

**APPENDIX D SAES-422
Multistate Research Activity
Accomplishments Report**

Project/Activity Number: NC1182

Project/Activity Title: Management and Environmental Factors Affecting Nitrogen Cycling and Use Efficiency in Forage-Based Livestock Production Systems

Period Covered: June 2023 to May 2024

Date of This Report: July 29, 2024

Annual Meeting Date(s): 4-5 June 2024, Spring Hill TN

Brief summary of minutes of the annual meeting:

State	Institution	Attending members
AR	University of Arkansas	Ken Coffey
KY	University of Kentucky	Rebecca McCulley
NE	University of Nebraska	John Guretzky
OH	The Ohio State University	David Barker
TN	University of Tennessee	Renata Nave
UT	Utah State University	Rhonda Miller

Activities:

Tuesday June 4 (CDT)
1:00 Welcome
1:30-3:30 Tour of MTREC Spring Hill
3:30 Nebraska – John Guretzky
4:00 Utah – Rhonda Miller
Wednesday June 5 (CDT)
9:00 Welcome and Introductions
9:10 Administrative Report – Dr. Scaglia
9:30 NIFA Report and Updates – Dr. Smith
9:50 Arkansas – Ken Coffey
10:10 Kentucky – Rebecca McCulley
10:30 Break
10:50 Ohio – David Barker
11:10 Tennessee – Renata Nave
11:30 Business Meeting
12:00 Adjourn

Business meeting minutes

- Seven participants.
- State report presentations: Arkansas, Kentucky, Nebraska, Ohio, Tennessee, and Utah.
- Updates by NIFA Representative: new program areas, funding opportunities, and updates in AFRI and NIFA.
- 5-year renewal with minimal alterations. The committee is in good standing.
- The next meeting location is Columbus, OH. Host: David Barker.
- Renata Nave incoming chair, 2025.

STATE REPORTS

NC182 - Management and Environmental Factors Affecting Nitrogen Cycling and Use Efficiency in Forage-Based Livestock Production Systems, 2024 Report

OBJECTIVE 1: Evaluate legume cultural and management strategies emphasizing legume establishment, N cycling and use efficiency, and GHG emissions.

OBJECTIVE 2. Assess the efficacy of secondary plant metabolites in legume species for increasing N retention and improving N cycling in forage-livestock systems.

OBJECTIVE 3. Quantify effects of pasture management strategies on N use efficiency by ruminant animals and N cycling in herbage and soils of grassland agro-ecosystems.

OBJECTIVE 4. Disseminate research results through coordinated extension/education activities, including extension publications, university course material, and regional and state conferences on nitrogen cycling and use efficiency and management of grass-legume mixtures.

ARKANSAS

UNIVERSITY OF ARKANSAS (KEN COFFEY AND MIKE POPP)

ACCOMPLISHMENTS

Short Term Outcomes:

Using poultry litter as a source for nutrients on pastures is commonplace in the mid-southern US. Broadcast application is less efficient than soil incorporation in terms of nutrient losses in runoff and via nitrogen volatilization. The tradeoff lies in cost vs. benefit across application methods. We evaluated sorghum-sudangrass, cowpea, and their mixture in pastures fertilized in 2021 using 3 ton/acre of litter that was either broadcast or subsurface applied in comparison to no litter to determine yield and forage quality implications across treatments over the course of 2021 and 2022. Sorghum-sudangrass had the highest yields regardless of fertilizer treatment. Mixtures did not improve yield nor forage quality as cowpea were outcompeted. Subsurface litter application enhanced crude protein. Sorghum-sudangrass with subsurfaced litter was the preferred treatment with highest relative profit over the course of this 2-yr study considered excessively droughty. The financial implications was large as subsurface application offered \$70/acre more than broadcast application in this study.

