

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

**Project/Activity Number:** NCCC-31

**Project/Activity Title:** Ecophysiological Aspects of Forage Management

**Period Covered:** June 2019 to May 2020

**Date of This Report:** September 9, 2020

**Annual Meeting Date(s):** Virtual, 22-23 July 2020

**Brief summary of minutes of annual meeting:**

State	Attending members	Institution	Reported remotely
AR		USDA-ARS	Amanda Ashworth
AR		University of Arkansas	Dirk Philipp
KY		University of Kentucky	Rebecca McCulley
MA		University of Maryland	Bill Lamp
MI		Michigan State University	Kim Cassida, Jim Kells (administrator)
MN		University of Minnesota	Jake Jungers
MO		University of Missouri	Harley Naumann
NE		University of Nebraska	John Guretzky
ND		North Dakota State University	Marisol Berti
OH		The Ohio State University	Marc Sulc
OR		Oregon State University	Guojie Wang
TN		University of Tennessee	Renata Nave
TX		Texas Tech University	Chuck West
TX		Texas A&M	Jamie Foster, Vanessa Olson
UT		Utah State University	Jennifer McAdam
WI		Univ. of Wisconsin, ARS-USDA	Valentin Picasso
WY		University of Wyoming	Anowar Islam

Attended business meeting but did not report: Jeff Volenec, Purdue University; Ben Tracy, Virginia Tech.

**Activities:**

<b>Wednesday July 22 (CDT)</b>	
10:00 Welcome, announcements, and updates	<b>State reports (Cont.)</b>
<b>10:10- 1:35 State reports</b>	1:05 Utah- Jennifer MacAdam
10:10 Arkansas-Dirk Philipp/ Amanda Ashworth	1:15 Wyoming- Anowar Islam
10:20 Kentucky- Rebecca McCulley	1:25 Wisconsin-Valentin Picasso
10:30 Maryland- Bill Lamp	1:35 Adjourn
10:40 Michigan-Kim Cassida	
10:50 Minnesota- Jake Jungers	<b>Thursday July 23 (CDT)</b>
11:00 Missouri- Harley Naumann	10:00 Business Meeting
11:10 Nebraska- John Guretzky	10:00 Jim Kells, Michigan State University
11:20 North Dakota- Marisol Berti	10:10 Jim Dobrowolski (NIFA Representative update)
<b>11:30 Coffee Break</b>	10:20 Forage course discussions (Chuck West and Jennifer MacAdam)
12:15 Ohio- Mark Sulc	<b>Business Meeting</b>
12:25 Oregon- Guojie Wang	- Annual report
12:35 Texas Tech- Chuck West	- Renewal of NCCC31
12:45 Texas A&M- Vanessa Olson/ Jamie Foster	- Publishing of special issues (3 total)
12:55 Tennessee- Renata Nave	12:30 Adjourn

\* Planned meeting and field visit planned in Laramie, WY was cancelled due to COVID-19.

**Business meeting minutes**

- Twenty participants. *Visitor*: Jose Franco (USDA-ARS)
- State report presentations: Arkansas, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oregon, Texas (Texas Tech and Texas A&M), Tennessee, Utah, Wyoming, and Wisconsin.
- Updates by new NIFA Representative: new program areas, funding opportunities, and updates in AFRI and NIFA.
- Discussion about online teaching, Chuck West and Jennifer MacAdam.
- 5 year renewal with minimal alterations. Committee is in good standing and is perceived to be a productive committee.
- Next meeting locations: Laramie, WY (since travel was not permitted in 2020). Host: Wyoming-Anowar Islam.
- Renata Nave incoming chair: 2021; Guojie Wang incoming secretary. Valentin Picasso nominated to be incoming chair, 2023.
- Valentin Picasso: will plan for a multistate grant proposal (e.g. CAP project) within the next few months.
- Jose Franco, Valentin Picasso and Jennifer MacAdam: editors for Special Issues – Agronomy. Three special issues (Multifunctional Forages; Biomass Crop Production, Management, and Ecophysiology; and New Paradigms in Sustainable Forage-Livestock Production Systems).
- NCCC31 committee is considering a 2-hour training event for writing impact statements for state reports. Incoming chair will make request to either host training in tandem with the meeting in 2021 or as a side meeting.

**STATE REPORTS**  
**NCCC31- Ecophysiological Aspects of Forage Management, 2020 Report**

**Arkansas Report 2019-2020**  
**University of Arkansas, Animal Science Department**

1. Impact Nugget

The group from the University of Arkansas is engaged in applied research and extension activities pertaining to the use of warm season annuals and perennial, and cool season perennial forage crops. We have also extending our activities into the areas of determining N fluxes in pastures and measuring N-use efficiencies across the soil-plant-animal interface. More recently, we have been working in the area of agroforestry and silvopastoral applications and continue to cooperate with university and USDA research stations and private landowners state-wide. Generated data and knowledge is published in peer-reviewed journals and summarized in extension publications such as newsletter articles and factsheets.

2. New Facilities and Equipment

None

3. Unique Project-Related Findings

None

4. Accomplishment Summaries

During 2019, two agroforestry-related projects were started: 1) assessment of annual and perennial forages in thinned pine tree plantations and 2) establishment of perennial forages in a thinned native hardwood forest. Forages were selected based on previous research and experience from participating landowners. We also continued a NIFA-funded project on the effects of tannin-containing silage diets on sheep intake and soil quality parameters and ammonia emissions after the application on native warm-season grasses of collected urine and feces resulting from this study. This is an extension from last year's objective of testing gaseous emissions profiles (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>) resulting from sheep urine and slurry applications on tall fescue in spring and fall. Arkansas (Department of Animal Science, Philipp et al.) published data on variety of basic forage-agronomy research topics. Outreach activities included the delivery of our findings during in-service training sessions, field days, and through various extension publications. A summary of all publications from the last reporting period is included at the end of this document.

5. Impact Statement

**Issue:**

Grazing systems resiliency is important for long-term sustainability of grassland agriculture. Arkansas is covered with wooded areas by 60% and opportunities exists to establish silvopastoral systems for enhanced diversity and income from timber and animal products. The high likelihood of changing climatic patterns will also require finding solutions to mitigate adverse effects from increasingly dry and hot summers. Silvopasture systems may offer the opportunity for cattle grazing with lower ambient temperatures yet sufficient forage growth in alleyways.

**Action:**

During 2019, we secured multi-year funding to evaluate establishment strategies and persistence of forages grown under silvopastoral conditions. Eight commonly used forages were selected including perennial, annual, grass, and legume species to monitor growth and environmental dynamics in pine tree

alleys located in the Arkansas River Valley. Plots were established in October of 2019 and will replanted and maintained for another 2-3 years. In addition to small-plot-research, we are working with landowners and producers to establish demonstrations and limited research in thinned forests on their properties with the goal of making our results highly accessible to the public. During spring and summer of 2020, we moved to thin a selected hardwood forest area to be used for testing emergence and growth of perennial cool season forages. In addition, we collected baseline soil samples to map the research hardwood area and will monitor changes in soil quality over time.

**Impact:**

This multi-year project serves as a testing ground for shaping silvopastoral systems that are sustainable and resilient due to their multi-use components. Our project provides information on the resilience of a variety of forage species and strategies for a multi-purpose use of wooded areas and grazing grounds.

**Contact:**

Dirk Philipp, Department of Animal Science

479/575-7914 / [dphilipp@uark.edu](mailto:dphilipp@uark.edu)

Cooperators: C. Nieman, J. Franco (USDA-ARS, Booneville, AR)

**Funding: This project is being realized with appropriations from USDA-Southern SARE.**

**6. Published Written Works (selected peer-reviewed and outreach-oriented)**

Nieman, C., and D. Philipp. 2019. Forage establishment in loblolly pine plantations in Arkansas. *Temperate Agroforestry*, Association for Temperate Agroforestry; 25:3.

Niyigena, V., K. Coffey, R. Rhein, J. Caldwell, W. Coblenz, D. Philipp, B. Shanks, A. Young. 2019. Intake and digestibility by gestating sheep offered alfalfa silage wrapped with plastic with or without an oxygen-limiting barrier after extended time delays. *Anim. Feed. Sci. Technol.*, Vol. 254, Article 114193.

Dold, C., Thomas, Andrew. L., Ashworth A. J., Philipp, D., Brauer, D.K., Sauer, T.J.; 2019. Carbon sequestration and nitrogen uptake in a temperate silvopasture system. *Nutrient Cycling in Agroecosystems*. 114:85-98.

Dirk Philipp, Ben Putman, Greg Thoma. 2019. ASAS-CSAS annual meeting symposium on water use efficiency at the forage-animal interface: Life cycle assessment of forage-based livestock production systems, *Journal of Animal Science*, Volume 97, Issue 4 Pages 1865–1873, <https://doi.org/10.1093/jas/skz035>

Adams, T.C., Philipp, D., Burner, D.M., Jennings, J., Peake, B.M., Ashworth, A.J., Pote, D.H., Burke, J.M. and Rhein, R. 2019. White (*Trifolium repens* L.) and Arrowleaf (*Trifolium vesiculosum* Savi) Clover Emergence in Varying Loblolly Pine (*Pinus taeda* L.) Tree Alley Spacings. *American Journal of Plant Sciences*, 10, 659-669. <https://doi.org/10.4236/ajps.2019.104048>

Bertucci, M.B., D. Philipp, J. A. Jennings, R. T. Rhein. 2019. Assessment of bermudagrass forage yield and nutrient uptake in response to phosphorus and potassium fertilization. Wayne A. Sabbe Research Series, CSES, University of Arkansas.

## Arkansas Report 2019-2020 USDA-ARS, Fayetteville, AR

### 1. Impact Nugget:

The USDA-ARS Unit, located at the University of Arkansas, conducts research and technology transfer on practices that reduce negative environmental impacts of poultry litter on air, soil, and water resources, while improving the agronomic value of this resource in pasture agroecosystems.

### 2. New Facilities and Equipment:

Volumetric Water Content (VWC) sensors, drone (NDVI and multi-spectral), and an electrical conductivity (EC) meter were procured to attain research-quality accuracy in measurement of soil water in an integrated agroforestry-animal grazing system.

### 3. Unique Project Related Findings:

1. Animal manures, which are valuable sources of nutrients, may also contain antimicrobial resistant (AMR) genes. Following 14-years of continuous pasture management, AMR genes in grassland soils following 14-years of poultry litter and cattle manure deposition were evaluated. Continuous grazing (relative to conservation best management practices such as rotation grazing) had the greatest abundance of AMR genes, thus suggesting overgrazing and continuous cattle manure deposition may increase AMR gene presence. Results suggest that conservation pasture management practices may minimize the presence and number of AMR genes in grassland soils.

2. Systems-level studies aimed at determining how soil properties are linked to plant production and ultimately animal response are lacking. A study was carried out to identify if grazing pressure is linked to soil properties, terrain attributes, and aboveground plant accumulation and nutritive value using GPS cattle tracking devices. Cattle avoided grazing areas with deeper soils (i.e. > 100 cm), which corresponded to reduced elevation and increased soil moisture spatially. Combining spatial behavioral monitoring technologies with pasture availability may improve grazing systems management spatially and temporally.

### 4. Accomplishment Summaries:

Developed a management recommendation for an ARS implement that minimizes nutrient losses to the air, soil, and water in silage systems. Poultry production in the southeastern US is a leading enterprise, as about half of the national broiler (meat chicken) production occurs in four southeastern states. Furthermore, use of by-products from poultry production, or the mixture of manure and bedding material, has the potential to close nutrient loops, as animal by-products are re-applied the following season to marginal soils. Although, conventional application methods entail evenly spreading poultry litter on the soil surface, which can result in up to 60% of the nutrients being lost to the air, soil, and water. In efforts to improve management options that aid in nutrient sustainability and improve crop yield, a research team from Booneville Arkansas and Auburn Alabama developed a prototype tractor-drawn implement for subsurface applications of dry poultry litter in conservation tillage systems. This sub-surface method for applying litter or the ‘subsurfer’ lowers nutrient runoff and ammonia emissions by at least 90%. Corn is arguably the world’s most important food crop owing to its diverse uses for animal fodder, cellulosic and grain-based ethanol, and primary and secondary products being consumed by humans. A study was conducted at three sites in Arkansas and Alabama by Fayetteville and Auburn scientists to evaluate optimum corn planting distances from sub-surface applied poultry litter for maximizing nutrient uptake

and reduction of nutrient losses under rainfed and irrigated conditions. Overall, yield and crop quality results suggest sub-surface banding poultry litter 13-cm from corn rows may be a viable replacement for inorganic fertilizers in fodder and grain systems, particularly in organic production systems. Adoption of subsurface banding poultry litter relative to surface applications of poultry litter and inorganic fertilizers would enhance soil and water conservation while improving nutrient cycling, sustaining crop production, and on-farm profitability.

Developed a method for rapidly quantifying spatial overlaps and gaps for precision agriculture tools in pastures. Scientists from Fayetteville and Booneville, Arkansas and University of Arkansas research partners developed an automated method for rapid determination of spatial coverage of precision agriculture technologies, such as auto-guided tractors and other self-propelled machinery that reduce over-application of on-farm nutrients and inputs by 10-20%. It is estimated that auto-guided tractors reduce on-farm inputs by as much as 20% and can save producers \$10.8-13.5 million annually by improving gains in equipment efficiency and enhancing yields. Moreover, producers can also reduce the over-application of fertilizers and herbicides, which reduces the negative environmental footprint of crop production and avoids unintentional input costs to the producer. Currently, roughly half of large-scale row crop producers are using tractor guidance, however, 82% of the total farms in the US are small farms but are largely not adopting these cost and environmental saving technologies. Therefore, this team: 1) developed a method to calculate overlaps and gaps, and 2) quantified overall gains by tractor guidance systems. Field research was conducted using fertilizer (inorganic and poultry litter) and sprayer applications with and without tractor guidance. USDA-ARS researchers developed a novel automated method for quantifying overlaps and gaps and proposes a new method for calculating spatial coverage efficiency. Results suggests that tractor guidance systems reduce overlaps (up to 6% of the total field area) and gaps (up to 16%) during field operations and improves the average overall efficiency by 8%. Hence, tractor guidance systems likely result in reduced input-use and shorter in-field operation time leading to improved economic and environmental savings. Our approach to estimate tractor guidance efficiency on small farms using actual field research is novel and may aid in adoption of tractor guidance, thus potentially improving efficiency gains on 82% of US farms.

## 5. Impact Statements

During 2019-2020, Arkansas (USDA-ARS, Ashworth et al.) published data on BMPs for reducing nutrient losses and antibiotic resistance, while improving forage production and soil health in pasture systems at the soil-plant-water nexus. Outreach activities included the delivery of our findings during in-service training sessions, field days, and through technology transfer. A summary of all publications and funding procured from 2019-2020 is included at the end of this document. Selected project impacts are listed above in detail.

1. Developed a management recommendation for an ARS implement that minimizes nutrient losses to the air, soil, and water in silage systems.
2. Developed a method for rapidly quantifying spatial overlaps and gaps for precision agriculture tools in pastures.

## 6. Published Written Works

*Refereed publications*

- Ashworth, A.J., P.A. Moore, Jr., R. King, J.L. Douglas, D.H. Pote, E. Pratt, and A.A. Jacobs. 2019. Switchgrass forage yield and compositional response to phosphorus and potassium. *Agrosystems, Geosciences & Environment*. 2:190010. doi:10.2134/age2019.02.0010
- Acharya, M., A.J. Ashworth, D.M. Burner, D. Pote, J., Burke, and J.P. Muir. 2019. Browse potential of bristly locust, sericea lespedeza, and smooth sumac for small ruminants. *Agroforestry Systems*. doi.org/10.1007/s10457-019-00479-0
- Yang, Y., A.J. Ashworth, J.M. DeBruyn, C. Willett, L.M. Durso, K.L. Cook, P. Moore, and P.R. Owens. 2019. Soil biodiversity is driven by long-term pasture management, poultry litter, and cattle manure inputs. *PeerJ—Life & Environment*. e7839. doi.org/10.7717/peerj.7839
- Yang, Y., A. Ashworth, K. Cook, C. Willett, A. Upadhyay, P. Owens, A. Donoghue, S. Rickie, J. DeBruyn, and P. Moore. 2019. Review of antibiotic resistance, ecology, dissemination, and mitigation in U.S. broiler poultry systems. *Frontiers in Microbiology*. 10:2639. doi.org/10.3389/fmicb.2019.02639
- Yang, Y., A. Ashworth, K. Cook, C. Willett, A. Upadhyay, P. Owens, A. Donoghue, S. Rickie, J. DeBruyn, and P. Moore. 2019. Review of antibiotic resistance, ecology, dissemination, and mitigation in U.S. broiler poultry systems. *Frontiers in Microbiology*. 10:2639. doi.org/10.3389/fmicb.2019.02639
- Yang, Y., K.M. Feye, Z. Shi, H.O. Pavlidis, M. Kogut, A.J. Ashworth, and S.C. Ricke. 2019. A historical review on antibiotic resistance of foodborne campylobacter. *Frontiers in Microbiology*. 10: 1509. doi.org/10.3389/fmicb.2019.01509.
- Ashworth, A.J., K. V. Knapp, F.L. Allen, and A.M. Saxton. 2020. Comparing yield trial locations based on their elicited expressions of genetic variance among soybean cultivars. *Crop Sci*. 60:1313–1324. doi:10.1002/csc2.20066
- Ashworth, A.J., P.R. Owens, and F.L. Allen. 2020. Long-term cropping systems management influences soil strength and nutrient cycling. *Geoderma*. 361. 114062, doi:org/10.1016/j.geoderma.2019.114062
- Rocateli, A.C., A.J. Ashworth, C.P. West, K.R. Brye, M. Popp, and J.R. Kiniry. 2020. Simulating switchgrass biomass productivity using ALMANAC. I. Calibration of soil water. *Agronomy Journal*. 112: 183– 193. doi: 10.1002/agj2.20054
- Anderson, K., P.A. Moore, Jr., C. Pilon, J. Martin, D.H. Pote, P.R. Owens, A.J. Ashworth, D. Miller, and P. DeLaune. 2020. Long-term study on the effects of buffer strips and grazing management on phosphorus runoff from pastures. *J. Environ. Qual.* 49: 85– 96. doi:10.1002/jeq2.20010
- Acharya, M., B.S. Howell, J. Burke, A.J. Ashworth, and R.W. Rorie. 2020. Relationship of anti-mullerian hormone to reproductive traits in katahdin ewes bred in late spring or fall. *Advances in Reproductive Sciences*. 8: 48-56. doi: 10.4236/arsci.2020.81005
- Ashworth, A.J., D.H. Pote, D.B. Watts, and T.R. Way. 2020. Effect of seeding distance from subsurface banded poultry litter on corn yield and leaf greenness. *Agronomy Journal*. 112:1679–1689. doi: 10.1002/agj2.20186
- Ashworth, A.J., P.A. Moore, Jr., R. King, J.L. Douglas, D.H. Pote, and A.A. Jacobs. 2020. Switchgrass nitrogen fertility response and nutrient cycling in a hay system. *Agronomy Journal*. 112:1963–1971. doi:10.1002/agj2.20156. 2020
- Amorim, H.C.S., A.J. Ashworth, B.J. Wienhold, M.S. Savin, F.L. Allen, A.M. Saxton, P.R. Owens, and N. Curi. 2020. Soil quality indices based on long-term conservation cropping systems management. *Agrosystems, Geosciences & Environment*. 3:e20036. https://doi.org/10.1002/agg2.20036
- Anderson, K., P.A. Moore, Jr., and J. Martin, and A.J. Ashworth. 2020. Effect of a new manure amendment on ammonia emissions from poultry litter. *Atmosphere*. 11, 225. doi:10.3390/atmos11030257
- Amorim, H.C.S., A.J. Ashworth, P.A. Moore, Jr., B.J. Wienhold, M.S. Savin, P.R. Owens, S. Jagadamma, T. Carvalho, and S. Xu. 2020. Soil quality indices following long-term conservation pasture management practices. *Agriculture, Ecosystems and Environment*. 301. 107060. doi.org/10.1016/j.agee.2020.107060

