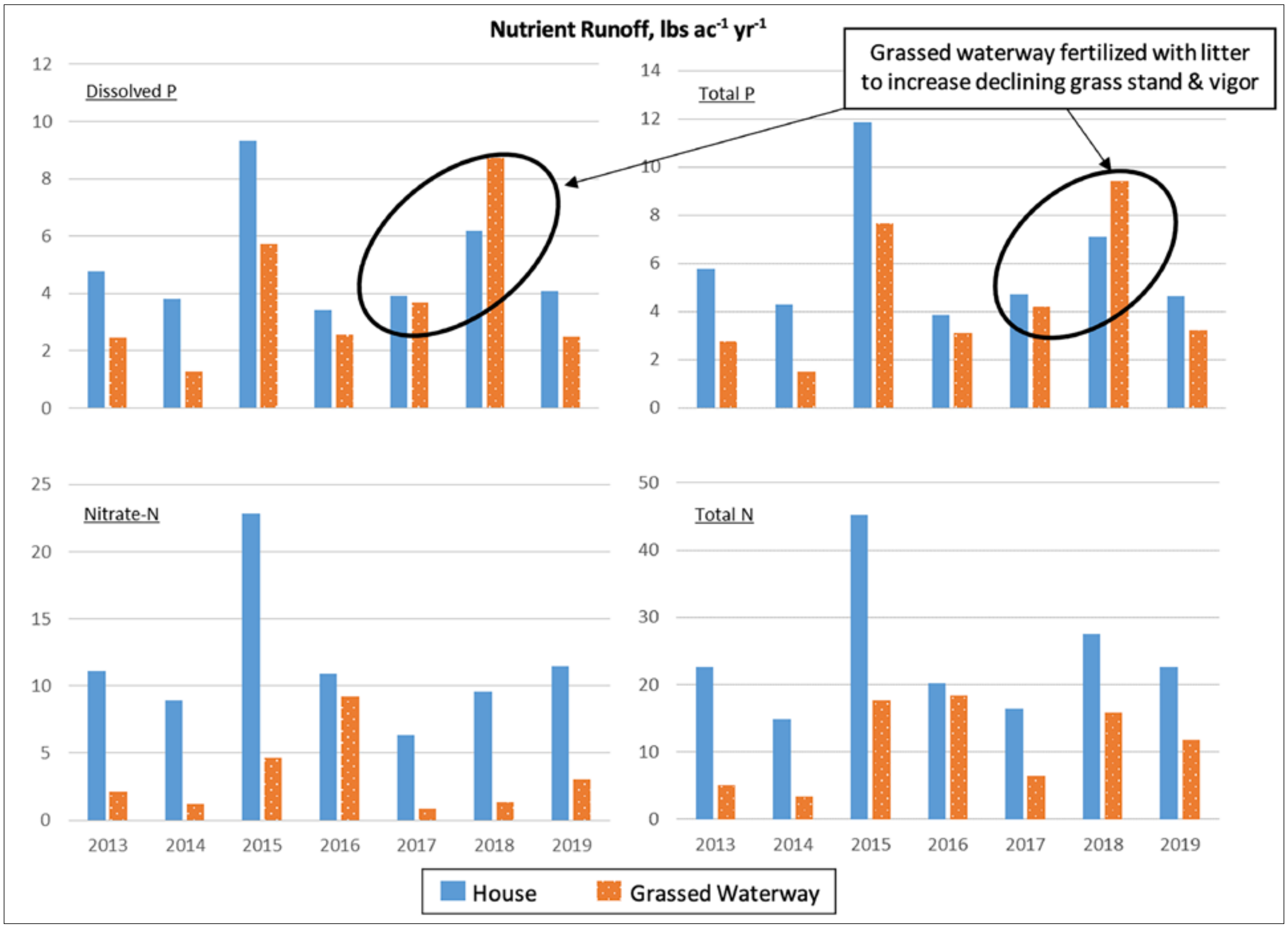


Figure 6. Total annual nutrient runoff (lbs ac^{-1} yr^{-1}) from two broiler houses (blue) and after flowing through a grassed a waterway (orange dots).

Marley Farm, cont.

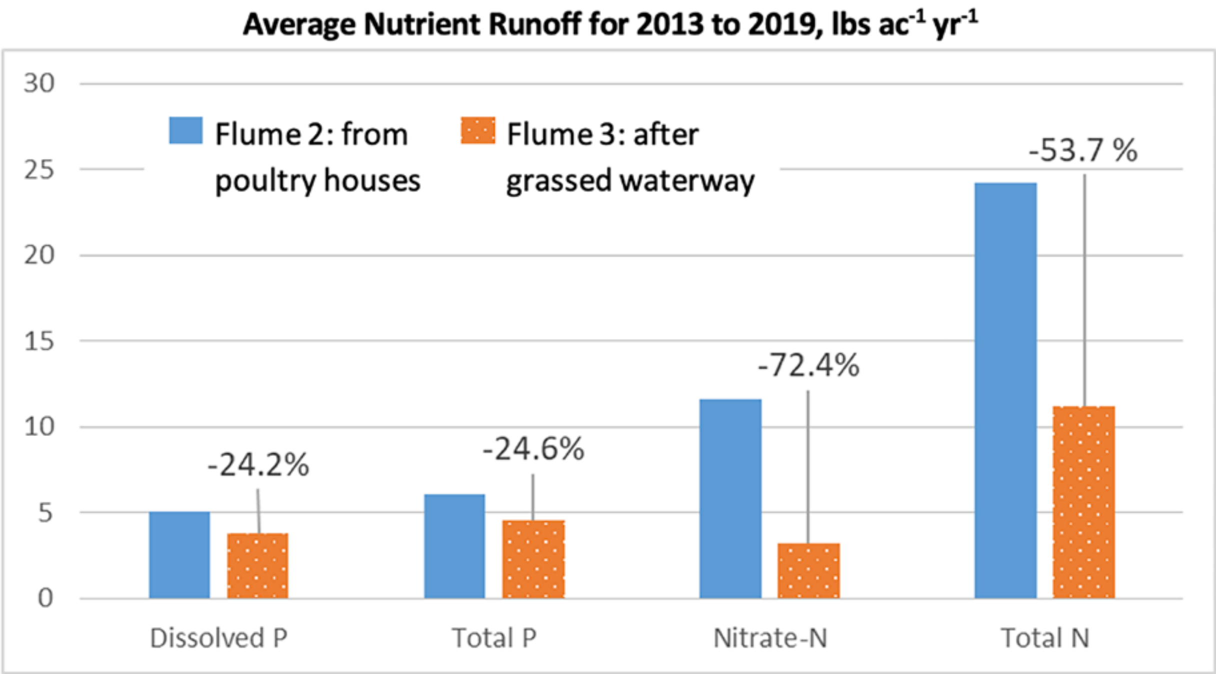


Figure 7. Average total annual nutrient runoff (lbs ac^{-1} yr^{-1}) from two broiler houses (blue) and after flowing through a grassed a waterway (orange dots) over a 7-year period from 2013 to 2019.

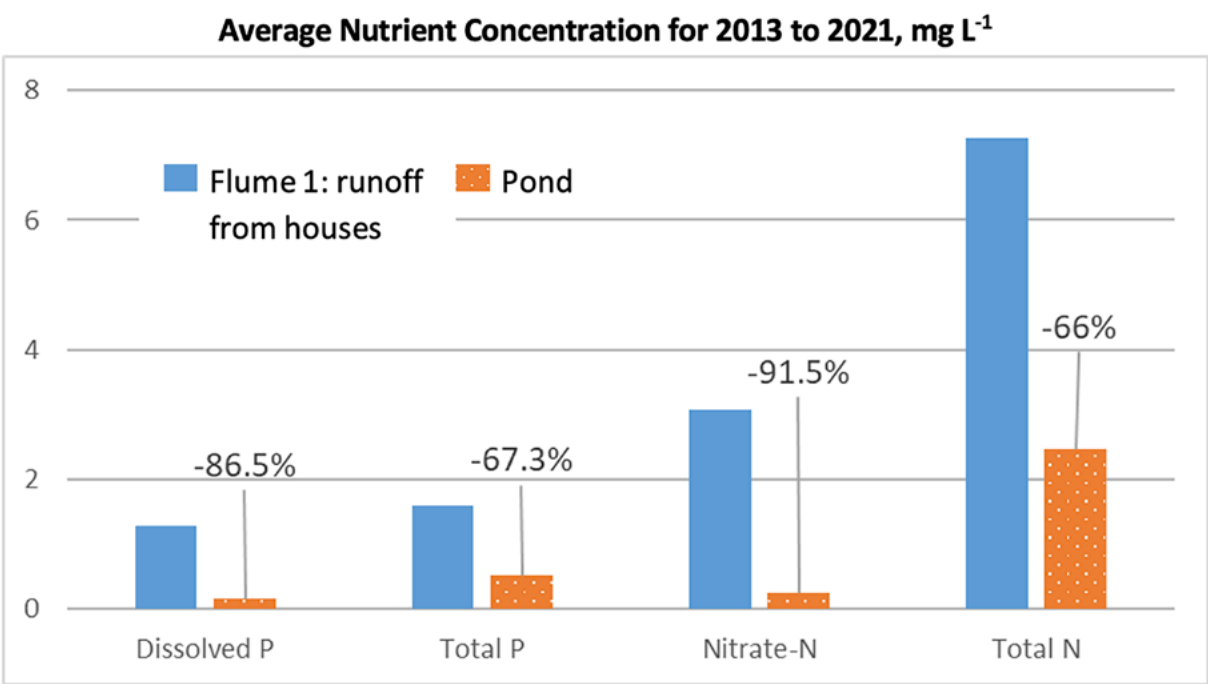


Figure 8. Average nutrient concentration (mg L^{-1}) of runoff measured leaving four broiler houses, before entering a pond (blue) and at pond overflow (orange dots) over a 9-year period from 2013 to 2021.

2-2 – Ron Morrow Farm: Pasture Beef

(Washington County) Wedington, Illinois River Watershed

At the Morrow Discovery Farm, we are studying the effect cattle management has on pasture nutrient dynamics by evaluating the impact rotational grazing, poultry litter application, and winter-feeding hay has on soil health and fertility, forage production and quality, and nutrient losses in runoff. The conservation practices evaluated at the Morrow Farm are "Rotational / Prescribed Grazing" (CP 528) and "Feed Management" (CP 592).

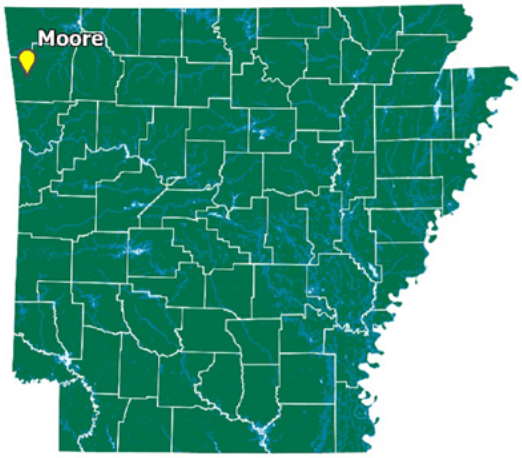
Improvements to soil health were significant for both the practice of winter-feeding hay and the addition of poultry litter when compared to control paddocks that were only grazed. Furthermore, treatment plots where hay bales were unrolled resulted in 19% greater forage production compared to unamended control areas, over a 2-yr period. The findings suggested that feeding hay makes an important contribution to soil nutrient levels that may be especially valuable for areas where above optimum soil test P levels may not be suitable for further litter, but still need additional N for agronomic yields.

Figure 9. Cattle eating hay out of a ring feeder (top left) and from unrolled bales (bottom left) during a winter hay feeding study at the Morrow Farm in January 2017. Ron Morrow pictured on a 4-wheeler while out checking on the herd at the Morrow Farm in May of 2021 (right).

2-3 – Curtis, Ralph, and Allan Moore Farm: Poultry

(Washington County) Lincoln, Illinois River Watershed

Project Complete (Year of Completion: 2021)



We started working with the Moore family as they were in the process of building an additional four new poultry houses, doubling the number of houses in broiler production on the farm. The new houses were designed to lower the nutrient footprint by installing an experimental BMP. Cement litter cleanout pads were poured to ease clean-up of any litter spillage occurring during cleanout compared to standard gravel entrances. This practice does not have a specific standard at the moment, but is similar to "Heavy Use Area Protection" (CP 561).

Since BMP installation, mean annual rates (lbs ac^{-1} yr^{-1}) of dissolved P, total P, nitrate-N, and total N runoff, have been 60, 67, 53, and 62% lower for houses with a BMP compared to original houses, while also decreasing soil erosion rates. Water quality monitoring on the farm and a cost analysis of each BMP will allow us to determine the effectiveness of each practice, in terms of $s per pound of nutrient decrease.

Figure 10. Allen Moore and his family.

Figure 11. Curtis Moore checking on his first delivery of broiler chicks at his new houses in December of 2014.

Moore Farm, cont.

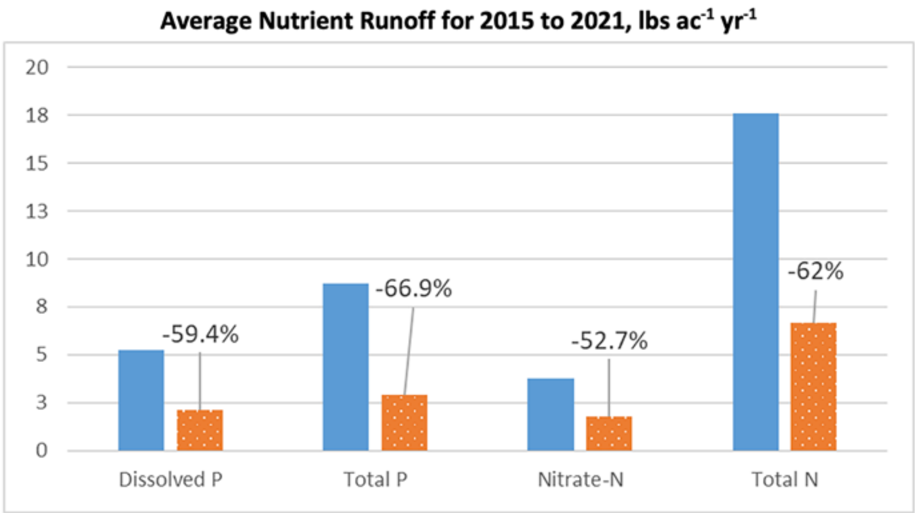


Figure 12. Average annual nutrient runoff (lbs ac^{-1} yr^{-1}) from the original gravel entry (blue) versus the concrete pad entry (orange dots) for a 7-year period from 2015 to 2021.

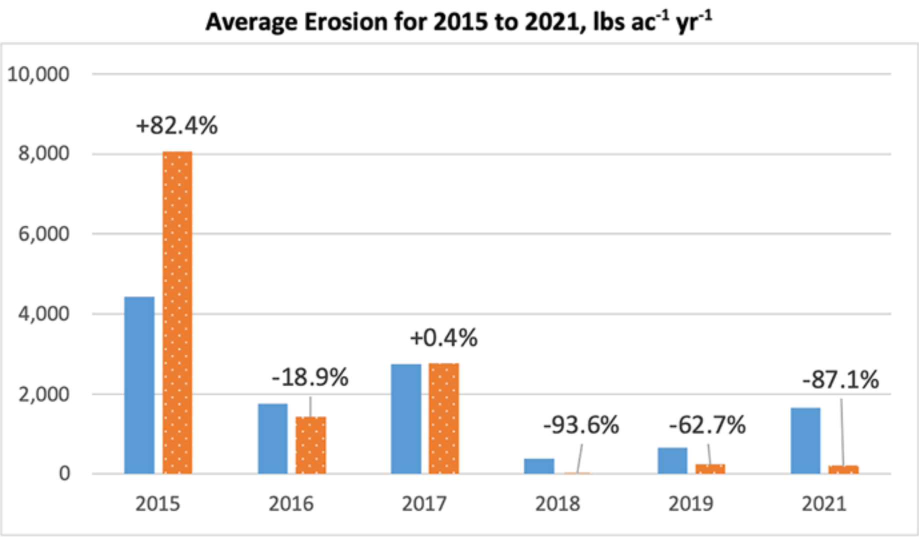
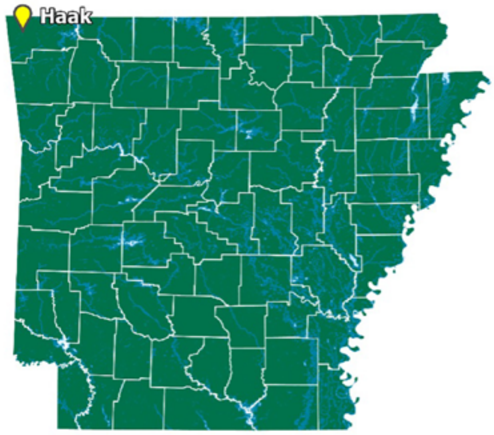


Figure 13. Average total suspended sediment runoff (lbs ac^{-1} yr^{-1}) from the original gravel entry (blue) versus the concrete pad entry (orange dots) for a 7-year period from 2015 to 2021.

2-4 – Bill Haak Farm: Dairy

(Benton County) Gentry, Lower Neosho Watershed

Contacts: James Burke and Karl VanDevender



The Haak dairy is located near Decatur in northwest Arkansas and has been in operation for approximately since 2016. The dairy milks up to 160 cows and the milk produced is collected on a daily basis. In addition, there are 120 beef cows and 40 stockers on the farm. For cattle grazing purposes, a rotational paddock system is employed with distributed cattle watering tanks.

Structural characteristics of the dairy include a pre-milking holding area associated with a milking parlor and a roofed open-air manure storage area. Other parts include a wastewater treatment system with underground pumping capabilities as well as a grass interception field and water meters dispersed throughout the farm.

Over the 4-year monitoring period, the wastewater treatment system has been significant in impeding the migration of nutrients to other areas of the farm. Water meter readings show the largest amount of farm water usage is for cattle drinking. Although the manure/sawdust mixture held in the open-air storage facility does not reach a proper composting temperature, its elevated temperatures indicate heightened microbial activity. Core samples from the manure/sawdust mixture collected in 2017 and 2020, show no statistically significant movement of manure nutrients downslope of the wastewater treatment system.

Figure 14. Bill Haak in the milking parlor.

Figure 15. The Haak family.

Haak Farm, cont.

Milk center wash-water treatment system nutrient concentration and percent solids content means were compared by sampling site over 2017 to 2020 (Table 1). Similar trends were observed for total N, total P and total K in the significantly decreasing order of the sampling sites: Trench entrance > basin discharge > pond. Dissolved P concentration for the pond was significantly lower than the basin discharge and trench entrance.

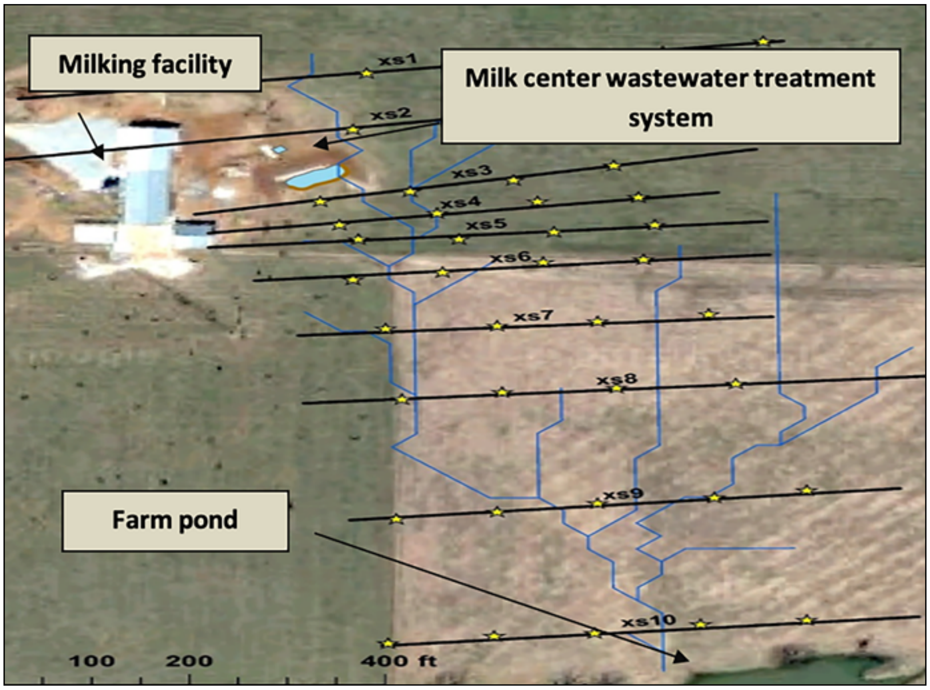


Figure 16. Aerial view of the Haak dairy farm and its features.