Outputs: N/A

Activities: N/A

Milestones: N/A

IMPACTS

Growing lambs were housed in individual pens with metal grate flooring for a feed intake and digestion study. Lambs were offered ad libitum access to diets of bermudagrass hay with either no additional enzyme or 2 mL/d of NutrZyme, a commercial nutrient supplement. Overall, there were no significant differences between the treatment and the control groups for nutrients digestibility, and nitrogen retention. Microbiome analyses revealed minor differences between the treatment and control groups, particularly with LEfSe analyses. Other studies would be necessary with various levels of NutriZyme or with other diets to explore its potential utilization in growing lambs.

PUBLICATIONS

Niyigena, V., K.P. Coffey, D. Philipp, M.C. Savin, J. Zhao, H.D. Naumann, J.M. Diaz, S.P. Park, R.L. Rhein, S.L. Shelby. 2024. Intake, digestibility, rumen fermentation and nitrogen balance in sheep offered alfalfa silage with different proportions of the tannin-rich legume sericea lespedeza. *Anim. Feed Sci. Technol.* 308:115863.
doi.org/10.1016/j.anifeedsci.2023.115863

Meyer, I., Popp, M. P., Nieman, C. C., Ashworth, A. J., & Owens, P. R. (2024). Agronomic and economic productivity of summer annual forage systems under different poultry litter application methods. *Crop, Forage & Turfgrass Management*, 10, e20281.
<https://doi.org/10.1002/cft2.20281>

**KENTUCKY
UNIVERSITY OF KENTUCKY (REBECCA MCCULLEY)**

ACCOMPLISHMENTS

Short-term Outcomes:

This year we primarily worked to get the manuscript generated by PhD student, Dr. Alayna Jacobs, on the effects of feeding biochanin A (BCA) on lamb urine chemistry and urine-applied soil trace gas emissions and microbial communities published. Publishing this work has proved challenging as reviewers often appeared to lack the interdisciplinary training required to evaluate the manuscript. They either knew the animal side or they knew the soil side but they struggled to understand the whole. We have had to go through several rounds of revisions but have it in for review again at Journal of Environmental Quality, and hope it will eventually be accepted there.

Outputs:

We generated several datasets quantifying the effects of feeding biochanin A on lamb urine chemistry and urine-applied soil mesocosm trace gas flux and microbial communities. We graduated one PhD student and are currently training a postdoctoral scholar in the subject area and in utilizing the required techniques. We have a refereed journal article produced with this data currently under review at Journal of Environmental Quality. We are continuing our work on this subject collaboratively with the USDA-ARS Forage Animal Production Research Unit.

Activities:

We have had to do multiple rounds of edits on the manuscript, including new calculations and statistics, and re-writing, creating new graphs, etc. Lots of time has been spent on writing responses to reviewers. We believe that the manuscript has improved as a consequence and this activity has helped us think about a new BCA incubation study that we plan to start this Fall. This has all been good training for the postdoc who is taking over the work from the PhD student.

Milestones: N/A**IMPACTS**

Our research illustrates that not only does feeding red clover-produced biochanin A improve animal nitrogen use efficiency, but it also results in lower trace gas fluxes from urine-applied soil. Biochanin A and its breakdown products are found in measurable quantities in urine from lambs fed BCA, and the greater the quantity of these metabolites in the urine the stronger the

measured reduction in ammonia volatilization from urine patches. Overall, these results indicate that feeding BCA can significantly improve sustainability of animal production systems.