Kharel, T.P., A.J. Ashworth, A. Shew, M. Popp, and P.R. Owens. 2020. Tractor guidance improves production efficiency by reducing overlaps and gaps. *Agricultural & Environmental Letters*. 5:e20012. doi.org/10.1002/ael2.20012

Kharel, T.P., A.J. Ashworth, P.R. Owen, and M. Buser. 2020. Spatially and temporally disparate data in systems agriculture: issues and prospective solutions. *Agronomy Journal*. 1–13. doi.org/10.1002/agj2.20285

#### *Proceedings and other publication*

Kharel, T.P., A.J. Ashworth, A. Shew, M. Popp, and P.R. Owens. 2020. GPS isn't just for road trips anymore. *Soil Science Society of America, American Society of Agronomy, and Crop Science Society of America News*. <https://www.soils.org/news/science-news/gps-isnt-just-road-trips-anymore>

### 7. Scientific and Outreach Presentations

#### *Invited presentations*

Nutrient Characteristics of Poultry Litter and Manure" to the Livestock and Poultry Environmental Learning Community (LPELC), 2020.

Soil Water Relationships in a Silvopastoral System. National Soil Survey Southern Regional Conference Soil Survey for Soil and Water Quality: Applications in the Natural State, Virtual Conference, 2020.

Technology Applications for Optimizing Farm Production. Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS) Conference, Minneapolis, MN, 2020.

Plant-Soil-Water Nexus: Agricultural Systems Research. Foundation for Food and Agriculture Research, Foster Our Future. Washington, D.C., 2020.

Investigating Relationships in Agroecosystems at the Plant-Soil Interface. USDA-ARS, Delta Water Management Research Unit and Arkansas State University. Jonesboro, AR., 2019.

#### *Abstracts , symposium and conference presentations*

Amorim, H.C.S, A.J. Ashworth, P.A. Moore, Jr., B.J. Wienhold, M.C. Savin, P.R. Owens, T.S. Carvalho, S. Xu, S.H.G. Silva, and N. Curi. 2020. Soil quality indexes improve following long-term manure deposition and conservation practices. Annual Soil Health Innovations Conference, Bozeman, MT.

Adhikari, K., I. Braden, P.R. Owens, A.J. Ashworth, C.P. West, and D. Smith. 2020. Topographic influence on soil phosphorus (P) distribution and P-indices in litter-amended pastures. 15th International Conference on Precision Agriculture, Minneapolis, MN.

Adams, T.C., A.J. Ashworth, T.P. Kharel, D. Philipp, P. Owens, and T. Sauer. 2020. Forage root decomposition in Silvopastoral systems is influenced by grazing, fertilization, and grass species. 11th Annual UMCA Agroforestry Symposium. Columbia, MO.

Amorim, H.C.S, A.J. Ashworth, T.J. Sauer, A. Thomas, P.R. Owens, M.C. Savin, Y.L. Zinn, S.H.G. Silva, T.S. Carvalho, and N. Curi. 2020. Soil organic carbon and fertility in a 17-year agroforestry site. 11th Annual UMCA Agroforestry Symposium, Columbia, MO.

Popp, M., Ashworth, A.J., K.R., Lindsay, P.R. Owens, and M. McCarver. 2020. Profitability of pasture aeration as affected by timing. American Society of Agronomy, Southern Branch Meeting. Louisville, KY.

Moore, P.A. Jr., K. Anderson, J. Martin, and A.J. Ashworth. 2020. Reducing ammonia emissions from poultry litter with a new litter amendment. American Society of Agronomy, Southern Branch Meeting. Louisville, KY.

Zhou, V. J. Larson, F.L. Allen, A.J. Ashworth, and V. Sykes. Crop rotation and bio-cover impact on no-tillage corn, soybean, and cotton profitability in Tennessee. 2020. [CD-ROM]. American Society of



Agronomy, Crop Science Society of America (ASA and CSSA), International Meetings, Madison, WI.

- Amorim, H.C.S., A.J. Ashworth, B.J. Wienhold, M.C. Savin, A.M. Saxton, P.R. Owens, and N. Curi. 2019. Soil quality indices based on long-term conservation cropping systems management. [CD-ROM]. ASA and CSSA, International Meetings, Madison, WI.
- Ngunjiri, M.W., A.J. Ashworth, P.R. Owens, C.D. Duren, and T.C. Adams. 2019. Mapping soil types and properties on tribal lands for enhanced soil management. Arkansas Soil Classifiers Meeting.
- Owens, P.R., Y. Jiang, Z. Sun, Q. Wang, J. Read, and A.J. Ashworth. 2019. Long-term spatial distribution of P and other elements following poultry litter applications. Agriculture and the Environment. Aarhus, Denmark.
- Moore, P.A. Jr., J. Martin, A.J. Ashworth, K. Anderson, D. Miller, P.R. Owens, D.H. Pote, and C. Pilon. 2019. Long-term effects of grazing management and buffer strips on phosphorus runoff from pastures fertilized with poultry litter. Agriculture and the Environment. Aarhus, Denmark.
- Ashworth, A.J., P.A. Moore, Jr., D.H. Pote, P.R. Owens, J.W. Martin, and K.R. Anderson. 2019. Developing best management strategies for reducing soluble phosphorus losses from poultry litter in grazing systems. International Interdisciplinary Conference on Land Use and Water Quality, Agriculture and the Environment. Aarhus, Denmark.
- Moore, P.A. Jr., K. Anderson, C. Pilon, J. Martin, D.H. Pote, P.R. Owens, A.J. Ashworth, D. Miller and P. DeLaune. 2019. Long-term study on the effects of buffer strips and grazing management on phosphorus runoff from pastures. American Society of Agronomy, Southern Branch Meeting. Birmingham, Alabama.
- Ashworth, A.J., D.H. Pote, T.R. Way, D.B. Watts, P.R. Owens, and L.C. Purcell. 2019. Effect of seeding distance from subsurface banded poultry litter on corn yield and leaf nitrogen in a conservation tillage system. American Society of Agronomy, Southern Branch Meeting. Birmingham, Alabama.

## 7. Collaborative Grants

None with NCCC31 members at this time. Others are listed below.

- 2020 AFRI Sustainable Agricultural Systems, entitled “Systems-based Integrated Program for Enhancing the Sustainability of Antibiotic-restricted Poultry Production,” \$10,000,000 for 2020-2025, Co-PI.
- 2020 ARS-Office of Technology Transfer, Innovation Fund, entitled “Quantifying Macropore Flow and Nutrient Leaching in Soil Column Representing Different Land-uses in Karst Landscapes,” \$35,000 for 2020-2021, PI.
- 2019 USDA-Agricultural Research Service, Herbert L. Rothbart Outstanding Early Career Scientist of the Year, \$25,000, Research Award, PI.
- 2019 USDA-Agricultural Research Service funding Opportunity in Antimicrobial Resistance, “Identifying Best Management Practices for Disrupting AMR Gene Transmission to the Environment” \$71,405 for 2019-2022, PI.
- 2019 Arkansas Department of Agriculture, “Novel Nutrient Management Options for Organic Edamame and Sweet Corn Production for New Veteran Farmers” \$40,000 for 2019-2021, PI.
- 2019 Southern Sustainable Agriculture Research and Education, Research and Education, “Innovative nutrient management options for sustainable pasture land intensification” \$296,498 for 2019-2022, Co-PI.

## **Indiana Report 2019-2020 Purdue University**

1. Impact Nugget:

Datasets have on alfalfa P and K nutrition and variety performance have been downloaded a combined total of over 5400 times (>5200 views).

2. New Facilities and Equipment: none

3. Unique Project Related Findings:

4. Accomplishment Summaries

The alfalfa P and K nutrition dataset:

This is a master file of merged excel files with data from several studies on the influence of phosphorus and potassium nutrition on alfalfa. It includes numeric data such as yield, plant mass, plant counts, and tissue concentration of various nutrients. Conventional wisdom states that plants that are poorly fertilized and do not have adequate phosphorus and especially low potassium will become winterkill. This study showed that plants did not necessarily die in winter with low potassium stress. Study dates: 1997 to 2004. Location/Latitude and Longitude: Throckmorton Purdue-Agricultural Center located 15 km south of West Lafayette, IN (40°N and 87°W).

The alfalfa variety test dataset:

The dataset contain archived copy of the Alfalfa Variety Performance Database originally compiled in 2000 by Daniel W. Wiersma and Wayne G. Hartman that contains forage yield and quality results, and plant stand estimates from over 700 alfalfa variety tests conducted by researchers in the US and Canada from 1986 through 1999. The database was used to analyze long-term trends in genetic improvement of alfalfa yield and agronomic performance.

Data were originally compiled in an Access database. This publication contains the database both in the Access database format (\*.mdb) and as mysql dump (\*.mysql). The \*.mdb file was fully operational in the version Access 2019 and the mysql data were successfully inserted into a MySQL data prior to their archiving. In addition, the data in individual tables were exported as a set of twenty one CSV files (plus two edited files) that were also preserved in this dataset.

Four additional datasets were created from the database tables and published in PURR. The alfalfa variety metadata dataset contains descriptors and characteristic of over 2900 alfalfa varieties and experimental lines used in these variety trials. Three companion datasets extracted from the original database contain the yield, forage quality, and stand persistence data.

5. Impact Statements

Devising cropping systems with the diverse phenologies and the broad adaptation necessary to exploit underutilized temporal and spatial niches is critical to enhancing the health and sustainability of the Midwest cornbelt. Work is underway to develop novel management systems for Midwestern US crop system intensification and diversification that will increase the output or value of multiple ecosystem services (ES) when compared to conventional management. This includes strategic inclusion of mulch (kura clover) and cover crop systems that will provide significant economic income for farmers without displacing or reducing yields of existing row crops. Performance metrics include enhancing profit and efficient use of water, nutrients, and radiation, while reducing production of greenhouse gases and loss of nutrients to surface waters.

6. Published Written Works *Cite them with CSSA, ASA references format*

### *Refereed publications*

- Zumpf, C., M.-S. Lee, S. Thapa, J. Guo, R. Mitchell, J.J. Volenec, and D.K. Lee. 2019. Impact of warm-season grass management on feedstock production on marginal farmland in Central Illinois. *GCB Bioenergy* DOI: 10.1111/gcbb.12627. p. 1-13.
- Rivera-Burgos, L.A., J. J. Volenec, and G. Ejeta. 2019. Biomass and bioenergy potential of brown midrib sweet sorghum germplasm. *Front. Plant Sci.* 20 September 2019. doi.org/10.3389/fpls.2019.01142.
- Welikhe, P., S.M. Brouder, J.J. Volenec, M. Gitau, and R.F. Turco. 2020. Development of phosphorus sorption capacity-based environmental indices for tile-drained systems. *J. Environ. Qual.* 49:378-391. doi.org/10.1002/jeq2.20044.
- Moreira, F.F., H.R. Oliveira, J.J. Volenec, K.M. Rainey, and L.F. Brito. 2020. Integrating high-throughput phenotyping and statistical genomic methods to genetically improve longitudinal traits in crops. *Front. Plant Sci.* DOI: 10.3389/fpls.2020.00681.
- Volenec, J.J. and C.J. Nelson. 2020. Carbon metabolism in forage plants. Chapter 4. In: M. Collins, C.J. Nelson, K.J. Moore and D.D. Redfearn (eds.). *Forages-The Science of Grassland Agriculture*. Volume II. 7th Edition. John Wiley & Sons, Inc., New York, NY. doi.org/10.1002/9781119436669.ch4.
- Brouder, S.M. and J.J. Volenec. 2020. Mineral nutrient acquisition and metabolism. Chapter 5. In: M. Collins, C.J. Nelson, K.J. Moore and D.D. Redfearn (eds.). *Forages-The Science of Grassland Agriculture*. Volume II. 7th Edition. John Wiley & Sons, Inc., New York, NY. doi.org/10.1002/9781119436669.ch5.
- Volenec, J.J., S.M. Brouder, and T.S. Murrell. 2020. Broadening the objectives of future potassium recommendations. In T.S. Murrell (ed.) *Frontiers in Potassium Science*. Springer, New York. 36 pp. (in press).
- Brouder, S.M., J.J. Volenec, and T.S. Murrell. 2020. The potassium cycle and its relationship to recommendation development. In T.S. Murrell (ed.) *Frontiers in Potassium Science*. Springer, New York. 43 pp. (in press).
- Bell, M.J., A.P. Mallarino, J.J. Volenec, S.M. Brouder, and D.W. Franzen. 2020. Considerations for selecting potassium placement methods in soil. In T.S. Murrell (ed.) *Frontiers in Potassium Science*. Springer, New York. 23 pp. (in press).

### *Proceedings publication*

### *Bulletins and Extension Factsheets*

### *Datasets*

- Berg, W. K.; S. Lissbrant, J.J. Volenec, S.M. Brouder, B.C. Joern, K.D. Johnson, and S.M. Cunningham. 2020 "Phosphorus and Potassium Influence on Alfalfa Nutrition (revised)." (DOI:10.4231/PPKB-VK18). (4114 views and 5135 downloads as of 8/28/2020; both versions).
- Wiersma, D., W.G. Hartman, S. Pejša, S.M. Brouder, and J.J. Volenec. 2020. Alfalfa Variety Trial Database, 1986-1999. Purdue University Research Repository. doi:10.4231/PHKH-4334. (74 views, 13 downloads as of 8/28/2020).
- Wiersma, D., W.G. Hartman, S. Pejša, S.M. Brouder, and J.J. Volenec. 2020. Metadata for alfalfa varieties and experimental lines 1986 to 1999. Purdue University Research Repository. doi:10.4231/FMY9-6966. (272 views, 69 downloads as of 8/28/2020).
- Wiersma, D., W.G. Hartman, S. Pejša, S.M. Brouder, and J.J. Volenec. 2020. Genetic and environmental variation in alfalfa forage quality from variety testing experiments conducted in North America between 1986 and 1999. Purdue University Research Repository. doi:10.4231/02PR-9H36. (257 views, 64 downloads as of 8/28/2020).

- Wiersma, D., W.G. Hartman, S. Pejša, S.M. Brouder, and J.J. Volenec. 2020. Genetic and environmental variation in alfalfa stand persistence from variety testing experiments conducted in North America between 1986 and 1999. Purdue University Research Repository. [doi:10.4231/KK4K-QD96](https://doi.org/10.4231/KK4K-QD96). (244 views, 63 downloads as of 8/28/2020).
- Wiersma, D., W.G. Hartman, S. Pejša, S.M. Brouder, and J.J. Volenec. 2020. Genetic and environmental variation in alfalfa forage yield from variety testing experiments conducted in North America between 1986 to 1999. Purdue University Research Repository. [doi:10.4231/Y31N-5R10](https://doi.org/10.4231/Y31N-5R10). (248 views, 64 downloads as of 8/28/2020).
- North American Alfalfa Improvement Conference, S. Pejša, and J.J. Volenec. 2020. Archived standard tests to characterize stress tolerance and agronomic performance of alfalfa cultivars. Purdue University Research Repository. [doi:10.4231/N24B-MV16](https://doi.org/10.4231/N24B-MV16). (61 views, 9 downloads as of 8/28/2020).

#### 6. Scientific and Outreach Presentations

- Volenec, J.J., S.M. Brouder, and T.S. Murrell. 2019. Broadening the objectives of future potassium fertilizer recommendations. Soil Sci. Soc. Amer. Meeting, Jan. 6-9, 2019. San Diego CA. <https://scisoc.confex.com/scisoc/2019sssa/meetingapp.cgi/Paper/116297>
- Volenec, J.J., and J.W. MacAdam. 2019. C. Jerry Nelson: A career with global impact. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Nov. 10 to 14, San Antonio, TX.
- Verm, V.K., J.J. Volenec, S.M. Brouder, and I. Chaubey. 2019. Parameterizing the cereal rye crop in SWAT model and evaluating its impact in watershed-scale simulations. Meeting of the American Geophysical Union. Dec. 9 to 13. San Francisco CA. Abstr. H33J-2066. Bibcode 2019AGUFM.H33J2066V.
- Deno, B., S.M. Brodruer, and J.J. Volenec. 2019. Cover cropping for sustainable co-production of bioenergy, food, feed (BFF) and enhancement of ecosystem services (ES). Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Nov. 10 to 14, San Antonio, TX.
- Brouder, S.M., J.J. Volenec, and D. Walker. 2020. Initiatives for advancing evidenced-based nutrient management in US Midwest agroecosystems. The Third International Conference of the Collaboration for Environmental Evidence, Ottawa, Ontario, Canada June 1-5.

