

# South Dakota (South Dakota State University) Annual Report - FY2022

**Report Status: Approved as of 06/29/2023**

## Contributing Organizations

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South Dakota State University

## Executive Summary

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### Overview

The College of Agriculture, Food and Environmental Sciences at South Dakota State University is home to both SDSU Extension and the South Dakota Agricultural Experiment Station. One of eight colleges that make up SDSU, our college has an integral role in fulfilling the land grant mission of the university. The college is the largest at SDSU in terms of student enrollment, faculty/staff, and building space. Stakeholder solutions for South Dakotans are found through the collaborative partnership of SDSU Extension and SDSU Agricultural Experiment Station.

SDSU Extension and the South Dakota Agricultural Experiment Station achieve their goals by strategically locating professionals across the state. Researchers and state extension specialists are located either on the SDSU campus in eastern South Dakota or at the SDSU West River Research and Extension Center in western South Dakota. Extension Field Specialists are located throughout the state at one of eight Regional Extension Centers. Outreach is also achieved by efforts carried out at the six Research Field Stations, four Tribal Extension program offices or by 4-H professionals at one of our 60 county extension offices. 4-H Youth Development programming begins on campus with leadership provided by the State 4-H Office.

SDSU Extension faculty and staff leverage technology to connect with and engage stakeholders across a variety of platforms. In addition to online courses, social media and podcasts, our system is committed to publishing timely, relevant and accessible content on our website, [extension.sdstate.edu](http://extension.sdstate.edu). During 1,463,275 sessions, 1,196,278 users consumed educational information totaling 2,087,677 pageviews. Our website audience is 46% male and 54% female with the following age demographics: 18-24 (23.46%), 25-34 (20.65%), 35-44 (19.92%), 45-54 (14.81%), 55-64 (12.04%) and 65+ (9.12%). SDSU Extension's virtual resources are consumed from 233 countries around the world with the majority of traffic coming from South Dakota and the United States.

### Critical Issue: Families, Youth, and Communities

The research activities in this program are supported by our partnership with College of Education and Human Sciences. Hatch funded projects within this Critical Issue include but are not limited to research that emphasizes agricultural institutions and economic performance, financial abuse within families, economic evaluation of food assistance, and assessing the impacts of technology adoption and diffusion in the food and agribusiness sector. Activities for SDSU Extension in this Critical Issue involve 4-H youth development, 4-H leadership, gerontology issues, child care, strategic planning, family financial wellness, rural sustainability, developing agritourism, and building community capacity.

### Critical Issue: Food Systems, Nutrition, Health, and Well-Being

The research activities in this program are supported by our partnership with the College of Education and Human Sciences. Hatch funded projects include but are not limited to research involving obesity prevention and wellness, diet and physical activity, carbohydrate based value added functional products, developing novel and sustainable processes and ingredients for dairy and food products, process interventions for enhancing microbial quality, safety, and nutrition of dairy foods, and identifying weight related behaviors for obesity prevention and wellness. Activities for SDSU Extension in this Critical Issue involve nutrition, healthy eating, physical activity, reducing healthcare costs, food preservation, chronic diseases, community gardens and Master Gardeners.

### Critical Issue: Natural Resources and Environmental Systems

The research activities in this program are primarily supported by our Department of Natural Resource Management. Hatch funded projects include but are not limited to research studies involving saline/sodic soils, assessing plant biodiversity, soil fertility practices, assessing impacts of land use, best practices for tall grass, value added products from biomass and biotechnology, digital soil mapping, agricultural best management practices on subsurface-drained (tiled) land, and prescribed fire to improve grasslands. Activities for SDSU Extension in this Critical Issue involve grassland management, wildlife habitat preservation, health of water resources, soils management, and range management strategies.