PUBLICATIONS

- McGrail, R.K., A.E. Carlisle, J.A. Nelson, R.D. Dinkins, and **R.L. McCulley**. 2024. Tall fescue and endophyte genetics influence vertical transmission and seed characteristics under climate change scenarios. Phytobiomes.
- Jacobs, A.A., R.S. Evans, J.K. Allison, W.L. Kingery, **R.L. McCulley**, and K.R. Brye. 2024. Tillage and cover crop systems alter soil particle size distribution in raised-bed-and-furrow row-crop agroecosystems. Soil Systems 8(1): 6.
doi.org/10.3390/soilsystems8010006
- Siebert, J., M. Sünnemann, Y. Hautier, A.C. Risch, J.D. Bakker, L. Biederman, D.M. Blumenthal, E.T. Borer, M.N. Bugalho, A.A.D. Broadbent, M.C. Caldeira, K.F. Davies, A. Eskelinen, N. Hagenah, J.M.H. Knops, A.S. MacDougall, **R.L. McCulley**, J.L. Moore, S.A. Power, J.N. Price, E.W. Seabloom, R. Standish, C.J. Stevens, S. Zimmermann, and N. Eisenhauer. 2023. Drivers of soil biological activity across global grasslands. Communications Biology 6, Article number: 1220.
- Spohn, M., S. Bagchi, L.A. Biederman, E.T. Borer, K.A. Brathen, M.N. Bugalho, M.C. Caldeira, J.A. Catford, S.L. Collins, N. Eisenhauer, N. Hagenah, S. Haider, Y. Hautier, J.M.H. Knops, S.E. Koerner, L. Laanisto, Y. Lekberg, J.P. Martina, H. Martinson, **R.L. McCulley**, P.L. Peri, P. Macek, S.A. Power, A.C. Risch, C. Roscher, E.W. Seabloom, C. Stevens, G.F. Veen, R. Virtanen, and L. Yahdjian. 2023. The positive effect of plant diversity on soil carbon depends on climate. Nature Communications 14, Article number: 6624.
- Vázquez, E., E.T. Borer, M.N. Bugalho, M.C. Caldeira, **R.L. McCulley**, A.C. Risch, E.W. Seabloom, G.R. Wheeler, and M. Spohn. 2023. The synergistic response of primary production in grasslands to combined nitrogen and phosphorus addition is caused by increased nutrient uptake and retention. Plant and Soil. <https://doi.org/10.1007/s11104-023-06083-7>

- Risch, A.C., S. Zimmermann, M. Schutz, E.T. Borer, A.A.D. Broadbent, M.C. Caldeira, K.F. Davies, N. Eisenhauer, A. Eskelinen, P.A. Fay, F. Hagedorn, J.M.H. Knops, J.J. Lembrechts, A.S. MacDougall, **R.L. McCulley**, B.A. Melbourne, J.L. Moore, S.A. Power, E.W. Seabloom, M.L. Silveira, R. Virtanen, L. Yahdjian, and R. Ochoa-Hueso. **2023**. Drivers of the microbial metabolic quotient across global grasslands. Global Ecology and Biogeography 32(6):904-918.
- Dee, L.E., P.J. Ferraro, C.N. Severen, K.A. Kimmel, E.T. Borer, J.E.K. Byrnes, A.T. Clark, Y. Hautier, A. Hector, X. Raynaud, P.B. Reich, A.J. Wright, C.A. Arnillas, K.F. Davies, A. MacDougall, A.S. Mori, M.D. Smith, P.B. Adler, J.D. Bakker, K.A. Brauman, J. Cowles, K. Komatsu, J.M.H. Knops, **R.L. McCulley**, J.L. Moore, J.W. Morgan, T. Ohlert, S.A. Power, L.L. Sullivan, C. Stevens, and M. Loreau. **2023**. Clarifying the effect of biodiversity on productivity in natural ecosystems with longitudinal data and methods for causal inference. Nature Communications 14:2607. <https://doi.org/10.1038/s41467-023-37194-5>
- Daleo, P., J. Alberti, E.J. Chaneton, W. Iribarne, P.M. Tognetti, J.D. Bakker, E.T. Borer, M. Bruschetti, A.S. MacDougall, J. Pascual, M. Sankaran, E.W. Seabloom, S. Wang, S. Bagchi, L.A. Brudvig, J.A. Catford, C.R. Dickman, T.L. Dickson, I. Donohue, N. Eisenhauer, D.S. Gruner, S. Haider, A. Jentsch, J.M.H. Knops, Y. Lekberg, **R.L. McCulley**, J.L. Moore, B. Mortensen, T. Ohlert, M. Partel, P.L. Peri, S.A. Power, A.C. Risch, C. Rocca, N.G. Smith, C. Stevens, R. Tamme, G.F. Veen, P.A. Wilfahrt, and Y. Hautier. **2023**. Environmental heterogeneity modulates the effect of plant diversity on the spatial variability of grassland biomass. Nature Communications. <https://doi.org/10.1038/s41467-023-37395-y>
- Weber, D., R.K. McGrail, A.E. Carlisle, J.D. Harwood, and **R.L. McCulley**. **2023**. Climate change alters slug abundance but not herbivory in a temperate grassland. PLOS ONE 18(3): e0283128.
- Frey, B., B. Moser, B. Tytgat, S. Zimmermann, J. Alberti, L. Biederman, E. Borer, A. Broadbent, M. Caldeira, K. Davies, N. Eisenhauer, A. Eskelinen, P. Fay, F. Hagedorn, Y. Hautier, A. MacDougall, **R.L. McCulley**, J. Moore, M. Nepel, S. Power, E. Seabloom, E. Vazquez, R. Virtanen, L. Yahdjian, and A. Risch. **2023**. Long-term N-addition disrupts the

