# 2017 Final Report Summary Sheet

## Grantee Information

| | |
|---|---|
| **Project Title:** | Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities Cereal Ry |
| **Institution:** | University of Illinois |
| **Primary Investigator**: | Lovell |
| **NREC Project #** | 2014-5-360112-241 2017-3-3 |

**Is your project on target from an IMPLEMENTATION standpoint?** ☒ Yes ☐ No
**If you answered "no" please explain:**

**Is your project on target from a BUDGET standpoint?** ☒ Yes ☐ No
**If you answered "no" please explain:**

**Based on what you know today, will you meet the objectives of your project on-time and on-budget?** ☒ Yes ☐ No
**If you answered "no" please explain:**

**Have you encountered any issues related to this project?** ☐ Yes ☒ No
**If you answered "yes" please explain:**

**Have you reached any conclusions related to this project that you would like to highlight?** ☒ Yes ☐ No
**If you answered "yes" please explain:**

Conclusion 1: One major finding is that cover crops do their job of scavenging nitrate in the spring. This result is encouraging and important for making recommendations for growers.

Conclusion 2. The plots have been managed using a minimal maintenance approach, and the lack of added fertilizer differentially impacts treatments. Forage productivity has declined over time without added fertilizer, while bioenergy crops continue to increase in yield over time.

Conclusion 3: Buffer conditions, including waterlogging and heavy soils, are strong determinants of the performance of different shrub species. Species like Salix (willow), Aronia (chokeberry), and Sambucus (elderberry) are well-adapted to buffer conditions, while others like Ribes (currant) perform very poorly in buffers.

**Have you completed any outreach activities related this project? Or do you have any activities planned?** ☒ **Yes** ☐ **No**

**If you answered "yes" please explain and provide details for any upcoming outreach:**

Completed Outreach, activities from 2017:

1. Lee, M.S. and S.T. Lovell. 2017. "Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities". Summer Farm Tour hosted by American Farmland Trust, Forrest IL (7/11/2017)
2. Lee, M.S., S. Wortman, D.K. Lee, N. Paulson, A. Yannarell, and S. Lovell. 2017. "Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities", ASA, CSSA, & SSSA International Annual Meetings, Tampa FL.( 11/7/2017)
3. Lee, M.S., S. Wortman, D.K. Lee, N. Paulson, A. Yannarell, and S. Lovell. 2017. "Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities", Illinois Nutrient Loss Reduction Strategy Workshop, Springfield IL. (11/29/2017)

Planned Outreach:

Nick Paulson will be authoring (with Co-PI Lee and graduate student Moonsub Lee) multiple short outreach articles on the economic considerations of the use of buffer strips suggested by the yield data from the control and treatment trials. Results from the study suggest that, even without considering the environmental benefits associated with water quality, buffer strips planted to perennial biomass or forage crops in areas of poor soil quality can result in overall economic gains to the producer. Continuing articles in the series will document and present the measured environmental benefits of the buffer strip treatments in terms of improved water quality. This outreach article series will be published on farmdoc daily, which has over 10,000 daily subscribers focused in the Midwest and extending across the country. The site receives more than 2 million unique visitors and 8 million page requests each year.

**Additional Notes:**

## BACKGROUND

The Multifunctional Buffers research program focuses on opportunities to establish and evaluate different perennial systems appropriate for marginal or sensitive areas (e.g. sloped land, floodplains, etc.) on Illinois farms. These buffers include monocultures and polycultures of perennial bioenergy crops, forages, shrubs producing fruits or floral cuttings, and corn/soy rotation with cover crops. From the treatments, we are evaluating the environmental benefits related to nitrogen recovery based on analysis of soil nutrients over time, subsurface leaching of nutrients, and abundance of specific soil microorganisms. This project develops solutions for farmers that could be both productive and environmentally beneficial.

## FIELD ACTIVITIES

**Urbana.** Activities have proceeded at the Urbana site, for the fourth year. Last winter (Feb 27, 2017) was the first harvest of floral cuttings, removing pussy willow 'sticks' with good catkins that could go to a local market. Plots containing herbaceous perennials were burned to minimize weed competition and remove overwinter residues in March 28, 2017. Soybean plots (control treatments) were sprayed with Roundup Weathermax & crop oil on April 28th and planted on Jun 1. Soil samples were collected for nitrogen analysis and soil microbes on May 17 from all plots. All suction lysimeters for water samples were checked on May 19, and the first water samples were collected on June 30. The first harvest of the forage plots was completed on June 23. The hairy vetch cover crop was broadcast over the "complex control" plot on Sept 22, and soybean harvest subsamples were collected for yield on November 1. Final year-end soil samples for soil N and microbes were also collected on November 1.

