

Multistate Research Activity Accomplishments Report 2022

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: 1 July 2020 – 30 June 2022

Date of This Report: July 13, 2023

Annual Meeting Date(s): January 25-26, 2023

Participants:

Nave, Renata - University of Tennessee;
Abagandura, Gandura - University of Nebraska;
Barker, David - Ohio State University;
Cassida, Kim - Michigan State University;
Coffey, Ken - University of Arkansas;
Franklin, Dorcas - University of Georgia;
Guretzky, John - University of Nebraska;
Hashemi, Masoud - University of Massachusetts;
Jacobs, Alayna - University of Kentucky;
Mamo, Martha - University of Nebraska;
McCulley, Rebecca - University of Kentucky;
Menendez, Hector - South Dakota State University;
Miller, Rhonda - Utah State University;
Popp, Michael - University of Arkansas;
Silva, Liliane - Clemson University;
Uddin, Elias - South Dakota State University.
Scaglia, Guillermo - Administrative Advisor;
Hamilton, Christina - NIMSS Coordinator;

Brief summary of minutes of annual meeting:

Wednesday 1/25/2023

4:00-4:10 Introductions. Apologies from Dr Sadowsky – retired; Dr Glaze-Corcoran – travelling

4:10-4:20 Christina Hamilton, NIMS Coordinator

- 1) C. Hamilton described detail for preparation of the Project report.. the report should be an integrated document, not a series of individual state reports (as in prior years). Emphasis should be reported for each objective in the project description, and highlighting areas of collaboration among project participants. The report should emphasize impacts and accomplishments, rather than specific research activity.
- 2) Since this is the 2022 meeting, reporting should include 2021 activity and 2022 activity. Its not essential to cover a specific calendar period, or for specific dates. We did not have a 2021 report, so all activity since the last (2020) report can be included.
- 3) Instructions for the Annual Report are posted at:
<https://www.ncra-saes.org/multistate-handbook> (see #7 for NIMSS multistate meeting and reporting requirements).
- 4) The NC1182 website is at: <https://www.nimss.org/projects/18596>

4:20-6:00 State Reports were presented (approx. 15 min per report, 10 min presentation, 5 mins questions and discussion): Kentucky, Nebraska, Michigan, Massachusetts, Arkansas, Georgia,

Thursday 1/26/2023

4:00-4:10 New introductions

4:10-4:20 Dr Scaglia, Comments from the Administrative Adviser

- 1) Our project was renewed 10/1/2019, and will end 9/30/2024, so a renewal should be submitted by Fall 2023 to get through the necessary approval process. Discussion followed on details of the writing process, and how this will be accomplished. Additional discussion will follow during General Business.
- 2) There was a question about Hatch vs NC1182 reporting. States vary on how Hatch reporting is accomplished, so each state representative should consult their Hatch Administrator. Some states use NC1182 participation to fulfill Federal requirements, and some states require a separate Hatch project for Federal requirements. In either case, the format for reporting state activity should be separate from NC1182 reporting.
- 3) Our Annual Report is due 60 days from the date of this meeting. The report should follow the objectives in the project description. Either bullet, or full text is permitted, but should be consistent throughout the report. The report should emphasize collaborative projects.

4:20-5:35 State Reports were presented (approx. 15 min per report, 10 min presentation, 5 mins questions and discussion): Tennessee, South Carolina, South Dakota, Utah, Ohio.

5:35 General Business

- 1) There was discussion about establishing a writing team to develop the document for the project renewal. Rather than meet in-person, it was considered best to have a Zoom meeting approximately mid-May to develop objectives and assign writing groups. Writing is best accomplished by designated individuals, with each effort collated into a document for review by the project participants. The goal is to have a draft prepared for discussion/approval by the time of our next Annual Meeting.
Action: Barker to submit a Doodle Poll to identify dates/times for a 2hr Zoom in mid-May to initiate the writing plan.
- 2) Annual Meeting. There was unanimous support for an in-person meeting. Preference was for a central location, near an airport hub. The program should allocate time for: i) state reports, ii) field/farm tour, iii) discussion of the project document. This might take 3 days. Two options were considered...
 - a) In conjunction with the American Society of Agricultural and Biological Engineers annual meeting, 7/9/2023 - 7/12/2023 Omaha, Nebraska
<https://www.asabe.org/Event-Detail/2023-annual-international-meeting>
possibly meeting for 3-4 hrs on each of 7/11 & 7/12, with a full day field trip 7/13
 - b) At Altana (in the vicinity of the airport), in late June (not 25-28/6) thru July.
Comprising 3 days/2 nights; Day 1 travel & 2-3 hrs evening meetings; Day 2 field trip and evening meetings?; Day 3 morning meetings & travel.