Abstracts , symposium and conference presentations (see above)

#### 7. Collaborative Grants

None with NCCC-31 members at this time.

#### 8. Graduate students and Post-doctoral Research Associates

- Deno, Brodrick. 2020. Cover cropping for sustainable co-production of bioenergy, food, feed and enhancement of ecosystem services. MS degree.
- Ghazanfarpour, Nayer. Modeling water quality and greenhouse emissions of contrasting cropping systems.
- Vema, Vamsi. Modeling landscape-scale hydrology and greenhouse gas emissions of cover and mulch cropping systems using the Soil Water Assessment Tool.
- Minai, Joshua. Improving soil test P and K recommendations using machine learning and artificial intelligence applied to large-scale farmer datasets.

## **Kentucky Report 2019-2020**

### **University of Kentucky**

#### 1. Impact Nugget

The forage group at the University of Kentucky (UK) conducts research on how symbioses between forage species and microbes affects forage production, nutritive value, secondary plant metabolites, invasive potential, resilience to climate change and mitigation potential. The forage extension program at UK is good-sized, productive, and well-known and respected for providing sound, timely advice to forage growers in the region. Both the research and extension teams work closely with the co-located USDA Forage Animal Production Research Unit (FAPRU).

#### 2. New Facilities and Equipment

The University of Kentucky transformed our western Kentucky farm and field station (UKREC), with a new building containing offices, meeting spaces, teaching facilities, and labs, built by generous support from the Kentucky Agricultural Development Board (\$15M) and additional philanthropic gifts. The new building is called the Grain & Forage Center of Excellence, is located in Princeton, KY, and houses one UK Forage Extension Specialist – Dr. Chris Teutsch.

The USDA-FAPRU group has received Federal money for a new building on the UK campus, which will likely house most of the UK forage group. Planning and construction are estimated to require five years.

#### 3. Unique Project-Related Findings

Soil carbon (C) sequestration plays an important role in mitigating global climate change, and certain land utilization strategies can exert a pronounced effect on carbon storage. Land use practices, such as planting previously cropped lands into perennial grasslands, can increase soil C sequestration; however, the temporal response of soil C pools to such changes in land use are likely complex and not well quantified. Using a space-for-time approach we assessed the response of soil C sequestration and microbial community composition during a five-year grazed pasture rotation following three years of vegetable production on a central Kentucky farm. After 5 years in pasture, soil organic C and N in the top 15 cm increased 20.6% and 20.1%, respectively, from year 1 levels, and particulate organic matter C (POM C) increased 53.5%. A carbon mineralization (CM) assay indicated that the potential release of CO<sub>2</sub> also increased with time in pasture rotation. When compared to permanent pasture (not previously used for vegetable production), soil microbial community composition differed in rotation years 1-3 but became similar in years 4 and 5. Multi-response permutation procedure (MRPP) analysis showed that CM and POM were key factors affecting microbial community composition. Soil microbial community composition also varied with time of year (season), but to a lesser degree than with pasture duration. Overall, incorporation of perennial pasture into cropping systems can have profound effects on microbial community composition and function, increasing soil organic C, and consequently enhancing the potential for C sequestration; however, whether these increases in C storage persist throughout the full cropping sequence (i.e., once the pasture has been returned to vegetables) and/or how these changes influence subsequent vegetable production remains to be evaluated.

#### 4. Accomplishment Summaries

During 2018-2019, faculty from University of Kentucky published data from forage and alfalfa variety trials, a number of scientific studies, and trained numerous undergraduate and graduate students. Outreach activities included the delivery of our findings through various in-service training sessions, field days, schools, farm visits, interaction with producer and commodity groups, and via numerous extension

outlets. We completed the second version of our climate change study and initiated a third focused on red clover and alfalfa, and we initiated new work in collaboration with USDA-FAPRU evaluating the effects of biochanin A (an isoflavone produced by red clover) on ruminant microbes and resulting N use efficiency and N excreta to the environment.

## 5. Impact Statements

*“Tall fescue and E. coenophiala genetics influence root-associated soil fungi in a temperate grassland”*

Issue: A constitutive, host-specific symbiosis exists between the aboveground fungal endophyte *Epichloë coenophiala* (Morgan-Jones & W. Gams) and the cool-season grass tall fescue (*Lolium arundinaceum* (Schreb.) Darbysh.), which is a common forage grass in the U.S., Australia, New Zealand, and temperate European grasslands. New cultivars of tall fescue are continually developed to improve pasture productivity and animal health by manipulating both grass and *E. coenophiala* genetics, yet how these selected grass-endophyte combinations impact other beneficial microbial symbionts such as mycorrhizal and dark septate fungi remains unclear. Without better characterizing how genetically distinct grass-endophyte combinations interact with belowground microorganisms, we cannot determine how adoption of new *E. coenophiala*-symbiotic cultivars in pasture systems will influence long-term soil characteristics and ecosystem function.

Action: We examined how *E. coenophiala* presence and host × endophyte genetic combinations control root colonization by belowground symbiotic fungi and associated plant nutrient concentrations and soil properties in a two-year manipulative field experiment. We used four vegetative clone pairs of tall fescue that consisted of one endophyte-free (E<sup>-</sup>) and one *E. coenophiala*-symbiotic (E<sup>+</sup>) clone each, where E<sup>+</sup> clones within each pair contained one of four endophyte genotypes: CTE14, CTE45, NTE16, or NTE19. After two years of growth in field plots, we measured root colonization rates of arbuscular mycorrhizal fungi (AMF) and dark septate endophytes (DSE), extraradical AMF hyphae in soil, total C, N, and P in root and shoot samples, as well as C and N in associated soils.

Impact: Although we observed no effects of *E. coenophiala* presence or symbiotic genotype on total AMF or DSE colonization rates in roots, different grass-endophyte combinations altered AMF arbuscule presence and extraradical hyphal length in soil. The CTE45 genotype hosted the fewest AMF arbuscules regardless of endophyte presence, and E<sup>+</sup> clones within NTE19 supported significantly greater soil extraradical hyphae compared to E<sup>-</sup> clones. Because AMF are often associated with improved soil physical characteristics and C sequestration, our results suggest that development and use of unique grass-endophyte combinations may cause divergent effects on long-term ecosystem properties.

*“Global change effects on plant communities are magnified by time and the number of global change factors imposed”*

Issue: Global change drivers (GCDs) are expected to alter community structure and consequently, the services that ecosystems provide. Yet, few experimental investigations have examined effects of GCDs on plant community structure across multiple ecosystem types, and those that do exist present conflicting patterns.

Action: In an unprecedented global synthesis of over 100 experiments that manipulated factors linked to GCDs, we show that herbaceous plant community responses depend on experimental manipulation length and number of factors manipulated. We found that plant communities are fairly resistant to experimentally manipulated GCDs in the short term (<10 y). In contrast, long-term (≥10 y) experiments show increasing community divergence of treatments from control conditions. Surprisingly, these community responses occurred with similar frequency across the GCD types manipulated in our database.

However, community responses were more common when 3 or more GCDs were simultaneously manipulated, suggesting the emergence of additive or synergistic effects of multiple drivers, particularly over long time periods. In half of the cases, GCD manipulations caused a difference in community composition without a corresponding species richness difference, indicating that species reordering or replacement is an important mechanism of community responses to GCDs and should be given greater consideration when examining consequences of GCDs for the biodiversity–ecosystem function relationship.

*Impact:* Human activities are currently driving unparalleled global changes worldwide. Our analyses provide the most comprehensive evidence to date that these human activities may have widespread impacts on plant community composition globally, which will increase in frequency over time and be greater in areas where communities face multiple GCDs simultaneously.

## 6. Published Written Works

### *Refereed Journal Articles*

Risch, A., S. Zimmermann, B. Moser, M. Schuetz, F. Hagedorn, J. Firn, P. Fay, P. Adler, L. Biederman, J. Blair, E. Borer, A. Broadbent, C. Brown, M. Cadotte, M. Caldeira, K. Davies, A. di Virgilio, N. Eisenhauer, A. Eskelinen, J. Knops, A. MacDougall, R.L. McCulley, B. Melbourne, J. Moore, S. Power, S. Prober, E. Seabloom, J. Siebert, M. Silveira, K. Speziale, C. Stevens, P. Tognetti, R. Virtanen, L. Yahdjian, and R. Ochoa-Hueso. *In Press*. Global impacts of fertilization and herbivore removal on soil net nitrogen mineralization are modulated by local climate and soil properties. Global Change Biology.

Ochoa-Hueso, R., E.T. Borer, E.W. Seabloom, S.E. Hobbie, A.C. Risch, S.L. Collins, J. Alberti, H.A. Bahamonde, C.S. Brown, M.C. Caldeira, P. Daleo, C.R. Dickman, A. Ebeling, N. Eisenhauer, E.H. Esch, A. Eskelinen, V. Fernandez, S. Gusewell, B. Gutierrez-Larruga, K. Hofmockel, R. Laungani, E. Lind, A. Lopez, R.L. McCulley, J.L. Moore, P.L. Peri, S.A. Power, J.N. Price, S.M. Prober, C. Roscher, J.M. Sarneel, M. Schutz, J. Siebert, R.J. Standish, S. Velasco Ayuso, R. Virtanen, G.M. Wardle, G. Wiehl, L. Yahdjian, and T. Zamin. **2020**. Microbial processing of plant remains is co-limited by multiple nutrients in global grasslands. Global Change Biology 26(8):4572-4582. doi: 10.1111/gcb.15146.

Gilbert, B., A.S. MacDougall, T. Kadoya, M. Akasaka, J.R. Bennett, E.M. Lind, H. Flores-Moreno, J. Firn, Y. Hautier, E.T. Borer, E.W. Seabloom, P.B. Adler, E.E. Cleland, J.B. Grace, W.S. Harpole, E.H. Esch, J.L. Moore, J. Knops, R.L. McCulley, B. Mortensen, J. Bakker, and P.A. Fay. **2020**. Climate and local environment structure asynchrony and the stability of primary production in grasslands. Global Ecology and Biogeography 29(7):1177-1188. doi: 10.1111/geb.13094. IF=7.647.

Sitters, J., E.R.J. Wubs†, E.S. Bakker, T.W. Crowther, P.B. Adler, S. Bagchi, J.D. Bakker, L. Biederman, E.T. Borer, E.E. Cleland, N. Eisenhauer, J. Firn, L. Gherardi, N. Hagenah, Y. Hautier, S.E. Hobbie, J.M.H. Knops, A.S. MacDougall, R.L. McCulley, J.L. Moore, B. Mortensen, P.L. Peri, S.M. Prober, C. Riggs, A.C. Risch, M. Schutz, E.W. Seabloom, J. Siebert, C.J. Stevens, and G.F. Veen. **2020**. Nutrient availability controls the impact of mammalian herbivores on soil carbon and nitrogen pools in grasslands. Global Change Biology 26(4):2060-2071. doi: 10.1111/gcb.15023.

Risch, A.C., S. Zimmermann, R. Ochoa-Hueso, M. Schutz, B. Frey, J.L. Firn, P.A. Fay, F. Hagedorn, E.T. Borer, E.W. Seabloom, W.S. Harpole, J.M.H. Knops, R.L. McCulley, A.A.D. Broadbent, C.J. Stevens, M.L. Silveira, P.B. Adler, S. Baez, L.A. Biederman, J.M. Blair, C.S. Brown, M.C. Caldeira, S.L. Collins, P. Daleo, A. di Virgilio, A. Ebeling, N. Eisenhauer, E. Esch, A. Eskelinen, N. Hagenah, Y. Hautier, K.P. Kirkman, A.S. MacDougall, J.L. Moore, S.A. Power, S.M. Prober, C. Roscher, M. Sankaran, J. Siebert, K.L. Speziale, P.M. Tognetti, R. Virtanen, L. Yahdjian, and B. Moser. **2019**. Soil net

nitrogen mineralization across global grasslands. Nature Communications (2019):4981.  
<https://doi.org/10.1038/s41467-019-12948-2>

Slaughter, L.C., J.A. Nelson, A.E. Carlisle, M. Bourguignon, R.D. Dinkins, T.D. Phillips, and R.L. McCulley. **2019**. Tall fescue and *E. coenophiala* genetics influence root-associated soil fungi in a temperate grassland. Frontiers in Microbiology 10: article 2380. Doi: 10.3389/fmicb.2019.02380.

Lin, D., R.L. McCulley, J.A. Nelson, K.L. Jacobsen, and D. Zhang. **2019**. Time in pasture rotation alters soil microbial community composition and function and increases soil carbon sequestration potential in a temperate agroecosystem. Science of the Total Environment 698 (2020) 134233.

Komatsu, K.J., M.L. Avolio, N.P. Lemoine, F. Isbell, E. Grman, G.R. Houseman, S.E. Koerner, D.S. Johnson, K.R. Wilcox, J.M. Alatalo, J.P. Anderson, R. Aerts, S.G. Baer, A.H. Baldwin, J. Bates, C. Beierkuhnlein, R.T. Belote, J. Blair, J.M.G. Bloor, P.J. Bohlen, E.W. Bork, E.H. Boughton, W.D. Bowman, A.J. Britton, J.F. Cahill, Jr., E. Chaneton, N.R. Chiariello, J. Cheng, S.L. Collins, J.H.C. Cornelissen, G. Du, A. Eskelinen, J. Firn, B. Foster, L. Gough, K. Gross, L.M. Hallett, X. Han, H. Harmens, M.J. Hovenden, A. Jagerbrand, A. Jentsch, C. Kern, K. Klanderud, A.K. Knapp, J. Kreyling, W. Li, Y. Luo, R.L. McCulley, J.R. McLaren, J.P. Megonigal, J.W. Morgan, V. Onipchenko, S.C. Pennings, J.S. Prevey, J.N. Price, P.B. Reich, C.H. Robinson, F.L. Russell, O.E. Sala, E.W. Seabloom, M.D. Smith, N.A. Soudzilovskaia, L. Souza, K. Suding, K.B. Suttle, T. Svejcar, D. Tilan, P. Tognetti, R. Turkington, S. White, Z. Xu, L. Yahdjian, Q. Yu, P. Zhange, and Y. Zhang. **2019**. Global change effects on plant communities are magnified by time and the number of global change factors imposed. Proceedings of the National Academy of Science 116(36):17867-17873.  
<https://doi.org/10.1073/pnas.1819027116>

Kagan, I.A., Goodman, J.P., Seman, D.H., Lawrence, L.L., and Smith, S.R. **2019**. Effects of harvest date, sampling time, and cultivar on total phenolic concentrations, water-soluble carbohydrate concentrations, and phenolic profiles of selected cool-season grasses in central Kentucky. Journal of Equine Veterinary Science 79:86-93. <https://doi.org/10.1016/j.jevs.2019.05.005>

Kagan, I.A., Anderson, M.L., Kramer, K.J., Seman, D.H., Lawrence, L.M., and Smith, S.R. **2019**. Seasonal and diurnal variation in water-soluble carbohydrate concentrations of repeatedly defoliated red and white clovers of central Kentucky. Journal of Equine Veterinary Science 84:102858, 1-7. 2019.  
<https://doi.org/10.1016/j.jevs.2019.102858>

McDowell, Karen, Victoria Taylor, Tim Phillips, Krista Lea, Ray Smith, Glen Aiken, and Michael Barrett. **2019**. Pregnant Mares Grazing a Novel Endophyte-Infected Tall Fescue Foal Normally. Journal of Equine Veterinary Science 74: 56-64.

Lovelli, Stella, Maria Valerio, Tim D. Phillips, and Mariana Amato. **2019**. Water use efficiency, photosynthesis and plant growth of Chia (*Salvia hispanica* L.): a glasshouse experiment." Acta physiologiae plantarum 41, no. 1: 3. <https://doi-org.ezproxy.uky.edu/10.1007/s11738-018-2795-4>

Grimes, Samantha J., Timothy D. Phillips, Filippo Capezzone, and Simone Graeff-Hönninger. **2019**. Impact of Row Spacing, Sowing Density and Nitrogen Fertilization on Yield and Quality Traits of chia (*Salvia Hispanica* L.) Cultivated in southwestern Germany. Agronomy 9, no. 3: 136.

Meyer, Susan, Margaret H. MacDonald, Nathan D. Reetz, Mihail R. Kantor, Lynn Carta, Zafar Ahmad Handoo, Mary J. Camp, and Tim D. Phillips. **2020**. Chia: Host status for *Meloidogyne incognita* and activity of plant extracts. Plant Disease. [doi.org/10.1094/PDIS-10-19-2171-RE](https://doi.org/10.1094/PDIS-10-19-2171-RE)



Cherney, J.H., S.R. Smith, C. Sheaffer, and D.J. Cherney. **2019**. Nutritive value and yield of reduced-lignin alfalfa cultivars in monoculture and in binary mixtures with perennial grass. *Agronomy J.* doi: 10.2134/agronj2019.05.0348

Dillard, S.L., Smith, S.R., Hancock, D.W. **2019**. Variability of ergovaline and total ergot alkaloid expression among endophytic tall fescue cultivars. *Crop Sci.* 59:1-10. Doi:10.2135/cropsci2018.12.0730

### ***Other Peer Reviewed Publications***

Henning, Jimmy C. and Laurie Lawrence. **2019**. Production and management of hay and haylage. Chapter 11, pp. 180-208. IN: Sharpe, P, ed. Horse Pasture Management. 1st edition. Academic Press, Elsevier.