***Fig 1.*** Buffer treatments at the Urbana site (left) and the forage plot after spring harvest (right, June)

**Forrest.** The trial site established spring 2016 in Forrest, IL (40˚48'N, 88˚24'W) is proceeding as planned for 2017. Herbaceous perennial plots were burned to minimize weed competition and remove overwinter residues on March 26. In treatments containing shrubs, a 12" band herbicide application of glyphosate and Princep was applied in-row on April 12. Control treatments were sprayed with Roundup Weathermax & crop oil on April 28th and planted on May 25. Soil samples were collected for nitrogen analysis and soil microbes on May 16 from all plots. Four suction lysimeters were damaged and replaced on May 31, and the first water samples were collected on June 30. The first harvest of the forage plots was completed on June 22, 2017. The rye cover crop was broadcast over the "complex control" plot on Sept 21, and corn harvest subsamples were collected for yield on Nov 1. Final year-end soil samples for soil N and microbes were collected on November 2-3.

**2017 RESULTS**

The forage and bioenergy plots at both sites remained productive through the 2017 season.

***Fig 2.*** Buffer treatments at the Forrest site (left) and the forage plots after spring harvest (right, June)

Shrubs in floral plots are promising, with pussy willow in particular thriving in the buffer conditions. In the plots containing edible shrubs, black currant was replaced with Aronia, which is better suited to the buffer conditions. The work with shrubs has been mostly exploratory in allowing us to gain a better understanding of which species are best suited to the conditions of the buffer environment, and also to determine guidelines for managing shrubs for productivity. Future research can focus further on performance of adapted species.

## Performance Based on Yield

Two treatments focus on bioenergy crops: 1) monoculture of switchgrass 'Kanlow, and 2) polyculture of the same switchgrass planted in combination with big bluestem, Indiangrass, and prairie cordgrass. The yields of treatments at Urbana have continued to increase from 2015 to 2017, as the perennial plants mature (Table 1, Figure 1). The Forrest site was just established in 2016, following the loss of research sites at Dixon Springs and St. Charles. Yields from 2017 were actually similar to the more mature Urbana location. At both sites, little difference between monoculture and polyculture was detected, suggesting that polycultures could be a good alternative for conserving biodiversity using native species.

Two treatments focus on forage crops: 1) monoculture of Virginia wildrye (*Elymus virginicus*), and 2) polyculture of Virginia wildrye combined with purple prairie clover, leafy prairie clover, and a mix of other species. Yields of forage crops differ for the monoculture versus the polyculture. At Urbana, the yields of monoculture of Virginia wildrye have actually declined over time (Table 2, Figure 2), likely due to the sensitivity of this crop to soil fertility. This project focused on low-maintenance options for farmers that would be designed to scavenge nitrogen from the system, so no fertilizer has been added to any of the treatments other than controls. The performance of the polyculture treatment remained stable over the period of 2015-2017, so this treatment is likely a better option for the low-maintenance buffer conditions. The yields at the Forrest site were as expected for the season one year after establishment.

**Table 1.** Biomass dry matter yields of bioenergy system grown in monoculture and mixtures during 2015 to 2017 at Urbana, IL and Forrest, IL.

a) Urbana site

| | Harvest Year | | |
|---|---|---|---|
| | 2015 | 2016 | 2017 |

| Cultivation | 2015 | 2016 | 2017 |
|---|---|---|---|
| | ---------- Mg ha$^{-1}$---------- | | |
| Monoculture | 9.2 | 14.7 | 18.8 |
| Polyculture | 7.5 | 13.6 | 18.0 |

b) Forrest site[§]

| | Harvest Year | | |
|---|---|---|---|
| | 2015 | 2016 | 2017 |
| Cultivation | ---------- Mg ha$^{-1}$---------- | | |
| Monoculture | - | - | 20.5 |
| Polyculture | - | - | 18.4 |