Overall, the largest amount of water used on the farm is for cattle drinking by a wide margin (81%) over milk center use (19%) and human needs (0.1%) (Figure 19). With an increase in cattle herd size, this should remain the largest use of farm water for a prolonged period of time. Recording and analyzing water meter readings on a monthly basis gives helpful insight into how water is used and distributed around this unique dairy operation.

Across all sampling dates, the manure/sawdust mix temperatures are consistently greater than ambient measurements, but do not quite reach the composting target of 130˚F (Figure 20). This may possibly be explained by the thermal mass and heightened microbial activity within the manure/sawdust mixture keeping temperatures elevated, but not quite at the composting target temperature.

Figure 17. The inclined cattle premilk holding area with exit lanes to the sides. Sawdust or shavings are spread prior to milking to aid in manure handling and storage via moisture absorption.

Figure 18. The open-air manure storage facility at the Haak dairy. The facility is adjacent to the milking parlor and contains a manure/sawdust mixture that is stored until needed for field applications or transport.

Haak Farm, cont.

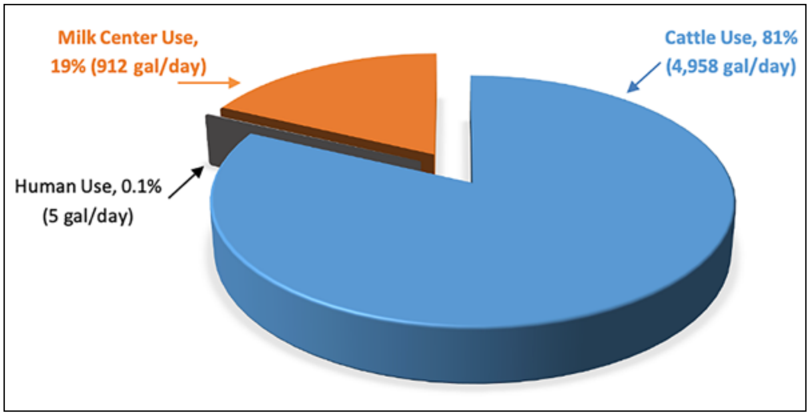


Figure 19. Average farm-water use (gal) calculated from monthly meter readings (2017 to 2020).

Table 1. Nutrient concentration and percent solids from 2017 to 2020

Site	# of samples	Total N	Total P	Dissolved P	Total K	Solids
		mg/L				%
Basin discharge	43	301.2 b*	66.7 b	54.6 a	154.7 b	0.6 b
Trench entrance	32	804.2 a	134.2 a	52.2 a	191.7 a	1.7 a
Pond	42	4.4 c	1.6 c	1.1 b	16.8 c	ND

** Values connected by the same letter are not significantly different (P = 0.05).*
ND = Not determined.

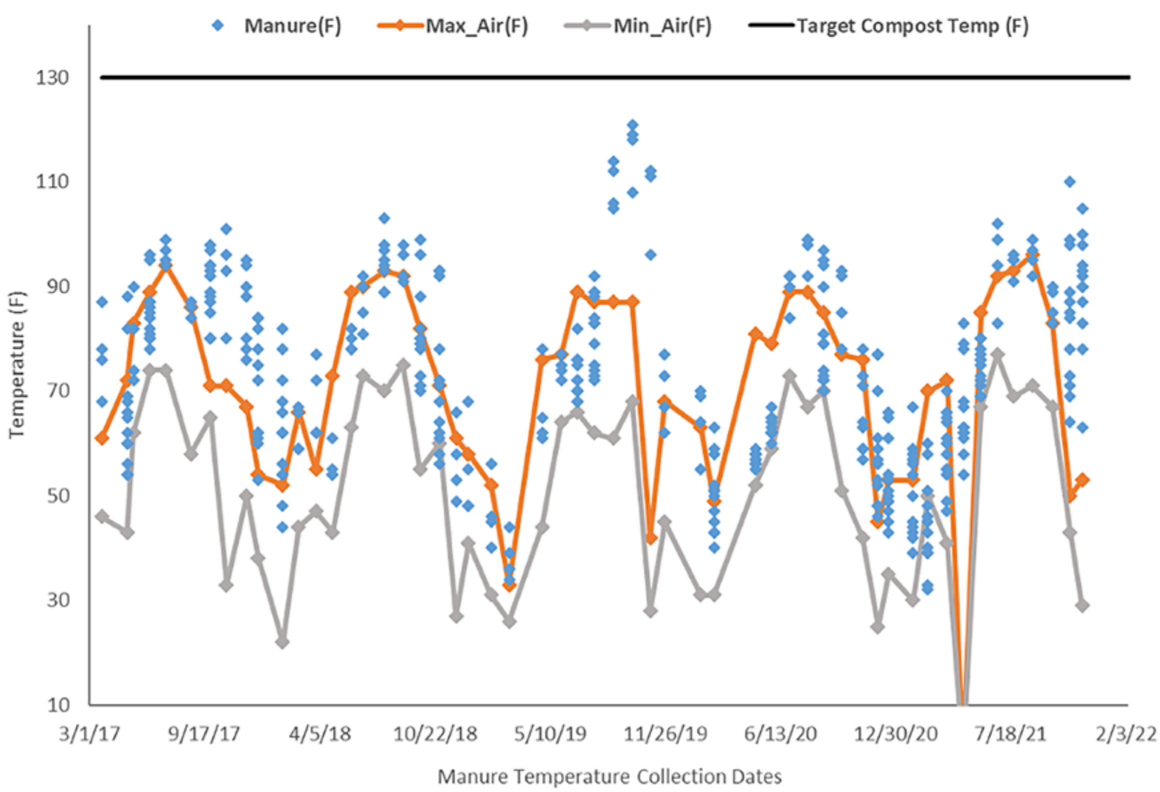


Figure 20. Manure and daily air temperature in relationship to target composting temperature.
Air temperature info from NOAA NCEI for GRAVETTE, AR Station USC00032930.

2-5 – Steve and Mark Morgan Farm: Peach Orchard

(Johnson County) Lamar, Dardanelle Reservoir Watershed

This farm is our first Horticulture Discovery Farm Specialty, on which we are partnering with Steve and Mark Morgan, owners and operators of Peach Pickin' Paradise.

The Morgan family has been farming peaches since the 1920s and are well respected in their community and across the state. This makes them ideal candidates for hosting a specialty crop Discovery Farm as they are already model growers who other growers look to as an example of success.

Because current research-based recommendations and training for irrigation in specialty crops in Arkansas are lacking, horticulture crop producers frequently struggle with efficiently managing irrigation, often either under or over irrigating. Additionally, growers must keep in mind the quality of their irrigation water as it must be compliant with federal food safety regulations under the Food Safety Modernization Act (FSMA).

The focus of this Horticulture Discovery Farm is two-fold:

1. to develop better irrigation practices for specialty crops and;
2. to provide specialty crop growers an on-farm demonstration of these practices.

We are monitoring irrigation water quality at Peach Pickin' Paradise to ensure it is compliant with federal food safety regulations under FSMA. We do this by regularly collecting water samples from the Morgan's water sources and sending them to the Water Quality Lab in the Arkansas Water Resources Center in Fayetteville, Arkansas.

By training Mark and Steve Morgan in the use of the installed soil moisture sensors, we hope to help them better the timing and efficiency of their irrigation program. As we learn with the Morgan's, we hope to use a grower-to-grower training model, in which we will work with the Morgan's to teach other growers how to improve the efficiency of their irrigation based on our research. This grower-to-grower training will take place in workshops focused on showing best management practices for irrigation in specialty crops. With our Horticulture Discovery Farm at Peach Pickin' Paradise, we hope to develop much needed irrigation recommendations for specialty crop growers across the southeast and improve irrigation conservation practices for specialty crops in Arkansas.

Watch this video introducing Arkansas' first Horticulture Discovery Farm (https://www.youtube.com/watch?v=jbrM2yagfGQ).

Figure 21. Three generations of the Morgan family.

Morgan Farm, cont.

Figure 22. Installation of a soil moisture sensor.

Figure 23. Ripe peaches growing in the orchard.

2-6 – John Maus Farm: Row-Crop

(Pope County) Atkins, Khun Bayou Watershed, Lake Conway – Point Remove Watershed

Project Complete (Year of Completion: 2019)

On this farm, there were around 200 acres of wheat, 240 acres of rice, 200 acres of corn, and 400 acres of soybean. We monitored runoff from four fields that had management ranging from cover crop, no cover crop, conservation tillage, and conventional tillage under a rotation of corn and soybeans.

Project Background

The overall goals of the project were to monitor edge-of-field runoff water quality on a farm in the Khun River – Arkansas River (HUC 12 – 111102030304) Watershed, which is the MRBI focus watershed, and Point Remove-Lake Conway Watershed in Central Arkansas. Four

Figure 24. View of one of the sampling stations at the Maus Discovery Farm.

Figure 25. Polypipe irrigating a field on the Maus Discovery Farm.

edge-of-field sites were installed on the Maus Farm and nutrient and sediment runoff monitoring initiated in mid-2014 and continued through December 2019 on four fields under irrigated corn for silage.

Impact of Conservation Practice on Nutrient Runoff: Land-levelling and Irrigation Management

The mean concentration of P, N, and sediment for all monitored fields were determined for each year of monitoring (Table 2). In the summer of 2015, all fields were land levelled to improve irrigation management and water use efficiency. While there was no difference ($P > 0.05$) in dissolved P, total P, and sediment concentration for each year (2015 to 2019), there was a significant decrease in nitrate-N and total N for 2015

Maus Farm, cont.

and 2016 and subsequent years monitored of 2017 to 2019 (P > 0.05; Table 3). This suggests that one year after land leveling (NRCS CP 464 - https://www.nrcs.usda.gov/sites/default/files/2022-09/Irrigation_Land_Leveling_464_CPS_10_2020.pdf) there was a decrease in N runoff from these fields (i.e., 2017 onwards). In fact, mean nitrate-N and total N concentrations averaged for 2017 through 2019 (0.31 and 1.87 mg L^{-1}, respectively) were a respective 25 and 60% lower than averaged for 2015 and 2016 (1.24 and 3.12 mg L^{-1}, respectively).

Figure 26. Map of the Maus Discovery Farm showing the four sampling stations.

Table 2. Differences in mean annual concentrations in runoff for the edge-of-field sites at the Maus Farm, Atkins, AR as a function of year of monitoring, determined by Student's t-test (Standard least squares with significance set at P = 0.05).

Year	Number of runoff events	Dissolved P	Total P	Nitrite-N	Total N	Sediment
		mg L^{-1}				
2015	67	0.28 d*	1.06 b	2.60 a	4.80 ab	582 a
2016	40	0.66 b	0.87 b	2.60 a	5.35 a	294 bc
2017	47	0.46 c	1.15 ab	0.99 b	3.00 bc	461 ab
2018	102	0.86 a	1.55 a	0.56 b	2.53 c	344 b
2019	54	0.52 bc	1.06 b	0.24 b	1.65 c	109 c

Columns not sharing the same letter are significantly different (P = 0.05).

Maus Farm, cont.

Table 3. Phosphorus and N applied as fertilizer and loss in runoff.

Site	Year	Rainfall	Runoff	Rainfall as runoff	P applied	P loss	Applied P loss	N applied	N loss	Applied N loss
		cm	cm	%	kg ha^{-1}	kg ha^{-1}	%	kg ha^{-1}	kg ha^{-1}	%
Maus 1	2015	87.99	44.46	50.5	56	6.85	12.2	280	18.79	6.7
	2016	38.43	9.44	24.6	56	0.98	1.8	280	7.54	2.7
	2017	20.35	7.38	18.0	206	0.59	0.3	680	2.14	0.3
	2018	98.35	45.10	46%	146	1.63	1.1	408	1.92	0.5
	2019*	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Average	**61.28**	**26.60**	**39%**	**116**	**2.51**	**3.8%**	**412**	**7.60**	**2.5%**
Maus 2	2015	68.49	14.42	21.7	56	2.04	3.6	280	3.79	1.4
	2016	7.72	0.37	4.8	56	0.16	0.3	280	1.11	0.4
	2017	28.14	20.37	70.6	206	1.24	0.6	680	2.87	0.4
	2018	106.81	117.79	110%	146	17.28	11.8	408	27.39	6.7
	2019	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Average	**52.79**	**38.24**	**52%**	**116**	**5.18**	**4.1%**	**412**	**8.79**	**2.2%**
Maus 3	2015	74.88	18.41	24.6	56	1.84	3.3	280	4.76	1.7
	2016	49.68	10.99	22.1	56	0.93	1.7	280	3.04	1.1
	2017	11.07	14.58	6.0	206	1.08	0.5	680	2.63	0.4
	2018	99.06	35.22	36%	146	5.34	3.7	408	8.89	2.2
	2019	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Average	**58.67**	**19.80**	**53%**	**116**	**2.30**	**2.3%**	**412**	**4.83**	**1.3%**
Maus 4	2015	54.81	15.26	27.8	56	1.32	2.4	280	5.66	2.0
	2016	32.84	10.57	32.2	56	0.88	1.6	280	2.83	1.0
	2017	10.52	7.99	47.4	206	0.55	0.3	680	1.87	0.3
	2018	87.86	48.21	55%	146	9.37	6.4	408	14.46	3.5
	2019	- -	- -	- -	- -	- -	- -	- -	- -	- -
	Average	**46.51**	**20.51**	**48%**	**116**	**3.03**	**2.7%**	**412**	**6.21**	**1.7%**

** No data for 2019 as limited runoff occurred between fertilizer application and flooding.*
*** Average is for 2015 to 2018 due to a lack of data for 2019.*

2-7 – Mike Wood Farm: Soybean-Wheat-Rice

(Cross County) Cherry Valley, L'Anguille Watershed

A 2,700 acre farm rotating soybeans, rice, and occasionally wheat in the State's Critical Groundwater Area, the Wood Farm uses flood irrigation as the preferred irrigation method for soybeans with a combination of surface sources (relift from the L'Anguille) and wells.

We are monitoring runoff, nutrients, and sediment from two fields on the Wood Farm, one of which uses traditional flood irrigation for both rice and soybean and drains through a switchgrass border, and the other which uses furrow irrigation for soybeans. Runoff will eventually be captured by a tailwater recovery system and reservoir.

Project Background

The L'Anguille River is located in eastern Arkansas in the Delta Eco-region. The main stem and tributaries of the L'Anguille River form the Hydrologic Unit Code 08020205. The river flows south from Jonesboro, Arkansas to its confluence with the St. Francis River near Marianna, Arkansas. The total drainage area of the L'Anguille River Watershed (LARW) is 938 mi^2, of which, almost one-half (300,000 acres) is managed in agricultural row-crops, primarily as soybean-rice rotations. The entire length of the L'Anguille River was included on the Arkansas 1998 303(d) list for not supporting aquatic life due to siltation/turbidity and remains on the 2010 303(d) List of Impaired Waterbodies for not supporting the fisheries designated use.

Since being declared an impaired watershed by the state, the L'Anguille River Watershed has been a priority of the Arkansas Nonpoint Source (NPS) Pollution Management Program. The Arkansas Natural Resources Commission (ANRC) designated the L'Anguille River Watershed as a priority watershed in the 2006-2010 NPS Management Plan, and again in the 2010 NPS Watershed Risk Matrix. In addition, the L'Anguille Watershed was identified by the USDA NRCS as a priority watershed in the MRBI. The MRBI offers an innovative voluntary approach

Figure 27. Flooded soybean field on the Wood farm.

Figure 28. Three generations of the Wood family.

Mike Wood Farm, cont.

Figure 29. Water sampling station on the Wood farm.

Figure 30. Water sampling station on the Wood farm.

to address regional water quality issues related to agricultural nonpoint source pollution, via implementation of targeted conservation practices. Previous federal financial assistance programs have lacked an adequate monitoring program necessary to assess the impact of these conservation efforts on local and regional water resources. Quantifying impact is a critical component to demonstrating the effectiveness of conservation practices in terms of justifying expenditures and developing an EPA approved Watershed Management Plan.

The MRBI provides cost-share funds for landowners in the L'Anguille River Watershed Coalition project area to implement conservation practices that will decrease nutrient and sediment runoff, conserve water, improve wildlife habitat, and sustain agricultural productivity. The 12-digit watersheds chosen for the L'Anguille River Watershed Coalition MRBI project were Black Fork-L'Anguille River, Copper Creek-L'Anguille River, Hydrick Creek-L'Anguille River, Indian Creek-L'Anguille River, McCracken Ditch, McFaran Branch-L'Anguille River, Powers Slough-L'Anguille River, Prairie Creek-L'Anguille River. This allowed farmers in the area to apply for funding to help with edge of field water quality monitoring. The farmers applied through the EQIP for Conservation Activities 201 and 202, for Data Collection and Evaluation and System Installation, respectively.

This project has provided edge-of-field monitoring and demonstration of the effectiveness of NRCS irrigation water management practices (Conservation Practice Code 449) to decrease the impairment of receiving waters, consistent with both Arkansas NPS Management and MRBI program goals.

Project Description

Two fields were monitored for irrigation water management. During years in which soybeans were grown, the field was divided into two hydrologically independent halves. The two fields (four monitoring stations in total) were monitored for a total of six years (2014 – 2020) and rotated crops annually between rice and soybeans. Each half of the field compared the use of a surge valve for irrigation against a control in which no surge valve was used. Soil moisture sensors indicated that the irrigations were effective in replenishing soil water down to 12 inches. Irrigation efficiency was calculated for each irrigation event as:

(irrigation amount - tail water loss) / irrigation amount

Mike Wood Farm, cont.

Results

This data indicates that surge valves integrated into Pipe Planner or PHAUCET designs can increase irrigation efficiency by around 20%, saving between 300,000 to 600,000 gallons of water per year. This coupled with the efficiency provided by computerized design of furrow irrigation with polytubing indicates that irrigation efficiency can be increased by reducing tailwater losses.

Figure 31. Map of the Wood Discovery Farm fields and sampling stations.