Action: Barker to submit an email Poll to identify dates and location for a 3-day meeting in June or July.

Accomplishments:

Short-term Outcomes: Quantitative, measurable benefits of the research outputs as experienced by those who receive them. Examples include the adoption of a technology, the creation of jobs, reduced cost to the consumer, less pesticide exposure to farmers, or access to more nutritious food.

The predominant outcomes from this project have been individual research studies within each state, that are described in “Activities”, below. In SC, through educational activities, there has been an increase in the incorporation of alfalfa into bermudagrass systems and the use of cool-season forage mixtures containing legumes. In AR, researchers have worked on two on-line, spreadsheet-based decision support software over the last couple of years. One, optimizes K-fertilizer application rates (Potash rate calculator – PRC) for soybean, corn, cotton, and rice by considering not only yield response to added fertilizer-K and soil-test K but also the price of the crop and the cost of fertilizer. The second Litter Soil Crop Calculator (LSC) models subsurface application of poultry litter in comparison to broadcasted poultry litter and commercial fertilizer with the intent of reducing N-volatilization, odor externalities, and nutrient runoff potential while reducing reliance on synthetic fertilizers. Both tools are available on-line at <https://agribusiness.uark.edu/decision-support-software.php>.

In GA, early findings were a result of farmers interest in preventing N losses through NH₃ volatilization and N₂O emissions and the impact that filth flies have on the amount of plant available N (inorganic N). Preliminary results indicated that with increase numbers of predators, filth flies numbers declined as do N losses of N₂O and NH₃. Researcher found that under extreme changes in weather, a very droughty to two very wet years strategic grazing and rolling out of hay increased N and P in the upper 0-5 cm soil layer. These grazing practices also lost Soil C in the Upper –10 cm but increase labile C (Oxidizable Permanganate Carbon) in the 10-20 cm soil layers. These findings related to Objectives 2 & 3.

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

The primary output from this project are research publications (listed below). Interim outputs include reports, data, and information that leads to publications. Other outputs include research results that are shared with producers at extension meetings, and agronomic information that is included into educational curriculum delivered to K-12, undergraduate and graduate students. The University of Arkansas produced decision software products, and delivered to stakeholders as an online resource. The majority of participants gave scientific presentations at professional meetings (typically are unpublished, or Abstracts). There were no patents from this program.

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

There is a critical need to determine ways to improve N-use efficiency at the soil, plant, and animal interface to improve long-term sustainability of livestock production while concurrently reducing potential pollutants and greenhouse (GHG) emissions. Recent work at University of Kentucky

suggests that a natural isoflavone compound present in red clover leaves, biochanin-A, may be used as a feed supplement to increase nitrogen use efficiency and resulting gains in steers. Despite production benefits, the overall environmental implications of biochanin-A feed supplementation have not been evaluated. They conducted a study to compare effects of feeding biochanin A to lambs on N loss in urine. In addition, GHG emissions from soils amended with urine from lambs fed no biochanin-A and lambs fed biochanin A at two different dosages were measured to assess potential effects on soil microbial communities and function. High levels of biochanin-A feed supplementation reduced soil N₂O and CH₄ emissions and completely eliminated ammonia volatilization for the first few days after urine application. However, no changes in soil microbial communities were detected nor were there differences in urine N content across feeding trials, which suggested that the mechanism by which biochanin-A reduces GHG fluxes was most likely related to changing soil enzyme activity. This research indicated that feeding lambs biochanin-A will reduce GHG fluxes from urine patches in pastures and thereby improve the sustainability of pasture-based animal production systems. This research contributed to Objectives 2 and 3 of NC-1182.