[§]Experimental plots were established in 2016

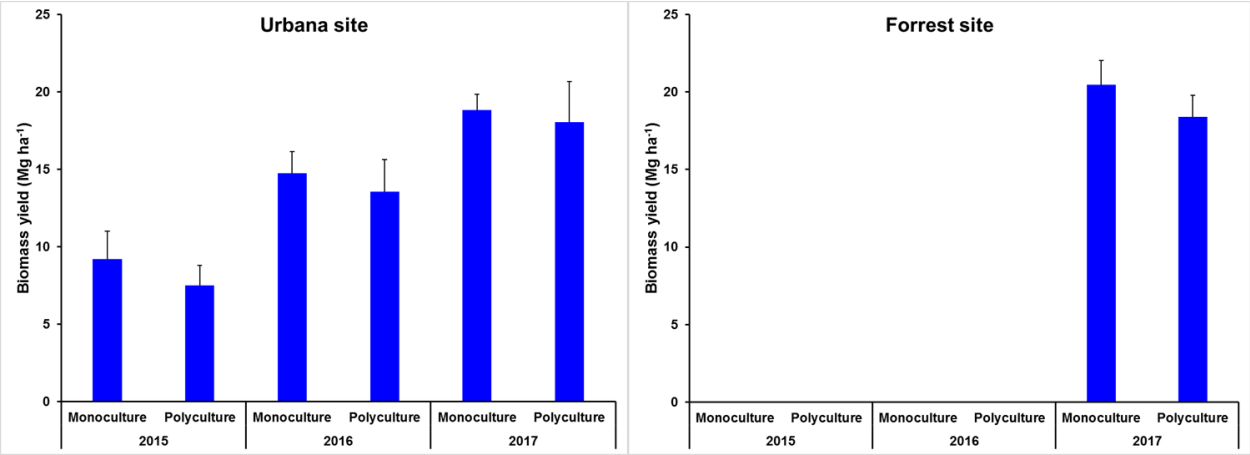


**Figure 1**. Biomass yields of bioenergy systems during 2015 through 2017 at Urbana and Forrest sites. Biomass was annually harvested after a killing frost or late fall.

**Table 2.** Forage system dry matter yields of treatments grown in monoculture and mixtures during 2015 to 2017 at Urbana, IL and Forrest, IL.

a) Urbana site

| | | Harvest Year | | |
|---|---|---|---|---|
| | | 2015 | 2016 | 2017 |
| Cultivation | Harvest time | ---------- Mg ha$^{-1}$---------- | | |
| Monoculture | 1$^{st}$ | 3.84 | 2.94 | 2.67 |
| | 2$^{nd}$ | 3.51 | - | 1.40 |
| Polyculture | 1$^{st}$ | 3.11 | 3.26 | 4.50 |
| | 2$^{nd}$ | 3.68 | 2.50 | 4.30 |

a) Forrest site[§]

| | | Harvest Year | | |
|---|---|---|---|---|
| | | 2015 | 2016 | 2017 |
| Cultivation | Harvest time | ---------- Mg ha$^{-1}$---------- | | |
| Monoculture | 1$^{st}$ | | | 4.11 |
| | 2$^{nd}$ | | | 4.01 |
| Polyculture | 1$^{st}$ | | | 4.60 |
| | 2$^{nd}$ | | | 6.00 |