community composition of functionally important N-cycling soil microorganisms across global grasslands. Soil Biology & Biochemistry 176: 10887.

Abstracts:

- 1) Wolfe, A.J., A.A. Jacobs, J.A. Nelson, A.E. Carlisle, R.K. McGrail, and R.L. McCulley. **2023**. Effect of grass-endophyte symbiotic diversity on pasture soil health in Kentucky. ASA-CSSA-SSSA Annual Meeting, St. Louis, MO.
- 2) McGrail, R.K., R.C. Pearce, S.T. Lucas, L. Moe, and R.L. McCulley. **2023**. Nutrient dynamic considerations for fiber dew retting. ASA-CSSA-SSSA Annual Meeting, St. Louis, MO.
- 3) McGrail, R.K., R.C. Pearce, S.T. Lucas, L. Moe, and R.L. McCulley. **2023**. Inclusion of industrial hemp in Kentucky's cropping rotation: effects on agroecosystem function. ASA-CSSA-SSSA Annual Meeting, St. Louis, MO.
- 4) McGrail, R.K., J.D. Moore, A.E. Carlisle, J.A. Nelson, and R.L. McCulley. **2023**. Novel fungal endophyte infection impacts grassland greenhouse gas emissions under climate stressors. AFGC Annual Meeting, Winston-Salem, NC.
- 5) Jacobs, A.A., M.D. Flythe, D.G. Ely, L. Munoz, J. May, J.A. Nelson, V. Stanton, and R.L. McCulley. **2023**. Feed supplementation with natural red clover product, biochanin A, decreases trace gas emissions from soil-applied livestock waste. AFGC Annual Meeting, Winston-Salem, NC.
- 6) McGrail, R.K., A.E. Carlisle, J.A. Nelson, R.D. Dinkins, and R.L. McCulley. **2023**. Plant and endophyte genetics influence vertical transmission under projected climate change scenarios. AFGC Annual Meeting, Winston-Salem, NC.
- 7) McCulley, R.L. **2023**. Climatic resiliency of Kentucky forage systems. AFGC Annual Meeting, Winston-Salem, NC.

Scientific and Outreach Presentations:

- 1) McCulley, R.L. **2023**. Climatic resiliency of Kentucky forage systems. AFGC Annual Meeting, Winston-Salem, NC.
- 2) McCulley, R.L. **2023**. Hosted International Grassland Congress attendees at the KY Climate Change facility, Lexington, KY.

**MASSACHUSETTS
UNIVERSITY OF MASSACHUSETTS (MASOUD HASHEMI)**

ACCOMPLISHMENTS

Short-term Outcomes:

Experiment 1:

- Increasing cutting height results in higher forage biomass for grazing
- We found a positive impact of N application and higher cutting height.
- Application of N compensates minimally for low grazing height.
- Forage quality (RFV) of forage after is reduced after cutting.