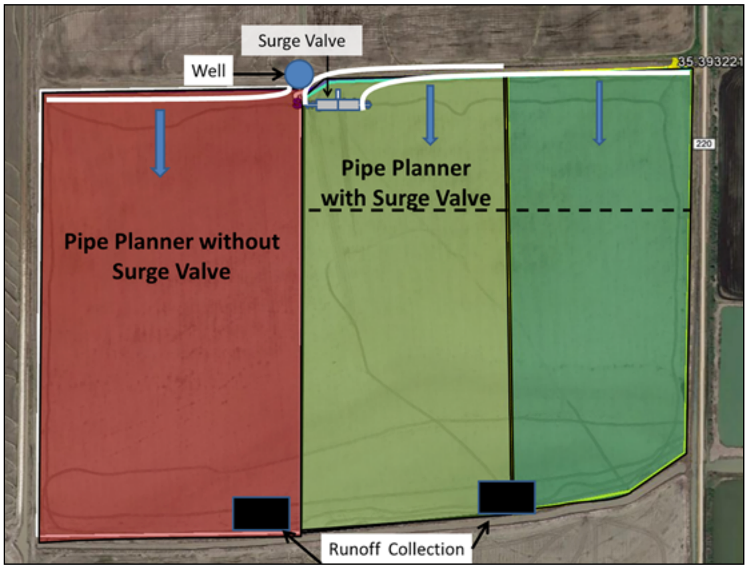
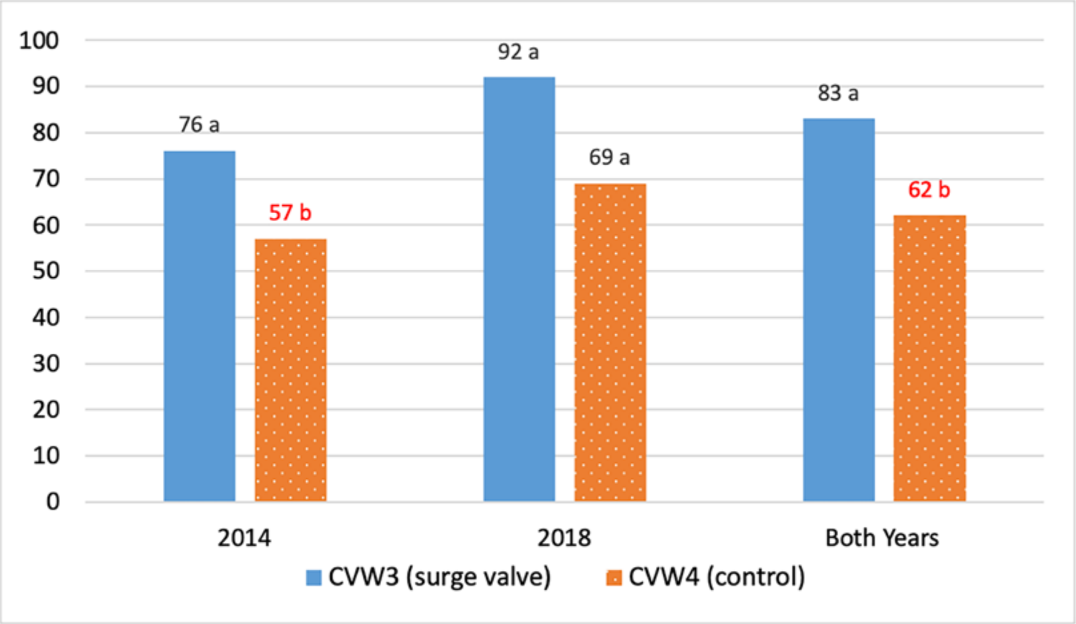


Figure 32. Field CVW3 (surge valve) & CVW4 (control) – Cherry Valley Wood Farm field 3 (58 ac) and 4 (47 ac) with runoff monitoring location.

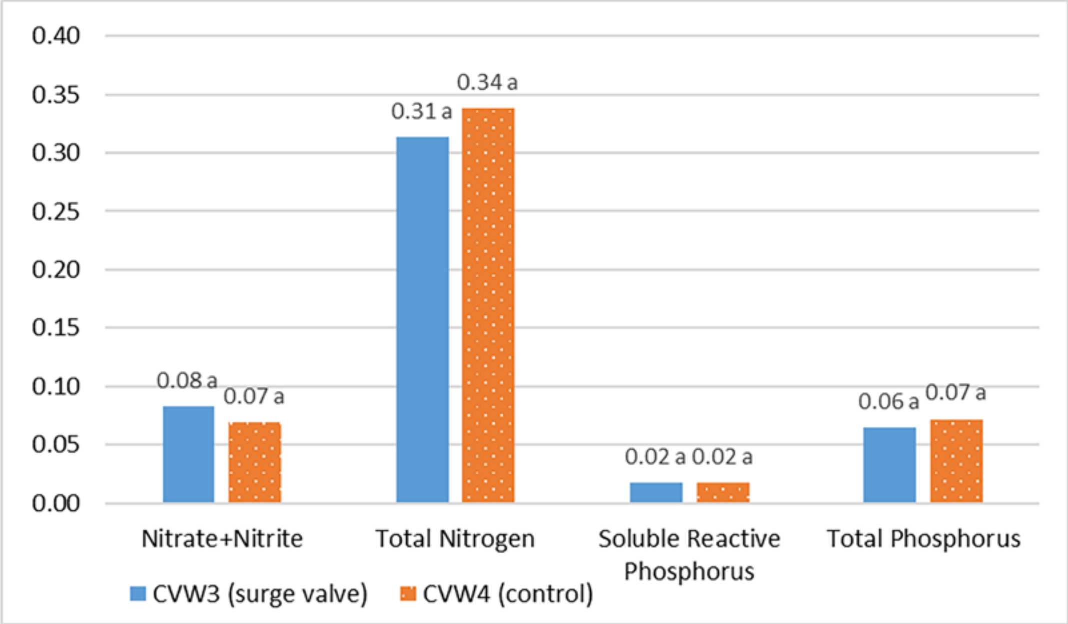
Mike Wood Farm, cont.

Figure 33. Average irrigation efficiency (%)* of the surge valve treatment versus the control.



Values not connected by same letter are significantly different.
** Irrigation Efficiency = (Effective Irrigation/Irrigation Applied)*100*

Figure 34. Mean nutrient mass loss in runoff (lbs ac^{-1}) during soybean years (4-year period for CVW3 and 3-year period for CVW4).



Values not connected by same letter are significantly different (n=37).

2-8 – Terry Dabbs Farm: Rice-Soybean-Corn

(Arkansas County) Stuttgart, Bayou Meto Watershed

The Dabbs Farm is a 1,500 acre row-crop farm concentrating on rice, soybean, and corn rotations in the State's Critical Groundwater Area, where most fields have been land-leveled and a tailwater recovery system collects all runoff water from this farm and returns it to the irrigation reservoir for re-use.

Figure 35. Runoff passing through a flume at one of the Dabbs monitoring stations.

We are monitoring water use and water quality (nutrients and sediment) on four fields with different cropping rotations and management, which include rice grown on zero-grade, rice grown on unleveled ground (control), rice grown on a precision-leveled field, and corn grown on a precision-leveled field. This combination of treatments allows us to compare different water management schemes, as well as compare water use of rice and corn at a field scale. We have also monitored the quantity and quality of recovery water immediately before it re-enters the reservoir.

Project Background

Declining groundwater levels in the Mississippi River Alluvial Aquifer have forced farms to rely on surface water for irrigation. This aquifer is the single largest source of groundwater for irrigation in the mid-south area of the United States. The Dabbs Farm uses surface water from a storage reservoir built in the 1920s, water re-lifted from the Bayou Meto during winter months, and stored overwinter in the reservoir, and by catching every drop of runoff water in tailwater recovery ditches. Over $1.5 million have been invested to engineer the farm to capture and re-use runoff as irrigation water. Essentially, runoff from all 1,200 acres stays on the farm and is not released to downstream waters.

Figure 36. Trent Dabbs and family.

On the Dabbs farm we are monitoring and characterizing nutrient losses during rice production. Mr. Dabbs also wants to focus on the effect of land

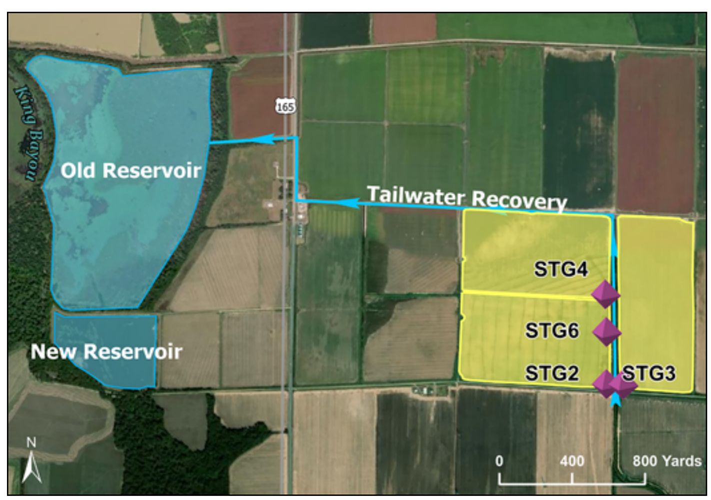


Figure 37. Map of the Dabbs Discovery Farm including fields being monitored and direction of flow through the tailwater recovery system into the reservoirs.

Dabbs Farm, cont.

Figure 38. View of the tailwater recovery ditch.

leveling on nutrient and sediment runoff as well as the N concentration in the flood water applied to rice.

To control the flooding of rice, earthen levees 12 to 18 inches high are constructed to create rice paddies between the levees. On fields with natural, non-uniform slopes, contour levees are constructed along natural slopes determined from land surveying. Spacing of levees can be quite variable within a given field and are spaced to maintain 6 inches of a uniform flood within a paddy. On slopes >3%, contour levees are close together while on smaller slopes, while on slopes <3% levees are spaced farther apart.

One of the most popular water conservation practices on rice fields is precision land leveling, which creates a uniform field slope. Precision land leveling is a costly practice, but offers several water management advantages over contour levee fields, such as reducing the number of levees, creating straight line levees, reducing water needs to flood, and more importantly improving drainage to remove flood water.

A third option in water management in rice is an expensive conservation practice known as zero grade (0% slope) rice. With zero grade, levees within a field are not needed to maintain flood depth, and without discharge, less water is needed to maintain flood depth. Water depth is controlled by a gate or flash board riser at the lowest end of the ditch. Zero grade can create drainage problems for other crops, such as corn or soybean.

Figure 40. One of the reservoirs on the Dabbs farm.

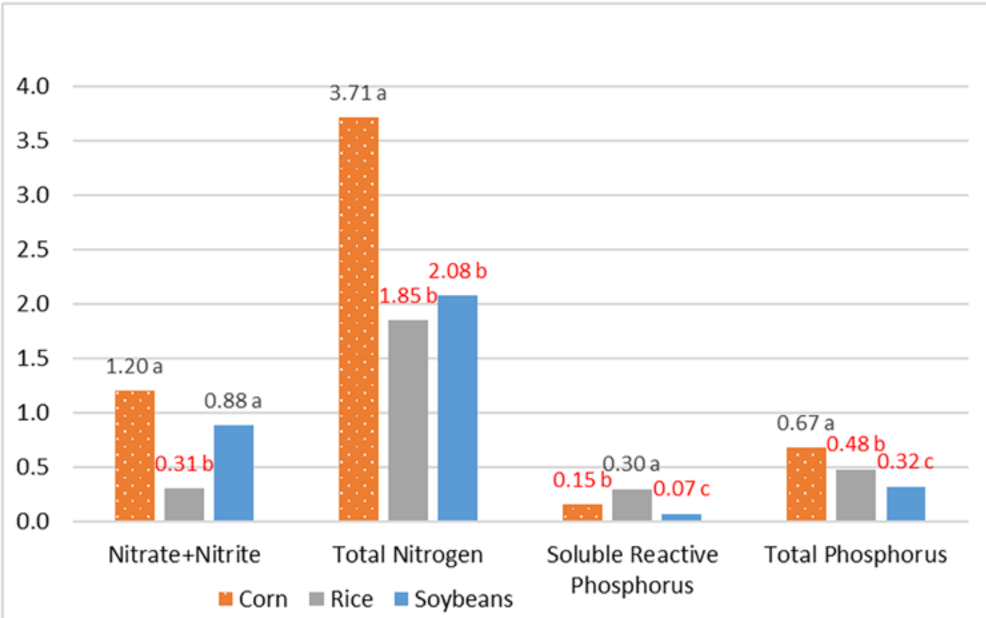
Figure 39. One of the Dabbs monitoring stations.

Figure 41. View of the tailwater recovery ditch.

Dabbs Farm, cont.

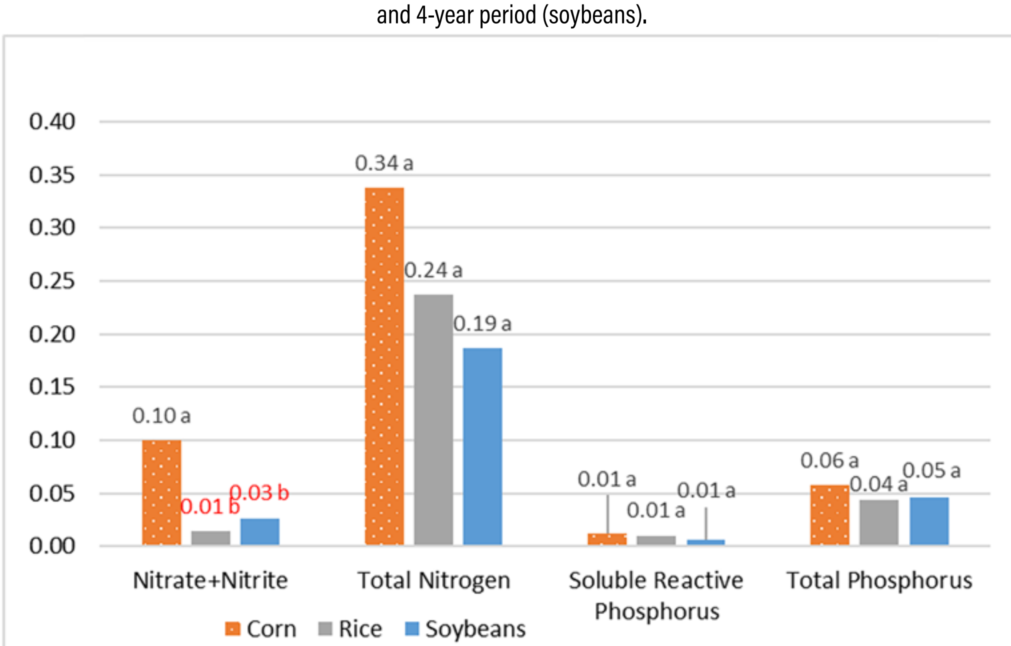
Results

Figure 42. Mean nutrient concentration in runoff (mg L^{-1}) for a 6-year period (corn, 2014-2019) and 8-year period (rice and soybeans, 2013-2020).



Values not connected by same letter are significantly different (P<0.01).
n=51 (corn), n=86 (rice), n=53 (soybeans)

Figure 43. Mean nutrient mass loss in runoff (lbs ac^{-1}) for a 2-year period (corn), 5-year period (rice), and 4-year period (soybeans).



Values not connected by same letter are significantly different (P<0.01).
n=36 (corn), n=55 (rice), n=39 (soybeans)

2-9 – Steve Stevens Farm: Cotton and Corn

(Desha County) Dumas, Bayou Macon Watershed

The C.B. Stevens Farm is a 1,500 acre row-crop operation concentrating on cotton and corn, which has implemented conservation tillage, cover crop, and irrigation management conservation measures.

We are monitoring water use and water quality (nutrients and sediment) to quantify the benefits of conservation tillage to decrease nutrient and sediment loss in runoff from cotton-corn rotations and enhance stream ecological improvement in the Bayou Macon Watershed. An additional measure of success will be the adoption of conservation tillage by other farmers in the watershed project area.

Figure 44. Wes Kirkpatrick on the Stevens Discovery Farm.

Figure 45. View of cotton on the Stevens farm.

Project Background

The middle portion of the Bayou Macon Watershed was one of several watersheds approved by NRCS as a MRBI project area. In 2011, The Desha County Conservation District submitted a MRBI proposal to the NRCS which was accepted and provides financial assistance to row-crop farmers who implement conservation practices in order to reduce sediment and nutrient loadings to Bayou Macon. The MRBI project area includes four, 12-digit sub-watersheds: 080500020104 (Canal 81- Lake Isaacs), 080500020201 (Canal 43), 080500020202 (Boggy Bayou), and 080500020203 (Canal 43-Clay Bayou). Within this project area, row-crop production is the primary land use (>75%) consisting of 130,880 acres producing rice, cotton, corn, and soybeans. Within this focus area, approximately 22,619 acres is eroding at the soil loss tolerance of 5 tons/acre/year or above. Currently, 3,941 acres

Figure 46. Water flowing through a trapezoidal flume.

Stevens Farm, cont.

are enrolled in the Conservation Reserve Program and 3,273 acres in the Wetland Reserve Program.

As part of that MRBI project, the University of Arkansas' Division of Agriculture is a partner and is committed to providing edge-of-field monitoring as a means of demonstrating the effectiveness of conservation practices on a real, working cotton farm within the project area. The C.B. Stevens Farm was chosen due to his desire to implement Conservation Activity 201 via an EQIP contract.

Project Description

The C.B. Stevens Farm is a row-crop farm concentrating on cotton and corn and is located in the Middle Bayou Macon Watershed, an approved MRBI project area in Desha County in southeastern Arkansas. Two automated edge-of-field monitoring stations were installed in two fields which were paired to compare surge valve (DUM1) vs no surge valve (DUM3) to determine the benefit of irrigation water management (Conservation Practice Code: 449) on soil and water conservation. An additional two monitoring stations were installed in two different fields that were paired to compare cover crop (DUM2) vs no cover crop (DUM4) to determine the benefit of cover crops (Conservation Practice Code: 340) on soil and water conservation.

Figure 47. Cotton field being irrigated with polypipe.

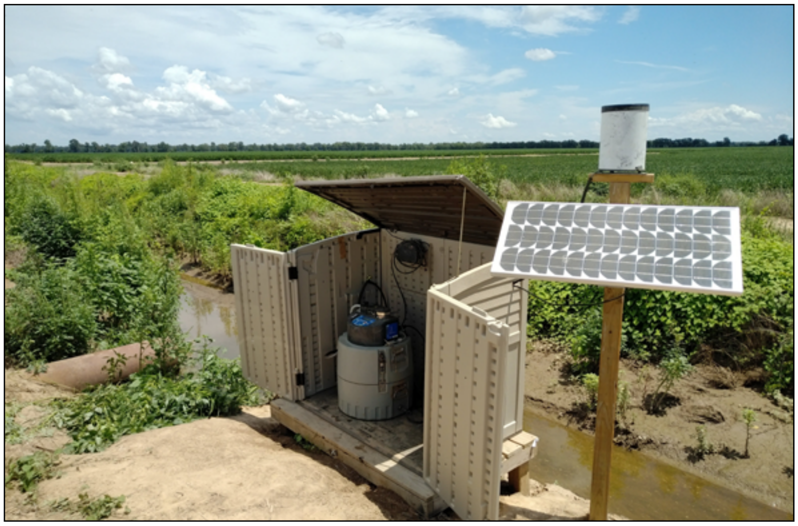


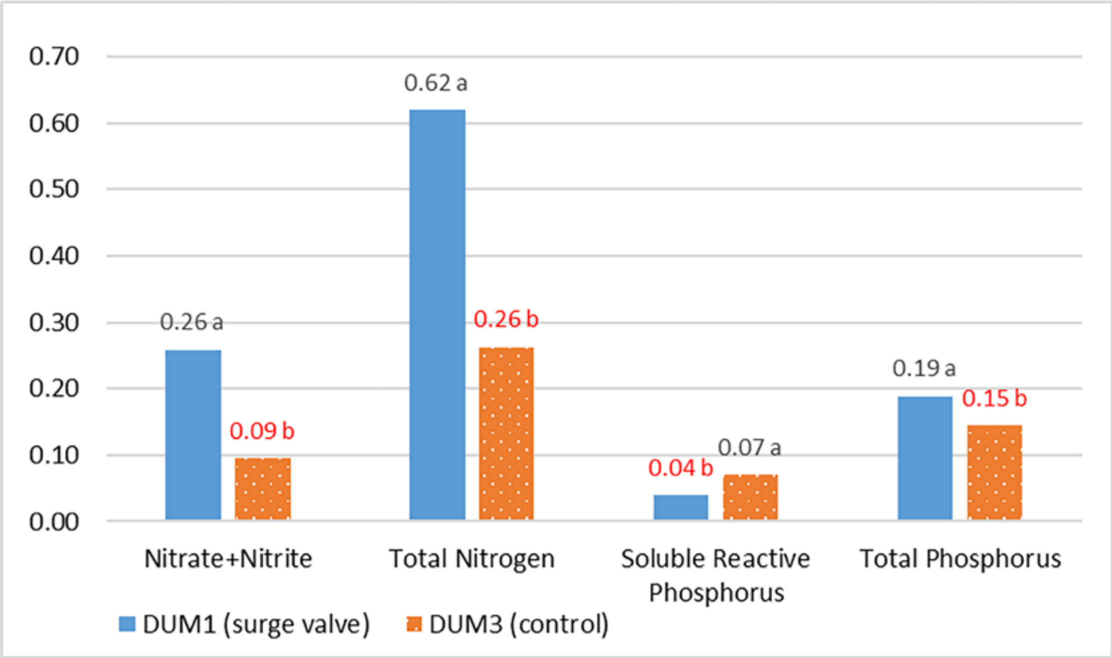
Figure 48. One of the monitoring stations on the Stevens farm.