[§]Experimental plots were established in 2016

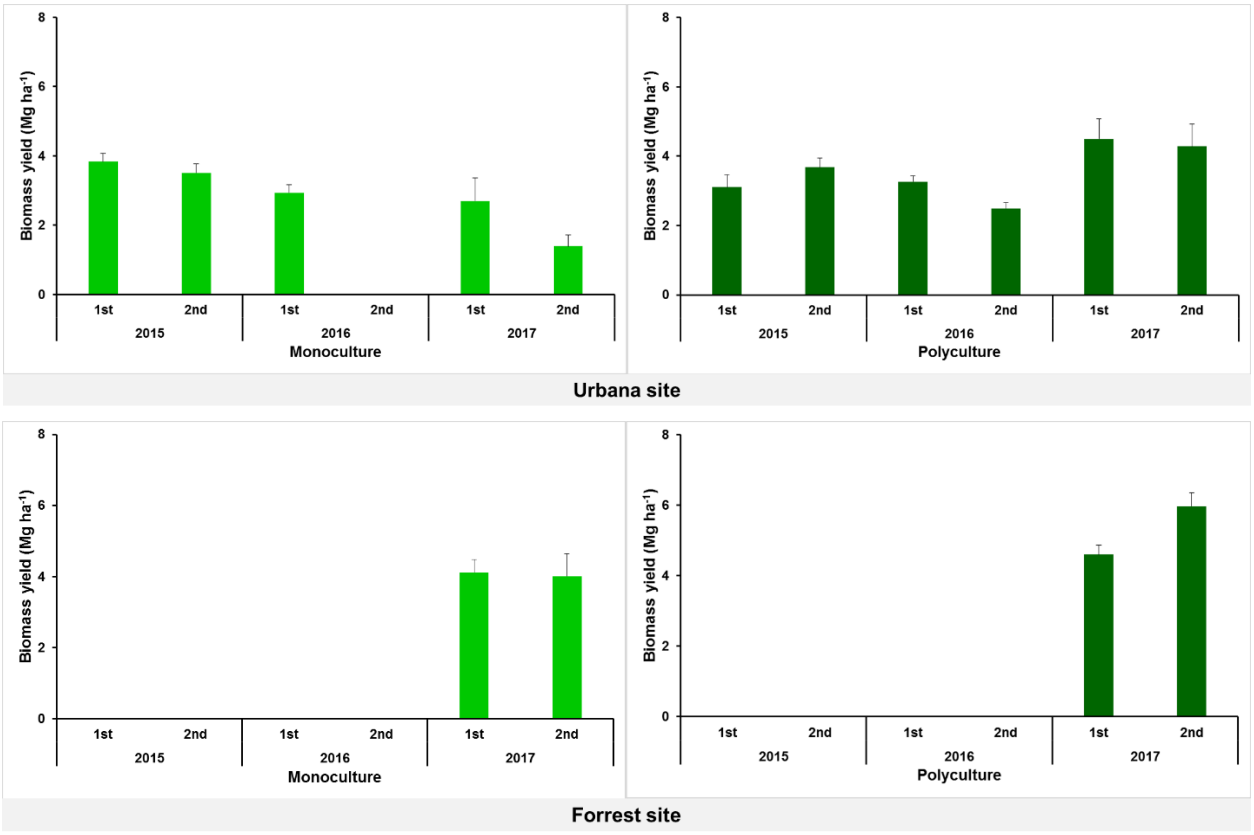


**Figure 2**. Yields of forage systems during 2015 through 2017 at Urbana and Forrest sites, IL. Biomass was harvested twice annually at the peak standing crop of cool season grasses (1st cut) and after a killing frost or late fall (2nd cut).

## Nitrate in Lysimeters.

Nitrate levels in forage and bioenergy crops were very low (typically < 1 mg $L^{-1}$) at all time periods throughout the growing season in 2015-2017 at Urbana (Figure 3). Since those treatments receive no fertilizer, the results are not surprising. For the corn-soybean rotation, the greatest release of nitrate was in the spring and in the fall in 2015 and 2016. In 2017, nitrate was greatest at the summer sampling period, likely due to the moisture conditions in that year. An encouraging finding is that the complex treatments typically have less nitrate in leachate in spring compared with simple treatments (Figure 4). The cover crops that are integrated in those complex treatments offer an important service in scavenging nitrate that might otherwise be lost from the system. Treatments with shrubs behave similarly to the forage monoculture (data not shown), since the same species (Virginia wildrye) was planted between shrub treatments.