Experiment 2:

- When managed well, stockpiling can significantly improve forage inventory.
- Use of clover in the stockpile can compensate for N application to achieve higher forage yield and quality.

Outputs:

Defined products (tangible or intangible) that are delivered by a research project. Examples of outputs are reports, data, information, observations, publications, and patents. Two publications are under preparation.

Activities:

Organized and specific functions or duties carried out by individuals or teams using scientific methods to reveal new knowledge and develop new understanding.

The results of the two experiments were presented in two field days and one hands-on training targeting dairy farmers.

Milestones: N/A

IMPACTS

We know that at least two farmers have adopted the stockpile management suggested by the researchers.

PUBLICATIONS

N/A

OHIO

OHIO STATE UNIVERSITY (DAVID BARKER)

ACCOMPLISHMENTS

Short-term Outcomes:

A combined undergraduate/graduate course (HCS5100) was established at Ohio State University that culminated in students taking the two exam requirements for the Certification as a Crop Consultant (CCA). The CCA program is administered by the Crop Science Society of America (CSSA), and offers university campuses the option of conducting exams as part of semesters, rather than at the twice-yearly exam options. The passing rate for students completing the international and local exams, was 52.8% and 26.7 better, respectively, than the national average. The exam included modules on 1) nutrient management (including N), 2) soil and water management, 3) IPM, and 4) Crop management. The course is offered annually in spring semester.

Outputs:

Ohio research produced outputs including annual data, and publications. A two-year grazing study to compare contrasting defoliation regimes (regular rotation vs fast rotation) was completed. Field work had been conducted at Jackson OH in 2021 and Wooster in 2022, and data analysis and a MS thesis was completed. Field measurements included forage and animal production. Lab analysis completed in early 2023 included forage nutritive analysis including NDF, ADF, and crude protein.

Activities:

The 5th and 6th years of a study to measure persistence of a native clover, *Trifolium stoloniferum* (running buffalo clover, RBC) were completed. RBC was planted at 8 locations in Ohio that were similar to its natural habitat. RBC is a perennial by virtue of rooting stolons, and the aim was to ensure planted populations were self-sustaining over time.

Milestones:

Preliminary work in Ohio had determined a process for producing individual plants from elongating stolons. RBC is a regulated species, and does not have a supply of seed or plants. Plants can be produced from rooted nodes, and as the stolon elongates, roots form at each petiole

junction (node) along the stolon. Rooted nodes can be separated from the stolon, potted, and grown into an independent plant for future study. Each stolon can grow as many as 20 independent plants. Using this method, 1300 plants were grown for field research.

IMPACTS

Running buffalo clover is a threatened plant species (downgraded from endangered in 2023), with a population in Ohio of approximately 9000 plants. The impact of this research was to successfully establish 10 new field populations during 2018 and 2019 that had become self-sustaining. A total of 1300 greenhouse plants were transplanted to field sites, and in 2023 had expanded to 4164 rooted crowns.

PUBLICATIONS

Lindsey, A.; Barker (2023) Improved Instructional Practices Improve Student Success on Certified Crop Adviser Exams. Natural Sciences Education
<http://doi.org/10.1002/nse2.20102>

Szymczak, de Moraes, Sulc, Barker, Monteiro, Lang, Moraes, Lemaire, Carvalho (2023) Convergence points of optimal herbage accumulation and intake rate by sheep grazing tall fescue. Grass and Forage Science. <http://doi.org/10.1111/gfs.12630>

A. Gauci, J. P. Fulton, A. Lindsey, S. A. Shearer, D. Barker & E. M. Hawkins (2023) “Precision of grain yield monitors for use in on-farm research strip trials”. Precision Agriculture
<https://doi.org/10.1007/s11119-023-10092-y>

Koirala, Barker, Gesch, Mohammed, Heller, Hard, Wells, Phippen, Tas, Lindsey (2023) Seed Treatment Affected Pennycress Establishment and Yield in Two Pennycress Lines. Frontiers in Ecology and Evolution – Interdisciplinary Climate Studies.
<https://www.frontiersin.org/articles/10.3389/fagro.2023.1205259/abstract>

**SOUTH CAROLINA
CLEMSON UNIVERSITY (LILIANE SILVA)**

ACCOMPLISHMENTS

Short-term Outcomes:

Ongoing research efforts have been focusing on the use of annual forage legumes and their impact on forage, animal and soil responses. The first year of a long-term study focusing on overseeding bermudagrass fields was completed in 2023, and forage and soil health parameters will continue to be measured in 2024. Two graduate students and one postdoctoral fellow are directly involved with the projects under this scope.