At AR, model improvements and further analyses are on-going to improve the value of the tools. The PRC tool is actively used by extension agents to inform producers of financial repercussions of alternative K-fertilizer application rates as the tool works on a field specific basis to take soil-test K and yield potential as well as current crop price and fertilizer cost into account. Forage research on summer annuals has shown subsurface application of poultry litter to lead to greater yield and greater profitability in comparison to broadcasted poultry litter. Papers and on-line testimonials are in progress.

In a field study at AR, crossbred steers grazed pasture of bermudagrass (CONT), bermudagrass overseeded with sorghum sudan grass (SS), or bermudagrass overseeded with sorghum sudangrass and cowpea (SSCP) in alternate drill passes. Animal gains were 2.3 lb/day in SSCP and 2.1 lb/day in SS vs. 1.7 lb/day from CONT. Grazing days were greatest in CONT (91 d) followed by SS (68 d), with the fewest grazing days in SSCP (60 d). The combination of gain and grazing days combined for similar gain/acre across treatments. However, since nitrogen fertilizer input was reduced with SSCP, those pastures had the greatest N-use efficiency.

At SC, research is being conducted to assess forage production and profitability of legume-based systems under a low input strategy in response to needs assessment in SC.

Researchers at University of Massachusetts conducted a greenhouse experiment to evaluate the effect of cutting height and nitrogen on grass regrowth and physiology. The agronomic effects of height and nitrogen on plant regrowth are well known, but there is limited information on the physiological effects that affect plant vigor and stress response. An additional study compared the tall fescue stockpile with orchardgrass stockpile and a mix of the two types of grass. Each grass treatment was crossed in a factorial design with four nitrogen treatments: 1) no late summer nitrogen, 2) 50 lbs/acre nitrogen in early August, 3) 50 lbs/acre nitrogen in late August, and 4) inclusion of red clover in a pasture. The plots were maintained for two years in the same location. Each year, the pastures were sampled in late October to assess the yield and forage quality of the different grasses with each nitrogen management treatment.

At SC, research studies reduced and enhanced the incorporation of legumes into forage and integrated crop-livestock systems by 2027 through the dissemination of research-based information and adoption of technologies.

At ME, two studies are in-progress to achieve this objective. In first study (study I), we are evaluating the effects of isoacid supplementation under two dietary conditions (i.e., four treatment groups) on milk yield, milk fatty acid profile, nutrient digestibility, and enteric methane emission of lactating dairy cows. In this study, 64 lactating dairy cows (i.e., 16 cows per treatment group) were used. A second study (study II), evaluated again three diet with varying levels of structural and non-structural carbohydrates on nutrient utilization efficiency and feed efficiency including microbial changes in the rumen, a compartment of ruminant stomach. This work contributed to Objectives 1 & 2.

In NE, the establishment and management of forage legumes has often been presented as an alternative to nitrogen fertilization to sustain pasture productivity and grazing livestock. Mixed stands of perennial grasses and legumes, indeed, often produce as much, if not more, forage biomass and greater forage quality as stands of nitrogen-fertilized grasses. Existing literature, however, contains little information on productivity of mixed stands of annual grasses and legumes that may be grazed and utilized on cropland. Across the last three years, our research has evaluated how co-seeding grasses and legumes in a grazed, double cropped, annual forage system affects aboveground biomass, soil nitrogen availability and greenhouse gas emissions. In contrast to hypotheses, though, we have found nitrogen-fertilized pastures to produce 23-31% and 9-21% more aboveground biomass across spring and summer production phases than legume-mixed and unfertilized pastures, respectively. A failure of legumes to compensate for lost grass productivity in the absence of fertilization explains poor performance from the legume-mixed system. In the summer production phase, though, co-seeding legumes reduced weedy biomass production by 42% and 23% relative to fertilized and unfertilized systems, respectively. A reduction in weedy biomass may be of benefit in crop rotations through relief of subsequent weed pressure.

Milestones: Key intermediate targets necessary for achieving and/or delivering the outputs of a project, within an agreed timeframe. Milestones are useful for managing complex projects. For example, a milestone for a biotechnology project might be "To reduce our genetic transformation procedures to practice by December 2004."