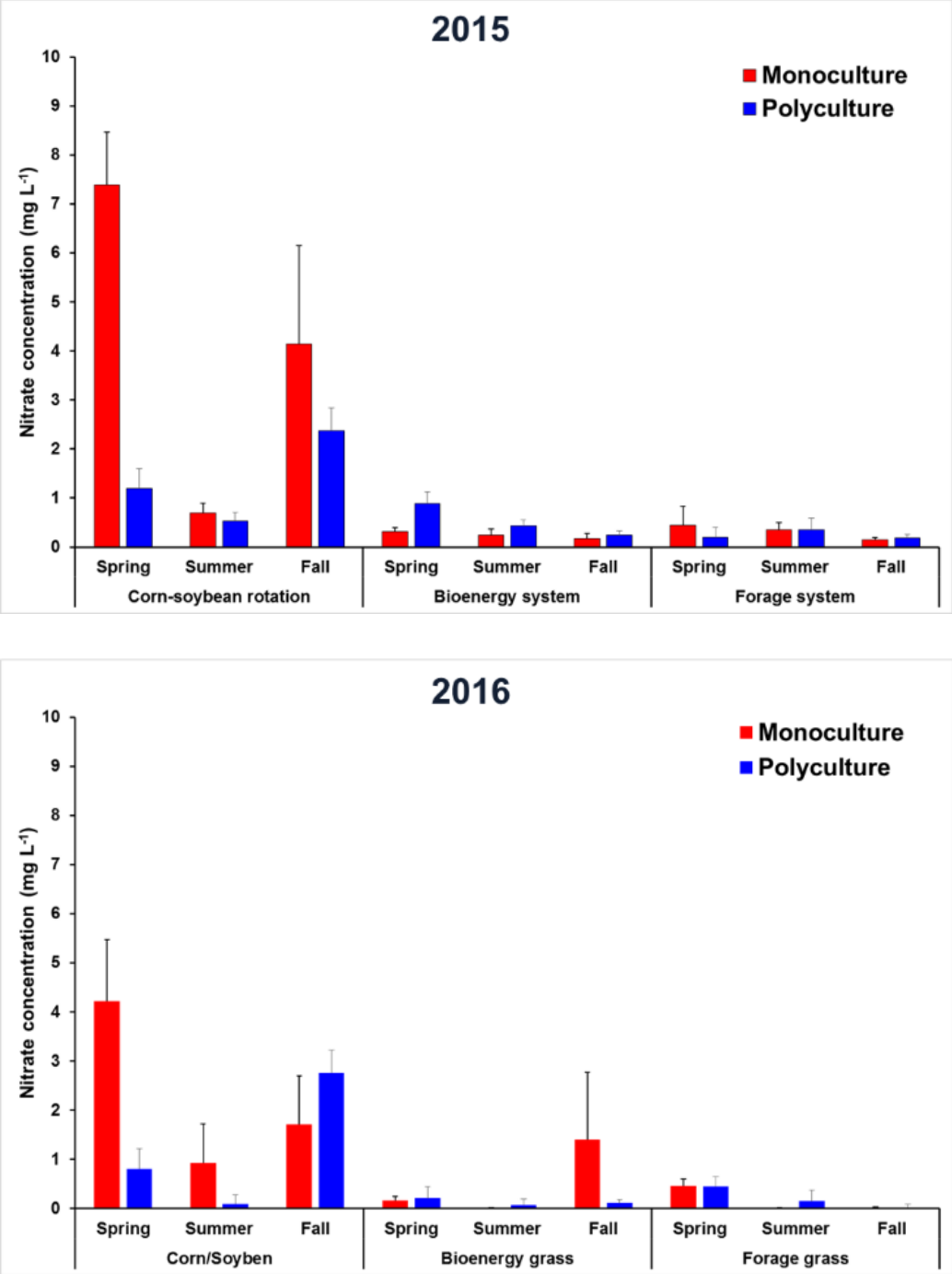


**Figure 3.** Nitrate concentration in soil surface water under corn-soybean, bioenergy and forage systems from 2015 through 2017. Soil surface water was collected from lysimeters installed in depth of 30 cm. (continued next page)

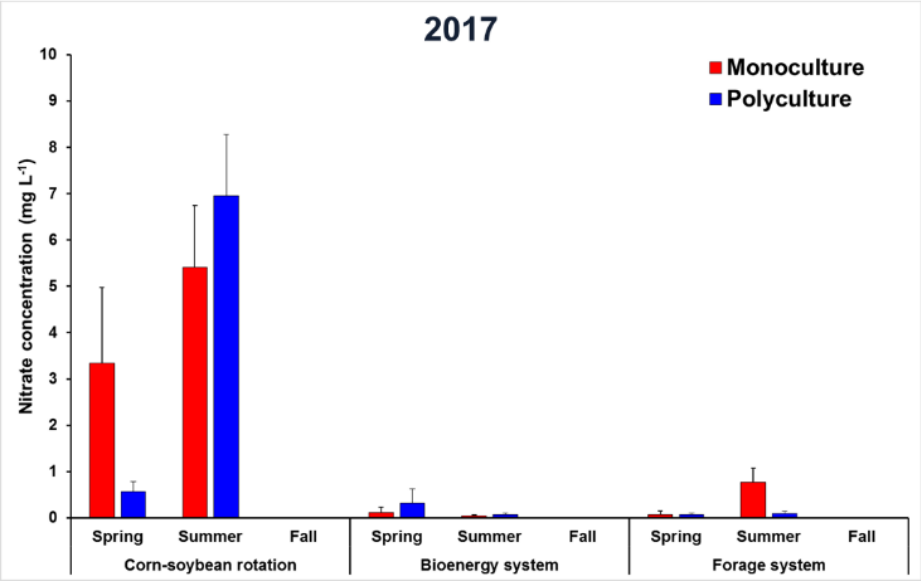


**Figure 3 (cont.).** Nitrate concentration in soil surface water under corn-soybean, bioenergy and forage systems from 2015 through 2017. Soil surface water was collected from lysimeters installed in depth of 30 cm.