### Critical Issue: Regenerative Agronomic Systems

The research activities in this program are primarily supported by our Department of Agronomy, Horticulture, and Plant Science, and our Department of Biology and Microbiology. Hatch funded projects include but are not limited to research studies in seed testing lab, oat breeding and genetics, applied agricultural genomics, small grains breeding, impacts of planting date and associated management practices, ecosystem services through sustainable soil health management, cover crops, management strategies for diseases of broadleaf crops, biotechniques to enhance wheat germplasms, winter wheat breeding and genetics, and biological control of small grain diseases. Activities for SDSU Extension in this Critical Issue involve precision agriculture technologies, agronomy field schools, cover crops, alfalfa growth and production testing, utilization of field peas in South Dakota, Pesticide Applicator Training, and Integrated Pest Management.

### Critical Issue: Regenerative Livestock Systems

The research activities in this program are primarily supported by our Department of Animal Science, Department of Dairy and Food Science, and our Department of Veterinary and Biomedical Sciences. Hatch funded projects include but are not limited to research optimizing feed utilization, health and nutrition management of the sow and young pig, evaluation of cattle diets, behavioral classification of sheep, influence of chilling rate on beef quality, cost-effective environmental monitoring system for swine and dairy operations, and strategies to optimize feedlot cattle production. Activities for SDSU Extension in this critical issue involve raising small ruminants profitably and sustainably, the enhancement of a sustainable dairy community through a multistate collaboration, mineral nutrition in cattle, sheep and goat production/needs assessment, integrated crop-livestock systems and cereal rye, heifer development, animal disease/research updates, and the Calf Value Discovery program.

## Merit and Scientific Peer Review Processes

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### Updates

None.

## Stakeholder Input

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Actions to seek stakeholder input that encouraged their participation with a brief explanation

None.

Methods to identify individuals and groups and brief explanation

None.

Methods for collecting stakeholder input and brief explanation

None.

A statement of how the input will be considered and brief explanation of what you learned from your stakeholders

None.

## Highlighted Results by Project or Program

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Critical Issue

### Families, Youth, and Communities

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## Caregiver Learning Workshop Series

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### **In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

Estimates suggest that 21.3% of Americans are caregivers. In South Dakota, 15.6% of adults age 45 and older are caregivers, with an additional 12.5% anticipating they will become a caregiver in the next two years. These individuals provide and monitor complex care in the home, navigate care systems, advocate for care recipient, and pay care services. Beyond what caregivers do for the care recipient, many are managing their own declining health, child rearing, employment, and other responsibilities. Caregivers experience financial burden, difficulties accessing respite care, challenges finding and navigating services, and lack knowledge and training about how to provide care. These individuals need access to unbiased educational information to aid them on their caregiving journey.

### **Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

To help connect caregivers with the educational content they need, South Dakota State University Extension (SDSU Extension) worked in collaboration with North Dakota State University Extension (NDSU Extension) to offer a 3-part Caregiver Learning Workshop series via Zoom. Workshops were offered in January, February, and March. Each workshop lasted one hour. The objectives of this series were for participants to increase their knowledge about planning for long-term services and supports, as well as increase their knowledge about resources available for long-term services and supports in North Dakota and South Dakota. SDSU Extension and NDSU Extension partnered with other individuals and organizations to offer this series. For example, speakers were recruited who were experts in the topics covered during each workshop (elder law attorney, Alzheimer's Association, Parkinson's Foundation, Dakota at Home, North Dakota Aging and Disability Resource connection, and an aging solo expert). To help reach caregivers who may not have access to the internet, organizations were encouraged to host watch parties. For example, a caregiver support organization in South Dakota agreed to host a watch party. Seventy people viewed the webinars individually and twenty-two viewed the webinars as members of watch parties.

Three SDSU Extension website articles were published during 2022 related to online caregiver learning opportunities:

- **SDSU Extension and NDSU Extension Host Free Virtual Workshops for Caregivers:** <https://extension.sdstate.edu/news/sdsu-extension-and-nds-u-extension-host-free-virtual-workshops-caregivers>
- **SDSU Extension to Host Online Caregiver Learning Workshops:** <https://extension.sdstate.edu/news/sdsu-extension-host-online-caregiver-learning-workshops>
- **Free Online Caregiver Support Panel Discussion:** <https://extension.sdstate.edu/news/free-online-caregiver-support-panel-discussion>