### ***Extension Publications***

Haramoto, E., J. Henning, C. Knott, C. Lee, and R. Smith. **2020**. Grain, Forage, and Cover Crop Guide. AGR-18.

Call, D., J. Grove, A.D. Karathanasis, C. Matocha, and L. Murdock. **2020**. Remediation of the Fragipan using Annual Ryegrass. AGR-250.

Henning, J., G. Olson, T. Phillips, R. Smith, and C. Teutsch. **2020**. 2019 Timothy and Kentucky Bluegrass Report. PR-767.

Henning, J., G. Olson, R. Smith, and C. Teutsch. **2019**. 2019 Long-Term Summary of Kentucky Forage Variety Trials. PR-774.

Bruening, B., J. Henning, G. Olson, R. Smith, and C. Teutsch. **2019**. 2019 Annual Grass Report: Warm Season and Cool Season (Cereals). PR-773.

Henning, J., G. Olson, T. Phillips, R. Smith, and C. Teutsch. **2019**. 2019 Cool-Season Grass Grazing Tolerance Report. PR-771.

Henning, J., L. Lawrence, G. Olson, T. Phillips, R. Smith, and C. Teutsch. **2019**. 2019 Cool-Season Grass Horse Grazing Tolerance Report. PR-772.

Henning, J., G. Olson, R. Smith, and C. Teutsch. **2019**. Alfalfa Grazing Tolerance Report. PR-769.

Henning, J., G. Olson, R. Smith, and C. Teutsch. **2019**. 2019 Red and White Clover Grazing Tolerance Report. PR-770.

Henning, J., G. Olson, T. Phillips, R. Smith, and C. Teutsch. **2019**. 2019 Orchardgrass Report. PR-765.

Henning, J., G. Olson, T. Phillips, R. Smith, and C. Teutsch. **2019**. 2019 Annual and Perennial Ryegrass and Festulolium Report. PR-768.

Henning, J., G. Olson, R. Smith, and C. Teutsch. **2019**. 2019 Alfalfa Report. PR-763.

Henning, J., G. Olson, R. Smith, and C. Teutsch. **2019**. 2019 Red and White Clover Report. PR-764.

Henning, J., G. Olson, T. Phillips, R. Smith, and C. Teutsch. **2019**. 2019 Tall Fescue and Bromegrass Report. PR-766.

## 7. Scientific and Outreach Oral Presentations

McCulley, R.L. **2019**. Long-term grazing experiments and soil carbon: What have we learned? ASA-CSSA-SSSA Annual Meeting, San Antonio, TX.

## 8. Collaborative Grants

McCulley, R.L. (PI). "Utilizing grass-endophyte technology to improve pasture soil health and resilience to climate change stressors and soil health." *NIFA-AFRI-Foundational – Agricultural Production Systems*. 2017-2021. **\$500,000**

McCulley, R.L. (PI). "Determining red clover drought resistance under abiotic stress and exploring effects of clover-produced isoflavones on animal nitrogen excreta, soil-to-atmosphere trace gas production, and soil microbial communities." *USDA-FAPRU-Specific Cooperative Agreement*. 2018 – 2023. **\$119,942**

Moe, L.A. (PI), S.T. Lucas, R.L. McCulley, R. Pearce, and G. Halich (Co-PIs). "The Hemp Effect: What impact will incorporating hemp into traditional crop rotations have on the provisioning of agroecosystem services?" *NIFA-AFRI-Foundational*, 2020 - 2024. **\$500,000**

## 9. Graduate Students

**River Dowell**, MS in Integrated Plant & Soil Sciences, expected graduation **2022**, title - TBD.

**Alayna Jacobs**, PhD in Integrated Plant & Soil Sciences, expected graduation **2022**, title – TBD.

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**Maryland Report 2019-2020**  
**University of Maryland**

1. Impact Nugget: Our current research emphasizes the spatial and temporal movement of insect pests and natural enemies in the farmscape, and their influence on ecosystem services within forage systems.
2. New Facilities and Equipment: none
3. Unique Project Related Findings: We discovered that a foliar pest affects biological nitrogen fixation, but the effect depends on soil nitrate levels. In addition, certain spider populations disperse from adjacent drainage ditches into crops to provide conservation biological control.
4. Accomplishment Summaries:

Detection of ingested DNA of *Vicia faba* from the gut content of potato leafhopper, *Empoasca fabae*. A. Avanesyan, N. Illahi, and W. Lamp

Potato leafhopper, *Empoasca fabae* (Hemiptera: Cicadellidae), is a sap-feeding insect and a wide-spread agricultural pest in the United States and Canada which causes substantial plant damage (hopperburn) triggered by a plant wound response. The leafhopper is highly polyphagous, with over 220 known reproductive host plant species in 26 plant families. Adults often occur on other plant species (e.g., corn, *Zea mays*), however, whether *E. fabae* actually feeds on these non-reproductive plants or uses them for resting is still poorly understood. A molecular approach has been shown to be an effective method for accurate confirmation of plant consumption by insect pests. Detection of plant DNA from the gut contents of sap-feeding insects, however, can be challenging due to potential low concentration of ingested plant DNA. Although a few previous studies have demonstrated the possibility of detecting various fragments of plant DNA from some of the sap-feeders, there are no protocols available for the potato leafhopper, *Empoasca fabae*, a significant agricultural pest. In this study we focused on optimizing a DNA-based method for host plant identification of *E. fabae*, and investigating the longevity of the ingested plant DNA as one of the potential applications of the protocol. We largely utilized and modified our previously developed PCR-based method for detecting host plant DNA from grasshopper and the spotted lanternfly gut contents. We have demonstrated that the *trnL* (UAA) gene can be successfully utilized for detecting a host plant DNA from the gut contents of *E. fabae* and determining plant DNA longevity (plant DNA was detectable up to 20 hours post ingestion). The sequences of *V. faba*, isolated from both plants and insect gut contents, are deposited at the NCBI GenBank database (accession no.: MK934667, MK837073). The developed protocol is a relatively quick and low-cost method for detecting plant DNA from *E. fabae* guts. It has a number of important applications – from determining host plants and dispersal of *E. fabae* to developing effective pest management strategies.

Dynamics of spider assemblages in drainage ditches and adjacent organic soybeans. D. Kutz, and W. Lamp.

Agricultural drainage ditches, which are common structures on farms along Maryland's Eastern Shore, are typically using to provide hydrological control for croplands located above high-water tables. Recently, drainage ditches have begun to receive attention as potential sources of beneficial arthropods for adjacent croplands, such as natural enemies of agricultural pests. Spiders, the most abundant generalist predators in agroecosystems, have been previously been

supported as abundant and diverse natural enemies living in drainage ditches in Maryland. To better understand to what extent spiders in drainage ditches colonize crops growing in adjacent croplands, we investigated the following research objectives: (1) to assess how spider assemblages in drainage ditches and their neighboring croplands change throughout the soybean growing season, (2) to determine what spiders colonize croplands from drainage ditches, and (3) to identify what environmental conditions influence spider assemblages and colonization between drainage ditches and croplands. We implemented an experimental design during the 2018 and 2019 soybean growing seasons on a private organic farm, where spiders were collected from drainage ditches and their adjacent soybean fields at specific distances leading into the field from the ditch via foliar sweep netting and pitfall trapping. During the preliminary 2018 growing season, one drainage ditch on our organic farm was selected to collect spiders from to test our experimental design. During the next soybean growing season in 2019, this methodology was expanded upon to include three drainage ditches and assess environmental data such as prey abundance, ground-level temperature and humidity, and plant assemblage metrics. We found that drainage ditches possess spider species that migrate to soybean fields as the growing season progresses, as soybean fields begin to offer comparable prey availability as drainage ditches later in the growing season. Spider diversity and abundance in drainage ditches was significantly higher than in-field diversity and abundance early in the growing season ( $p < 0.05$ ). As the soybean growing season progressed, spider assemblages in ditches and soybean fields became more similar in diversity and abundance. Linear regression analysis comparing prey abundance and spider abundance across drainage ditches and their adjacent croplands found that prey abundance has a positive significant association with spider abundance in these habitats. Drainage ditches were found to simplify in their plant diversity as the growing season progresses, and thus provide less prey abundance for spiders over time, while soybean fields increased in prey abundance as they grew.

#### 4. Impact Statements

##### 5. Published Written Works *Cite them with CSSA, ASA references format*

###### *Refereed publications*

Wilson-Ounekeo, R., and W. Lamp. 2020. Perceptions and responses of residents to the nuisance black fly *Simulium jenningsi* (Diptera: Simuliidae) in the mid-Atlantic United States. *Journal of Medical Entomology* (in press).

Avanesyan<sup>#</sup>, A., and W. Lamp. 2020. Use of molecular gut content analysis to decipher the range of food plants of the invasive spotted lanternfly, *Lycorma delicatula*, *Insects* 11, 215.

Avanesyan<sup>#</sup>, A., T. Maugel, and W. Lamp. 2019. External morphology and developmental changes of tarsal tips and mouthparts of the invasive spotted lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae) *PLoS ONE* 14(12): e0226995.

Avanesyan<sup>#</sup>, A., K. Snook, P. Follett, and W. Lamp. 2019. Short-term physiological response of a native Hawaiian plant, *Hibiscus arnottianus*, to injury by the exotic leafhopper, *Sophonia orientalis* (Hemiptera: Cicadellidae). *Environmental Entomology* 48: 363-369.

#### 6. Scientific and Outreach Presentations

Lamp, W. 2019. Beneficial Biodiversity Associated with Agricultural Drainage Ditches on the Delmarva

Peninsula. DELMARVA Cooperative Seed Grant Program Summit, Newark, DE.

## 7. Collaborative Grants

2020-2023, USDA-SARE Novel Approaches Program, W. Lamp as lead PI with S. Zebelo and D. Owens as co-PIs, “Managing Agricultural Drainage Ditches for Conservation Biological Control on the Delmarva Peninsula”, \$197,728.

2020-2021, Maryland Agricultural Experiment Station, W. Lamp as lead PI with D. Hawthorne and A. Avanesyan as co-PIs, “Identification of host plant use by the invasive spotted lanternfly (*Lycorma delicatula*) using next-gen DNA sequencing technology”, \$29,928.

2018-2020, Maryland Department of Agriculture Block Grant Program through USDA, W. Lamp as PI, “The invasive spotted lanternfly, *Lycorma delicatula*, and its specialty crop host plants: insect host usage at each developmental stage”, \$37,831.

2017-20, USDA-Alfalfa and Forage Research Program, lead PD with Mark Sulc and James Jasinski (Ohio State University) and Yong-Lak Park and Tom Griggs (West Virginia University) as co-PDs, “Proximal and remote sensing of alfalfa canopies for early detection of insect stress and rapid integrated pest management decision-making”, \$289,993.

## 8. Graduate students

Thompson, M. 2019. Evaluating the effect of potato leafhopper (Family: Cicadellidae) feeding on biological nitrogen fixation of alfalfa (*Medicago sativa*). Unpub. Masters thesis, University of Maryland.

Kutz, D. 2020. Agricultural drainage ditches as sources of beneficial spiders to enhance conservation biocontrol in adjacent croplands. Unpub. Masters thesis, Univ. of Maryland.

## North Dakota Report 2019-2020

### North Dakota State University

#### 1. Impact Nugget:

Forages research in North Dakota has its main focus in alfalfa production management and cover crops for grazing. Integration of forages research into cropping systems has allowed us to get funding to continue research in forages.

#### 2. New Facilities and Equipment:

None

#### 3. Unique Project Related Findings:

*Accomplishments summaries:*

##### **Obj. 1. Forage crops**

In 2019, activities included testing alfalfa varieties and other forages. Results are published in the forages website (<http://www.ag.ndsu.edu/plantsci/forage/index.html>).

a) ***Mixtures for forage grazing:*** Annual ryegrass, chicory, and plantain mixtures were the lowest yielding mixtures as well as turnip-hybrid brassica mixtures. Forage sorghum (FS) and millet dominated the mix even at 2 lbs, pure live seed (PLS)/acre. FS regrowth was faster than other cover crops dominating the mix in the fall grazing. Mixtures with FS yielded about the same than FS alone. Legumes were lost after the first cut. Forage brassicas increased in the mix after the first cut.

b) ***Alfalfa-corn intercropping:*** It is a good option for farmers that grow corn silage and alfalfa. This project will be starting again in 2020.

##### **c) *K fertilization and its impact on yield, quality, and winter hardiness of alfalfa***

The experiment was conducted at two fields with low K in the soil (<100 mg/kg K) and two different smectite-to-illite ratio (high and low). Three alfalfa varieties were fertilized with three rates of K<sub>2</sub>O (0, 168, and 336 kg K<sub>2</sub>O/ha) at seeding, and 168 and 336 kg K<sub>2</sub>O/ha as split-application. There was a slight response to yield with increased K<sub>2</sub>O rate ( $r^2=0.62$ ). Difference on clay ratio was not observed.

##### **d) *Alfalfa management practices and their effect on arbuscular mycorrhizal (AM) populations - towards improving health, productivity, and sustainability of alfalfa production***

Root samples were taken from alfalfa K fertility trial and sent to South Dakota for further analysis on AM populations abundance and genotyping.

##### **Obj. 2. Bioenergy crops**

a) ***Perennial forage grasses:*** Twelve different species of perennial grasses have been evaluated annually since 2014 both for forage and potential as bioenergy crop.

b) ***Life cycle assessment of energy crops and agricultural residues for sustainable materials development:*** This work included to make a comprehensive literature review of seven energy, fiber, and oilseed crops used as feedstocks for sustainable materials.

##### **c) *Life cycle assessment and environmental impact of cover crops as relay crops into corn and soybean.***

Preliminary results showed a better environmental performance of winter camelina and field pennycress for impact categories such as eutrophication, erosion and pollinators, while winter rye outperformed the other crops and the control in carbon footprint and impact on soil C stock.

##### **Obj. 3. Cover crops**

a) ***Cover crops variety and seeding date trial:*** The experiment was established in 2019 in Fargo on two seeding dates, 1 August and 15 August. All results of biomass yield, and N accumulation of cover crops are available in the forages web page.

b) ***Fall-seeding or interseeding of cover crops in standing soybean to manage soybean cyst nematode (SCN):*** This study evaluated managing SCN by fall-seeding or interseeding non-host crops into

standing soybean. Even in very low levels of SCN (< 50 eggs/100 cm<sup>3</sup>), SCN populations can explode up to 140-fold if a SCN-susceptible variety is planted. SCN populations increased 2-4 fold even in the SCN-resistant variety. Fall-planted cover crops reduced SCN populations in the resistant variety only. Fall-seeded cover crops preceding soybean is a potential tool to manage SCN.

- c) ***N credits of cover crops to corn and sugarbeet.*** The results indicate legumes do provide some N credit to corn, but not to sugarbeet. Winter cover crops deplete soil moisture in the spring reducing stand establishment in sugarbeet reducing yield thereafter.
- d) ***Interseeding of cover crops into standing sugarbeet.*** Four cover crops were interseeded into standing sugarbeet in June and July in 2018 and 2019. Early planting had better cover crop stand, but reduced root yield. Cover crops scavenged excess nitrate leading to increased sugar content.
- e) ***Development of NIR calibrations for cool- and warm-season cover crops biomass, camelina , canola and flax seeds.*** Calibrations for NIR forage quality and seed quality (oil, protein, ash, fatty acids) analysis were developed.

Four publications were completed and published in this objective see references. Andersen et al., 2020, Peterson et al, 2019, Wittenberg et al., 2019, Anderson et al., 2019. Three graduate students working on this objective graduated (Andersen, Wittenberg, Peterson)

#### 4. Impact Statement

The forage program at NDSU **is the only program that provides non-biased information to farmers** on the performance of forages in ND. Forages acreage, without including CRP or native rangeland, was 3,321,202 acres in 2018. **Forages are the third most important crop in acreage in ND** after wheat and soybean. Diverse studies in alfalfa management conducted by this project have demonstrated that forage yield can be easily increased on average at least by 0.3 ton/acre/yr. Alfalfa acreage in ND in 2018 was 481,834 acres and alfalfa-grass mixtures 942,768 acres. An increase in forage yield of 0.3 tons/acre/year x 1,424,602 acres (alfalfa & alfalfa-grass) @ \$100/ton of hay equals an economic impact of **\$42,738,060/yr.** Alfalfa-corn intercropping allows alfalfa to be established in the corn year. This system increases alfalfa yield in Year 2 by 2.5 tons/acre compared with a spring-seeded alfalfa with a net profit of \$80/acre. The acres of corn silage-alfalfa rotation in ND are about 150,000 acres x \$80= **\$1,200,000** in monetary impact.