Figure 49. Map of the Stevens Discovery Farm fields and sampling stations.

Stevens Farm, cont.

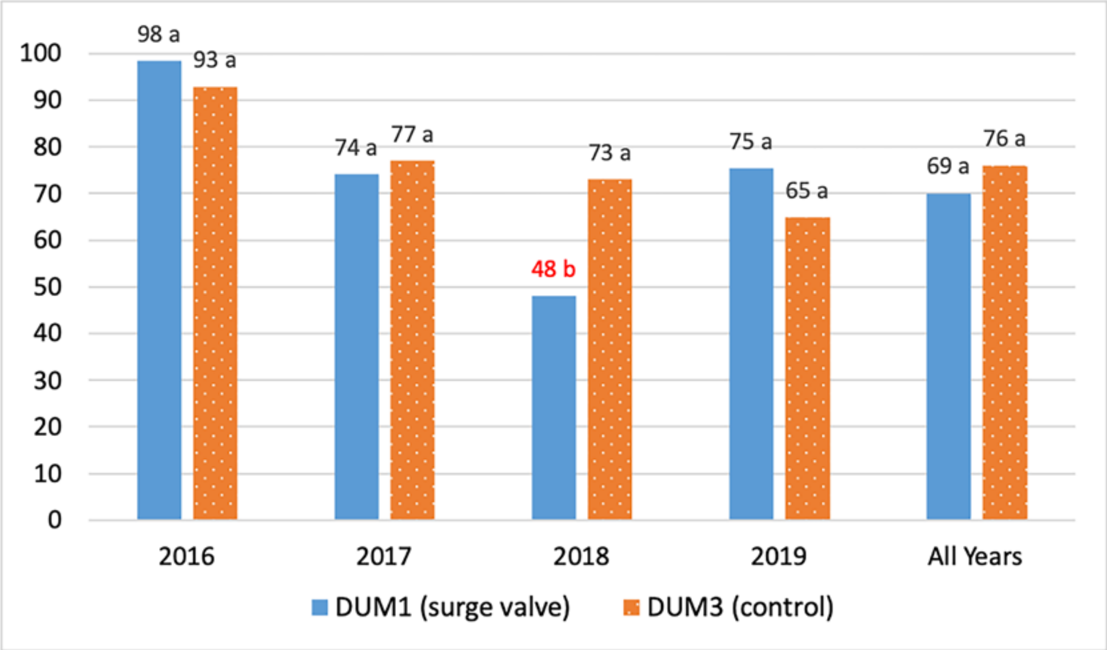
Results

Figure 50. Mean nutrient loss in runoff (lbs ac^{-1}) between surge valve treatment and the control for a 7-year period (DUM1, 2014-2020) and 8-year period (DUM3, 2013-2020).



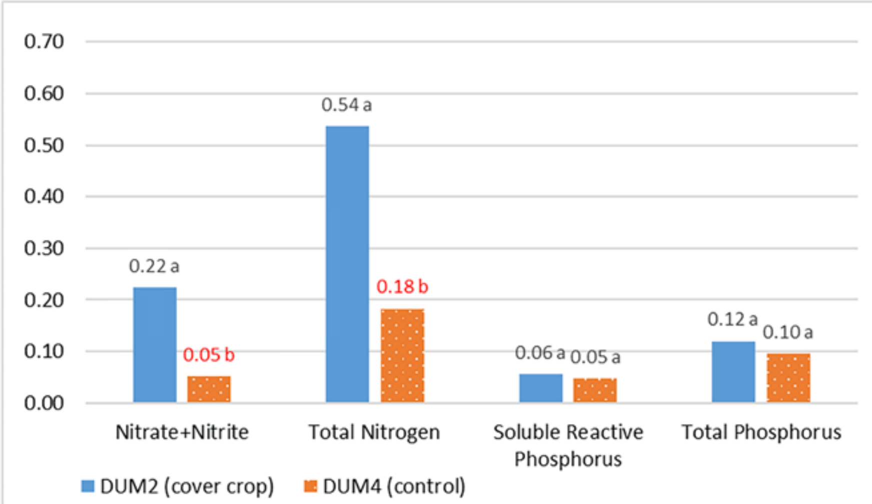
Values not connected by same letter are significantly different (P<0.01 [N+N, TN, SRP], P<0.05 [TP]).
n=166 (DUM1), n=214 (DUM3)

Figure 51. Average irrigation efficiency (%)* of the surge valve treatment versus the control.



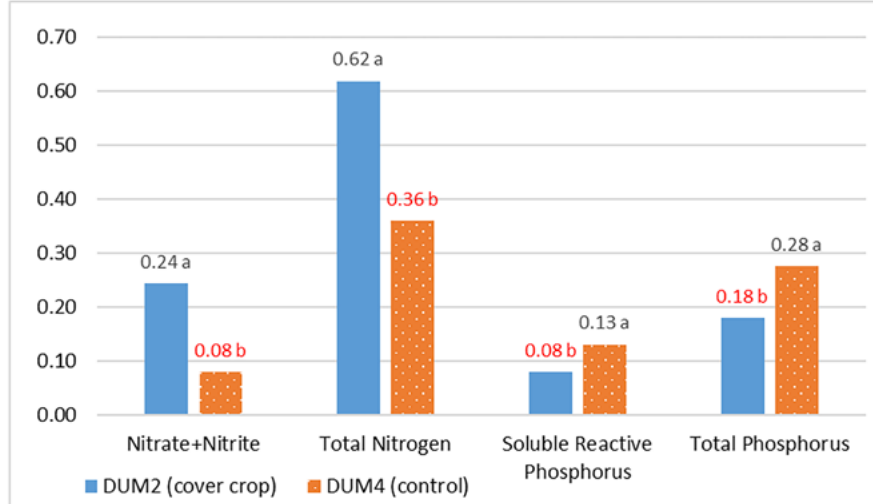
Values not connected by same letter are significantly different (P<0.02).
* Irrigation Efficiency = (Effective Irrigation/Irrigation Applied)*100

Figure 52. Mean nutrient loss in runoff (lbs ac-1) during the growing season (May through September) of cover crop treatment versus control for an 8-year period from 2013 to 2020.



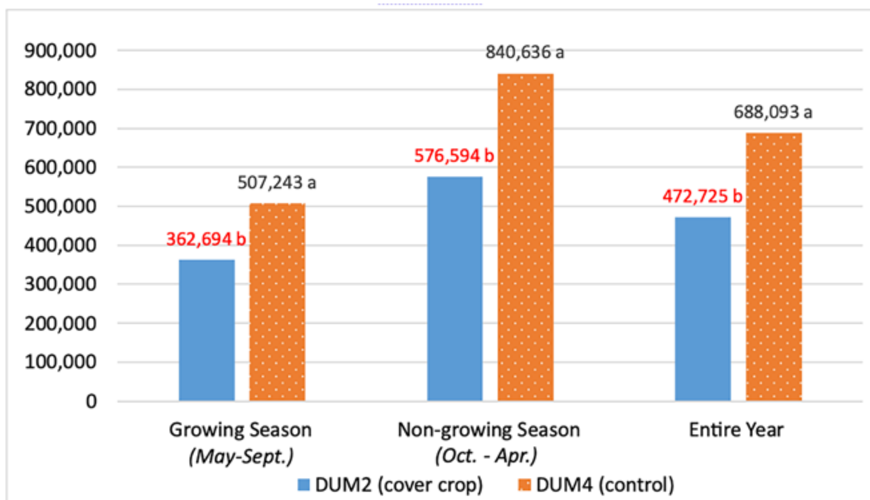
Values not connected by same letter are significantly different (P<0.01).
n=117 (DUM2), n=97 (DUM4)

Figure 53. Mean nutrient loss in runoff (lbs ac-1) during the non-growing season (October through April) of cover crop treatment versus control for an 8-year period from 2013 to 2020.



Values not connected by same letter are significantly different (P<0.01).
n=122 (DUM2), n=112 (DUM4)

Figure 54. Mean total flow volume per runoff event (gal) for growing season (May through September), non-growing season (October through April), and entire year between the cover crop treatment versus the control for an 8-year time period (2013-2020).



Values not connected by same letter are significantly different (P<0.01).
n=118 (DUM2-growing), n=125 (DUM2-non-growing), n=97 (DUM4-growing), n=118 (DUM4-non-growing)

2-10 – Lawrence Conyer Farm: Row-Crop

(Jefferson County) Pine Bluff, Bayou Bartholomew Watershed

Project Complete (Year of Completion: 2020)

The Conyer farm is a row-crop operation concentrating on rice, corn, and soybeans that has implemented conservation tillage and the application of mixed cover crops on several fields. Here the NRCS National Water Quality Initiative (NWQI) offers assistance to landowners who want to improve water quality and aquatic habitats in priority watersheds with impaired streams.

The monitoring design is two adjacent fields with discrete outlet points. These field sites are 18.2 and 19.3 acres. Two water monitoring stations have been set up on opposite sides of the field where the water drains off the field. This will allow the water leaving the field to be collected and analyzed for sediment and nutrient concentrations. Approximately 20 acres of the field is planted in cover crops, while the remainder of the field serves as a control (no cover crops planted).

Figure 55. Recently cut rice field on the Conyer farm.

Figure 56. Flooded furrows on the Conyer farm.

Project Background

Bayou Bartholomew is the longest Bayou in the United States. Its watershed is considered an 8-digit HUC identified as 08040205. The watershed includes parts of seven counties in Arkansas (Jefferson, Lincoln, Drew, Ashley, Cleveland, Chicot, and Desha) and two Louisiana parishes (Morehouse and Ouachita). Major towns in this watershed include Star City, Monticello, and Hamburg, Arkansas as well as Bastrop, Louisiana. The two most dominant land uses in this watershed include forestry and crops. Due to

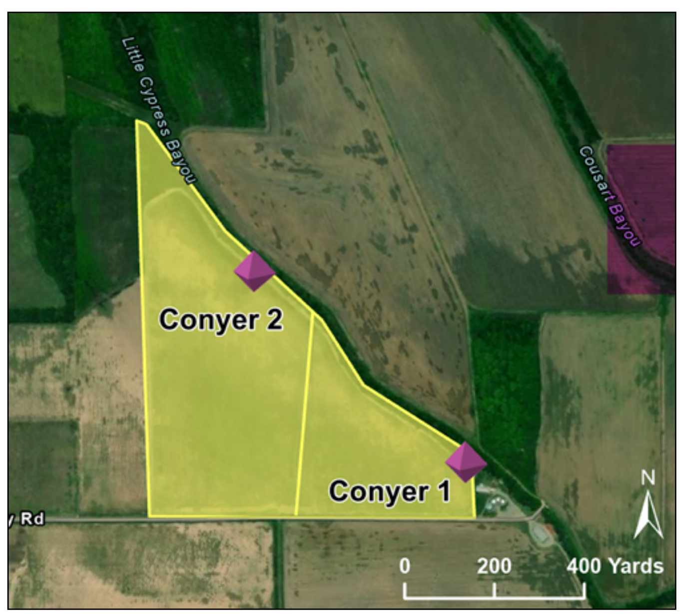


Figure 57. Map of the Conyer Discovery Farm field and monitoring stations.

dissolved oxygen, lead and organics in the water, these watersheds do not meet the 303(b), and 305(d) reports under the Federal Clean Water Act. Both Arkansas and Louisiana are interested in Bayou Bartholomew. The Arkansas portion of Bayou Bartholomew is a priority watershed according to the ANRC.

Figure 58. One of the monitoring stations on the Conyer Discovery Farm.

Project Description

The Lawrence Conyer farm is a row-crop farm located within the Bayou Bartholomew Watershed at Cousart Bayou-Little Cypress Bayou, an approved NWQI project area in Jefferson County in southeastern Arkansas. The objective of this study was to provide baseline data on constituents present in runoff before and after any cover crop treatment was implemented. The monitoring design consists of two adjacent fields with discrete outlet points. These field sites are 18.2 and 19.3 acres. Conyer 1, control field site, and Conyer 2, treatment site, both had a rice-soybean-soybean planting rotation, but Conyer 2 was also utilized as the treatment site that included a mix of radish, black oats, and clover cover crop during non-growing season. Two automated edge-of-field monitoring stations were installed according to Conservation Activity 202 specifications. These two fields were paired to compare cover crop (Conyer 1) vs no cover crop (Conyer 2) to determine the benefit of cover crops (Conservation Practice Code: 340) on soil and water conservation.

Figure 59. Runoff flowing out of the drainage pipe equipped to the monitoring station.

Figure 60. Flashboard riser installed on the PVC pipe that runs through the levee.

On the northeast side of the field nearest Little Cypress Bayou, there is a turnrow levee separating the field and the Bayou. On each field of the two fields there is a PVC pipe built through the levee. A flashboard riser is installed on each PVC pipe for instances when the farmer wants to block water flow (Figure 60). Flooding rice would be one example. All of the water draining off of the field travels through one of these two PVC pipes before it enters the wooded area adjacent to the Bayou that flows parallel to the northeast side of the field.

2-11 – Ellis Bell Farm: Row-Crop with Cover Crops

(St. Francis County) Forrest City, L'Anguille River Watershed

Project Complete (Year of Completion: 2020)

The Bell Farm is a row-crop operation concentrating on rice, corn, and soybean rotation with cover crops. Approximately 80 acres are managed with cover crops planted on half of the field and no cover crops as a control on the other half. The field has two drainage pipes and associated sampling sites: one for each half of the field. This allows for a comparison of sediment and nutrient runoff with and without cover crops. The field has been previously land-leveled to improve irrigation water management.

Measurement of well-water flow produced when the pump is running at a specific RPM is being used to create a customized irrigation water management plan for the farm.

Project Background

The Bell Farm is located in the L'Anguille watershed (HUC = 08020205). The NRCS selected the St. Francis and Cross County portion of the L'Anguille River to be part of the MRBI project in 2012. A description of the MRBI related to this project can be found in the Mike Wood Farm Project Background, as this farm is also in the L'Anguille watershed. Figure 64 below shows the 12-digit watersheds chosen for this project. They were Lick Creek (HUC 080202050409), Big Tellico Creek (HUC 080202050501), Spybuck Creek (HUC 080202050504), Coffee Creek (HUC 080202050507) and an Unnamed Creek (HUC 080202050503). This allowed farmers in the area to apply for funding to help with edge of field water quality monitoring. The farmers applied through the Environmental Quality Incentive Program (EQIP) for Conservation Activities 201 and 202.

Figure 61. Water flowing out of an irrigation flowmeter.

Figure 62. View of one of the monitoring stations with flashboard riser.

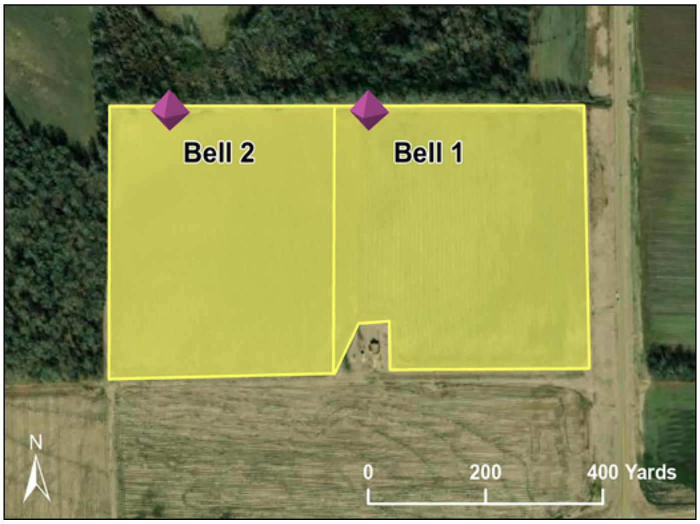


Figure 63. Map of the Bell Discovery Farm field and monitoring stations.

Bell Farm, cont.

Project Description

The Ellis Bell farm is a row-crop farm located in the Spybuck Creek-L'Anguille Watershed, an approved MRBI project area in St. Francis County in Northeastern Arkansas. Two automated edge-of-field monitoring stations (Bell 1 and Bell 2) were installed in 2015 according to Conservation Activity 202 specifications. Each sampler collects drainage water for half of the field. Half of the field was planted with cover crops (Bell 1) and the other half of the field served as a control without cover crops (Bell 2).

On the north side of the field, there is a levee separating the field and the drainage ditch. On each half of the field there is a metal pipe built through the levee. A flashboard riser is installed on the metal pipe for instances when the farmer wants to block water flow (Figure 65). Flooding rice would be one example. All of the water draining off of the field travels through one of these two metal pipes before it enters the drainage ditch that flows parallel to the north side of the field.

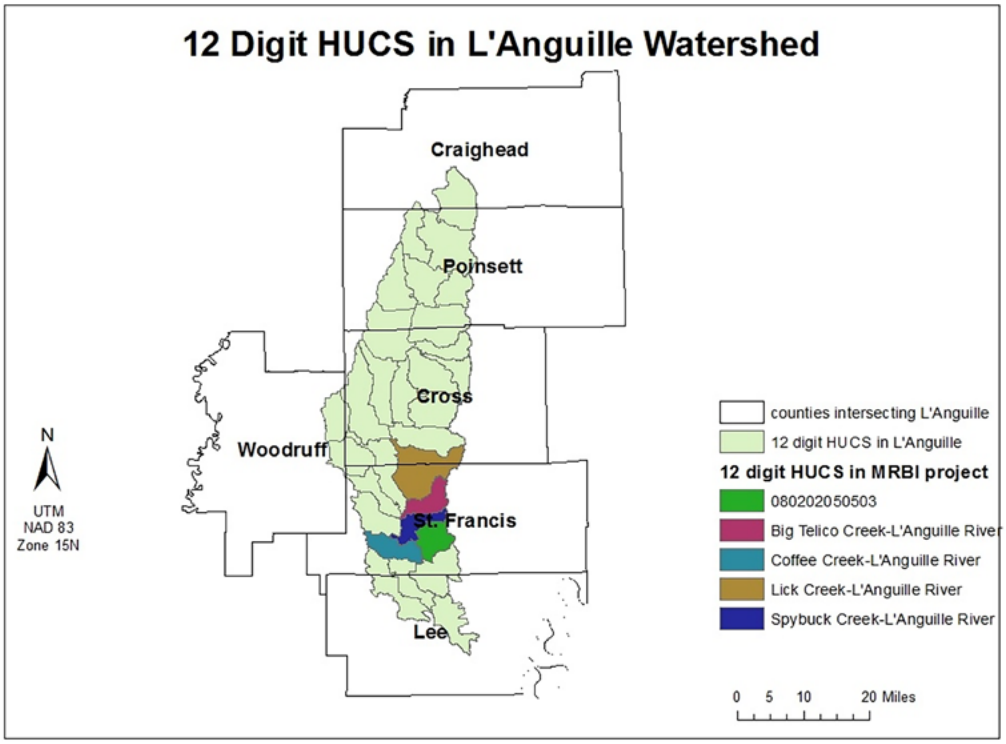


Figure 64. Location of the 12-digit Hydrologic Unit Codes (HUCs) that are part of the Mississippi River Healthy Basin Initiative (MRBI).