### **Briefly describe how your target audience benefited from your project's activities.**

A family or informal caregiver is a person who provides unpaid help to a friend or relative to assist with Activities of Daily Living (ADLs; walking, eating, dressing, bathing, toileting, etc.) and Instrumental Activities of Daily Living (IADLs; preparing meals, managing money, shopping, managing medications, etc.). A person becomes a caregiver for many reasons, including recovery from surgery or illness, chronic disease, or end-of-life decline. Family or informal caregivers were the target audience of the Caregiver Learning Workshops series. By participating in this series, caregivers gained additional knowledge about planning for long-term care, as well as greater knowledge about services and supports available in North Dakota and South Dakota to caregivers. Forty-one individuals agreed to complete the evaluation. These individuals report intentions to

complete necessary elder law forms, contact or refer a service provider, contact a financial planner, or identify friends to service as their decision maker. By participating in this series, individuals gained additional information and insight about caregiving.

**Briefly describe how the broader public benefited from your project's activities.**

The number of caregivers are projected to increase as the baby boom generation enters their 70s and 80s. Seventy percent of individuals who survive to age 65 will need help with routine chores and errands before end-of-life. As a result, few individuals or organizations will be left untouched by caregiving. Many individuals become caregivers, finding themselves unprepared to navigate the intricacies of this role. Beyond the challenges of understanding services and supports, caregivers are often employed and report that caregiving has affected them at work (arrive late, leave early, unpaid leave, early retirement, using work time for care issues, etc.). Connecting caregivers with education and resources benefits the public by encouraging caregivers to access services and supports available to them earlier which may reduce the work-related impact of caregiving. In addition, caregivers with enhanced knowledge about services and supports available may increase the chance that care can be provided in lower cost home and community-based settings. This is critical given that two-thirds of long-term services and support are paid for by public sources (Medicaid and Medicare) and efforts are being made to offer these services in lower cost settings.

**Strengthening Financial Security and Building Community Life**

Project Director

Ann Schwader

Organization

South Dakota State University

Accession Number

7001903



**Marketing Hometown America**

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**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

Marketing Hometown America (MHA) was originally created as a response to the demographic changes happening in the rural Great Plains. Some communities realized that the quality of life they provide can be marketed and can often be one of the key relocation factors for people looking to move to rural areas (Cantrell, Burkhart-Kriesel, Johnson, Narjes, and Vogt, 2008; Winchester 2012). With the advancement of technology and a greater interest toward rural migration, there are more opportunities and avenues for how rural communities can attract and capture new talent, entrepreneurs, and working populations who will, in turn, build local economies. To reflect this renewed interest, an MHA revision was undertaken to incorporate a decade's worth of experience and knowledge from key researchers and educators working on this issue. For example, in the University of Minnesota's Rural Movers Study (2019) it was discovered that that three-quarters of new residents had not previously lived in their destination community. Yet, many of our rural communities continue their recruitment efforts toward returning alumni and are not focused on others who may be looking for what they have to offer.

USDA funded research, (C. Burkhart-Kriesel, R. Cantrell, 2006, UNL) indicated that there was a disconnect between what rural communities were showcasing as their assets and what newcomers were looking for as they relocated. In 2022, revisions that were accomplished by a 4-state team of Extension staff (NE, SD, MN, IA) during the Pandemic were completed and rolled out in communities. A stronger focus on diversity, inclusion and equity was added to both the Facilitator training and Community Recruitment pieces. This strengthened the educational materials for use in more multi-cultural, diverse communities.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

The objectives of the MHA curriculum are multi-faceted with community and individual outcomes:

- Individuals will understand how a community can market itself to attract and retain community members.



- Learn and practice the skills of positive community dialogue to increase community members ability to market their community. Identify what newcomers are looking for as they relocate to a rural community.
- Discover overlooked local assets that can be highlighted to attract newcomers and retain community members.
- Build and implement marketing action plans that incorporate realistic and achievable strategies to successfully market a community.
- Understand the importance of a positive image that can be projected throughout the community, including virtual channels such as websites and social media.
- Increase the community's capacity to address future issues through community engagement practices.