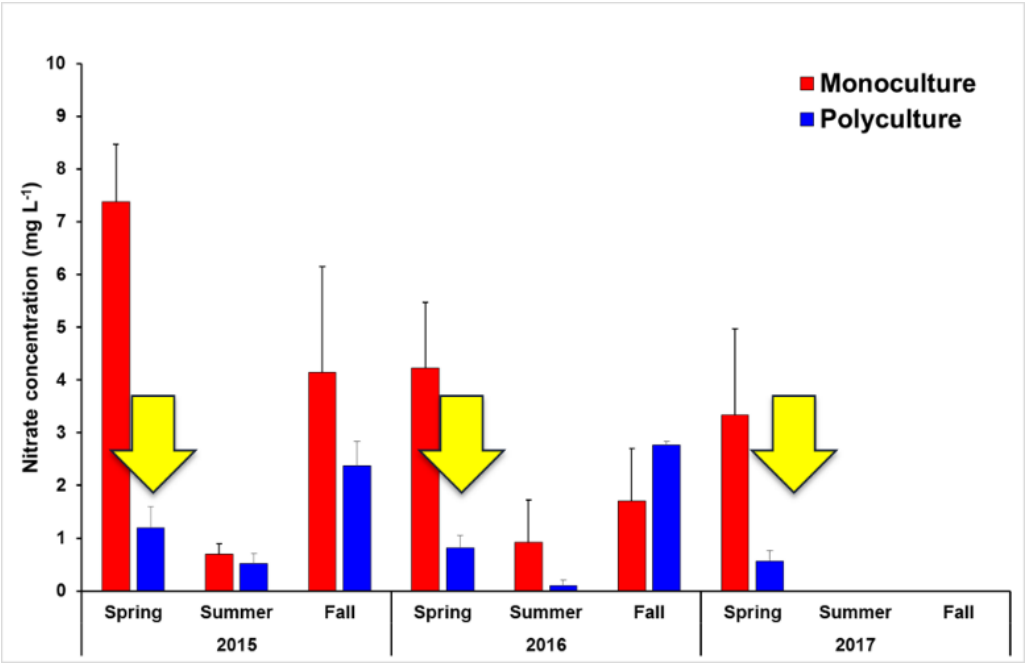


**Figure 4.** Nitrate concentration in soil surface water under corn-soybean rotation with (polyculture)/without (monoculture).

## SOIL MICROBES

**Urbana.** We have extracted microbial DNA from 240 soil samples collected from these plots since 2014, and we are analyzing these DNA extracts to learn about microbial populations that drive three critical nitrogen-cycling processes (nitrification, denitrification, and nitrogen fixation) (Figure 5).

**Forrest.** We have extracted microbial DNA from 120 soil samples collected from this site since the plots were first established in 2016, and we will use these DNA extracts to learn about nitrogen-cycling microorganisms that respond to our perennial systems.

**Dixon Springs and St. Charles (previous sites).** We did not conduct any field work at these sites, for reasons that have been detailed in our previous reports. However, we have extracted microbial DNA from 192 soil

samples that were collected from experimental plots that we established at these sites in 2014 and 2015. By comparing the nitrogen-cycling microorganisms that we detect at these sites with those from Urbana and Forrest, we will have a more comprehensive understanding of how our perennial systems affect these important groups of soil organisms in different parts of Illinois.