Impacts:

This section focuses on actual or intended potential long-term outcomes and impacts. Committees should build information around the activity's milestones, as identified in the original proposal. The report should also reflect on the items that stakeholders want to know, or want to see. List any grants, contracts, and/or other resources obtained by one or more project members as a result of the project's activities. Include the recipients, funding source, amount awarded and term if applicable. If the committee is filing an annual report, the impacts will cover only the current year of the project; for termination reports, list impacts from the entire span of the project.

Additional Definitions of "Impact":

"The economic, social, health or environmental consequences derived as benefits for the intended users. These are usually quantitatively measured either directly or indirectly as indicators of benefits. (An example of an impact would be improved human nutrition for so many individuals through genetically engineering rice to contain the precursors to vitamin A.)"

Source: National Multistate Guidelines - Glossary

"The quantifiable difference a land-grant program makes in the quality of life for its clients and general citizenry.' Supplementing that brief statement is also the definition of an impact statement: 'A brief document that describes the social, environmental, and/or economic difference that your research, teaching, or extension efforts have made on the public. Specifically, it states your accomplishments and the payoff to society.'"

Source: National Impact Statement Writing Team

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

In SC, researchers have developed recommendations for forage legumes as a handbook to be distributed to producers. Additional grant applications are currently being established/written, aiming to address the main area of this project, but funding has not been acquired for research yet on the timeframe of the report. Two USDA Climate-smart grants were approved and are currently in the final stage of contracting.

In AR, dietary studies with livestock found a greater proportion of the excreted nitrogen should be available to the forages in the pasture system in a more slowly-released form to provide nitrogen for an extended period of time and improve the nitrogen use by the forages growing in the pasture system. Reducing emissions of nitrogenous gasses should reduce greenhouse gas and nitrogen pollution from forage-based livestock production systems.

In ME, studies to mitigate enteric methane will not only improve environmental sustainability but also economic sustainability through improvement of efficiency because 2-12 % of energy consumed by the lactating cows could be lost as enteric methane. Supplementation of feed additives have been found to be effective to mitigate enteric emission while improving feed efficiency. However, effects of feed additives might depend on the dietary composition of lactating cows. Thus, our studies (study III & IV) will demonstrate the effectiveness of feed additives under different scenarios which will help us identifying best scenarios for economic and environmental sustainability.

The research at NE, has potential to impact the broader public because of its emphasis on evaluating use of legumes versus nitrogen fertilizer in forage-based livestock production systems. Greater use of legumes versus nitrogen fertilizer will reduce greenhouse gas emissions and nitrogen losses to the environment, thereby reducing impact of agriculture on climate change and costs to ameliorate non-point source pollution of U.S. water systems. Use of legumes in forage-based livestock production systems also has the potential to enhance habitat for wildlife like grassland birds that depend on seeds from forbs and pollinators like bees and butterflies that use floral resources, pollen, and nectar for nutrient and energy intake.

Milestones: Key intermediate targets necessary for achieving and/or delivering the outputs of a project, within an agreed timeframe. Milestones are useful for managing complex projects. For example, a milestone for a biotechnology project might be "To reduce our genetic transformation procedures to practice by December 2004."

Separate milestones are used within respective projects at each state as appropriate to accomplish proposed research

Indicators: Qualitative surrogate observations or indirect measures of quantitative performance measures which permit monitoring the achievement of outcomes when direct measurement of performance is difficult, too costly, or not possible. An indicator of cultivar adoption might be seed certification records, rather than actual land area planted to that cultivar.

In NE, The target audience for this research has been the science community, beef cattle producers and consultants, and students at the University of Nebraska-Lincoln. The targeted audience benefited through sharing of research findings in Nebraska Beef Cattle Reports and in meeting presentations and abstracts, and lectures delivered on nitrogen management in forages. The double cover cropping experiment described in our major activities provided an opportunity for an undergraduate student, Benjamin Niyodusenga, to gain research experience while working on the project. Benjamin presented a poster on the research at the University of Nebraska-Lincoln Summer Research Symposium and a poster and an oral presentation on the research at the ASA-CSSA-SSSA International Annual Meetings in Baltimore, Maryland. A graduate student trained who worked on these projects included Kelton Adair, M.S. in Animal Science in December 2022. A grant submission related to nitrogen management to the Nebraska Soybean Board in 2022 was funded at \$52,366. We also submitted a grant for the USDA Climate Smart program, \$46 million, proposing low-carbon intensity beef in a climate smart supply chain using innovative housing and manure management to recycle concentrated, renewable nitrogen fertilizer, but it was not funded. Also not funded was a USDA NIFA AFRI Foundational Knowledge of Agricultural Production Systems grant proposal titled "Enhancing Legumes, Forage Quality, and Soil Nitrogen in Grazed, Double Cover Crop Systems.