The impact of bioenergy crops research it is hard to value monetarily, since there is not commercial production of energy crops in ND yet. But FS can yield up to 10 tons DM/acre at \$30-50/ton for biomass feedstock gross income will be \$300-500/acre. In 2018, FS acreage increased in 26% from 35,843 acres in 2017 to 48,753 acres in 2018, at \$50/ton value by 5 tons/acre (2 cuts) as feed, the economic impact equals **\$12,188,250/yr.**

Cover crops acreage increased 89% from 2012 to 2017 in North Dakota, with a total of 404,267 acres. Legume cover crops planted after wheat in one of our studies reduced the need of fertilizing corn by 50 lbs N/acre. Additionally, the research of interseeding cover crops into standing corn and soybean has indicated cover crops retain-30-50 lbs of N in their biomass preventing nitrate leaching off the root zone of the cover crops. With a very conservative N credit of legume cover crops of only 10 lbs N/acre, the economic value of reducing the fertilization in corn in 3,068,997 acres x 10 lbs N/acre saving x \$0.35 lb N, is **\$10,741,489/yr.** Cover crops forage value can add \$30/acre revenue by grazing. If only 1% of the wheat acreage (7,605,263 acres) was planted to cover crops for grazing after harvest, the economic impact would be **\$2,281,579/yr.**

**In summary, the forages, biomass, and cover crops project at NDSU impacts the state's economy by: a) increasing alfalfa and other forages yield, b) decreasing N rates in corn, c) increasing soil health and crop yields in the long term, and d) providing additional forage for grazing in the fall. Total potential economic impact to the state= \$56,961,128 annually.**

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## 5. Published written work

### Peer-reviewed publications

1. Podder, S., D. Samarappuli, James V. Anderson, and **M.T. Berti\***. 2020. Phenotyping a diverse collection of forage sorghum genotypes for chilling tolerance. *Agronomy*, 10:1074  
doi:10.3390/agronomy10081074
2. Niu, Y., Z. Luo, L. Cai, J.A. Coulter, Y. Zhang, and **M. Berti**. 2020. Continuous monoculture of alfalfa and annual crops influence soil organic matter and microbial communities based on the substrate utilization pattern analysis in rainfed Loess Plateau of China. *Agronomy* 10:1054,  
doi:10.3390/agronomy10071054
3. Teuber, O., D. Samarappuli, and **M.T. Berti\***. 2020. Nitrogen and sulfur fertilization in kale and swede for grazing. *Agronomy* 10(5), 619; doi:10.3390/agronomy10050619
4. Spiess, J. D.A. McGranahan, B. Geaumont, K. Sedivec, M. Lakey, **M.T. Berti**, T.J. Hovick, R.F. Limb. 2020. Patch-burning buffers forage resources and livestock performance to mitigate drought in the northern Great Plains. *Rangeland Ecol. Manag.* 73(4):473-481
5. Acharya, K., G. Yan, and **M.T. Berti**. 2020. Evaluation of diverse cover crops as hosts of two populations of soybean cyst nematode, *Heterodera glycines*. *Crop Protection* 135,105205  
doi:1016/j.cropro.2020.105205
6. Andersen, B., D.P. Samarappuli, A. Wick and **M.T. Berti\***. 2020. Faba bean and pea can provide late-fall forage grazing without affecting maize yield the following season. *Agronomy*, 10:80.
7. Peterson, A., D. Samarappuli, and **M.T. Berti\***. 2019. Intersowing cover crops into standing soybean in the US Upper Midwest. *Agronomy* 9: 264 <http://dx.doi.org/10.3390/agronomy9050264>
8. Wittenberg, A., J.V. Anderson, and **M.T. Berti\***. 2019. Winter and summer annual biotypes of camelina have different morphology and seed characteristics *Ind. Crops Prod.* 135:230-237
9. Anderson, J.V., A. Wittenberg, H. Li., and **M.T. Berti**. 2019. High throughput phenotyping of *Camelina sativa* seeds for crude protein, total oil and fatty acids profile by near infrared spectroscopy. *Ind. Crops Prod.* 137:501-507.
10. Acharya, K., G. Yan, and **M.T. Berti**. 2019. Can camelina, crambe, and brown mustard reduce soybean cyst nematode populations? *Ind. Crops. Prod.* 140:111637.

### Proceedings and Abstracts

**Berti, M.T.\***, G. Yan, D. Samarappuli, A. Peterson, A. Wittenberg, and J.V. Anderson. 2019. Potential benefits to the environment by integrating winter camelina in current cropping systems of the northern Great Plains of the USA. p. 131 In European Biomass Conference and Exhibition. 27-30 May 2019, Lisbon, Portugal. Available at <http://www.etaflorence.it/proceedings/index.asp> (verified 10 June 2019).

### Scientific and Outreach Presentations

1. Neubauer, M., **M.T. Berti**, J.V. Anderson, W. Chao, and D. Horvath. 2020. Vernalization and cold acclimation of two divergent *Camelina sativa* biotypes: An RNAseq time course study. Plant Biology Worldwide Summit, Washington, DC, 27-31 July, (Virtual)



2. Cecchin, A., **M.T. Berti\***, and G. Pourhashem, 2020. Evaluating environmental impacts of introducing winter camelina and field pennycress into the current cropping systems in the upper Midwest of the USA. In 28<sup>th</sup> European Biomass Conference and Exhibition. 6-9 July 2020, Marseille, France (Virtual).
3. **Berti, M.T.** 2020. Potassium Impact on yield, quality, and winter hardiness. Midwest Forage Association Annual Conference. Wisconsin Dells, WI, 18-19 February 2020.
4. **Berti, M.T.** 2020. Cover crops North Dakota Report. Midwest Cover Crop Council Conference. Kansas City, MO 10-12 February 2020.
5. **Berti, M.T.** 2020. Cover crop seed regulations and crop variety v. selection. Cover Crops In-Service, An in-person training for NDSU Extension agents, NRCS, and SCD personnel. Carrington, ND, 13 January 2020. *Invited.*
6. **Berti, M.T.** 2020. Selecting cover crops by function. An in-person training for NDSU Extension agents, NRCS, and SCD personnel. Carrington, ND, 13 January 2020. *Invited.*
7. Greenberg, A., **M.T. Berti**, D.P. Samarappuli, A. Peterson, S. Cabello, A. Wittenberg, and K. Mozea. 2020. Impact of potassium fertilization on yield, quality, and winter hardiness of alfalfa. American Forage and Grassland Council Conference Greenville, SC, 5-8 January 2020.
8. Mozea, K. **M.T. Berti**, K. Sedivec, A. Peterson, A. Wittenberg, S. Cabello, and A. Greenberg. 2020. Biomass yield and botanical composition of annual forage mixtures for grazing. American Forage and Grassland Council Conference Greenville, SC, 5-8 January 2020.
9. **Berti, M.T.** 2019. Managing soybean cyst nematode with cover crops. Prairie Grains Conference Grand Forks, 11-12 December 2019. *Invited*
10. **Berti, M.T.** 2019. Timing and establishment of cover crops. Dakota Innovation Research and Technology Workshop Fargo, ND, 9-11 December 2019. *Invited*
11. **Berti, M.T.** and Y. Lawley 2019. High protein forage options and interseeding alfalfa in corn. Dakota Innovation Research and Technology Workshop Fargo, ND, 9-11 December 2019. *Invited*
12. Cabello, S., S. Podder, **M.T. Berti**, D. Samarappuli, B. Andersen, A. Wittenberg, and A. Peterson. 2019. Cover crops decrease initial water content, sugarbeet root yield, and residual NO<sub>3</sub>-N in the northern Great Plains. ASA-CSSA-SSSA International Annual Meetings, San Antonio, TX, 10-13 November 2019.
13. Cabello, S., S. Podder, **M.T. Berti**, D. Samarappuli, B. Andersen, A. Wittenberg, and A. Peterson. 2019. Legume fall-planted cover crops slightly increased corn yield in the northern Great Plains. ASA-CSSA-SSSA International Annual Meetings, San Antonio, TX, 10-13 November 2019.
14. Wittenberg, A., **M.T. Berti**, A. Peterson, D.P. Samarappuli, A. Greenberg, K. Mozea, S. Cabello, S. Podder, and J.V. Anderson. 2019. Sowing date affects winter camelina stand. ASA-CSSA-SSSA International Annual Meetings, San Antonio, TX, 10-13 November 2019.
15. Franzen, D.W., **M.T. Berti**, S. Matthews, and A. Wick. 2019. Increase in non-exchangeable ammonium after cover crop rye and forage radish. ASA-CSSA-SSSA International Annual Meetings, San Antonio, TX, 10-13 November 2019.
16. **Berti, M.T.**, 2019. Importance of integrating cover crops into cropping systems. First International Cover Crops Conference, Lanzhou, China 20-26 September, 2019. *Invited speaker.*
17. Wittenberg, A., **M.T. Berti**, A. Peterson, D.P. Samarappuli, A. Greenberg, K. Mozea, S. Cabello, S. Podder, and J.V. Anderson. 2019. Fall sowing dates in camelina affected plant density. 31<sup>th</sup> Annual Meeting of the Association for the Advancement of Industrial Crops (AAIC). Tucson, AZ, 8-11 September 2019.
18. Lakey, M., D. McGranahan, K. Sedivec, **M. Berti**. 2019. Heterogeneous forage quality determines livestock use when implementing patch burn-grazing on Kentucky bluegrass-invaded rangeland. Annual conference Society for Range Management, Minneapolis, MN.

*Other publications (magazines, extension/online/bulletins)*

1. Meehan, M., M. Keena, **M.T. Berti**, K. Sedivec, M. Ostlie, and E. Gaugler. 2020. Integration of Crop & Livestock Systems in North Dakota. 2020.Beef & sheep report.
2. **Berti, M.T.** 2020. Frost damage in alfalfa: what to do after it? Crop &Pest Report Bull. No. 4, NDSU Extension Serv. 21 May 2020.
3. **Berti, M.T.** and O. Teuber, 2020. Fertilization of full-season forage brassicas for grazing. Forage Focus May 2020, p.7.
4. Sedivec, K., M. Meehan, E. Gaugler, **M. Berti**, F. Brummer, P. Nester 2020. Annual cover crop options for grazing in the northern Plains. Bull. R1759. North Dakota State University Extension Service.
5. **Berti, M.T.**, and H. Bücking. 2020. Alfalfa productivity and nutrient uptake is related to interaction with soil microbiome. Forage Focus March 2020. Midwest Forage Association, St. Paul, MN p.18-19.
6. **Berti, M.T.**, and A. Greenberg. 2020. Potassium fertilization does not increase alfalfa forage yield in the seeding year. Forage Focus. March 2020. Midwest Forage Association, St. Paul, MN p. 3-4
7. Holin, F. and **M. Berti**. 2020. Researcher works to Reduce Potassium Deficiency in Alfalfa. Clippings, Midwest Forage Association, St. Paul, MN. February 27, 2020.
8. **Berti, M.T.** and G. Yan. 2019 host & non-host cover crops of soybean cyst nematode. 27 June 2-19. NDSU FactSheet.
9. Meehan, M., **M. Berti**, K. Sedivec, and J. Block. 2019. Cool Weather May Decrease Forage Production, Quality. NDSU Ag Communications.  
<http://www.ag.ndsu.edu/news/newsreleases/2019/june-10-2019/cool-weather-may-decrease-forage-production-quality>

### 7. Collaborative grants

USDA-NACA09/2020-08/2022. Agronomic and molecular responses of maize and sunflower to competition with cover crops and alfalfa. \$ 60,000, PI.

NC-SARE, 10/1/2020-9/30/2022, Training for effective delivery of science-based soil health information – It’s about more than just content, It’s about messaging skills. \$89,817, Co-PI

Midwest Forage Association, 5/2020-4/2021. Testing new high quality perennial cool-season forage grasses with improved winter hardiness and persistence, \$2000, PI

USDA-NIFA- 3/2020-02/2024. Managing disturbance for multi-functional rangelands: livestock, plant, and pollinator responses to management strategies that differentially use fire and grazing, \$499,242, co-PI

2019-2021 USDA-NIFA- ASAFS Alfalfa management practices and their effect on arbuscular mycorrhizal fungi (AMF) populations- towards improving health, productivity, and sustainability of alfalfa production” \$429,011. In collaboration with Heike Bucking and Sara Bauder South Dakota State University

### 8. Graduate students

**Samuel Bibby, MS:** Alfalfa-corn intercropping a two- row spacing of corn. Expected graduation May 2022

**Kenneth Mozea, MS:** Full-season cover crops grazing mixtures. Expected graduation 2021

**Amy Greenberg, MS:** Potassium fertilization in alfalfa. Expected graduation 2021.

**Swarup Podder, MS:** Chilling tolerance in forage sorghum. Graduated May 2019

## Oregon Report 2019-2020 Oregon State University

### 1. Impact Nugget:

Development of new methodology or approaches:

- Se fertilization to growing forages by spraying to increase forage Se concentration to meet livestock needs and to avoid white muscle syndrome.
- Sequential grazing to increase pasture carrying capacity and improve animal performance.

Implementation of solutions or adoption of recommendations developed:

- Match the right forage species with irrigation water rights or producers' specific objectives to achieve agricultural sustainability while conserving salmon habitat.

Cleaner environment and healthier communities:

- Novel forage species such as birdsfoot trefoil, plantain, and chicory in Oregon grazing pastures lowers methane emission potential, urine leaching to the groundwater, and increases atmospheric nitrogen fixation potential to lower the nitrogen fertilizer demand.

### 2. New Facilities and Equipment: NA.

### 3. Unique Project Related Findings: NA.

### 4. Accomplishment summaries:

**Collaborative Efforts:** Oregon State University Extension and Research faculty have initiated a “Forage and Livestock Systems” working group. The mission of this working group is to increase collaboration on planning and executing high priority projects. One collaborative project, led by David Hannaway, is developing an “Oregon Forages” website (<https://forages.oregonstate.edu/oregon>). This website, primarily focused on Oregon, will include comprehensive content of forage and livestock topics and segments devoted to the interrelationships among soil, water, plant, animal, and human health and the economic and social implications of developing sustainable agricultural systems. This site will simplify the search for information by county agents and specialists, farmers and ranchers, and agricultural agency personnel and build stronger linkages among research, outreach, and classroom and eCampus teaching efforts. Progress to date includes developing the organizational outline of 19 topic areas, numerous sub-topics, and content authors. Initial drafts have been completed for many of the sections and a review process is being developed. This review process is necessary for ensuring “scholarly accomplishments” credit for authors.

#### **Research: PI and Project Descriptions**

**Serkan Ates:** Evaluation of novel forage species, especially legumes and other forbs, to diversify forage production and extend the grazing season for dairy and sheep grazing systems.

**David Hannaway:** Modeling and mapping of forage species suitability leading to improved species and cultivar selection.

**Guojie Wang:** Evaluation of forage species for increased water use efficiency and seasonal forage production to develop systems that balance agricultural production needs for irrigation water with ecological needs for ecosystems services including wildlife and fish habitat.

### 5. Published Written Works:

Refereed publications:

Cicek, Harun, **Serkan Ates**, Gazi Ozcan, Mehmet Tezel, Jennifer G. Kling, Mounir Louhaichi and Gurhan Keles. 2020. Effect of nurse crop and seeding rate on the persistence, productivity and nutritive value of sainfoin in a cereal-based production system. *Grass and Forage Science* 75: 86-95.

- Gultekin, Yunus, Shelby Filley, Mary Smallman, **David Hannaway**, **Serkan Ates**. 2020. Pasture production, persistence of legumes and lamb growth in summer-dry hill pastures. *Grass and Forage Science*. Article ID: GFS12497. DOI 10.1111/gfs.12497.
- Qin, Ruijun, C. Noulas, D. Wysocki, X. Liang, **G. Wang** and S. Lukas. 2020. Application of plant growth regulators on soft white winter wheat under different nitrogen fertilizer scenarios in irrigated fields. *MDPI-Agriculture*. DOI: 10.3390/agriculture10070305.
- Smith, R.W., M. Webb, D. Kidd and **D.B. Hannaway**. 2020. Mapping pasture species suitability using fine scale soils and climate data. *Crop & Pasture Sci.* 70 (12): 1175-1183. <https://doi.org/10.1071/>.
- Tan, Shuhao, Weizhu Dai, Ruxin Zhang, and **David B. Hannaway**. 2020. Multi-household Grassland Management Pattern Promotes Ecological Efficiency of Livestock Production. *Ecological Economics*: 171. <https://doi.org/10.1016/j.ecolecon.2020.106618>
- Wilson, Randi L., Massimo Bionaz, Jennifer W. MacAdam, Karen A. Beauchemin, Harley D. Naumann, and **Serkan Ates**. 2020. Milk production, nitrogen utilization, and methane emission of dairy cows grazing grass, forb, and legume-based pastures. *Journal of Animal Science*. <https://doi.org/10.1093/jas/skaa220>
- Zhang, Ruxin, ShuhaoTan, **David Hannaway**, and Weizhu Dai. 2020. Multi-household grassland management pattern promotes ecological efficiency of livestock production. *Ecological Economics* 171 106618. <https://doi.org/10.1016/j.ecolecon.2020.106618>
- Zhu, Yajuan and **Guojie Wang**. 2020. Rainwater use process of *Caragana intermedia* in semi-arid zone, Tibetan Plateau. *Frontiers in Earth Science-Hydrosphere*. <https://doi.org/10.3389/feart.2020.00231>.

#### Bulletins and extension factsheets:

- Fery, Melissa, **David Hannaway**, David Chaney, Maud Powell, and Garry Stephenson. 2020. Introduction to Pasture & Grazing Management. Oregon State University Extension Service Circular (in review).
- Dreves, A., N. Kaur, M. Bohle, **D. Hannaway**, G. Fisher, and S. Rondon. 2020. Insect and Mite Pests of PNW Pastures. (In PNW review)
- Hannaway, David B.** et al. 2020. Oregon Forages. <https://forages.oregonstate.edu/Oregon>

#### 6. Scientific and Outreach Presentations:

- Carmona-Flores, L., M. Bionaz, T. Downing, M. Sahin, **S. Ates**. 2020. Effects of diversity and spatial separation of pastures on milk yields, N partitioning, and methane emissions in dairy cows. ADSA2020 Virtual Annual Meeting, June 24.
- Ford, H., S. Busato, E. Trevisi, Y. Gultekin, M. Bionaz, and **S. Ates**. 2020. Chicory and plantain-dominated forb pasture improves health and rumen N efficiency in lactating dairy cows. ADSA2020 Virtual Annual Meeting. June 24.
- Melathopoulos A.P. and **S. Ates**. 2020. Evaluating the nectar and pollen resources for honey bees in western Oregon non-irrigated pasture systems. 79th Annual Pacific Northwest Insect Management Conference. January 6-7. Portland, Oregon.
- Wilson, R.L., M. Bionaz, J.W. MacAdam, K.A. Beauchemin, H.D. Naumann, and **S. Ates**. 2020. Milk production, nitrogen utilization, and methane emission of dairy cows grazing grass, forb, and legume-based pastures. ADSA2020 Virtual Annual Meeting. June 6.

#### 7. Collaborative Grants

- Ates, S. et al. 2020-2021. Methane emissions from grazing and confined dairy cows in the PNW.

Oregon Dairy Farmers' Association.