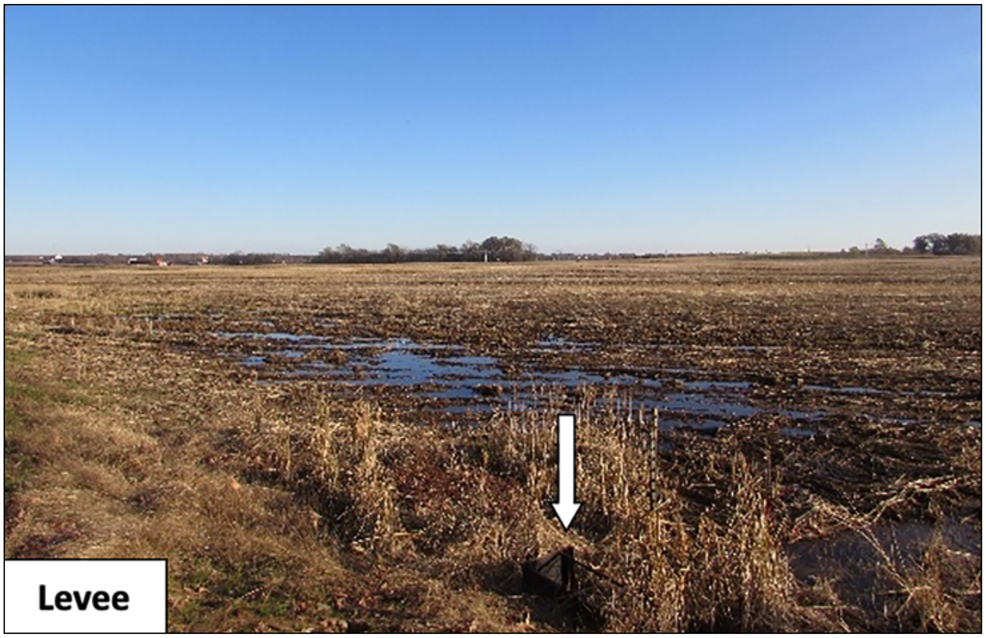
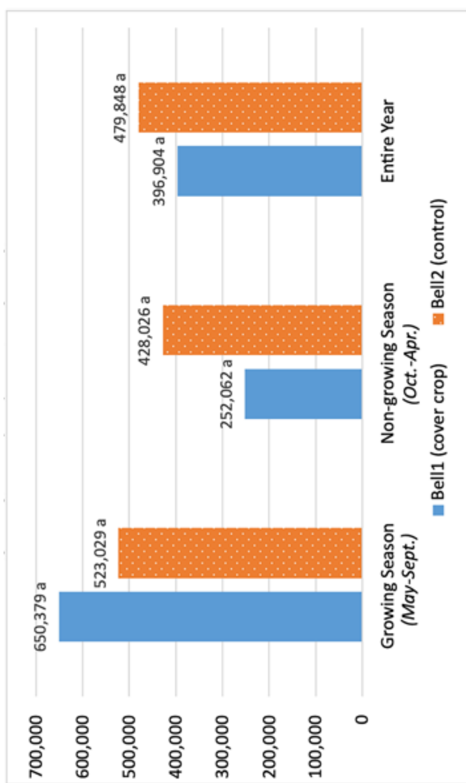


Figure 65. Flashboard riser installed on the metal pipe that runs through the levee. The white arrow is pointing to the flashboard riser.

Bell Farm, cont.

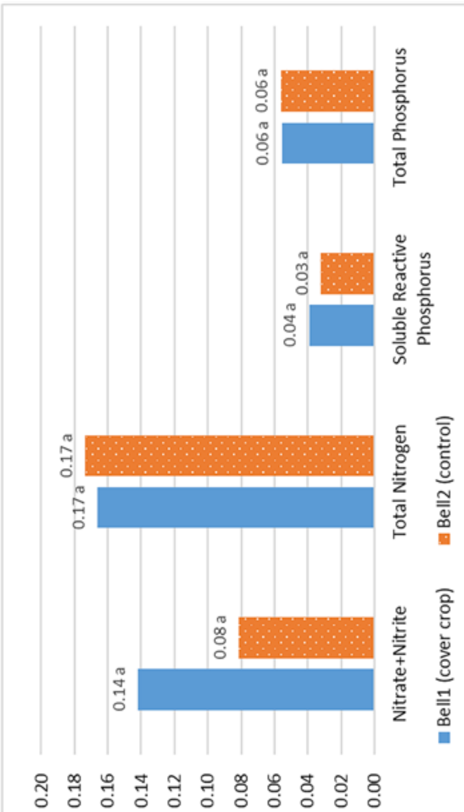
Results

Figure 66. Mean total flow volume per runoff event (gal) for growing season (May-September), non-growing season (October-April), and entire year between the cover crop treatment versus the control for a 3-year period (growing) and 4-year period (non-growing).



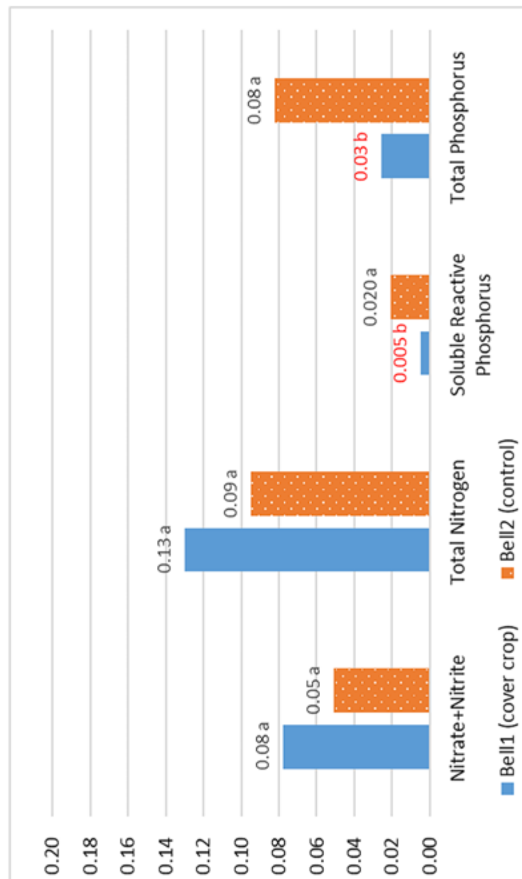
Values not connected by same letter are significantly different (P<0.05).
n=12 (Growing), n=21 (Non-growing, Bell1), n=10 (Non-growing, Bell2)

Figure 67. Mean nutrient loss in runoff (lbs ac-1) during the growing season (May through September) of cover crop treatment versus control for a 3-year period (2016-2017, 2019).



Values not connected by same letter for a parameter are significantly different (P<0.05).
n=12

Figure 68. Mean nutrient loss in runoff (lbs ac-1) during the non-growing season (October through April) of cover crop treatment versus control for a 4-year period (2016-2019).



Values not connected by same letter for a parameter are significantly different (P<0.01).
n=21 (Bell1), n=10 (Bell2)

2-12 – Long Lake Plantation: Row-Crop

(Phillips County) Helena, Lower White Watershed

The Long Lake Plantation Farm is a row-crop operation concentrating on corn and soybean rotation with cover crops, where two fields have been divided in half with water monitoring stations installed to collect runoff from each side of the field. Half of the field will serve as a control and the other half will have a treatment.

One 95-acre field land leveled in fall 2017 receives reduced tillage, basic irrigation water management, and nutrient management conservation practices. Half the field will have cover crops and the other half will not. The second 50-acre field has reduced tillage, irrigation water management, nutrient management, and cover crops. As a subset of nutrient management only half of the field will receive poultry litter.

Figure 70. Taylor grandchild holding a hefty harvest.

Figure 69. A field with greens on the Long Lake Plantation Discovery Farm.

Project Background

The Long Lake Plantation farm is located in the Lower White watershed (HUC = 08020303), located in Phillips County in eastern Arkansas. Within this 8-digit watershed, the White River is listed as a low priority Category 5 stream impaired for dissolved oxygen (water quality standard non-attainment) on the 2016 303(d) list by the ADEQ (ADEQ, 2020). The Long Lake Plantation – Taylor Farm resides in the 10-digit Long Lake Bayou-Little Bee Bayou watershed (HUC = 0802030304) and 12-digit Town of

Figure 71. Discovery Farm technician Michael Freyaldenhoven processing a water sample.

Figure 72. Panoramic view of one of the Long Lake Plantation Discovery Farm fields.

Long Lake Plantation, cont.

Preston Place-Long Lake Bayou sub-watershed (HUC = 080203030401) (Figure 74).

Project Description

Two automated edge-of-field monitoring stations, LLP1 and LLP2, were installed in a 49-acre field that was divided in half to be hydrologically separated and collect runoff from each side of the field. The entire field has reduced tillage, irrigation water management, nutrient management, and cover crops. As a subset of nutrient management only half of the field will receive poultry litter (treatment).

An additional two monitoring stations (LLP3 and LLP4) were installed in late 2019 on a 94-acre field that was also hydrologically separated with one monitoring station collecting runoff from each half. The southeast half of the field (LLP4) receives a cover crop (treatment) while the northwest half (LLP3) serves as the control. The entire field has reduced tillage and irrigation water management.

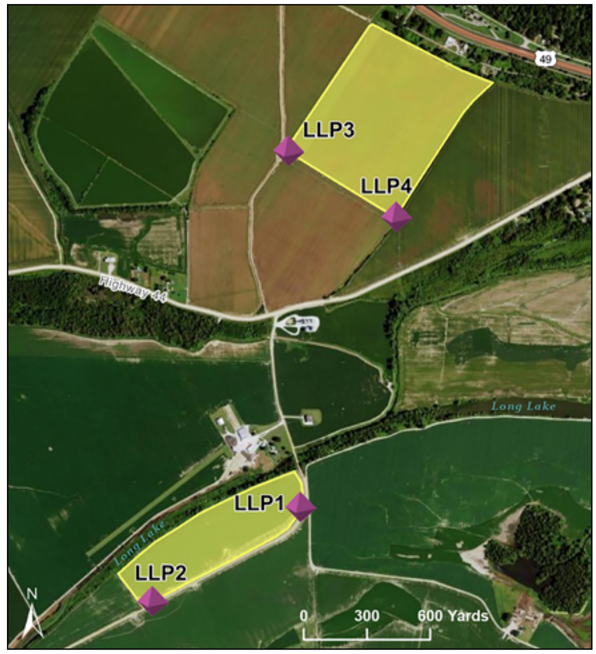


Figure 73. Map of the Long Lake Plantation Discovery Farm fields and monitoring stations.

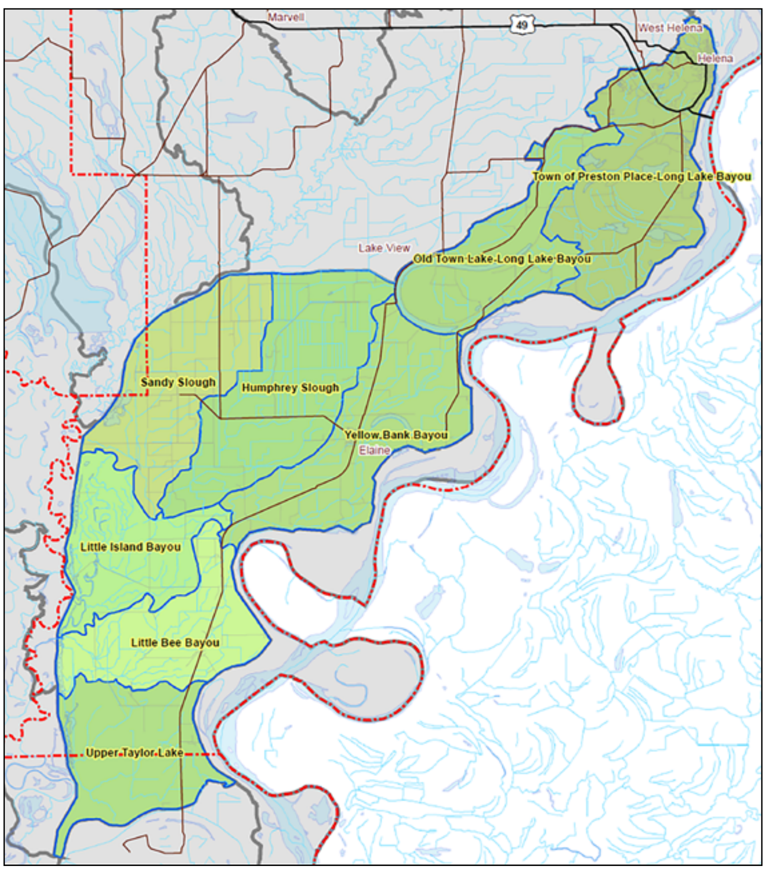


Figure 74. Location of 12-digit sub-watersheds within the 10-digit Long Lake Bayou-Little Bee Bayou (Center for Advanced Spatial Technologies).

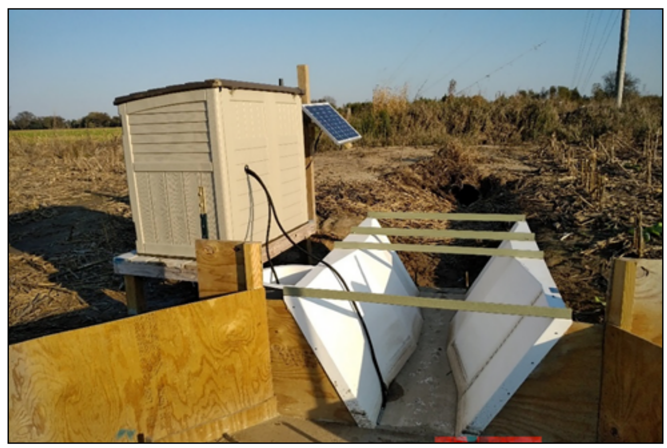


Figure 75. Monitoring station with trapezoidal flume on one of the Long Lake Plantation Discovery Farm fields.


Figure 76. Monitoring station with trapezoidal flume on the LLP3&4 field.

Long Lake Plantation, cont.

Results

Figure 77. Mean nitrogen loss (lb ac^{-1}) of poultry litter treatment versus the control for a 3-year period (2018-2019, 2021).

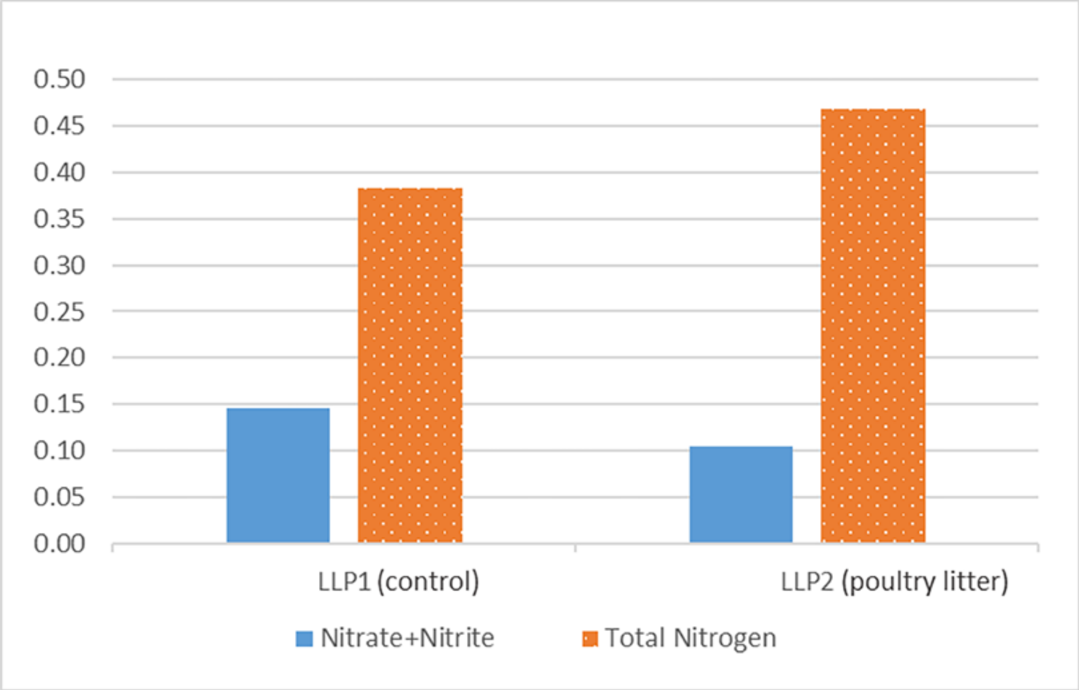


Figure 78. Mean phosphorus loss (lb ac^{-1}) of poultry litter treatment versus the control for a 3-year period (2018-2019, 2021).

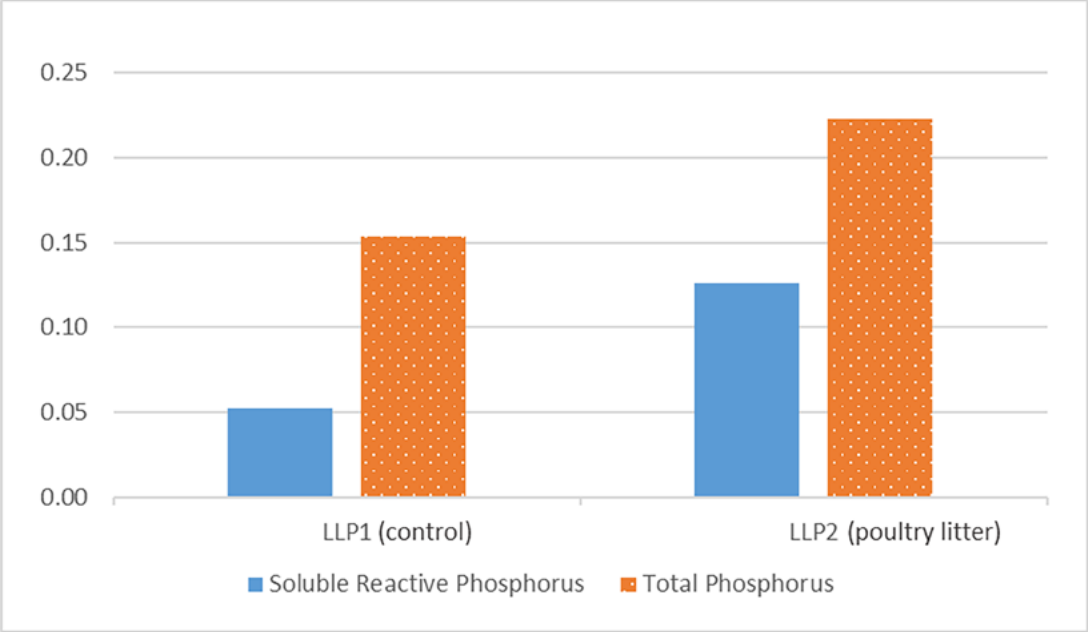


Figure 79. Mean nitrogen loss (lb ac^{-1}) of cover crop treatment versus the control for a 2-year period (2020-2021).