Publications: For SAES-422 reports list the publications for **current** year only (with the authors, title, journal series, etc.). If the list exceeds the maximum character limit below, an attachment file may be used. (Max characters = 50,000. Single line breaks are not preserved, use double line breaks instead or use a <p> tag to separate paragraphs.)

Publications (since 2020):

Journal Articles

1. Andrade, B.O., J.D. Dallmann, J.D. Volesky, W.H. Schacht, and J.A. Guretzky. 2021. Grassland plant community response to interacting disturbances and temporal variability. *Restoration Ecology* <https://doi.org/10.1111/rec.13495>. Bianca Ott Andrade (post-doc), Josiah Dallmann (M.S. student).
2. C.A. Welchons, R.G. Bondurant, T.J. Klopfenstein, A.K. Watson, J. Parsons, J.C. MacDonald. 2021. Performance and economics of backgrounding yearling beef steers on smooth brome grass pastures. *Applied Animal Science*. 37:68-76.
3. T.J. Spore, Z.E. Carlson, K.H. Wilke, G.E. Erickson, T.J. Klopfenstein, J.C. MacDonald, A.K. Watson. 2021. Effects of replacing wet distillers grains with supplemental SoyPass in forage-based growing cattle diets. *Trans. Anim. Sci.* 5:1-10. Publications:
4. Price, J.N., J. Sitters, T. Ohlert, P.M. Tognetti, C.S. Brown, E.W. Seabloom, E.T. Borer, S.M. Prober, E.S. Bakker, A.S. MacDougall, L. Yahdjian, D.S. Gruner, H. Olde Venterink, I.C. Barrio, P. Graff, S. Bagchi, C.A. Arnillas, J.D. Bakker, D.M. Blumenthal, E.H. Boughton, L.A. Brudvig, M.N. Bugalho, M.W. Cadotte, M.C. Caldeira, C.R. Dickman, I. Donohue, S. Gregory, Y. Hautier, I.S. Jonsdottir, J.L. Lannes, R.L. McCulley, J.L. Moore, S.A. Power, A.C. Risch, M. Schutz, R. Standish, C.J. Stevens, G.F. Veen, R. Virtanen, and G.M. Wardle. 2022. Evolutionary history of grazing and resources determine herbivore exclusion effects on plant diversity. *Nature Ecology & Evolution* 6(9): 1290-1298. <https://doi.org/10.1038/s41559-022-01809-9>
5. Vázquez, E., P.-M. Schleuss, E.T. Borer, M.N. Bugalho, M.C. Caldeira, N. Eisenhauer, A. Eskelinen, P.A. Fay, S. Haider, A. Jentsch, K.P. Kirkman, R.L. McCulley, P.L. Peri, J. Price, A.E. Richards, A.C. Risch, C. Roscher, M. Schütz, E.W. Seabloom, R.J. Standish, C.J. Stevens, M.J. Tedder, R. Virtanen, and M. Spohn. 2022. Nitrogen but not phosphorus addition affects symbiotic N₂ fixation by legumes in natural and semi-natural grasslands located on four continents. *Plant and Soil* 478: 689-707. <https://doi.org/10.1007/s11104-022-05498-y>
6. Nepel, M., R. Angel, E.T. Borer, B. Frey, A.S. MacDougall, R.L. McCulley, A.C. Risch, M. Schutz, E.W. Seabloom, and D. Woebken. 2022. Global grassland diazotrophic communities are structured by combined abiotic, biotic, and spatial distance factors but resilient to fertilization. *Frontiers in Microbiology*. doi: 10.3389/fmicb.2022.821030
7. Gill, A.L., P.B. Adler, E.T. Borer, C.R. Buyarski, E.E. Cleland, C.M. D'Antonio, K.F. Davies, D.S. Gruner, W.S. Harpole, K.S. Hofmockel, A.S. MacDougall, R.L. McCulley, B.A. Melbourne, J.L. Moore, J.W. Morgan, A.C. Risch, M. Schutz, E.W. Seabloom, J.P. Wright, L.H. Yang, and S.E. Hobbie. 2022. Nitrogen increases early-stage and slows late-stage decomposition across diverse grasslands. *Journal of Ecology* 110(6):1376-1389. doi: 10.1111/1365-2745.13878
8. Langley, J.A., E. Grman, K.R. Wilcox, M.L. Avolio, K.J. Komatsu, S.L. Collins, S.E. Koerner, M.D. Smith, A.H. Baldwin, W. Bowman, N. Chiariello, A. Eskelinen, H. Harmens, M. Hovenden, K. Klanderud, R.L. McCulley, V.G. Onipchenko, C.H. Robinson, and K.N. Suding. 2021. Do tradeoffs govern plant species responses to different global change treatments? *Ecology* 103(6):e3626. doi: 10.1002/ecy.3626
9. Arnillas, C.A., E.T. Borer, E.W. Seabloom, J. Alberti, S. Baez, J.D. Bakker, E.H. Boughton, Y.M. Buckley, M.N. Bugalho, I. Donohue, J. Dwyer, J. Firn, R. Gridzak, N. Hagenah, Y. Hautier, A. Helm, A. Jentsch, J.M.H. Knops, K.J. Komatsu, L. Laanisto, R. Laungani, R.L. McCulley, J.L. Moore, J.W. Morgan, P. Luis Peri, S.A. Power, J. Price, M. Sankaran, B. Schamp, K. Speziale, R. Standish, R. Virtanen, and M.W. Cadotte. 2021. Opposing community assembly patterns for