- Ates, S. et al. 2020. Feeding spent hemp biomass to lambs as a model for cattle: cannabinoid residuals, animal health, and product quality. Oregon Beef Council.
- Ates, S. et al. 2020. Lamb growth, grazing behavior and welfare in agrivoltaic systems. Oregon State University Agricultural Research Foundation Grant.
- Ates, S. 2020. Improving Soil Biodiversity and Grazing Days with Cover Crops on Irrigated Pasture in Oregon's High Desert. USDA Western Sustainable Agriculture Research and Extension (SARE) Farmer Rancher Researcher Grant.
- Bionaz Massimo, S. Ates, and M. Smallman. 2020-2021. Legume hay with high bioactive compounds and organic selenium to improve the transition from pregnancy to lactation using sheep as animal model. Oregon State University Agricultural Research Foundation Grant.
- Bionaz Massimo, S. Ates, J. Durringer, and J. Cruickshank. 2020-2021- Feeding dairy cows spent hemp biomass instead of alfalfa: effect on health and performance of cows and cannabinoids residuals in milk (Oregon Dairy farmers Association).
- Durringer Jennifer, Serkan Ates, Bionaz Massimo. 2020. Nutritional and potency characterization of hemp as a possible feed source for livestock. Oregon State University Agricultural Research Foundation Grant.
- Melathopoulos, A., M. Moretti, and S. Ates. 2020-2022. New opportunities for establishing NRCS pollinator habitat in the Pacific Northwest. Natural Resources Conservation Service, USDA.
- Melathopoulos, Andony and S. Ates. 2019-2020. Evaluating the nectar and pollen resources of alternative livestock forages to alfalfa. National Honey Board.
- Norberg, S., L. Yu, G. Zanton, G. Shewmaker, G. Wang, D. Llewellyn and S. Fransen. 2020. Determining genetic factors that influence protein quality and yield in alfalfa. USDA-NIFA.
- Wang, G. 2020. Cover crops after forage spring triticale in eastern Oregon. Oregon State University Agricultural Research Foundation Grant.
- Wang, G. 2020. Developing a fall-winter grazing system by using fodder beets. Oregon State University Agricultural Research Foundation Grant.
- Wang, G. 2020. Irrigation and seeding date effects on winter grasses and forbs forage production and quality in eastern Oregon. Oregon Beef Council.
- Wang, G. 2020. Long-term forage production of perennials effects on soil health under limited and competing water resources in eastern Oregon. Oregon State University Agricultural Research Foundation Grant.

#### 8. Graduate Students:

- Blair, Sally. 2020. Using annual forages to extend grazing season in early spring and late fall. Master of Science. Thesis. Oregon State University.
- Carmona, Flores, L. F. 2020. Effects of Diversity and Spatial Separation of Pastures on Forage Production, Milk Yields, N Partitioning and Methane Emissions. Master of Science Thesis. Oregon State University.
- Gultekin, Yunus. 2020. Pasture Production and Lamb Growth from Dryland Hill Pastures in Western Oregon. Master of Science Thesis. Oregon State University.
- Sahin, Elif. 2020. Breeding for Improved Forage Digestibility and Yield Potential in Tall Fescue. Master of Science Thesis. Oregon State University.
- Sahin, Muhammet. 2020. Selection for Persistence in Red Clover (*Trifolium pratense* L.) Through Improved Tolerance to Northern Anthracnose. Master of Science Thesis. Oregon State University.

Wilson, R. L. 2020. Milk Production, Pasture Performance, and Environmental Sustainability of Specialized Pastures. Master of Science Thesis. Oregon State University.

**Texas 2019-2020 report**  
**Texas A&M System Research Report**

1. Impact Nugget

Texas A&M AgriLife Research has improved the resource efficiency of forage production by developing summer dormant cool-season grasses, refining best management practices of novel and existing grasses and legumes, evaluating the impact of supplementation on grazing cattle, and furthering the understanding of the fundamentals of the water footprint when forages are integrated into agriculture systems.

2. New Facilities and Equipment

Purchased a new forage harvester to evaluate winter annual small grain forages.

3. Unique Project Related Findings

Texas A&M AgriLife Research evaluated the nutritive value as impacted by management of forage sorghum and small grains, evaluated the potential for Teff, *Brachiaria*, or summer-dormant cool-season grasses to be incorporated into Texas forage systems. Recent forage sorghum silage research confirmed that harvest timing and management are critical to optimize forage sorghum silage quality and that sorghum crops that fail to produce grain can be ensiled for livestock feed. Determined the potential of cool-season legume hay cover crops or warm-season legume dual crops to secure soil and the impact on water footprint, determined the feasibility and effectiveness of incorporating co-products, such as distillers grains and lipid-extracted algae into agriculture systems, released native grass, legume and other herbaceous forb cultivars, and disseminated results to land owners.

4. Accomplishment Summaries

During 2019-2020, faculty from Texas A&M University, AgriLife Research and Extension (Bell, Foster, Kimura, Malinowski, Muir, Olson, Redmon, and Rouquette) published data on variety of basic forage-agronomy research topics. Outreach activities included the delivery of our findings during in-service training sessions, field days, and through various extension publications. Faculty at Texas A&M AgriLife Research, Texas A&M University-Kingsville, Texas Native Seed, Texas A&M University, and Tarleton State University have formed a working group focused on domesticating and promoting native grassland grasses and forbs for wider use in rangeland revegetation, cultivated pasture, ornamental horticulture, wildlife habitat and feed, and bioenergy.

5. Impact Statements

Issue: There are no perennial cool-season grasses which are adapted, and persistent in Texas.

Action: Texas A&M AgriLife has developed a summer-dormant tall fescue line TAL-02 that will be commercialized by Grasslands Innovation, NZ, and we are in the final stage of developing 2 cultivars of orchardgrass, and 2 cultivars of perennial ryegrass.

Issue: Sorghum is more drought tolerant than corn; therefore, sorghum is a more efficient crop in semi-arid regions. There is a paucity of information on the nutritive value of sorghum silage, compared to corn silage.

Action: Sorghum lines among BMR types are not equal in their nutritive value, recommendations on those which have the least lodging and greatest potential for sorghum silage were recommended to land owners.

Issue: Fallow periods in row-cropping agriculture leave the soil prone to erosion and reduced organic matter and water holding capacity.

Action: Cotton and sorghum production is not reduced by use of cool-season legume cover crops when incorporated into strip-till cotton-sorghum rotations, water footprint is still under long-term evaluation.

Issue: Improvement in livestock production can only occur by improvements to the quantity and quality of forages in the diet. Warm-season perennial grasses are the mainstay of livestock production in Texas; however, these are typically lesser in quality than cool-season grasses.

Action: We have generated data on relatively new warm-season annual forage, teff, for the forage producers in the Rolling Plains of Texas.

Contact:

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[361-358-6390/jlfoster@ag.tamu.edu](mailto:361-358-6390/jlfoster@ag.tamu.edu)

Cooperators: Bell, Kimura, Malinowski, Muir, Olson, Redmon, and Rouquette

## 6. Published Written Works

### *Book/Journal Issue*

Clayton, Megan, Suzanne Contreras Walsh, Larry Redmon, and Robert Shaw. 2020. *Bluestem Grasses in Texas: A Field Guide to Native and Introduced Species*. TX AgriLife Extension Service, College Station, TX.

Muir, J. P. and J.C.B. Dubeux, Jr. (eds.). 2019. *Arboreal Legumes for Multiple Uses*. Legume Perspectives Journal. Legume Society Issue 17.

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Rouquette, Jr., M. and Glen E. Aiken (Ed). *Management strategies for sustainable Cattle Production in Southern Pastures*. Elsevier Academic Press. San Diego, CA. USA.

### *Book Chapters*

Belesky, D.P., J.W. Walker, K.A. Cassida, and J.P. Muir. 2020. Forbs and Browse Species. In Moore, K.J., M.C., C.J. Nelson and D.D. Redfearn (eds.) *Forages, Volume 2: The Science of Grassland Agriculture*, 7th Ed. pp. 347-368. Wiley-Blackwell, Hoboken, NJ USA.

Corriher-Olson, V., L.A. Redmon, and M. Rouquette, Jr. 2019. Weed Control in Pastures. In: M. Rouquette and G.E. Aiken, editors, *Management Strategies for Sustainable Cattle Production in Southern Pastures*. Elsevier.

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*Refereed Journal Articles*

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*Symposium Proceedings*  
All postponed to 2021

*Abstracts*

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Dube, N., A. Chang, X. Shen, J. Landivar, and J.L. Foster. 2020. Unmanned aircraft system (UAS) based forage biomass prediction using an artificial neural network. ASA-CSSA-SSSA 2020 International Meetings, Pheonix, AZ, Nov. 8-11. (Abstr.)

Dubeux, J.C.B, L.E. Sollenberger, V.X.O Apolinario, L. Garcia, MVF dos Santos, J.P. Muir, J.M.B Vendramini, J.H.A. Rangel, and N. DiLorenzo. 2019. Ecosystems services from warm-climate forage

legumes. American Society of Agronomy/Crop Science Society of America & Soil Science Society of America. 9-13 Nov 2019, San Antonio TX. Abstract 68-1. <https://scisoc.confex.com/scisoc/2019am/meetingapp.cgi/Paper/118128>

Finn, N.A., N. Cherry, J.P. Muir, and W. B. Smith. 2019. Livestock Literacy: Ensiling Newspaper as a Renewable Fiber Source for Ruminant Animals. Southern Section Meetings Proceedings, 26-29 January 2019 Oklahoma City, OK. JOURNAL OF ANIMAL SCIENCE. 97(Supplement\_1), 56-56.

Foster, J.L., P.E. Bekewe, H.L. Neely, C.B. Neely, L.E. Tomlin, and K.L. Lewis. 2020. Wheat double cropping systems to improve soil health. Soil and Water Conservation International Annual Conference, Des Moines, IA, Jul. 26-29. (Abstr.)

Garcia, A., J.L. Foster, G. Schuster, A. Umphres, and J.A. McGinty. 2020. Weed management systems in imidazolinone tolerant sorghum (*Sorghum bicolor*) in south Texas. Subtropical Agriculture and Environments Society, Weslaco, TX, Feb. 7. (Abstr.)

Garcia, T. J., Brady, J. A., Guay, K. A., Muir, J. P., and Smith, W. B. 2019. Reduce Reuse ReRumen: Preservation method of rumen fluid collected from slaughtered cattle affects in vitro digestibility. JOURNAL OF ANIMAL SCIENCE. 97(Supplement\_1), 66-67.

Garcia, A., J.A. McGinty, J.L. Foster, G. Schuster, and A. Umphres. 2020. Weed management systems in imidazolinone tolerant grain sorghum in south Texas. Weed Science Society of American Annual Meeting. Maui, HI, Mar 2-5. (Abstr.)

Jones, B.W., W.B. Smith, B.D. Lambert, J.P. Muir, and E. Kan. 2019. Effects of garlic extract and citrus flavonoid feed additive on dairy cow performance. Proc. Annual Meeting American Dairy Association, Austin TX Poster T134.

Lourencon, R.V., S.P. Hart, T.A. Gipson, and J.P. Muir. 2019. Tannins as antinutritive chemicals in red cedar. Southern Section Meetings Proceedings, 26-29 January 2019 Oklahoma City, OK.

McLawrence, Javid, Cara Case, Jessie I. DuPont, Reshmi Sarkar, Ishu Verma, Francis M. Rouquette, Jr., and Anil Somenahally. 2019. Quantifying root biomass, microbial biomass and soil organic pools under long term grazing lands management strategies. ASA-CSSA-SSSA. Abst. 501-1109. San Antonio, TX

Muir, J.P., MVF dos Santos, C.V. Patto. 2019. Feed the world: domesticate a novel legume. Proc. American Society of Agronomy/Crop Science Society of America & Soil Science Society of America. 9-13 Nov 2019, San Antonio TX. Abstract 68-5.

<https://scisoc.confex.com/scisoc/2019am/meetingapp.cgi/Paper/118005>

Niraula S, Choi YK, Paynes K, Muir JP, Chang WS, Kan E. 2019. Effects of wood-derived biochar on Bermudagrass (*Cynodon spp.*) growth and the rhizosphere microbiome. ASM meeting, Nov. 7-9, 2019, San Antonio, USA.

O'Daniel, Sydney E., David G. Riley, Kelli J. Kochan, Penny Riggs, Francis M. Rouquette, Ronald D. Randel, and Thomas H. Welsh. 2019. Comparison of telomere length in age-matched primiparous and multiparous Brahman cows. ASAS. Abst. J. Anim Sci 97:363-364. Austin, TX.

Pintar, J., A.J. Gyawali, A.P. Smith, H. Neely, J.L. Foster, and P. Bekewe. 2020. Developing spatial sampling strategies for monitoring microbial exoenzyme activity for soil health. ASA-CSSA-SSSA 2020 International Meetings, Pheonix, AZ, Nov. 8-11. (Abstr.)

Reyes-Cabrera, Joel, et al, Francis Rouquette, et al. 2019. Root morphology traits of switchgrass across a latitudinal gradient in the US. ASA-CSSA-SSSA. Abst. 308-3. San Antonio, TX.

Selph, L., D.G. McGahan, J.P. Muir, & E. Kan. 2019. Effects of Pre-Enriched Manure and Cellulosic Biochars on Soil Physiochemical Properties and Forage Growth. 2019 ASA-CSSA-SSA International Annual Meeting, 10-13 November, San Antonio Texas. Abstract 68-5.

<https://scisoc.confex.com/scisoc/2019am/meetingapp.cgi/Paper/121661>

Shen, X, J. Landivar, A. Chang, N. Dube, and J.L. Foster. 2020. Identifying botanical composition and accuracy assessment on high-resolution imagery of grassland mixtures. ASA-CSSA-SSSA 2020 International Meetings, Phoenix, AZ, Nov. 8-11. (Abstr.)

Smith, Gerald R. and Francis M. Rouquette, Jr. 2019. Developing forage cowpeas for cover crops, wildlife stewardship and livestock production systems. ASA-CSSA-SSSA. Abst. 132-1. San Antonio, TX

Victoria, M., H.R. Leggette, J.L. Foster, H. Neely, C. Neely, K. Lewis, P. Bekewe, B.J. Gerrish, and J. Parrella. 2020. Measuring adoption of soil health practices of wheat producers in Texas. National Agricultural Communication Symposium, Louisville, KY, Feb. 2-3. (Abstr.)

Victoria, M., H.R. Leggette, J.L. Foster, H. Neely, C. Neely, K. Lewis, P. Bekewe, B.J. Gerrish, and J. Parrella. 2020. Minding the microbes: The adoption of soil health management techniques by Oklahoma wheat producers. Soil and Water Conservation International Annual Conference, Des Moines, IA, Jul. 26-29. (Abstr.)

Woli, P., F. M. Rouquette Jr., C. R. Long, L. O. Tedeschi . 2020. A Dynamic Model of Nutritive Value Components of Bermudagrass Forage to Estimate TDN for Pastures in the Southern United States. ASA-CSSA-SSSA. C06 Forage and Grazinglands. Virtual.

Wood, S.L., L.M. Baker, N.M. Cherry, J.P. Muir, and W.B. Smith. 2019. Calf-inated Cups: Disposable Coffee Cups as a Fiber Source in Ruminant Diets. Southern Section Meetings Proceedings, 26-29 January 2019 Oklahoma City, OK. JOURNAL OF ANIMAL SCIENCE. 97(Supplement\_1), 54-55.

#### *Extension Publications*

Rouquette, Jr, Monte. 2019 Management strategies for sustainable pastures and beef production. Res. Center Tech. Rept. 2019-1

#### *Popular Articles*

Fannin, Blair and V. Corriher-Olson. Managing pastures after a prolonged drought. AgriLife Today. July 2020. (reprinted The Eagle).

Fears, R., J.L. Foster, and C.A. Clark. 2020. Farmers first: Growing the right grass. The Eagle Land and Livestock Post, Bryan, TX, Mar 30.

Lackritz, Matt and V. Corriher-Olson. Armyworms return to parts of East Texas. CBS 19. July 24, 2020.

Russell, Adam and V. **Corriher-Olson**. Texas Crop and Weather Report—April 23, 2019. AgriLife Today. April 2019. (reprinted AgFax, The Cattleman)

Russell, Adam and V. Corriher-Olson. Texas Crop and Weather Report- April 7, 2020. As warm season grasses emerge, hay producers should help maximize growth. AgriLife Today. April 2020.

Russell, Adam and V. Corriher-Olson. Texas Crop and Weather Report- May 19, 2020. Mother Nature delivers mixed bag for hay producers. AgriLife Today. May 2020.

Russell, Adam and V. Corriher-Olson. Forage webinar aims to save ranchers money. July 20, 2020. AgriLife Today.

#### 7. Scientific Outreach Presentations

Foster, J.L. Fertilizing: Options and Accurate Prescriptions. 2020 Advocating for Agriculture, Texas A&M AgriLife Corpus Christi Based Specialists. Apr. 14, 2020.

Foster, J.L. Selection and Management of Introduced and Native Grasses. Natural Resources Webinars, Texas A&M AgriLife Extension. Sept. 5, 2019. <https://texasrangewebinars.tamu.edu/webinars/selection-and-management-of-introduced-and-native-grasses/>

Foster, J.L. Soil and Water Conservation in South Texas Cropping Systems. Karnes County Soil and Water Conservation District. Kenedy, TX, Feb. 11, 2020.

Foster, J.L. Cover Crop Options for South Texas. Restoring Ecosystem Function with Affordable Agricultural Practices Field Day. D'Hanis, TX, Oct. 29, 2019.

Olson, V.C. Blackland Income Growth. Restricted vs. Non Restricted Herbicide Use. Waco, TX. Jan 15, 2019.

Olson, V.C. East Texas Pasture Management Program. Soil fertility & fertilizers. Overton, TX. Feb. 22, 2019.

Olson, V.C. East Texas Pasture Management Program. Control of Forage Insect Pests. Overton, TX. Feb. 21, 2020.