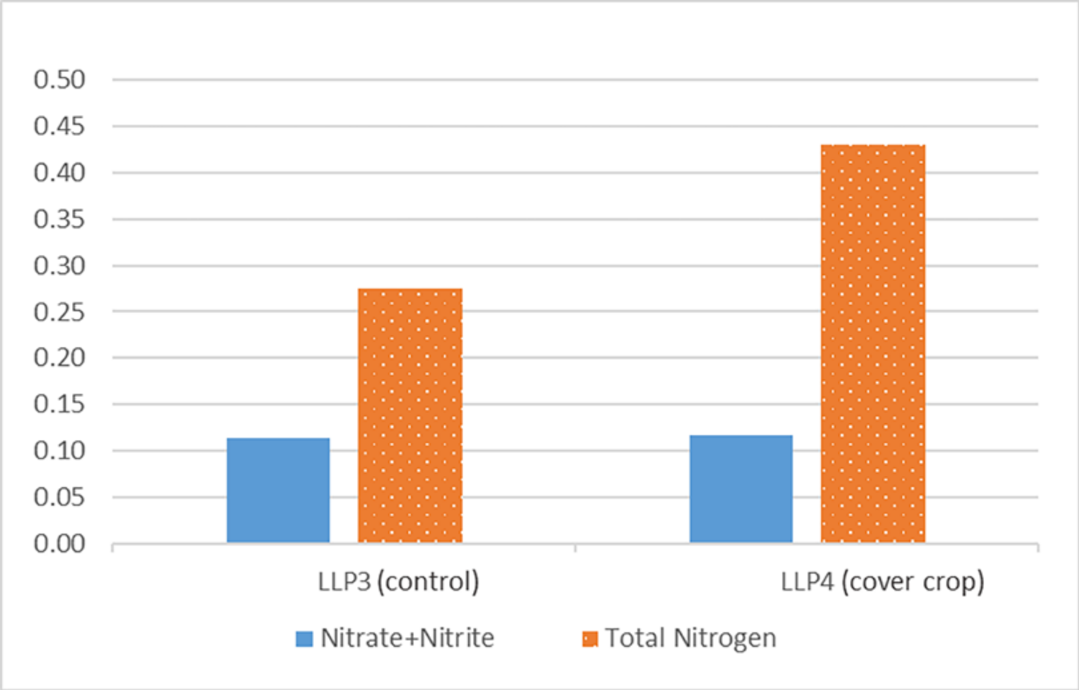
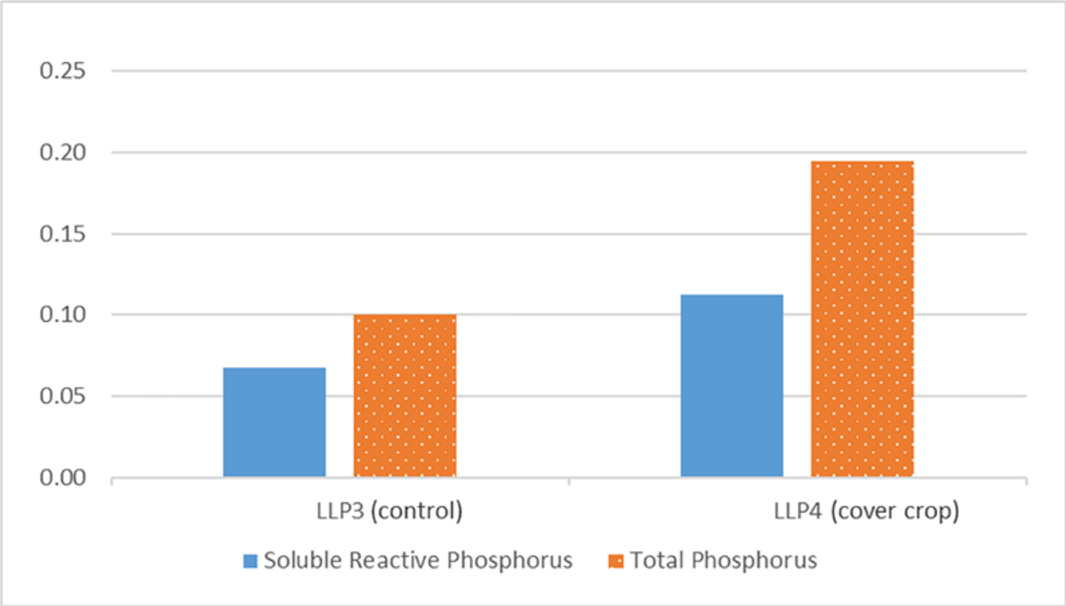


Figure 80. Mean phosphorus loss (lb ac^{-1}) of cover crop treatment versus the control for a 2-year period (2020-2021).



2-13 – Lacy Farm: Wildlife Habitat and Cover Crops

(Jackson County) Newport, Upper White-Village Creek Watershed

The Lacy Discovery Farm located in the Upper White-Village Creek watershed focuses on wildlife habitat and cover crops. Gay Lacy Farms owns about 4,000 acres of farmland located in Newport Arkansas along the White River. The Lacy farm produces soybeans, rice, and corn, in addition to managing for wildlife hunting leases. Seasonal hunting for waterfowl and deer is a substantial component of Lacy's operation.

The Lacy farm relies on the White River as their primary water source for irrigation and flooding for waterfowl management. However, sections of the farm are at the mercy of Mother Nature and the Corps of Engineers flood control regime. As such, some fields may be flooded starting in winter even until July.

In partnership with the University, the Lacy farm began experimenting with cover crops as a conservation practice and to attract deer and waterfowl. They subsequently have branded and marketed their wildlife enterprise as 3D: Duck + Deer Destination. Wildlife biologists from the University of Arkansas System Division of Agriculture, Arkansas Game and Fish Commission, Quail Forever and Ducks Unlimited have assisted with developing a wildlife plan including suggestions for habitat practices. The Arkansas Forestry Commission has written a plan for managing forested areas on the property. We are analyzing runoff and soil health data of Japanese millet as a cover crop to attract wildlife, to a more traditional cereal rye cover crop, in rotation with soybean production. Additionally, on-farm economic data have been collected about the farm's wildlife enterprises.

Figure 81. Flowering vegetation near a levee on the Lacy Discovery Farm field.

Figure 82. Lacy Discovery Farm monitoring station and field prepped for planting.

Figure 83. Monitoring station with housing unit atop trapezoidal flume.

Lacy Farm, cont.

Figure 84. Monitoring station with water flowing through the flume.

Figure 85. Preparing an earthen levee along the field border.

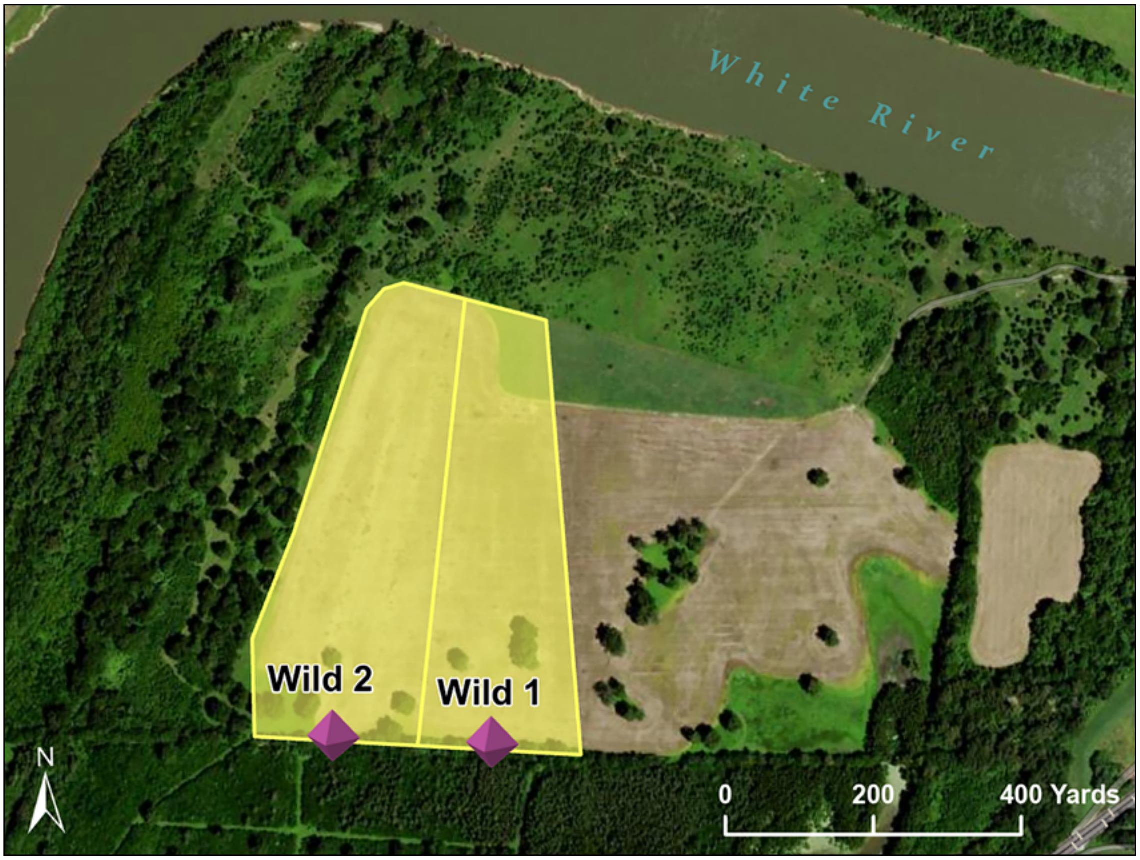


Figure 86. Map of the Lacy Discovery Farm field and monitoring stations.

2-14 – Haigwood Farm: Row-Crop

(Jackson County) Newport, Upper White-Village Creek Watershed

The Haigwood Farm is a row-crop farm located near the White River in the Upper White-Village Creek watershed (HUC - 11010013). In 2021 prior to becoming a Discovery Farm, the fields underwent zero-grade laser land leveling. Land leveling can help to conserve water and reduce runoff and soil erosion. However, the leveling process can remove a significant amount of topsoil when can lead to a temporary decrease in yield and soil health. On this Discovery Farm we are investigating how the application of poultry litter at various rates affects crop yield, soil health, soil physical properties, and runoff water quality on new land leveled fields.

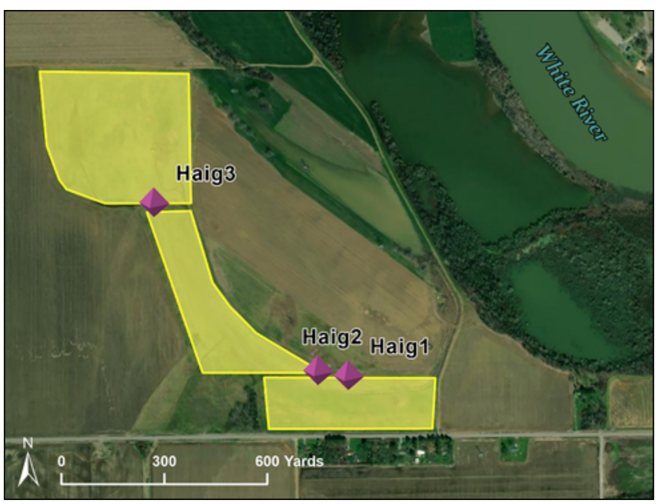


Figure 87. Map of the Haigwood Discovery Farm fields and monitoring stations.

Three of the newly land leveled fields on Haigwood farm are now part of the Discovery Farm data collection and management program. The fields total 75 acres with one 35-acre field and two 20-acre fields. Starting with the 2022 growing season the farm uses a rice-rice-soybean crop rotation. The two 20-acre fields (Central and South) are utilizing a flooded field management strategy to grow rice. The 35-acre field (North) is growing irrigated row rice and uses the excess water to help flood the Central field. Each of the three fields have an edge-of-field water quality monitoring station and irrigation flow meters installed. Additionally, soil samples are being collected in each field for: routine soil nutrients, soil health, soil physical properties, and microbiological functional soil samples. Soil samples were collected prior to the application of poultry litter and after the field were land leveled.

Figure 88. One of the monitoring stations on the Haigwood Discovery Farm.

Figure 89. Tractor working on one of the Haigwood Discovery Farm fields.

Poultry litter is an organic soil amendment that is readily available in Arkansas, but has not yet gained widespread popularity for row-crops in eastern Arkansas. Poultry litter can add value as an N, P, and K fertilizer and may also be able to help build soil health and structure. The poultry litter application rates for this project are 2, 3, and 4 tons/acre for the North, Central, and South fields, respectively. The objectives of this Discovery Farm are to study irrigation water use for newly land-leveled fields, determine what rates poultry litter can safely be applied to row-crops without producing excessive nutrient runoff, and determine if utilizing greater rates of poultry litter on newly land leveled field can help to more rapidly rebuild the soil health, soil microbiome, and soil structure.

2-15 – Anheuser-Busch: Sustainable Water Use in Rice Production

Anheuser-Busch has invested over $58 million in improving sustainability at their existing operations. To show their commitment to environmental sustainability, Anheuser-Busch has set four goals including Water Stewardship, which is to have 100% of their operations engaged in water efficiency, and Smart Agriculture. Through the Smart Agriculture program, they are extending sustainability efforts along the supply chain from field to farm to processor to end user. Anheuser-Busch purchases 21.6 million bushels of rice per year. Their rice mill in Jonesboro, Arkansas processes 2.6 million pounds of rice a day. Anheuser-Busch has direct relationships with rice farmers and is committed to helping rice farmers document sustainability efforts.

The Arkansas Discovery Farm program has partnered with Anheuser-Busch to help rice farmers to document sustainability efforts and to evaluate soil and water conservation practices for continuous practices.

Goals and Objectives

The overarching goal of this partnership and work is to help rice farmers become more efficient in water use and to document continuous improvement towards sustainability including profitability and natural resource conservation. The specific objectives are:

1. Compare the water use efficiency (WUE = Crop Yield/ Unit of Water Used) of three different approaches to water management in rice production including multiple-inlet flooding (also referred to MIRI rice), furrow-irrigated rice (also referred to as row rice) and alternative wetting and drying (also referred to intermittent flooding) with respect to zero-grade rice production which will be used as the control,
2. Determine and compare the effect of the three different water management systems and the zero-grade control on runoff volume as well as the quality or runoff at the edge-of-the field,
3. Compare the effect of the three different water management systems on soil fertility including nutrient uptake, spatial variability of nutrient distribution in soils and how soil test results relate to nutrients lost in runoff,
4. Compare sustainability metrics among the four treatments using the Field-to-Market Field Print Calculator,
5. Compare the economics and return on investment of the different treatments, and
6. Develop and deliver an educational program on sustainability especially with regard to water use, for rice farmers.

Three Discovery Farms are being established to achieve these goals and objectives.

Bradley

The Bradley Farm is a row-crop operation in Craighead County near Jonesboro and is a part of the Lower St. Francis watershed.

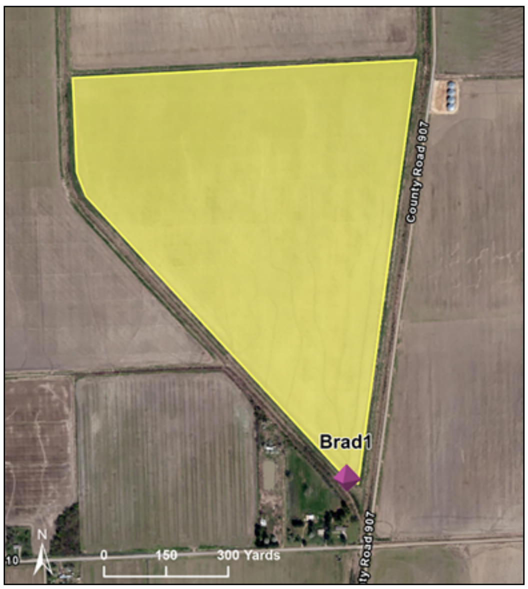
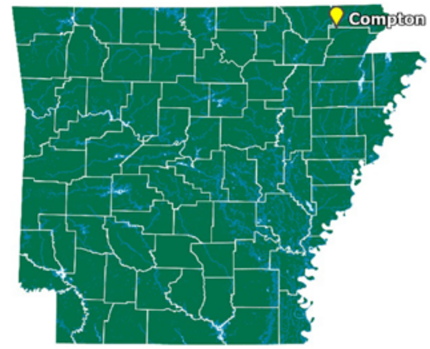


Figure 90. Map of the Bradley Discovery Farm field and monitoring station.

Figure 91. View of the flashboard riser at the southern end of the Bradley Discovery Farm field.

Compton

The Compton Farm is a row-crop operation in Greene County near Delaplaine and is part of the Cache watershed.



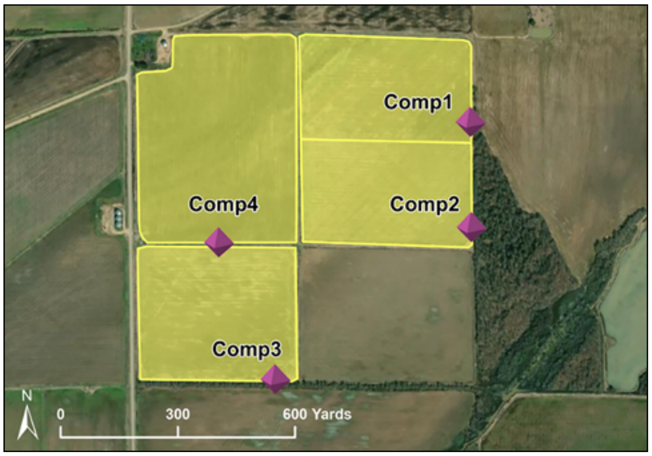
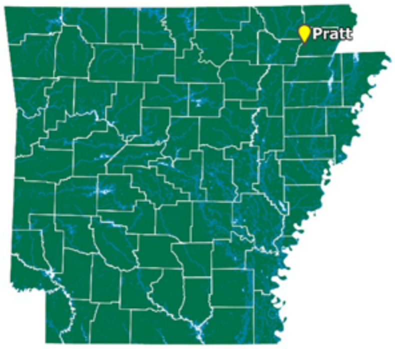


Figure 92. Map of the Compton Discovery Farm fields and monitoring stations.

Figure 93. Flooded rice on one of the Compton Discovery Farm fields.

Figure 94. One of the monitoring stations on the Compton Discovery Farm



Pratt

The Pratt Farm is a row-crop operation in Greene County near Walnut Ridge and is part of the Cache watershed.

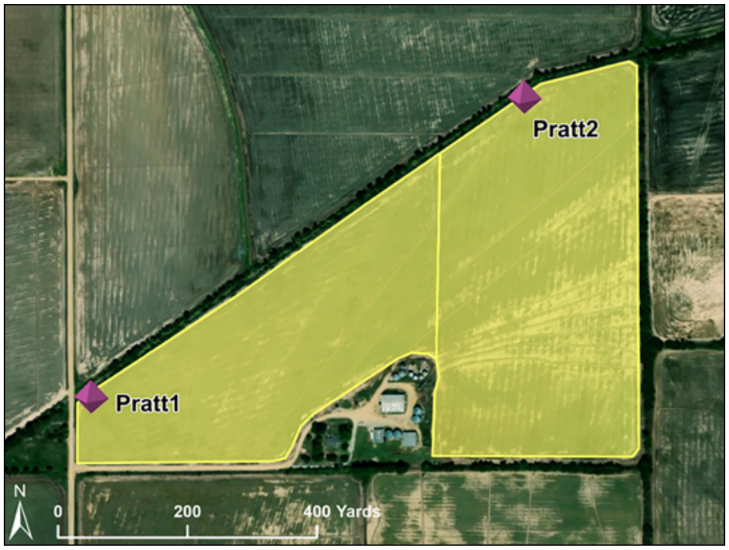


Figure 95. Map of the Pratt Discovery Farm field and monitoring stations.

Figure 96. Front view of one of the monitoring stations on the Pratt Discovery Farm field, with drainage ditch in the background.

Figure 97. Side view of one of the monitoring stations with turnrow and rice growing on the field.

Chapter 3: Discovery Farm Virtual Field Trips

The USDA NRCS has provided funding for the University of Arkansas System Division of Agriculture to integrate the efforts of the Arkansas Discovery Farms and the Arkansas Soil Health Alliance to educate a statewide network of participants through a series of no-cost virtual research-based, interactive demonstrations and educational experiences. At the time this publication went to press, we had 920 live attendees, 7,029 YouTube views and have reached 52,000 plus viewers on Facebook.

This series of Soil & Water Conservation Virtual Field Trips (VFTs) focuses on the conservation benefits our researchers have developed with respect to water quality, irrigation water use, climate change, soil health, profitability and sustainability through their partnership with farmers on selected farms including some farmers involved in the Arkansas Discovery Farms Program. We have a live question and answer segment during each live broadcast.