- dominant and nondominant plant species in herbaceous ecosystems globally. *Ecology and Evolution* 11(24):17744-17761. doi: 10.1002/ece3.8266
10. Ebeling, A., A.T. Strauss, P.B. Adler, C.A. Arnillas, I.C. Barrio, L.A. Biederman, E.T. Borer, M.N. Bugalho, M.C. Caldeira, M.W. Cadotte, P. Daleo, N. Eisenhauer, A. Eskelinen, P.A. Fay, J. Firn, P. Graff, N. Hagenah, S. Haider, K.J. Komatsu, R.L. McCulley, C.E. Mitchell, J.L. Moore, J. Pascual, P.L. Peri, S.A. Power, S.M. Prober, A.C. Risch, C. Roscher, M. Sankaran, E.W. Seabloom, H. Schielzeth, M. Schutz, K.L. Speziale, M. Tedder, R. Virtanen, and D.M. Blumenthal. 2021. Nutrient enrichment increases invertebrate herbivory and pathogen damage in grasslands. *Journal of Ecology* 110(2):327-339. doi: 10.1111/1365-2745.13801
 11. Jing, X., C.M. Prager, E.T. Borer, N.J. Gotelli, D.S. Gruner, J-S. He, K. Kirkman, A.S. MacDougall, R.L. McCulley, S.M. Prober, E.W. Seabloom, C.J. Stevens, A.T. Classen, and N.J. Sanders. 2021. Spatial turnover of multiple ecosystem functions is more associated with plant than soil microbial B-diversity. *Ecosphere* 12(7): e03644. Doi: 10.1002/ecs2.3644
 12. Oliver, K. B., Popp, M. P., Slaton, N. A., Drescher, G. L., Roberts, T. L. (2022). Profit-maximizing potassium fertilizer recommendations for corn and cotton. *Agronomy Journal*, 114, 3358-3376. DOI: 10.1002/agj2.21205
 13. Stults, T. J., Popp, M. P. (2022). A Decision-Support System for Economic Feasibility of Subsurfaced Poultry Litter. *Journal of Applied Farm Economics*, 5(1), 28-48. Purdue University. <https://docs.lib.purdue.edu/jafe/vol5/iss1/3/>
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 15. Grote, A.J., C.C. Nieman, A.R. Morgan, K.P. Coffey, D. Philipp, E.B. Kegley, J.L. Edwards. 2023. Using supplemental condensed tannin to mitigate tall fescue toxicosis in non-pregnant, non-lactating ewes consuming tall fescue silage. *Anim. Feed Sci. Technol.* 295:115516. doi.org/10.1016/j.anifeedsci.2022.115516
 16. Diaz, J.M., K.P. Coffey, W.K. Coblenz, D. Philipp, V. Niyigena. 2022. Intake, digestibility, and nitrogen balance by sheep offered ensiled tall fescue, meadow fescue, or orchardgrass that was fertilized with dairy slurry or urea. *Anim. Feed. Sci. Technol.* 292:115447. doi.org/10.1016/j.anifeedsci.2022.115447
 17. Gunter, S. A., M. S. Gadberry, K. P. Coffey, C. A. Moffet. 2022. Comparison of two software programs for fitting one- and two-compartment age-dependent non-linear digestion models for ruminants: empirical data. *Anim. Prod. Sci.* doi:10.1071/AN21311.
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 20. Nieman, C. C., W. K. Coblenz, and K. P. Coffey. 2021. Application of poultry litter and moisture effects on rye-ryegrass-fescue baleage. *Crop, Forage, Turfgr. Manage.* DOI: 10.1002/cft2.20118.
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25. Dahal, S., Franklin, D.H., Subedi, A., Cabrera, M.L., Ney, L., Fatzinger, B. and Mahmud, K., 2021. Interrelationships of Chemical, Physical and Biological Soil Health Indicators in Beef-Pastures of Southern Piedmont, Georgia. *Sustainability*, 13(9), p.4844.
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29. Cassity-Duffey, K., M.Cabrera, J. Gaskin, f D. Franklin, D. Kissel, and U. Saha. 2020. Nitrogen mineralization from organic materials and fertilizers: Predicting N release. *Soil Science Society of America Journal*, 84(2), pp.522-533.