The Marketing Hometown America educational framework is an Extension-based program designed to help communities develop a plan to attract new residents. More specifically, it guides rural community leaders and residents in making decisions about how to market themselves and by listening to a wide variety of voices in the process. The program is designed as a series of small community group conversations, a process originally developed by the group, Everyday Democracy, which encourage participants to see their community assets through the eyes of new residents. Through these discussions they identify and implement actions to create a more welcoming and inviting place for those wishing to relocate, and those already in residence.

Extension Community Vitality staff train 6-8 people as facilitators who lead small group discussions. During the structured discussions, group members work through a guidebook to identify and implement actions that create a more welcoming and inviting place for those wishing to relocate, and those already in residence. The MHA community process includes “circles” of 8 to 10 people meeting four times for approximately 2 hours each time.

During 2022, there were two full Marketing Hometown America programs completed in the Martin and White River communities in South Dakota. A total of fifteen community facilitators completed six hours of training and led small groups. Sixty-five community residents participated in the small group dialogues, and over one hundred people attended the Action Forums in the two communities. Currently, Martin has 5 Action Committees working on projects to improve their community, and White River has 3 Action Committees working on projects for positive change in their community. A Ripple Effect Mapping activity will be completed in 2024 to assess both programs for impact.

During 2022, two SDSU Extension website articles were published related to Marketing Hometown America:

- **Marketing Hometown America:** <https://extension.sdstate.edu/marketing-hometown-america>
- **Marketing Your Hometown:** <https://extension.sdstate.edu/marketing-your-hometown>

### **Briefly describe how your target audience benefited from your project's activities.**

Audiences for Marketing Your Hometown program are intentionally diverse. Rural communities work to select diverse facilitators who are trained by SDSU Extension to lead small groups. In Martin, South Dakota, seven facilitators were trained, with two Native Americans and five Caucasians in the mix. Small group participants ranged in ethnicity, and many are still involved in committees working on priority programs they have selected. Leaders have asked participants to be more involved in City Council activities, joining the Chamber of Commerce, and increasing their confidence to address key needs in Martin. The program helps communities create a welcoming spirit to attract new residents, learn what new residents look for in a rural community, discover local assets that attract new residents, and implement a marketing plan.

Based on earlier MHA programming outcomes, communities that used the MHA curriculum were shown to have created new social media/marketing campaigns, new county-wide partnerships, recruitment of new businesses, new or updated welcoming signs, a workforce recruitment initiative, new or re-organized community organizations focused on building a

more socially active community and personal growth of individuals. All the actions were designed and focused on marketing their communities to attract newcomers and build social capital to retain existing residents. Building this belongingness or as one economic developer stated, “the stickiness” of a community is essential to the long-term resiliency of that community. A South Dakota resident stated, *“MHA has inspired me to become more involved in my community. As someone who is a transplant, it helped me meet more people. They also have become my friends.”*

**Briefly describe how the broader public benefited from your project's activities.**

People in communities that have completed Marketing Hometown America have shown growth in self-confidence. This is evidenced by an increased number of lay people presenting their ideas to their City Council and even running for City offices. The broader public learns that anyone in a community can outline a project, create a team and move through the channels needed to implement actions. It lends to more broad involvement and better discussions when community projects are planned, and decisions are made. Martin, South Dakota is working on branding their community and has already collaborated with the City Council to get a sunflower painted on their water tower.

**[An Economic Analysis of Food Insecurity and Obesity: Implications for Consumers, Industry and Government](#)**

Project Director

Andrea Leschewski

Organization

South Dakota State University

Accession Number

1014886



**Final result: An Economic Analysis of Food Insecurity and Obesity: Implications for Consumers, Industry and Government 11/22/17-11/26/22**

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**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

The US is currently faced with two major food and nutrition issues, representing both extremes of hunger: food insecurity and obesity. The objective of this study is to provide an economic analysis of the role of consumers, government, and the food industry in reducing food insecurity and obesity in the US. Findings from this study will help identify and understand household demand for foods linked to obesity and food insecurity, provide policymakers with insight on the effectiveness of food and nutrition programs and policy, and provide the food industry with feedback on the effect of their health-related marketing efforts.