Free to high school science teachers, 7E and GRC-3D Lesson Guides that meet the Arkansas Department of Education's Next Generation Science Standards (NGSS) framework were created and made available for this series. Anyone can use our lesson guides. For links to the VFT lesson guides, visit: https://www.uaex.uada.edu/farm-ranch/special-programs/Education_in_Agriculture/virtual-field-trips/videos.aspx

Who could benefit from our Virtual Field Trips (VFTs):

- Farmers
- Producers
- Certified crop advisors
- Teachers
- Students of all ages
- Those in the agriculture industry
- Families
- Anyone interested in learning about soil and water conservation

VFT Title	Description	Scan QR Code
Poultry Agricultural Sustainability	Agricultural Sustainability Series: We discussed why sustainability is important to the Arkansas commercial poultry industry. Tyson Foods shared their sustainability journey and faculty at the University of Arkansas System Division of Agriculture talked about the history of commercial poultry industry in Arkansas and why sustainability is important.	
Rice Agricultural Sustainability	Agricultural Sustainability Series: We discussed why sustainability is important to the Arkansas and U.S. Rice Industry. We heard from a local rice producer; industry leaders representing the Riceland Foods, Inc., Anheuser-Busch; and from the University of Arkansas System Division of Agriculture's Rice Research Extension Centers in Stuttgart and Hindsville, AR.	
Soybean Agricultural Sustainability	Agricultural Sustainability Series: We discussed why sustainability is important to the Arkansas and U.S. Soybean Industry. We heard from industry leaders representing the U.S. Soybean Export Council, the Arkansas Soybean Association, and a local soybean producer.	
Cotton Agricultural Sustainability	Agricultural Sustainability Series: We discussed why sustainability is important to the U.S. Cotton Industry. We learned more about the Trust Protocol and BCI as well as heard from a producer panel of Arkansas producers and their experiences with these programs and why they think this is important.	
Wildlife Discovery Farm	Join this virtual tour of a Wildlife Discovery Farm and learn from University of Arkansas System Division of Agriculture experts, wildlife biologists, and Mr. Lacy, owner of Lacy Farm in Newport, about integrating conservation practices with on-farm activities to improve waterfowl and deer habitat.	
An Introduction to Agricultural Sustainability	Agricultural Sustainability Series: We explained what sustainability looks like in the world of agriculture and how continuous improvement is being addressed along the supply chain including what retailers now want from agriculture producers.	
Arkansas Soil and Water Conservation: Soil Health	This VFT explores how the physical, chemical, and biological properties of soil affect that ecosystem. Learn about research-based soil health practices taught by our University of Arkansas System Division of Agriculture Soils Instructor and hear from the Arkansas Soil Health Alliance and a local farmer about their real-life experiences with improving soil health.	
Improve Water Quality & Reduce Water Use with Surge Irrigation	This VFT highlights the Wood's soybean and rice farm in Cherry Valley, Arkansas. You will learn how the Arkansas Discovery Farms Program is helping improve water quality and help reduce water use by using computerized irrigation management, soil moisture sensors, and surge valve irrigation.	

VFT Title	Description	Scan QR Code
Improving Soils and Profitability Through Collaboration	This VFT highlights how the collaboration of these three organizations who share a common goal of helping our farmers: the Natural Resource Conservation Service, the Arkansas Conservation Districts, and the University of Arkansas System Division of Agriculture. They work together to create soil health on-farm demonstrations that teach farmers research-based conservation methods that can help farmers to be more profitable while taking care of the natural resources we all share.	
Protecting Water Resources Through Conservation on a Poultry-Beef Grazing Farm	This field trip explores how the Arkansas Discovery Farm Program is helping farmers document how their conservation measures protect local water resources, while maintain profitability. This VFT was held at the Jeff and Marsha Marley poultry and beef farm along with the Beaver Water District in northwest Arkansas.	
Exploring Winter Cover Crops for No-till Watermelon Production	This VFT focuses research being conducted on no-till watermelon production in Arkansas. It is held at the University of Arkansas Vegetable Research station in Kibler, where we explain the best practices for incorporating cover crops into no-till watermelon production, what cover crop mixes work best and how to plan for weed, disease and insect pest management.	
Farm Surface Water Irrigation Aquifer Issues	This VFT focuses on Critical Groundwater Areas and features the Dabbs Discovery Farm near Stuttgart and the Marion Berry Pump Station (Bayou Meto). The Dabbs (Lori, Terry and Trent, Arkansas Discovery Farm members) speak about water conservation practices on their farm in the Grand Prairie critical groundwater region. Ed Swaim, Executive Director at Bayou Meto Water Management District, talks about the Bayou Meto Project and using our rivers to reduce groundwater overdraft.	
Introduction to the Arkansas Discovery Farm Program	This first of two Discovery Farms VFTs defines and explains the benefits of the AR Discovery Farm Program.	
Discovery Farms Making a Difference	This second of two Discovery Farms VFTs covers the water quality and soil health practices used on these farms to enhance profitability and sustainability.	
Irrigation Technology and Scheduling Practices	This VFT discusses various technological advancements that are being used today in agricultural fields across the state to increase irrigation efficiency and maintain sustainability.	

Figure 98. Irrigation Technology and Scheduling Practices Virtual Field Trip (VFT) subject matter experts from left to right: Dr. Michele Reba (USDA-ARS), Mike Hamilton (Irrigation Specialist), Charolette Bowie (USDA-NRCS), Robert Goodson (Phillips Co. CEA), and Dr. Arlene Adviento-Borbe (USDA-ARS).

Figure 99. Farm Surface Water Irrigation Aquifer Issues Virtual Field Trip (VFT) speakers: Lee Riley (left) (University of Arkansas System Division of Agriculture), Terry Dabbs (Dabbs Discovery Farm), Edward Swaim (Executive Director at Bayou Meto Water Management District), Trent Dabbs and Lori Dabbs (both from the Dabbs Discovery Farm).

Figure 100. Discovery Farms Making a Difference Virtual Field Trip (VFT): videographer, speakers: Dr. Bill Robertson, Mike Hamilton, Dr. Mike Daniels, Pearl Webb, Lee Riley, Matt Fryer, and Video Production Team Lead, Kerry Rodtnick.

Figure 101. Introduction to AR Discovery Farm Program Speaker: Mike Sullivan with the USDA-NRCS.

Figure 102. Discovery Farms speakers: Dr. Bill Robertson, Mike Hamilton, Dr. Mike Daniels, Pearl Webb, Lee Riley, and Matt Fryer.

Figure 103. Introduction to AR Discovery Farm Program speakers: Terry Dabbs, Andrew Wargo, Dr. Mike Daniels, Steve Stevens, Debbie Moreland, and Matt Fryer.

Chapter 4: Soil Health Satellite Farm Results

Soil health is defined by NRCS as the continued capacity of a soil to function as a vital living ecosystem to sustain plants, animals, and humans. This definition is broad and encompasses the physical, biological, and chemical properties of soil, which are all related and intertwined. Chemical properties, like soil pH, affect plant growth and microbiology (biological properties), and when some chemical properties (soil pH, sodium content, etc.) get way out of typical ranges, they affect soil physical properties. Biological properties, including plant root growth and microbial activity, greatly affect soil physical properties like bulk density and aggregates stability. Soil physical properties affect biological properties by influencing water movement and use in the soil (Brye et al., 2013). All of that is simplified, but in short, all three properties of soil (chemical, physical, and biological) are intertwined and should be considered when looking at soil health.

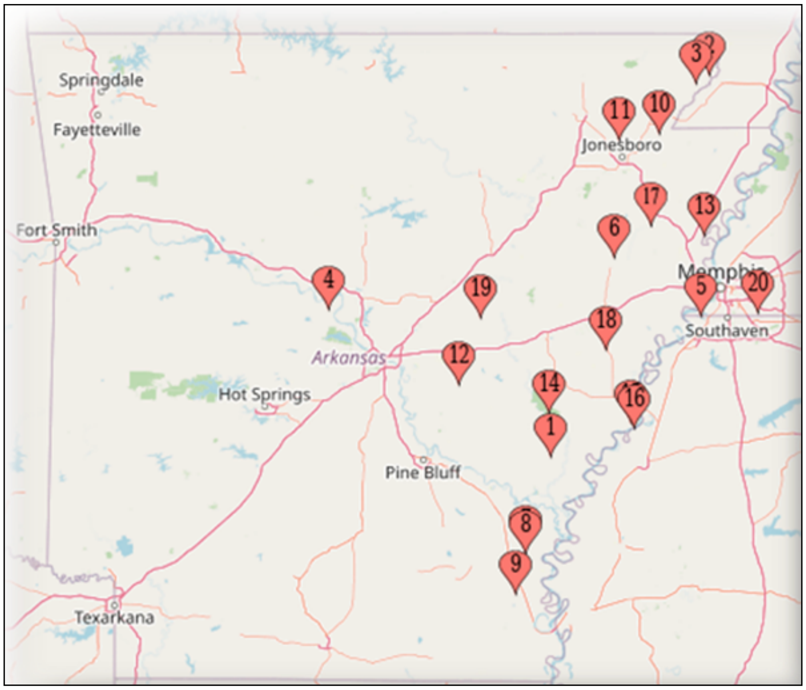


Figure 104. Soil health demonstration site locations in Arkansas and Tennessee.

The NRCS recommends five practices to improve soil health:

1. Minimize soil disturbance (no-till)
2. Maximize living roots for as long as possible (cover crops)
3. Maximize soil cover (cover crops and preserving residue)
4. Maximize plant diversity (crop rotation and cover crop diversity)
5. Grazing (integrating livestock)

In attempt to measure the effects of the first four recommended practices on soil health, 20 field sites across the Arkansas delta, river valley, and Memphis, Tennessee area (Figure 104) were split in two to compare soil health practices where cover crops and no-till are implemented to no cover crops over a 3-year period. To quantify soil health practices on various soil properties, several soil samples and measurements were taken on each half of each field in year 1 and again in year 3 and listed in Table 4. In addition, economic analysis was conducted on each field to compare the soil health management system to the more conventional system where no cover crops are used.

Table 4. Soil samples and measurements taken on each half of each field site to compare the effects of cover crops and no-till compared to no cover crop.

Soil Measurement/ Sample	Sample/ measurement depth (inch)	Quantity collected*	Notes
Routine sample	0-6	1	Each sample represented no more than 20 acres and used for lime and fertilizer recommendations, and organic matter levels
Nematode sample	0-10	1	Each sample represented no more than 20 acres. Taken at cover crop termination and at cash crop maturity.
Haney Soil Health sample	0-6	1	Each sample represented no more than 20 acres and used as a soil health indicator.
N-STaR sample	0-6	1	Each sample represented no more than 20 acres and used as a soil health indicator.
Particle size sample	0-6	1	Each sample represented no more than 20 acres and used to calculate the % sand, silt, and clay.
Bulk Density sample	0-4	5	To quantify soil compaction
	4-8	5	
Aggregate stability sample	0-2	3	To quantify how well the soil holds together, forms soil colloids, and resists erosion
	2-4	3	
Water infiltration rate	surface	3	To quantify how fast water soaks into the soil using the SATURO automated infiltrometer
Soil moisture sensors	6, 12, 18, and 30	1	The 4 sensor depths were installed in a single location on each half of the field to measure how deep water moved down the profile and to dictate irrigation scheduling.

**The quantity of samples/measurements collected on each half of the field.*

Below will be descriptions and results of the soil samples/measurements taken in year 1 of the demonstration sites that had a duration of time ranging from 1 to 5 years where cover crops and no-till were implemented on the cover crop side of the field. Major differences are not expected until our final samples have been collected and analyzed.

Routine Soil Test

Routine soil testing is used for lime and fertilizer recommendations supported by ample years of research across crops. This test supplies information regarding soil pH, nutrient concentrations, and other soil chemical properties. Soil pH and nutrient levels were addressed for each crop grown in the demonstrations by following University of Arkansas fertilizer and lime recommendation.

N-STaR Soil Test

N-STaR (nitrogen soil test for rice) samples collected from the 0-6 in depth were collected, not for nitrogen recommendations, but as a possible soil health test. The N-STaR soil test measures nitrogen in the organic form (amino acids and amino sugars) and the inorganic form, ammonium (NH_4). These organic forms of nitrogen are present within the body of microorganisms and are closely related to the amount of biological activity taking place in the soil.

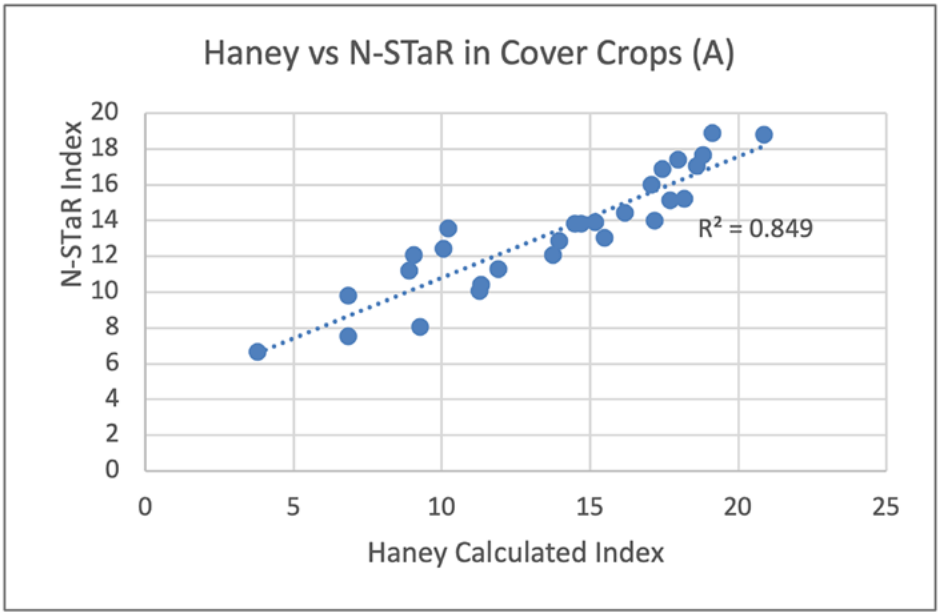
Figure 105. Soil sample cores being collected in a bucket.

This matters because biological activity plays a large role in building soil structure to allow water to infiltrate and be held. We didn't expect to see a difference in this measurement since the cover crop treatment hadn't been established vary long before the sample was taken. We expect to see a difference when we take this sample again at year three of this demonstration.

Haney Soil Health Test

This test incorporates several biological and chemical lab tests, based on the result of those tests, it gives you a "soil health index value" and often has its own fertilizer and lime recommendations along with a cover crop prescription. This test gives good information that can be used to compare the same field over time, but it has many limitations. The index value given doesn't give much useful information, but the individual lab test values can be useful. The fertilizer recommendations given have not be researched and should not be used. This test should only be used as a general indicator of soil health over time for individual fields.

Figure 106 shows soil health index values estimated from N-STaR results graphed against the Haney soil health index values for the initial samples taken in year 1 of the 20 demonstration fields. With high R^2 values, it is clear that the N-STaR index is comparable to the Haney Soil Health test. **We expect to validate the N-STaR soil test as a tool to track soil health over time because N-STaR test costs about 80% less for sample analysis than the Haney test.**



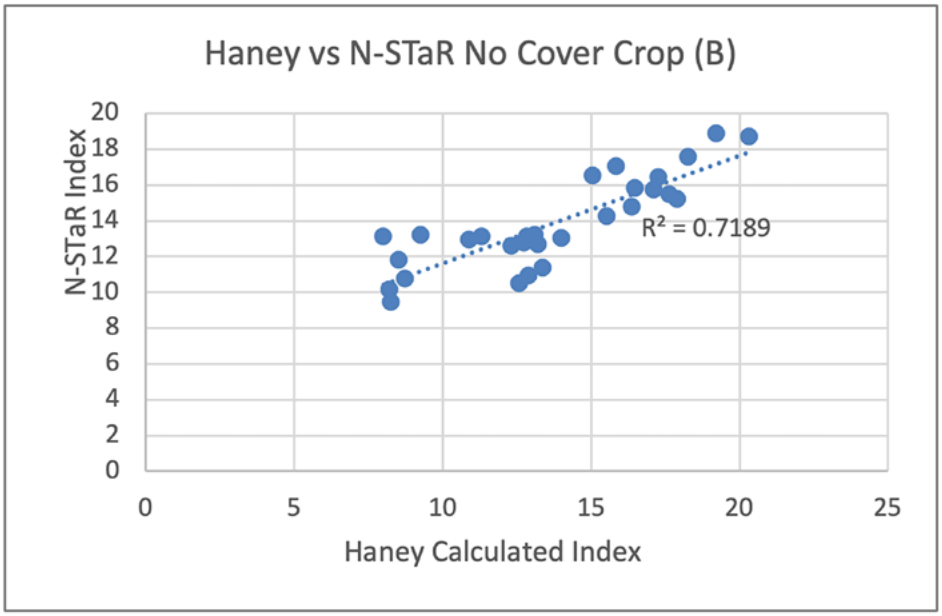
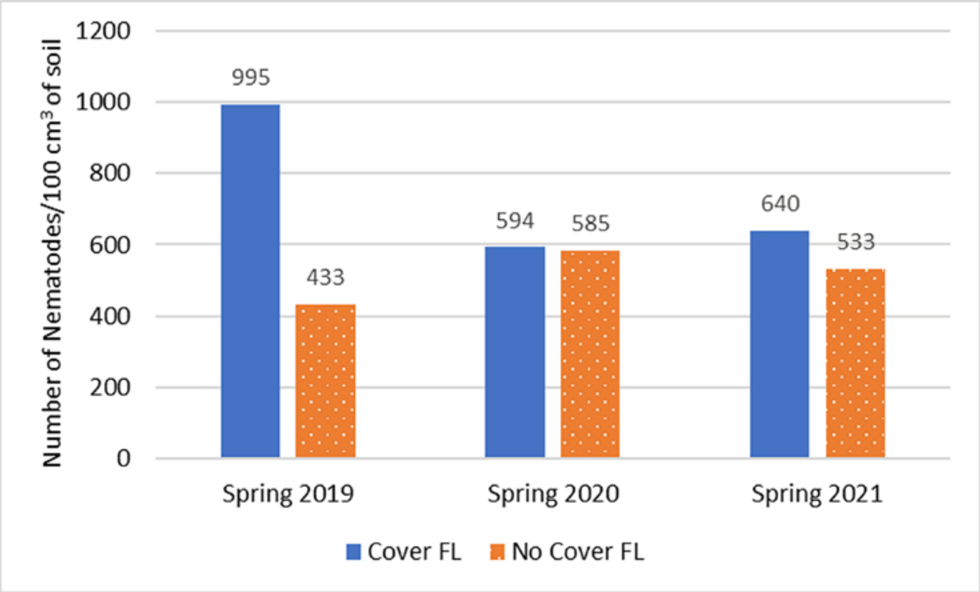


Figure 106. The correlation of N-STaR nitrogen soil test (0-6 in sample) and the Haney soil health index value (from 0-6 in sample) for both the cover crop (A) and no cover crop (B) side of the field for the initial samples collected in year one of the 20 demonstration sites.

Nematode Soil Samples

Nearly all cover crops have the potential to maintain or increase a population of plant-parasitic nematodes, with some having more potential than others. Nematodes infect and reproduce on living root tissue, especially as soil temperatures warm. Nematode samples were taken at the 0-10 inch depth in the fall and again in the spring at cover crop termination to see any potential population increases.

As the soil cools during the winter, nematodes move down the soil profile and beyond the soil sampling depth, while others die due to the lack of a living host or ability to migrate to a host. Soil temperatures need to exceed 60 degrees F before southern root-knot nematodes (and others) can actively migrate toward a host root, infect, and reproduce.



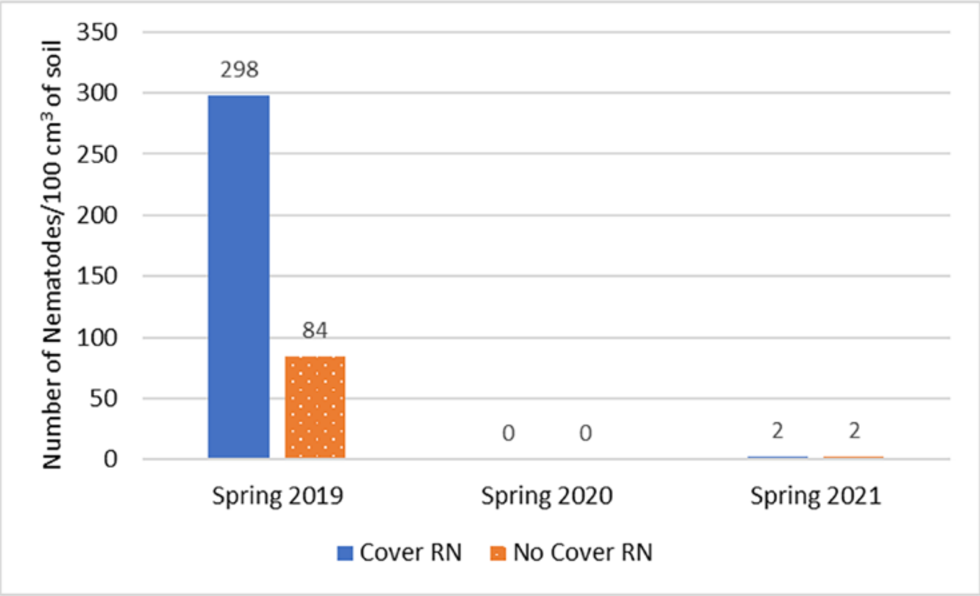


Figure 107. Root-knot and free-living nematode averages (8 to 19 locations depending on the year) comparing a cover crop vs no cover crop treatment for 0-10 inch samples collected in the spring near cover crop termination for the 2019, 2020, and 2021 crop production seasons.