Olson, V.C. East Texas Pasture Management Program. Weed Control in Pastures & Hay Meadows. Overton, TX. Feb. 21, 2020.

Olson, V.C. East Texas Pasture Management Program. Laws & Regulations of Pesticide Use. Overton, TX. Feb. 21, 2020.

Olson, V.C. Reduce Winter Feeding with Stockpiled Forage and Winter Pasture Program. Stockpiled Forage. Virtual. August 20,2020.

Olson, V.C. Reduce Winter Feeding with Stockpiled Forage and Winter Pasture Program. Cool season forages and variety selection. Virtual. August 20,2020.

Olson, V.C. Reduce Winter Feeding with Stockpiled Forage and Winter Pasture Program. Establishment of cool season forages. Virtual. August 20,2020.

Olson, V.C. Reduce Winter Feeding with Stockpiled Forage and Winter Pasture Program. Fertilization of cool season forages. Virtual. August 20,2020.

Rouquette, Jr, F. M. 2019. Invited Symposium: Relevance of Long-Term Research in meeting tomorrow's challenges in agriculture. Fifty Years of Stocking Rates on Bermudagrass Pastures: Planning, Persistence, and Good Fortune ASA-CSSA-SSSA. Abst. 297-4. San Antonio, TX

van Santen, Edzard, William B. Smith, and Francis M. Rouquette, Jr. 2019. Invited Symposium: Big data and the digital environment in forage and grazing lands research. Statistical approaches in forage and grazing lands research: Traditional vs “Big Data”. ASA-CSSA-SSSA. Abst. 221-3. San Antonio, TX.

8. Collaborative Grants between Stations and Members Awarded in 2019-2020

Muir, J.P. et al. Texas Government Land Office: Houston Catastrophic storm mitigation. 2020. Co-PI sub to TIAER. Total awarded: \$1,500,000

Muir, J.P. et al. NIFA-Non-land Grant Colleges of Agriculture. 2020-2021. Biobased Carbon for Enhancing a Sustainable Crop-Livestock System. Co-PI with Kan, AgriLife. Total awarded: \$300,000.

Muir, J.P. et al. Camp Bowie pollinator grassland restoration. 2019-2020. Co-PI sub to TAMUK. Total awarded: \$9,989.

Muir, J.P. et al. Texas Water Research Institute, Research, Engineering and Extension grants: Creation and Deployment of Water-Use efficient Technology Platforms “Water Seed Grant Initiative” for FY20-21. PI. Native Texas Ornamentals for Municipal Water Use Efficiency. 2019-2021. Total awarded: \$330,000.

Muir, J.P. et al. USDA-NRCS via co-PI with TAMU Kingsville. Domesticating native central Texas grasses & forbs. 2019-2020. Total awarded: \$100,000

## **Texas Report 2019-2020 Texas Tech University**

Principle investigator: Chuck West

Postdoctoral associate: Krishna Bhandari

Graduate students: Madhav Dhakal, Kathryn Radicke, Yedan Xiong

Support staff: Philip Brown, Paul Green

### **1. Impact Nugget:**

Interseeding alfalfa can improve grazed grasslands by adding a high-protein forage species and increasing the system productivity, but runs the risk of soil water depletion owing to its relatively high consumptive use of water. Interseeding alfalfa at low density into native grasses on the Texas High Plains enriches the crude protein and digestible energy concentrations and forage yield of the pastures with minimal exacerbation of soil water depletion. The overall effect is to lower the water footprint of protein and digestible energy production at low cost.

### **2. New Facilities and Equipment.**

None

### **3. Unique Project Related Findings.**

1. Interseeding alfalfa into existing stands of native short grasses was demonstrated to be a low-cost, water-efficient method of increasing yield and forage quality of the grassland with negligible effect on soil water depletion. The water footprint ( $m^3$  of ET per kg of DM, CP, and DOM produced) and marginal cost revenue increment of pasture improvement was lower with wide row (71 cm) than with narrow row (36 cm) planting. We have thus extended the use of alfalfa for summer grazing in mixtures with introduced and native grass stands. These advancements provide excellent options for farmers to convert irrigated cropland to ultra-low irrigation or rainfed grassland as irrigation becomes more limited for annual row crops owing to the depletion of the Ogallala Aquifer.

2. Various indices of soil health were demonstrated to increase in value by growing perennial pastures, especially with alfalfa, after converting land from growing continuous cotton to forages.

3. The warm-season grass, WW-B.Dahl old world bluestem, deters harmful soil-dwelling insects (i.e. red imported fire ants and harvester ants) without significantly reducing numbers of beneficial and neutral insects.

### **4. Accomplishment Summaries.**

The overall aim is to help irrigated row-crop producers in the Texas High Plains adapt to declining water supplies by integrating grazing into the cropping system. Our strategy is to develop forage management systems that diversify agricultural land use away from continuous row-crop monoculture receiving high irrigation input toward profitable, low-water-use grazing systems. We have demonstrated three practices involving the legumes alfalfa in mixture with introduced old world bluestem, with tall wheatgrass as a protein bank, and most recently with native short grasses as ways to boost animal productivity with minimal or no irrigation. Advances were made in improving the ALMANAC model for predicting forage growth under varying water supplies. We also demonstrated the benefits of perennial grasses and alfalfa to enhance indices of soil health and pollinator insect numbers with perennial forages growing with alfalfa.

### **5. Impact Statements.**

Alfalfa shows great promise to improve low-irrigation pastures and enhance productivity and profitability of beef stocker production at low cost and low water usage in the Texas High Plains both in mixture with the warm-season grass WW-B.Dahl, the cool-season grass tall wheatgrass, and in mixture of native short grasses in rainfed conditions. This is despite the reputation of alfalfa as a highly water-



consumptive crop. WW-B.Dahl old world bluestem builds soil organic matter and provides a soil with positive indicators for soil health, such as greater diversity of bacterial, fungal, and mycorrhizal populations, and enzymes that favor cycling of N, P, and S, and this even more true when growing with alfalfa.

## 6. Published Written Works.

### *Refereed Journal Articles*

Xiong, Yedan., C.P. West, C.P. Brown, and P.E. Green. 2019. Digital image analysis of old world bluestem cover to estimate canopy development. *Agron. J.* 111:1247-1253. doi:10.2134/agronj2018.08.0502

Braden, I.S., A.J. Ashworth, and C.P. West. 2019. Spatial soil nutrient-plant-herbivore linkages: A case study from two poultry litter-amended pastures in Northwest Arkansas. *Agrosyst. Geosci. Environ.* 2:180036. doi:10.2134/age2018.09.0039.

Dhakal, M., C.P. West, S.K. Deb, G. Kharel, and G.L. Ritchie. 2019. Field calibration of PR2 capacitance probe in Pullman clay-loam soil of Southern High Plains. *Agrosyst. Geosci. Environ.* 2:1-7. doi:10.2134/age2018.10.0043

Bhandari, K.B., C.P. West, D. Klein, and S. Subbiah. 2019. Essential oil composition of ‘WW-B.Dahl’ old world bluestem [*Bothriochloa bladhii*] grown in the Texas High Plains. *Industrial Crops Products* 133:1-9. doi:10.1016/j.indcrop.2019.03.013

Dinkins, R.D., P. Nagabhyru, C.A. Young, C.P. West, and C.L. Schardl. 2019. Transcriptome analysis and differential expression of tall fescue harboring different endophyte strains in response to water deficit. *Plant Genome* 12:180071. doi:10.3835/plantgenome2018.09.0071

Dhakal, M., C.P. West, and C. Villalobos. 2019. Establishment and stand development of alfalfa interseeded into native grass mixture: Cultivar and row spacing effects. *Crop Sci.* 59:2271-2279. doi:10.2135/cropsci2019.03.0156

Bhattarai, Bishwoyog, S. Singh, C.P. West, and R. Saini. 2019. Forage potential of pearl millet and forage sorghum alternates to corn in water limiting condition of Texas High Plains - A review. *Crop Forage Turf Management* 5:190058. doi:10.2134/cftm2019.08.0058

Rocateli, A.C., A.J. Ashworth, C.P. West, M.P. Popp, K.R. Brye, and J.R. Kiniry. 2020. Simulating switchgrass biomass productivity using ALMANAC. I. Calibration of soil water. *Agron. J.* 112:183-193. doi:10.2134/agronj2019.04.0251

Dhakal, M., C.P. West, S.K. Deb, C. Villalobos, and G. Kharel. 2020. Row spacing of alfalfa interseeded into native grass pasture influences soil-plant-water relations. *Agron. J.* 112:274-287. doi:10.1002/agj2.20012

Bhandari, Krishna, C.P. West, and V. Acosta-Martinez. 2020. Assessing the role of interseeding alfalfa into grass on improving pasture soil health in semi-arid Texas High Plains. *Appl. Soil Ecol.* 147: Article 103399. doi:10.1016/j.apsoil.2019.103399

Dhakal, M., C.P. West, C. Villalobos, C.P. Brown, and P.E. Green. 2020. Interseeding alfalfa into native grassland for enhanced yield and water use efficiency. *Agron. J.* 112:1931-1942. doi:10.1002/agj2.20147

Dhakal, Madhav, C.P. West, C. Villalobos, J.O. Sarturi, and D.K. Deb. 2020. Trade-off between nutritive value improvement and crop water use for an alfalfa-grass system. *Crop Sci.* 60:1711-1723. doi:10.1002/csc2.20159

Bhattarai, B., S. Singh, C. West, G. Ritchie, and C. Trostle. 2020. Water depletion pattern and water use efficiency of forage sorghum, pearl millet, and corn under water limiting condition. *Agric. Water Manage.* [In press] doi:10.1016/j.agwat.2020.106206

Bhattarai, B., S. Singh, C. West, G. Ritchie, and C. Trostle. 2020. Effect of deficit irrigation on physiology and silage yield of BMR forage sorghum, BMR pearl millet, and corn. *Crop Sci.* [In press] doi:10.1002/csc2.20171

Bhandari, K., S. Longing, and C.P. West. 2020. Bees occurring in corn production fields treated with atoxigenic *Aspergillus flavus* (Texas, USA). *Agronomy* 10:571-580. doi:10.3390/agronomy10040571

Bhandari, K.B., S.D. Longing, and C.P. West. 2020. Soil microbial communities in corn fields treated with atoxigenic *Aspergillus flavus*. *Soil Systems* 4(2): Article 35. doi:10.3390/soilsystems4020035

Bhandari, K.B., V. Acosta-Martinez, J. Cotton, and C.P. West. 2020. Changes in soil microbial communities in dryland forage production systems in semi-arid Texas High Plains. *Appl. Soil Ecol.* [In press]

Mitchell-McCallister, D.M., A.M. Cano, and C.P. West. 2020. Meta-analysis of water use efficiency in deficit irrigation systems in the Texas High Plains. *Irrig. Sci.* [In press]

#### *Poster Presentations and Abstracts*

Radicke, K.L., L. Slaughter, C.P. West, B.J. Petermann, D.D. Henry. 2020. Soil health relations with greenhouse gas emissions in semi-arid pastures. Proc. American Forage Grassl. Council. 5-8 January, Greenville, SC.

#### *Popular Articles*

Rudnick, D., J. Aguilar, A. Andales, J. Schneekloth, and C. West. 2020. The lowdown on soil moisture monitoring. In Special edition *Water Current* magazine of the Nebraska Water Center, University of Nebraska. Spring, 52(1):7-8. <https://watercenter.unl.edu/resources/waterCurrent/2020Spring.pdf>

West, C., P. Brown, R. Kellison, and C. Powers. 2020. Innovations in forages and grazing in the High Plains. In Special edition *Water Current* magazine of the Nebraska Water Center, University of Nebraska. Spring, 52(1):9-10. <https://watercenter.unl.edu/resources/waterCurrent/2020Spring.pdf>

#### **7. Scientific and Outreach Oral Presentations**

West, C.P. 2019. Grazing options for rainfed and reduced irrigation scenarios. 2019. TAWC Annual Field Day, Sep. 12, Muncie, TX.

West, C.P., and D.M. McCallister. 2019. Irrigation technologies with potential to improve water use efficiency. Symposium: Managing Limited Water Resources In A Changing Climate. 10-13 Nov. American Society of Agronomy annual meeting, San Antonio, TX.

Otuya, R.K., L.C. Slaughter, C.P. West, V. Acosta-Martinez, and S.K. Deb. 2019. Soil microbial communities and soil health in semi-arid pastures of the Texas Southern High Plains. 6-9 Jan. Annual Meetings Abstracts, Soil Science Society of America, Madison, WI.

Kharel, G., S. Deb, C. West, and L. Slaughter. 2019. Evaluation of thermal conductivity models for semiarid pasture soils. 6-9 Jan. Annual Meetings Abstracts, Soil Science Society of America, Madison, WI.

Neupane, Jasmine, W. Guo, A. Raihan, Z. Lin, Y. Sun, C. West, and F. Zhang. 2019. Influence of soil physical properties and topography on cotton yield under different irrigation rates. Texas Tech University Graduate Student Research Poster Competition. 26 March.

West, C.P. 2019. Water decline and climatic stress impacts agricultural land use in the Texas High Plains. Symposium on After Design: Monitoring and Managing the Texas Landscape. Texas Tech University. 4-5 April.

Ritz, R., D.M. McCallister, and C. West. 2019. Connecting agricultural water conservation education from students to producers and consumers. April 10, Texas Tech University. Regional Engaged Scholarship Symposium.

Dhakai, M., C.P. West, S.K. Deb, C. Villalobos, and G. Kharel. 2019. Trade-off between forage quality improvement and crop water use for alfalfa-grass system. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

West, C.P., and D.M. McCallister. 2019. Irrigation technologies with potential to improve water use efficiency. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Hayhoe, Katharine, Anne Stoner, and C.P. West. 2019. High-resolution climate projections for agriculture and water management. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Bhattarai, B., S. Singh, C.P. West, C.L. Trostle, and G.L. Ritchie. 2019. Forage sorghum, pearl millet, and corn physiology, nutrient content, and yield under deficit irrigation. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Bhattarai, B., S. Singh, C.P. West, C.L. Trostle, and G.L. Ritchie. 2019. Soil water depletion patterns and water use efficiency of forage sorghum, pearl millet, and corn under deficit irrigation. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Lin, Zhe, W. Guo, Y. Sun, C.P. West, and F. Jin. 2019. Unmanned aerial systems and crop modeling for irrigation scheduling in the Southern High Plains. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Radicke, Kathryn, C.P. West, and D.D. Henry. 2019. Can alfalfa in mixture with grass reduce enteric methane emissions from cattle on pasture? 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Radicke, Kathryn, J. Ning, C.P. West, and C.P. Brown. 2019. Assessment of drone image analysis of legume cover in pastures in relation to ground assessment. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Bhandari, K.B., S.D. Longing, and C.P. West. 2019. Honey bees and other focal species in corn treated with atoxigenic strains of *Aspergillus flavus*. 10-13 Nov., San Antonio, Annual Meetings Abstracts, ASA-CSSA-SSSA, Madison, WI.

Alfalfa in low-irrigation and rainfed grass-based pastures in West Texas. Rancher's Thursday Lunchtime Series–Alfalfa Management. Oklahoma State University Extension Service. Aug. 13, 2020

**8. Fund leveraging, specifically, collaborative grants between stations and members.**

Long-term agro-ecosystems research and adoption in the Texas Southern High Plains. USDA Southern SARE Large Systems Research program. \$100,000 per year from 2014-2019. Lead PI.

Sustaining agriculture through adaptive management resilient to a declining Ogallala Aquifer and changing climate. Meagan Schipanski (CSU, Lead PI) and 12 co-PDs including C.P. West. USDA-NIFA-AFRI CAP. \$10,000,000. My share \$294,638 over 4 years. Funding starting in 2016.

K. Bhandari, S. Longing, C.P. West. Honey bees and other focal species in corn treated with atoxigenic strain of *Aspergillus flavus*. Texas Corn Producers Board. \$45,764. My share \$40,000. 2019.

C.P. West, S.D. Longing, and K.B. Bhandari. Assessing water use efficiency, soil health, and pollinators within a transition from irrigation to dryland management in the Texas High Plains. USDA-NIFA Southern Regional Sustainable Agriculture Research and Education (SARE). \$299,208.

**9. Graduate student Dissertation**

Kathryn Radicke, PhD. August, 2020. Effect of the Inclusion of Legumes Within Perennial Grasses on Water Footprint, Economic Value, and Methane Emission. Dept. Plant & Soil Science. Texas Tech University.

**Utah Report 2019-2020**  
**Utah State University**

1. Impact Nugget:
2. New Facilities and Equipment:  
None
3. Unique Project Related Findings:
4. Impact Statements and Accomplishments
5. Published Written Works

*Refereed publications*

Costes-Thire, M., Laurent, P., Ginane, C., & Villalba, J. (2019). Diet selection and trade-offs between condensed tannins and nutrients in parasitized sheep. *Veterinary Parasitology*, 271, 14-21.

Gaudin, E., Costes-Thire, M., Villalba, J., Hoste, H., Gerfault, V., & Ginane, C. (2019). Relative abilities of young sheep and goats to self-medicate with tannin-rich sainfoin when infected with gastrointestinal nematodes. *Animal*, 13, 1498-1507.

Lagrange, S., & Villalba, J. (2019). Tannin-containing legumes and forage diversity influence foraging behavior, diet digestibility, and nitrogen excretion by lambs. *Journal of Animal Science*, 97, 3994-4009.

Lagrange, S., Lobon, S., & Villalba, J. (2019). Gas production kinetics and in vitro degradability of tannin-containing legumes, alfalfa and their mixtures. *Animal Feed Science and Technology*, 253, 56-64.

MacAdam, J. W. (2019). The value of condensed tannins in forages: overview of the symposium. *Crop Science* 59: 858-860.

Mata-Padrino, D.J., D.P. Belesky, C.D. Crawford, B. Walsh, MacAdam, J. W., & S.A. Bowdridge (2019). Effects of grazing birdsfoot trefoil-enriched pasture on managing *Haemonchus contortus* infection in Suffolk crossbred lambs. *Journal of Animal Science* 97: 172-183.