State reports

1. E.A. Schumacher, G.E. Erickson, H.C. Wilson, M.M Norman, J.C. MacDonald, A.K. Watson, T.J. Klopfenstein. Comparison of rumen undegradable protein content of conventional and organic feeds. *Nebraska beef cattle report*, MP108:45-49.
2. K.C. Adair, K.H. Wilke, A.K. Watson. 2023. Forage evaluation of crested wheatgrass. *Nebraska beef cattle report*, MP116:29-31.
3. T.J. Spore, H.C. Wilson, N.R. Meier, G.E. Erickson, J.C. MacDonald, T.J. Klopfenstein, A.K. Watson. 2022. Impact of urea on corn silage growing cattle diets. *Nebraska beef cattle report*, MP115:22-25.

Abstracts

1. Niyodusenga, B., Mamo, M., Abagandura, G., Butler, M., Guretzky, J. 2022. Effects of animal integration and nitrogen fertilization on greenhouse gas emissions. Oral Presentation at the ASA-CSSA-SSSA. International Annual Meeting. Baltimore, Maryland.
2. Niyodusenga, B., Mamo, M., Abagandura, G., Butler, M., Guretzky, J. 2022. Benefits of animal integration and nitrogen fertilization on soil nitrogen levels during the growing season. Poster Presentation at the ASA-CSSA-SSSA. International Annual Meeting. Baltimore, Maryland.
3. Niyodusenga, B., Mamo, M., Abagandura, G., Butler, M., Guretzky, J. 2022. Effect of cover crops, grazing, and nitrogen fertilization on greenhouse gas emissions. Poster Presentation at the University of Nebraska-Lincoln Summer Research Symposium, Lincoln, Nebraska.
4. K. Adair, A. Watson, J. MacDonald, K. Wilke. 2022. Evaluation of forage quality of crested wheat grass. *J. Anim. Sci.* 100 (Suppl. 2):220. Midwest ASAS meetings.
5. Fouraker, M., G. Abagandura, M. Mamo, and J. Guretzky. 2021. Greenhouse Gas Emissions Affected By Grazing and Nitrogen Sources on Annual Pasture [Abstract]. ASA, CSSA, SSSA