"Free-living" nematodes do not reproduce on a living host, like soybean, but rather are bacterial-, fungal- or nematode-feeders. Thus, free-living nematodes are beneficial microbes by feeding on other parasitic nematodes like the root-knot nematode, bacteria and fungi that break down organic matter and improve soil health.

Figure 107 shows root-knot and free-living (beneficial) nematode averages from 8-19 sites (depending on the year) from 0-10 inch soil samples collected in the spring near cover crop termination for 2019, 2020, and 2021 for both the cover crop and no-cover crop samples. The threshold for root-knot nematodes is 50 (for cotton) or 60 (soybean) nematodes/100 cm³ of soil.

Bulk Density Soil Samples

Bulk density is the weight of soil (grams) in a known volume (cm^3). In short, bulk density measures the degree of compaction of the soil, and like all other soil measurements, bulk density varies by soil texture. As bulk density decreases, water infiltration and root penetration increase due to increases in pore space and soil structure. Bulk density generally decreases when no-till and cover crops are implemented.

When averaged across 20 sites, the bulk density of the cover crop vs no-cover crop side of the fields were not very different from each other. This was not surprising due to the lack of time of cover crop and no-till implementation. Differences are expected for the final bulk density samples that were collected in year 3 of the demonstration once results are returned from the lab.

Figure 108. Taking a bulk density soil sample.

Aggregate Stability Soil Samples

Aggregate stability is a measure of how well a soil resists erosion and forms aggregates (very small soil clods) that hold together to allow water to soak in instead of silting over and crusting. The measurement is improved by utilizing no-till and cover crops, but it can take many years (often more than 5) to see major increases in aggregate stability.

Due to the lack of time of cover crop and no-till implementation on these fields, it was no surprise that differences were not seen in the initial aggregate stability soil sample data. Small differences are expected to start to show up in our final samples being processed in the lab now.

Soil Moisture Sensors

Figure 108. Watermark soil moisture sensor unit.

When no-till and cover crops are implemented, we expect to see water infiltration depth to increase compared to when no cover crops are used. As infiltration depth increases, so does the rooting depth of the cash crop, which is often confirmed with moisture sensor changes displayed at deeper depths where cover crops were grown. Often in conventionally tilled fields, moisture sensors show that water doesn't soak in past 6 inches deep. Where there is little water, there is minimal nutrient uptake by the crop. Like all other soil measurements, these measurements can be extremely variable across the field, so proper sensor placement in the same soil texture is vital for accurate comparisons.

Soil moisture sensors can be an indirect measure of soil heath by measuring how deep water is allowed to soak into the soil as shown in Figure 110 below. The 12 and 30 inch sensor lines were removed for easy viewing. As the lines move down the graph the wetter the soil, and as the lines move up the graph the dryer the soil. Where cover crops have been implemented, water soaks down to 18 inches during an irrigation event unlike the side of the field with no cover crop. This is commonly seen across our demonstration sites, even in the 1st year of cover crop implementation.

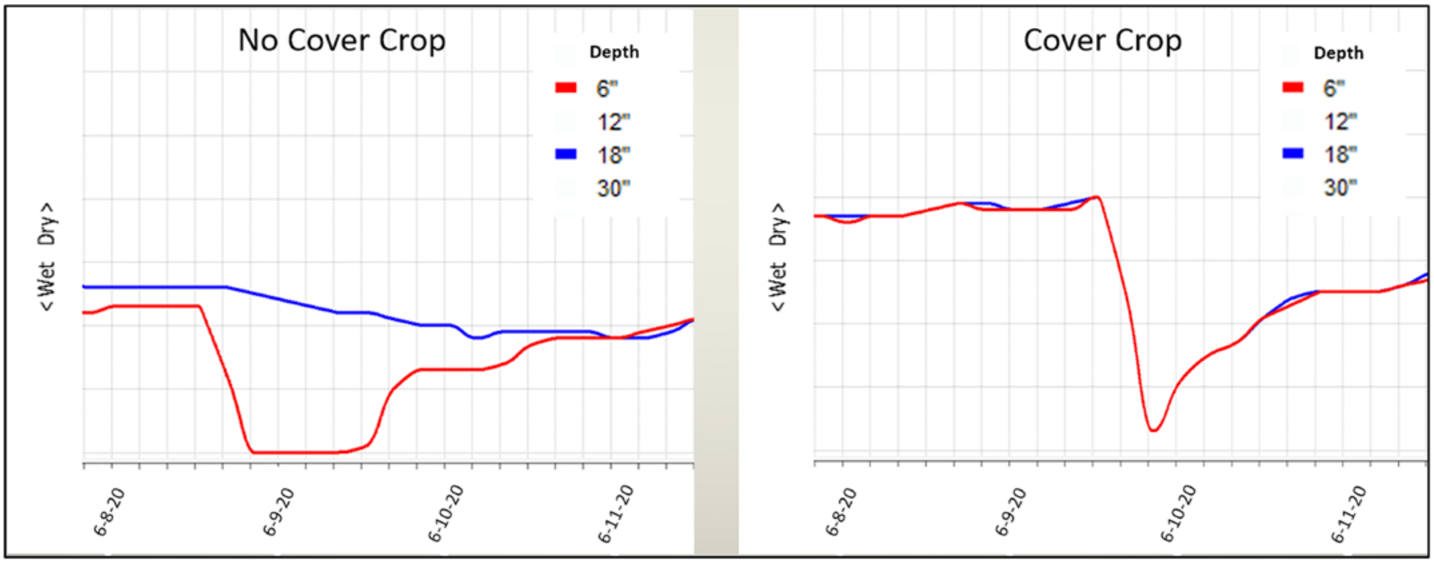


Figure 110. Graphs showing soil moisture at 6 and 18 inch depths following an irrigation event comparing cover crop implementation to no cover crop.

Infiltration Rates

When no-till and cover crops are implemented, we expect to see water infiltration rates to increase compared to when no cover crops are used. The measurements we take may not show this in every situation, and there can be many explanations for this, with the most probable being the fact that infiltration measurements are extremely variable across the field.

Figure 111. View of a SATURO infiltrometer.

Research shows that hundreds or more measurements would need to be taken across a field to capture the variability. Due to the drastic variability across a field, water infiltration improvements are more easily observed visually after a significant rainfall event because it is likely that the few infiltration measurement locations will fail to accurately representative the entire half of the field. The real value of this measurement will be when infiltration rates taken in the same spot at the first and final year are compared.

All of these aspects and measurements matter because it helps the producer to work toward improving the overall function of their soils which will improve efficiency in all areas of production which is the main goal of managing for soil health.

Chapter 5: Sustainability Metrics

Cotton Research Verification Sustainability Program

Amanda Free, Bill Robertson, Mike Daniels, and Bradley Watkins

Practices that lead to improved soil health often improve profitability and sustainability as well as have a positive impact on the field's environmental footprint. The objectives of this 5-year project were to 1) improve efficiency specifically regarding irrigation water use, 2) increase soil health, and 3) document differences in farmer standard tillage fields to that of a modified production system no-till cover through the utilization of the Fieldprint Calculator. The Fieldprint Calculator, https://calculator.fieldtomarket.org/, is a tool developed by Field to Market: The Alliance for Sustainable Agriculture. The Fieldprint Calculator was designed to help educate producers on how adjustments in management could affect environmental factors. The University of Arkansas Cotton Research Verification Sustainability program conducted research in eight fields from 2015 to 2019. Each field included different irrigation sets, which allowed for comparison of farmer standard practices (till no-cover) to that of a modified production system (no-till cover). All fields were monitored for inputs, entered in the Fieldprint Calculator, and used to calculate expenses. The yield on no-till cover increased an average of 6.1% and was $0.02/lb lint cheaper to produce than Farmer Standard tillage no-cover in 2015 to 2019. The metrics from the Fieldprint Calculator all favored no-till cover with regards to improving sustainability. Soil conservation or erosion was reduced by 77%, and greenhouse gas emissions decreased by 9%. Several improvements were observed by using no-till and cover crops in this study resulting in increased yield, decreased footprint size, and increased profitability.

In this five-year study (2015 to 2019) to improve soil health, no-till with cover crop practices resulted in a 6% increase in lint yield and increased water use efficiency, requiring 22% less water to produce a pound of cotton (Table 5). Increased water infiltration caused irrigation water to move more slowly through the no-till cover fields. Soil conservation or soil erosion was decreased almost 77% using no-till with cover. Additional research is needed to further evaluate how lint yield and profitability are influenced by seasonal rainfall interactions with improved water infiltration, which appears to be yield-limiting in the mid-south in wet years. The adoption of practices to improve soil health will likely be limited until producers become more comfortable reducing expenses. A slight yield increase coupled with reducing expenses will have a more consistent positive impact on profitability.

Table 5. Harvested lint yield, operating expenses, and metrics used to evaluate sustainability as affected by tillage and cover crops in eight fields averaged across five years (2015–2019).

Parameters	No-till Cover	Till No-Cover	% Change No-till vs. Till
Yield (lb lint harvest/ac)	1397	1312	6.1%
Operating Expenses ($/ac)	570.06	550.81	3%
Operating Expenses ($/lb lint harvested)	0.421	0.444	-5.5%
Land Use (ac/lb lint eq.) *	0.00065	0.00071	-7.9%
Soil Conservation (Tons/lb lint eq. /yr.) *	0.00184	0.00326	-77%
Irrigation Water Use (ac-in./lb lint eq. above dryland lint yield) *	0.020	0.024	22.4%
Energy Use (BTU/lb lint eq.) *	4816	5378	-11.6%
Greenhouse Gas Emissions (lb CO2eq/lb lint eq.) *	1.28	1.40	-9.2%

** To account for the economic contribution of cotton seed to the value of lint with regards to sustainability, harvested lint yield/0.83 = lint yield equivalent.*

Chapter 6: Soil Microbiology and Ecology

Overview

The soil microbial population, consisting of bacteria, fungi, archaea, and protists, greatly influences different soil functions and may vary based on the cropping system. Although, soil biota is comprised of a small portion (<0.05% dry weight), but is a valuable indicator of soil health. However, only 20% of the soil health indicators are biological indicators, thus, inclusions and development of more microbial metrics of soil health is necessary.

Figure 112. Dr. Kishan Mahmud preparing a soil sample in the field.

Soil health/soil microbiology research for Arkansas Discovery Farms includes a wide array of field and laboratory tasks ranging from sterile field soil sampling to in-situ analysis of soil active carbon, soil extracellular enzyme activity, and abundance of different bacterial and fungal population by functional gene analysis. Seven Discovery Farms (three in northwest Arkansas and four in the Delta) have been identified and six have already been sampled for soil microbial analysis. Analysis of soil active carbon will indicate the labile carbon pool that is readily available in soil for microbial consumption. Extracellular enzyme analysis includes important soil carbon, nitrogen, and phosphorus cycling enzymes, for instance, beta-glucosidase, N-acetyl-beta-glucosaminidase, phosphatase, and urase. Quantifying different functional groups of bacteria and fungi involved in crucial soil processes such as ammonification, nitrification, phosphorus solubilization is another important avenue of the soil health – soil microbiology research.

Goal

Complexity in soil habitat and food sources tends to increase soil biological complexity and building healthy soil biology leads to a feedback process in agronomic farms where soil biota sustains and enhances their own habitat and contributes to other organisms' survival. The goal of our research is to assess how adopting different management practices in different Discovery Farms ranging from row-crops to grazing lands in Arkansas affects the soil biology. These management practices will help bring a stable condition for soil macroorganisms and microbial communities so that these communities can continue to keep the soil healthy for crop production and environmental protection.

Chapter 7: Plans for the Future

Research on Discovery Farms will expand in the future through the work of the following grants which were awarded in 2022.

I. Biochar as a Soil Amendment in Eastern Arkansas Agricultural Production

Project Goals:

1. To demonstrate the effect that soil-incorporated additions of biochar have on soil moisture conservation in eastern Arkansas row-crop agriculture,
2. To demonstrate the effects of two soil-applied biochar rates vs untreated-biochar soil over time on soil health parameters such as, cation exchange capacity (CEC), pH, base saturation, nutrient retention, and bulk density on small plots. These parameters will be measured by conducting soil sampling events along with subsequent chemical and physical soil test analyses,
3. To train professionals involved with environmental science agencies in the application and overall effects of biochar usage,
4. To educate Arkansas agricultural producers of the benefits of biochar usage in areas such as soil water retention and crop yield enhancement, and
5. To create an advisory board in Arkansas that can aid and assist producers whenever concerns arise about biochar.

II. Bio-inoculum Using LEM (local effective microorganisms) Compost and its Effect on Soil Health and Nutrient Factors in the Delta

Project Goals:

1. To assess the efficacy of LEM in fortifying compost nutrient content by measuring compost quality and maturity,
2. To assess the effects of LEM incorporated compost over two seasons in improving soil aggregate stability, soil pH and EC,
3. To assess the effects of LEM inoculated vs commercial bio-inoculum inoculated compost on soil N and P cycling by measuring potential N mineralization and plant available P,
4. To quantify and compare the general soil microbial activity by measuring soil reactive carbon and soil extracellular enzymes in soil applied with LEM treated compost vs commercial bio-inoculum inoculated compost, and
5. To measure the impact of compost inoculated with LEM vs commercial bio-inoculum inoculated compost on crop nutrition.

III. Cool-season Forage Cover Crops and Vegetation Barrier on Soil Health Improvement on Grazing Lands

Project Goals:

1. Demonstrate and compare outcomes of drilled and broadcasted multi-species cover crops used as a cool season forage crop in a permanent pasture in terms of practice agronomics, soil and forage biophysical properties (i.e., soil health, soil organic carbon storage, soil water infiltration, and forage biomass production and quality), and
2. Establish a 65.6-foot (20-meter) drilled vegetative buffer at pasture drainage outlet, where Arkansas Discovery Farm program has collected 6 years of baseline data, in order to evaluate effect on sediment and nutrient reductions and water infiltration.

Chapter 8: Conservation Practice Summary

Below is a list of some of the Conservation Practices offered by the NRCS that have been used across some of our Arkansas Discovery Farms. For a full list of Conservation Practices, visit the Arkansas Conservation Practice Catalog.

Cover Crop—340

Practice Description: Crops including grasses, legumes and forbs for seasonal cover and other conservation purposes.

Purpose:
This practice is applied to achieve one or more of the following:
- Reduce erosion from wind and water
- Increase soil organic matter content
- Promote biological nitrogen fixation
- Increase biodiversity
- Weed suppression
- Provide supplemental forage
- Soil moisture management
- Minimize and reduce soil compaction

Feed Management—592

Practice Description: Managing the quantity of available nutrients fed to livestock and poultry for their intended purpose on confined livestock and poultry operations with a whole farm nutrient imbalance, with more nutrients imported to the farm than are exported and/or utilized by cropping programs.

Purpose:
- Supply the quantity of available nutrients required by livestock and poultry for maintenance, production, performance, and reproduction; while reducing the quantity of nutrients, especially nitrogen and phosphorus, excreted in manure by minimizing the over-feeding of these and other nutrients
- Improve net farm income by feeding nutrients more efficiently

Grassed Waterways—412

Practice Description: A shaped or graded channel that is established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet.

Purpose:
This practice is applied to achieve one or more of the following:
- Convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding
- Reduce gully erosion
- Protect/improve water quality

Integrated Pest Management—595

Practice Description: A site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies.

Purpose:
This practice is applied to achieve one or more of the following:
- Prevent or mitigate off-site pesticide risks to water quality from leaching, solution runoff and adsorbed runoff losses
- Prevent or mitigate off-site pesticide risks to soil, water, air, plants, animals and humans from drift and volatilization losses
- Prevent or mitigate on-site pesticide risks to pollinators and other beneficial species through direct contact
- Prevent or mitigate cultural, mechanical and biological pest suppression risks to soil, water, air, plants, animals and humans

Irrigation Land Leveling—464

Practice Description: Reshaping the surface of land to be irrigated, to planned lines and grades.

Purpose:
This practice applies to the leveling of land irrigated by surface or subsurface irrigation systems. The leveling is based on a detailed engineering survey, design, and layout. Land to be leveled shall be suitable for irrigation and for the proposed methods of water application. Soils shall be deep enough that, after leveling, an adequate usable root zone remains that will permit satisfactory crop production with proper conservation measures. Limited areas of shallow soils may be leveled to provide adequate irrigation grades or an improved field alignment. The finished leveling work must not result in exposed areas of highly permeable soil materials that would inhibit proper distribution of water over the field.

Irrigation Tailwater Recovery—447

Practice Description: A planned irrigation system in which all facilities utilized for the collection, storage, and transportation of irrigation tailwater and/or rainfall runoff for reuse have been installed.

Purpose:
This practice shall be applied as part of a conservation management system to support one or more of the following:

- Conserve irrigation water supplies
- Improve off-site water quality

Irrigation Water Management—449

Practice Description: The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner.

Purpose:
This practice is applied to achieve one or more of the following:

- Manage soil moisture to promote desired crop response
- Optimize use of available water supplies
- Minimize irrigation induced soil erosion
- Decrease non-point source pollution of surface and groundwater resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate
- Proper and safe chemigation or fertigation
- Improve air quality by managing soil moisture to reduce particulate matter movement

Nutrient Management—590

Practice Description: Managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments.

Purpose:
This practice is applied to achieve one or more of the following:

- Budget and supply nutrients for plant production
- Properly utilize manure or organic by-products as a plant nutrient source
- Minimize agricultural non-point source pollution of surface and groundwater resources
- Protect air quality by reducing nitrogen emissions (ammonia and NO2 compounds) and the formation of atmospheric particulates
- Maintain or improve the physical, chemical and biological condition of soil

Pond—378

Practice Description: A water impoundment made by constructing an embankment or by excavating a pit or dugout. Ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the auxiliary spillway elevation is 3 feet or more.

Purpose:
This practice is applied to provide water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality.

Prescribed Grazing—528

Practice Description: Managing the harvest of vegetation with grazing and/or browsing animals.

Purpose:
This practice may be applied as a part of conservation management system to achieve one or more of the following:

- Improve or maintain desired species composition and vigor of plant communities
- Improve or maintain quantity and quality of forage for grazing
- Improve or maintain surface and/or subsurface water quality and quantity
- Improve or maintain riparian and watershed function
- Reduce accelerated soil erosion, and maintain or improve soil condition
- Improve or maintain the quantity and quality of food and/or cover available for wildlife
- Manage fine fuel loads to achieve desired conditions

Residue Management, Mulch Till—345

Practice Description: Managing the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting the soil-disturbing activities used to grow crops in systems where the entire field surface is tilled prior to planting.

Purpose:
This practice is applied to achieve one or more of the following:

- Reduce sheet and rill erosion
- Reduce wind erosion
- Reduce soil particulate emissions
- Maintain or improve soil condition
- Increase plant-available moisture
- Provide food and escape cover for wildlife

Residue Management, No-Till, and Strip Till—329

Practice Description: Managing the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops.

Purpose:
This practice is applied to achieve one or more of the following:

- Reduce sheet and rill erosion
- Reduce wind erosion
- Improve soil organic matter content
- Reduce CO_2 losses from soil
- Increase plant-available moisture
- Provide food and escape cover for wildlife

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DIVISION OF AGRICULTURE

RESEARCH & EXTENSION

University of Arkansas System

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