Outputs: N/A

Activities: N/A

Milestones: N/A

IMPACTS

N/A

PUBLICATIONS

Vasco, C.; Burt, J.; Mullenix, M.K.; Silva, L.S.; Groce, K.; Manson, K.; Prevatt, C.; Tucker, J. 2023. Agronomic and structural responses of stockpiled alfalfa-bermudagrass systems. *Crop, Forage, and Turfgrass Management*. doi: 10.1002/cft2.20223

Abstracts

1. Silva, L., Beer, B., Furlan, R., Adkinson, J., Seavey, K. Evaluation of cool-season forage species as decision tool for forage and livestock producers in South Carolina. 2024 National Association of County Agricultural Agents Conference.

Scientific Presentations

1. Silva, L.; Seavey, K., Adkison, D. Agronomic and nutritive value responses of warm-season annual forage mixtures managed under grazing. 2024 American Forage and Grassland Council. Mobile, Alabama.

Outreach Presentations

1. 2024 New and Beginner Farmer Program. Best Management Practices Workshop. March 28th. Edisto REC, Blackville, SC.

2. Invited speaker at the South Carolina Certified Crop Advisors. Cover crops use on row crop systems. December 7, 2023. Santee, SC.

**TENNESSEE
UNIVERSITY OF TENNESSEE (RENATA NAVE OAKES)**

ACCOMPLISHMENTS

Short-term Outcomes:

This year we prioritized the publication of Dr. Marcia Quinby’s PhD work, on corn production under the white clover living mulch systems.

We were able to publish two manuscripts, as well as an abstract proceedings at the International Grassland Congress held in Kentucky.

Outputs:

Results originated from the project titled “Diversifying corn production systems with white clover living mulch” which encouraged us to continue research in this area. We were able to submit a proposal to the NIFA-Organic Transitions Program, and received funding to initiate a project focusing on the use of perennial legumes as living mulched for organic corn production. The project is currently underway.

Activities:

N/A

Milestones:

N/A

IMPACTS

Perennial forage legumes, such as white clover, can be included as a living mulch in corn silage and grain production in the Southeast. White clover decreases the need to plant cover crops annually and also leads to a reduction in weed pressure. Under normal weather conditions, corn grain and silage produced similar yields, but adding white clover allowed for a greater overall production, likely due to the added N. White clover as a living mulch also showed

positive applications in grazing systems, but further studies are warranted to help advance the use of living mulch in the Southern U.S.

PUBLICATIONS

Quinby, M*., R.L.G. Nave, Sykes, V. R., Bates, G. E., C. Sams and O.G. Almeida. 2023. Corn (*Zea mays* L.) Production in Living Mulch Systems Using White Clover (*Trifolium repens* L.) under Different Nitrogen Fertilization Rates. *Agronomy*. doi.org/10.3390/agronomy13092377.

Almeida, O.G*., C.G.S. Pedreira, J. Assis, B.C. Pedreira, F. Junior, and R.L.G. Nave. 2023. Defoliation management and nitrogen fertilizer rate affect canopy structural traits of grazed guineagrass (*Megathyrsus maximus*) cv. Zuri under rotational stocking. *Crop and Pasture Sci*. doi:10.1071/CP22388.

Quinby, M*., R.L.G. Nave, Sykes, V. R., Bates, G. E., and M. Levi and N. Hill. 2023. Diversifying corn production systems with living mulches in the southeastern United States. doi.org/10.1002/agj2.21294.