- International Annual Meeting, Salt Lake City, UT. 7-10 November 2021. <https://scisoc.confex.com/scisoc/2021am/meetingapp.cgi/Paper/133697>
6. Fouraker, M., G. Abagandura, M. Mamo, J. Guretzky. 2021. Effect of Nitrogen Management on Grazed Double Cropped Annual Pasture [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Salt Lake City, UT. 7-10 November 2021. <https://scisoc.confex.com/scisoc/2021am/meetingapp.cgi/Paper/133696>
 7. Dallmann, J., Andrade, B., Schacht, W., Volesky, J., Guretzky, J. (Presenter), 2021. Plant Community Response to Disturbances in Nebraska Sandhills Upland Prairie. Nebraska Section of the Society for Range Management Annual Meeting, October 13, 2021.
 8. T. Spore, M. Jolly-Breithaupt, N. Meier, G. Erickson, T. Klopfenstein, J. MacDonald, A. Watson. 2021. Effects of increasing urea in corn silage diets and duration of ensiling on the rumen undegradable protein content of corn silage. J. Anim. Sci. 99 (Suppl. 2):2521. Midwest ASAS meetings.
 9. Subedi, A., Franklin, D., Espinoza, N., & Cabrera, M. (2022). Differences in soil carbon, nitrogen, and nitrogen emissions between pastures fertilized with either broiler litter or mineral fertilizer. International Meeting Tri-society
 10. Espinoza, N., Franklin, D., Subedi, A., & Cabrera, M. (2022). Filth Fly Effects on nitrogen losses from cattle manure in continuously grazed systems. International Meeting Tri-societies
 - 11.

Conference and Other outputs

1. Meyer, I., M. Popp, C. Nieman and K. Coffey. 2023. “Economic Feasibility and Soil Health Implications of Improved Bermudagrass Pastures Using Alternative Nutrient Management Strategies”. Selected Paper. Southern Agricultural Economics Annual Meeting, Oklahoma City, Feb. 4-8, 2023.
2. I., M. Popp, C. Nieman and K. Coffey. 2023. “Economic Feasibility of Grazing Feeder Cattle on Sod-seeded Sorghum Sudan Grass Using Poultry Litter for Fertility”. Selected Paper. Southern Agricultural Economics Annual Meeting, Oklahoma City, Feb. 4-8, 2023.
3. <https://agribusiness.uark.edu/decision-support-software.php> provides on-line access to decision makers.
4. Uddin ME (Invited Speaker). Evaluation of enteric methane mitigation strategies in cattle using in-vivo experiment and holistic life cycle assessment. Minnesota 83rd Nutrition Conference organized by the Department of Animal Science, University of Minnesota, and University of Minnesota Extension and held at Mankato Minnesota from 21-22 September, 2022.
5. M. Bulnes, J. Bonilla, M. Suazo, G. Begalli, A. F. Souza, J. Lefler, L. Marotz, J. Osorio, Uddin ME. 2022. Effects of supplementing rumen direct-fed endomicrobials to dairy cows during pre-and postpartum on milk production and composition. Minnesota Institute of Food Technologist Great Plains Subsection Conference held at SDSU in March-2022 (Graduate student secured the 1st place in poster competition).
6. M. Bulnes, J. Bonilla, M. Suazo, G. Begalli, A. F. Souza, J. Lefler, L. Marotz, J. Osorio, Uddin ME, 2022. Effects of supplementing rumen direct-fed endomicrobials to dairy cows during pre-and postpartum on milk production and composition. American Dairy Science Association (ADSA) Meeting-2022 held at Kansas City, Missouri from 19-22 June, 2022.
7. Espinoza, N., Franklin, D., Subedi, A., Cabrera, M., Hinkle, N., & Stewart, L. (2022). How are filth flies involved in wasting nitrogen?. <https://lpecl.org/how-are-filth-flies-involved-in-wasting-nitrogen/>
8. Franklin, D., Subedi, A., & Cabrera, M. (2022). Can Grazing Systems Affect Plant Available N and P?. <https://lpecl.org/can-grazing-systems-effect-plants-available-n-and-p/>

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**Limited to three pages or less exclusive of publications, details may be appended.*