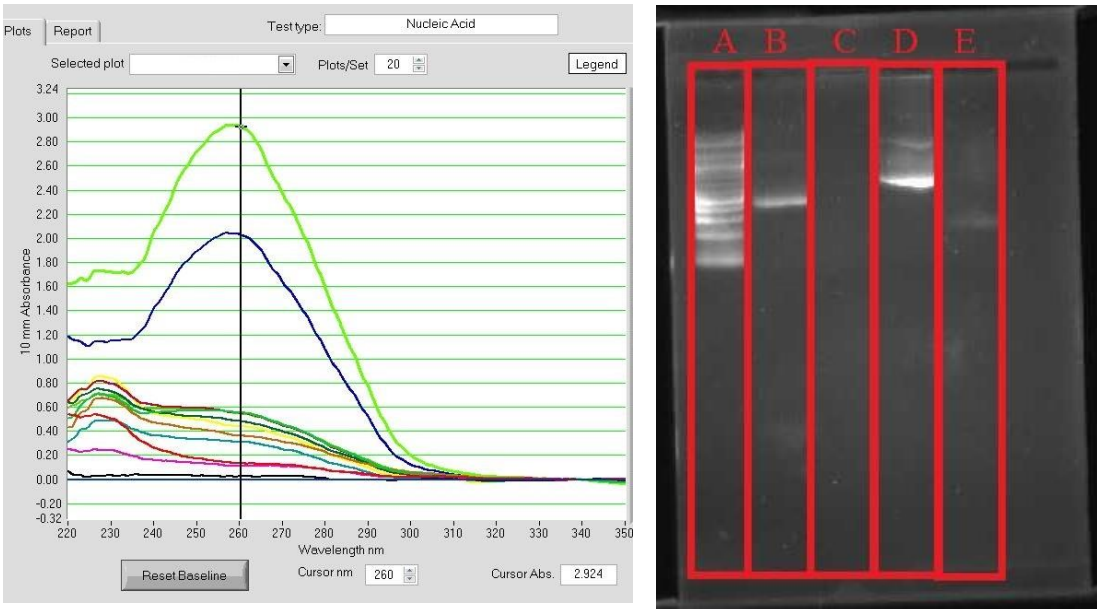


**Figure 5.** On the left is the result from a spectrometer, showing light absorbed by soil samples. The peaks at wavelength 260 nm indicate DNA extractions were successful. On the right is the result of PCR replicates of specific DNA of interest by gel electrophoresis. The band on each lane indicates the PCR was successful, except where a gene might not be present in the sample.

## CONCLUSIONS

**Outcomes:** One major finding is that cover crops do their job of scavenging nitrate in the spring. This result is encouraging and important for making recommendations for growers. A second key finding is that the lack of added fertilizer (from minimal maintenance strategy) differentially impacts treatments. Forage productivity has declined over time without added fertilizer, while bioenergy crops continue to increase in yield. A third finding is that buffer conditions, including waterlogging and heavy soils, are strong determinants of the performance of different shrub species. Species like Salix (willow) and Aronia (chokeberry) are well-adapted to buffer conditions, while others like Ribes (currant) perform very poorly in buffers.

**Challenges:** The weather has resulted in some challenges, with very wet conditions followed by periods of hot/dry. We are managing this issue by watering the younger shrubs as needed.

**Outreach:** Results have been presented at several venues in the past year:

1. Lee, M.S. and S.T. Lovell. 2017. "Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities". Summer Farm Tour hosted by American Farmland Trust, Forrest IL (7/11/2017)
2. Lee, M.S., S. Wortman, D.K. Lee, N. Paulson, A. Yannarell, and S. Lovell. 2017. "Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities", ASA, CSSA, & SSSA International Annual Meetings, Tampa FL.( 11/7/2017)
3. Lee, M.S., S. Wortman, D.K. Lee, N. Paulson, A. Yannarell, and S. Lovell. 2017. "Multifunctional buffers on marginal farmland to improve the environmental profile of agriculture and diversify production opportunities", Illinois Nutrient Loss Reduction Strategy Workshop, Springfield IL. (11/29/2017)

Nick Paulson will be authoring (with Co-PI Lee and graduate student Moonsub Lee) multiple short outreach articles on the economic considerations of the use of buffer strips suggested by the yield data from the control and treatment trials. Results from the study suggest that, even without considering the environmental benefits associated with water quality, buffer strips planted to perennial biomass or forage crops in areas of poor soil quality can result in overall economic gains to the producer. Continuing articles in the series will document and present the measured environmental benefits of the buffer strip treatments in terms of improved water quality. This outreach article series will be published on farmdoc daily, which has over 10,000 daily subscribers focused in the Midwest and extending across the country. The site receives more than 2 million unique visitors and 8 million page requests each year.

**Budget:** No changes are required at this time.