Stewart, E. K., Beauchemin, K. A., Dai, X., MacAdam, J. W., Christensen, R., & Villalba, J. (2019). Effect of tannin-containing hays on enteric methane emissions and nitrogen partitioning in beef cattle. *Journal of Animal Science*, 97, 3286-3299.

Stonecipher, C.A., Thacker, E., Welch, K.D., Ralphs, M.H., Monaco, T.A. 2019. Long-term persistence of cool-season grasses planted to suppress broom snakeweed, downy brome, and weedy forbs. *Rangeland Ecology and Management*. 72:266-274.

Villalba, J., Beauchemin, K. A., Gregorini, P., & MacAdam, J. W. (2019). Pasture chemoscapes and their ecological services. *Translational Animal Science*, 3, 829-841.

Villalba, J., & Manteca, X. (2019). A Case for Eustress in Grazing Animals. *Frontiers in Veterinary Science*, 6, 303.

Villalba, J., Spackman, C., & Lobon, S. (2019, January). The interplay between exposure and preference for unpalatable foods by lambs. *Applied Animal Behaviour Science*, 212, 44-51.

*Conference Papers and Presentations*

MacAdam, J. W. 2019. The elevated carbohydrate concentrations of high altitude-grown perennial legume forages. *Crop Science Society of America*, San Antonio, Texas.

Villalba, J., Pedernera, M., Mereu, A., 2019. Preference for inorganic sources of calcium and phosphorus in sheep, American Society of Animal Science (ASAS) - Canadian Society of Animal Science (CSAS), Austin, Texas, July 8, 2019 - July 11, 2019.

Villalba, J., Pedernera, M., Mereu, A., 2019 Preference for inorganic sources of magnesium and phosphorus in sheep," American Society of Animal Science (ASAS) - Canadian Society of Animal Science (CSAS), Austin, Texas, July 8, 2019 - July 11, 2019.

Volenc, J.J., MacAdam, J. W. 2019. C. Jerry Nelson: A Career with global impact. Crop Science Society of America,

## Wyoming Report 2019-2020 University of Wyoming

### 1. Impact Nugget:

The University of Wyoming's research has made selection for well-adapted high performing accessions/lines which resulted in development of cultivars that are suitable for Wyoming and neighboring states. The studies at the university contributed to the improvement of productivity of local and regional producers and would provide economic benefits in the long-run.

### 2. New Facilities and Equipment:

A brand new planter (Land Pride Drill with satellite receiver installed) has been purchased for planting forage and other species more efficiently for different experiments.

### 3. Unique Project Related Findings:

The weather in Wyoming in 2019 was comparatively dry compared to 2017 and 2018. This allowed to better compare growth and yield performance of accessions/lines of consecutive different years.

### 4. Accomplishments:

In Wyoming, forages are very important and the mainstay of livestock production. Alfalfa is an important forage crop in the US and produces high quality forage. Frequent harvest and baling of alfalfa lead to high removal of nutrients, particularly potassium (K), from the soil. This results in soil K depletion with a detrimental effect on productivity of alfalfa in subsequent growing seasons. Annual application of K is important to sustain K levels in soil to increase alfalfa production in long term. Yield response of alfalfa to K when it is added to soils with high-test K levels is not clear. The objective of the study is to determine the effect of K fertility along with harvest time management on the productivity of newly released alfalfa cultivars. Data being collected include plant growth, dry matter yield, forage quality, and K uptake. It is anticipated that the results obtained from this study will help recommend the best fertility management guide for alfalfa producers in Wyoming and neighboring states.

Grasslands are invaluable for livestock grazing, wildlife habitat, recreational opportunities, and soil, water and air protection. However, increase in anthropogenic disturbance carried out for economic or development purposes has resulted in degradation of grasslands. Highly adaptive species with potential to establish in these degraded environments can contribute to grassland productivity and improve the land use. Unfortunately, bringing together the strategies for successful establishment of desirable species in harsh environment is still a challenge. The objective of this project is to evaluate the establishment of cool-season perennial grasses and legumes in disturbed environments. Monoculture and combinations of seeding mixture of cool-season grasses and legumes were sown in three planting times (late spring, early fall, and late fall) in two environmental conditions (irrigated and dryland). Each block contained three planting dates and 11 seeding mixtures. Three planting dates included June 1 (late spring), August 15 (early fall), and November 15 (late fall) in 2018. Plant density was recorded in the growing seasons of 2019 and 2020. Additional information about weed, plant cover, and dry matter yield could elaborate the establishment of desirable species in these growing conditions and enhance management strategies for vegetation establishment in degraded environment.

New and suitable plant materials demand is a long-term issue and is increasing continuously especially in the Intermountain West region. The objective of this long-term study is to evaluate different advanced lines of C3 grasses with the inclusion of some local checks in relation to their growth, yield, and quality response to irrigation, drought, and planting time. Species used in this

study include tall fescue (seven lines), tall wheatgrass (three lines), western wheatgrass (five lines), and wildrye (two lines). Data collected on different growth parameters, persistence, and forage quality from 2009 - 2019 seems to be different among species and lines. Long-term data collection will help select and develop superior and well-adapted cultivars.

#### 5. Impact Statements:

Research at the University of Wyoming has made selection for well-adapted high performing accessions/lines which resulted in development of cultivars that are suitable for Wyoming and neighboring states. This contributed to the improvement of productivity of local and regional producers and in the long-run, would provide economic benefits.

Studies on determining cost effectiveness of establishing alfalfa, sole grass (fertilized with N), sole legumes, and grass-legume mixtures and how efficient these practices are utilizing irrigation water and fertilizer, in particular K, have positive impacts. Results will help recommend the best establishment and management practices that will be profitable to Wyoming producers by reducing production cost significantly.

#### 6. Published Written Works:

##### *Peer-Reviewed Journal Articles*

- Khatiwada, B., Acharya, S.N., Larney, F.J., Lupwayi, N.Z., Smith, E.G., Islam, M.A., and Thomas, J.E. 2020. Benefits of mixed grass-legume pastures and pasture rejuvenation using bloat-free legumes: A review. *Canadian Journal of Plant Science*. (In press).
- Nilahyane, A., Islam, M.A., Mesbah, A.O., Herbert, S.K., and Garcia y Garcia, A. 2020. Growth, water productivity, nutritive value, and physiology responses of silage corn to water stress. *Agronomy Journal*. 112:1625-1635. doi: 10.1002/agj2.20015.
- Islam, M.A. and Adjesiwor, A.T. 2020. Nitrogen fertilization in tall fescue: Productivity, agronomic efficiency and relative profitability. *Grassland Science*. 66:67–73. doi: 10.1111/grs.12261.
- Homer, A., Islam, M.A., Krall, J.M., Nachtman, J.J., and Groose, R.W. 2019. Registration of ‘WyoWinter’ Feed Pea for the US Central Great Plains. *Journal of Plant Registrations*. 13:128-133. doi:10.3198/jpr2018.07.0047crc.
- Aryal, P. and Islam, M.A. 2019. Establishment of forage kochia in seeding mixtures with perennial grasses. *Grassland Science*. 65:147–154. doi: 10.1111/grs.12228.

##### *Book Chapter (Refereed)*

- Islam, M.A. and Baidoo, M.M. 2020. Potassium Effect on Growth and Physiology of Alfalfa. In: *Handbook of Plant and Crop Physiology*, 4<sup>th</sup> Edition (M. Pessarakli, Ed.). CRC Press, Taylor & Francis Publishing Company, Florida. (Accepted).
- Islam, M.A. and Obour, A.K. 2020. Drought Physiology of Forage Crops. In: *Handbook of Plant and Crop Physiology*, 4<sup>th</sup> Edition (M. Pessarakli, Ed.). CRC Press, Taylor & Francis Publishing Company, Florida. (Accepted).
- Islam, M.A. and Adjesiwor, A. T. 2020. Moisture Stress and its Effects on Forage Production Systems. In: *Handbook of Plant and Crop Stress*, 4<sup>th</sup> Edition (M. Pessarakli, Ed.). CRC Press, Taylor & Francis Publishing Company, Florida. (In press).
- Islam, M.A. and Nilahyane, A. 2020. Water Stress Effects on Growth and Physiology of Corn. In: *Handbook of Plant and Crop Stress*, 4<sup>th</sup> Edition (M. Pessarakli, Ed.). CRC Press, Taylor & Francis Publishing Company, Florida. (In press).

##### *Abstracts*



- Lee, B.P., Ritten, J.P., Islam, M.A., Herreid, J.S., and Jabbour, R. 2020. Harvest Timing for Alfalfa Weevil Control. Proceedings of the Western Agricultural Economics Association Annual Meeting June 28-30, 2020. Santa Fe, NM (Western Agricultural Economics Association).
- Herreid, J.S., Lee, B.P., Islam, M.A., Ritten, J.P., and Jabbour, R. 2020. Effects of harvest timing on alfalfa weevil. Proceedings of the Entomological Society of America Pacific Branch Annual Meeting April 19-22, 2020. Spokane, WA (Entomological Society of America).
- Islam, M.A. and Baidoo, M. 2019. Potassium and Harvest Time Affect Forage Production, Nutritive Value, and Potassium Uptake of Alfalfa. Proceedings of the ASA-CSSA-SSSA International Annual Meetings November 10-13, 2019. San Antonio, TX (American Society of Agronomy, Crop Science Society of America, Soil Science Society of America).
- Islam, M.A. and Baidoo, M. 2019. Soil Potassium Levels and Its Effect on Alfalfa Productivity. Proceedings of the SSSA International Soils Meeting January 6-9, 2019. San Diego, CA (American Society of Agronomy, Crop Science Society of America, Soil Science Society of America).

*Extension publications*

- Islam, M.A. and Ashilenje, D. 2020. Grass Hay Quality and Storage. *In: Basic Grass Management Strategies for Wyoming Landowners*. University of Wyoming Extension Bulletin, Ed. J. Vardiman, J.S. Thompson, and S.L. Miller. University of Wyoming, Laramie (*Accepted*).
- Islam, M.A. and Ashilenje, D. 2020. Hay Production. *In: Basic Grass Management Strategies for Wyoming Landowners*. University of Wyoming Extension Bulletin, J. Vardiman, J.S. Thompson, and S.L. Miller. University of Wyoming, Laramie (*Accepted*).
- Baidoo, M. and Islam, M.A. 2019. Potassium and Harvest Management Effect on Alfalfa Production under Controlled Conditions. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 7-8. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Shilpakar, C. and Islam, M.A. 2019. Competitive Ability of Native and Non-Native Grasses with Cheatgrass. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 9-10. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Baidoo, M. and Islam, M.A. 2019. Yield Response of Reduced Lignin and Conventional Alfalfa Cultivars to Potassium. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 49-50. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Islam, M.A., Baidoo, M. and Shilpakar, C. 2019. Evaluating Chickpea Cultivars at Different Nitrogen Rates for Forage and Grain Production. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 53-54. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Islam, M.A., Baidoo, M. and Shilpakar, C. 2019. Forage Yield of Cool Season Grasses Planted in Fall Under Irrigated and Dryland Conditions. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 57-58. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Jabbour, R. Islam, M.A., Lee, B., and Ritten, J. 2019. Integration of Early Harvest with Biological Control for Sustainable Alfalfa Production. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, p. 59. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Shilpakar, C. and Islam, M.A. 2019. Establishment of Cool-Season Perennial Grasses and Legumes in Disturbed Environments. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 65-66. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Islam, M.A., Baidoo, M. and Shilpakar, C. 2019. Evaluation of Roundup Ready Alfalfa for Adaptability to Wyoming Conditions. 2019 Field Days Bulletin, University of Wyoming Agricultural

- Experiment Station, pp. 67-69. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Islam, M.A., Baidoo, M. and Shilpakar, C. 2019. Evaluation of Forage Sorghum Cultivars Under Irrigated and Dryland Conditions. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 77-79. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Islam, M.A., Baidoo, M. and Shilpakar, C. 2019. Tall fescue-Alfalfa Mixtures for Improved Forage Production. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 80-81. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Horn, B., Islam, M.A., Smith, D., Jeliakov, V., and Garcia y Garcia, A. 2019. Perennial Cool-Season Grasses under Irrigation for Hay Production and Fall Grazing. 2019 Field Days Bulletin, University of Wyoming Agricultural Experiment Station, pp. 94-95. Available at <http://www.uwyo.edu/uwexpstn/publications/field-days-bulletin/2019-field-day-bulletin.pdf>.
- Islam, M.A. 2020. Potassium application and cutting schedules can improve alfalfa productivity – Part IV. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, May 30, 2020.
- Islam, M.A. 2020. Potassium application and cutting schedules can improve alfalfa productivity – Part III. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, April 11, 2020.
- Islam, M.A. 2020. Potassium application and cutting schedules can improve alfalfa productivity – Part II. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, February 29, 2020.
- Islam, M.A. 2019. Potassium application and cutting schedules can improve alfalfa productivity – Part I. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, November 30, 2019.
- Islam, M.A. 2019. Establishment and management of birdsfoot trefoil - a non-bloating forage legume. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, September 14, 2019.
- Islam, M.A. 2019. Irrigation systems and nitrogen rates can improve yield and water use efficiency of corn for silage. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, July 13, 2019.
- Islam, M.A. 2019. Grass-legume mixtures can maximize farm profits – another example from a recent study. *Wyoming Livestock Roundup*, the Weekly News Source for Wyoming’s Ranchers, Farmers, and Agribusiness Community, May 11, 2019.
- Islam, M.A., and Baidoo, M. 2019. Improving alfalfa productivity. *Progressive Forage*, Issue 10, November 1, 2019, pp. 29-31. Available at <https://www.progressiveforage.com/forage-types/alfalfa/improving-alfalfa-productivity>.

#### 7. Scientific and Outreach Oral Presentations

- Lee, B.P., Ritten, J.P., Islam, M.A., Herreid, J.S., and Jabbour, R. 2020. Harvest Timing for Alfalfa Weevil Control. The Western Agricultural Economics Association Annual Meeting June 28-30, 2020. Santa Fe, NM.
- Herreid, J.S., Lee, B.P., Islam, M.A., Ritten, J.P., and Jabbour, R. 2020. Effects of harvest timing on alfalfa weevil. The Entomological Society of America Pacific Branch Annual Meeting April 19-22, 2020. Spokane, WA.
- Islam, M.A. and Baidoo, M. 2019. Potassium and Harvest Time Affect Forage Production, Nutritive Value, and Potassium Uptake of Alfalfa. The ASA-CSSA-SSSA International Meetings November 10-13, 2019. San Antonio, TX. Attendance: 32.

- Islam, M.A. 2019. WERA 1014 Regional Project Report: On-going/Completed Research. University of Idaho, Nancy M. Cummings Research, Extension, and Education Center, Salmon, ID, October 15-16, 2019. Attendance: 27.
- Islam, M.A. 2019. Effect of Potassium and Harvest Time on Forage Production, Nutritive Value, and Potassium Uptake of Alfalfa: An Update. W2012 - Enhancing management, production, and sustainability of grazing ruminants in extensive landscapes Meetings, July 25-26, 2019. MSU Northern Agriculture Research Center, Havre, MT. Attendance: 25.
- Islam, M.A. 2019. Wyoming NCCC-31 Report-Ecophysiological Aspects of Forage Management. University of Wisconsin, July 17-18 2019. Madison, WI. Attendance: 22.
- Islam, M.A. 2019. An Update of Forage Research at Lingle. SAREC Field Day, August 21, 2019, Lingle, WY. Attendance: 55.
- Islam, M.A. 2019. Assessing Roundup Ready Alfalfa. SAREC Field Day, August 21, 2019, Lingle, WY. Attendance: 50.
- Islam, M.A. 2019. Alfalfa Research Updates in WY. The 7<sup>th</sup> Annual Wyoming Forage Field Day, May 30, 2019. Park County Fairgrounds, Powell, WY. Attendance: 90.

8. Fund leveraging, specifically, collaborative grants between stations and members

- USDA-NIFA ASAFS Program. 2019-2022. Afshar, R.K., Islam, M.A., Qin, R., and Liang, X. Increasing yield, quality, and economy of alfalfa hay through grass species selection and planting configuration under full and limited irrigation conditions. \$500,000.
- USDA NIFA Crop Protection and Pest Management (CPPM). 2019-2022. Jabbour, R., Rand, T.A., Peairs, F., Islam, M.A., Ritten, J., and Lee, B. Integration of Early Harvest with Biological Control for Sustainable Alfalfa Production. \$324,998.
- Y Cross Ranch Tuition and Fee Award, COANR, UW. 2020-2021. Islam, M.A. Planting configuration study for alfalfa and grasses. \$9,000.
- Specialty Crop Block Grant Program – Farm Bill (SCBGP-FB), USDA Wyoming Department of Agriculture. 2019-2021. Islam, M.A. Evaluation of Yacon in Rotation with Fenugreek in Wyoming Environments. \$50,000.
- Energy GA Fellowships, UW. 2018-2020. Islam, M.A. Reclamation of disturbed areas used by gas industries in Wyoming by using some promising grass and legume genotypes. \$55,008.
- Y Cross Ranch Tuition and Fee Award, COANR, UW. 2018-2019. Islam, M.A. Developing a potassium fertility management program on alfalfa. \$9,000.
- Edward H. and Susan King Lloyd Graduate Research Award, UW. 2018-2019. Islam, M.A and Baidoo, M. Potassium and harvest management in alfalfa. \$3,000.
- UW School of Energy Resources. 2018-2019.
- Stahl, P.D., Eberle, C.A., Norton, J.B., Islam, M.A., and Coupal, R.H. Use of Coal Residues as a Soil Amendment. 2018-2021. \$83,000.

9. Graduate students training and advising

- Current: Advising 3 graduate students (one Ph.D. and 2 M.S.).
- Graduated: One M.S. in spring 2019.

10. Other relevant accomplishments and activities

- Forage production, management, quality, and economic returns have been presented at Wyoming Forage Field Day, Agriculture Experimentation Field Days, and local and regional workshops/meetings.