This project aims to address two major issues impacting US households: 1) food insecurity, and 2) obesity.

Collectively, results from each of this project's three objectives will highlight a holistic approach that consumers, industry, and government can employ in order to address two key challenges facing US households: 1) food insecurity, and 2) obesity. Specifically, this project will characterize household demand for foods linked to obesity and food insecurity, provide policymakers with insight on the effectiveness of food and nutrition programs and policy, and provide the food industry with feedback on the effect of their health-related marketing efforts.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1: Analyze consumer demand for food products that are fundamental to food and nutrition policy. (100% Accomplished)**

Consumer demand for two policy relevant categories of food were analyzed: 1) healthy food away from home (FAFH), and 2) SNAP restricted foods.

**Healthy Food Away from Home**

Determinants of household acquisition of healthy FAFH from restaurants were identified using the USDA's National Household Food Acquisition and Purchase Survey. Study results indicate household acquisition of healthy FAFH varies with income, food assistance, FAFH purchase frequency, dieting, restaurant type, household composition, region and season. Results suggest increased availability of healthy FAFH needs to be supplemented by targeted advertising and promotions, revisions to nutrition education programs, improved nutrition information transparency, and value pricing to improve the dietary quality of FAFH acquisitions.

**SNAP Restricted Foods**

A pair of studies analyzed consumer expenditures on SNAP restricted foods. In Study One, SNAP household expenditures on current and proposed SNAP restricted foods were characterized and compared with cash expenditures to provide insight on the potential impact of proposed food purchase restrictions. Results suggest legislation restricting specific foods (sugar-sweetened beverages, snack foods) will be less effective than legislation restricting all WIC-ineligible foods. Study Two evaluated the impact of proposed SNAP purchase restrictions by comparing SNAP participant and income-eligible non-participant expenditures on current SNAP restricted foods. Findings indicate the share of households purchasing and household expenditures on current SNAP-restricted foods were similar among SNAP participants and income-eligible non-participants.

**Objective 1 Impact:** Research conducted under Objective 1 provides policymakers and the food industry with insight needed to improve the nutritional quality of US households' food purchases. Characterization of household expenditures on current and proposed SNAP restricted foods indicates food purchase restrictions alone are unlikely to impact SNAP household food purchases. Similarly, results suggest the addition of healthy menu items at restaurants should be complemented by initiatives to increase healthy food demand.

**Objective 2: Evaluate the effectiveness of current and proposed food and nutrition assistance, food and nutrition education and food access policies and programs. (100% Accomplished)**

The following food and nutrition assistance and nutrition education policies were examined in this project: 1) food and nutrition assistance COVID-19 policy responses, 2) SNAP food purchase restrictions, 3) SNAP retailer authorization requirements, 4) food and nutrition assistance program take-up, and 5) nutrition education program evaluation.

**Food and Nutrition Assistance COVID-19 Policy Responses**

Two studies analyzed the impact of food and nutrition assistance program policy responses to the COVID-19 pandemic on household food sufficiency. The first study examined the effect of the SNAP Online Purchasing Pilot (OPP) on food sufficiency during the early stage of the pandemic. The SNAP OPP was rapidly expanded to address pandemic-induced barriers to food access among SNAP households. Results indicate the OPP improved food sufficiency among low-income households by 2.25 percentage points early in the pandemic, a 3 percent increase relative to mean food sufficiency. This finding suggests online benefit redemption has the potential to improve food sufficiency by mitigating food access barriers.

A second study examined the association between the mode of school meal distribution and food sufficiency during the pandemic. National School Lunch Program and School Breakfast Program distribution modes considered include meal pickup, meal delivery, on-site meals, and Pandemic Electronic Benefit Transfer (P-EBT). Probit model estimates indicate on-site meals and P-EBT are associated with reductions in food insecurity, while meal pick-up is associated with increased food insecurity.

**SNAP Food Purchase Restrictions**

A pair of studies analyzed proposed SNAP food purchase restrictions. These studies are described in detail under Objective 1.

**SNAP Retailer Authorization Requirements**

The impact of SNAP retailer authorization on the nutritional quality of SNAP participants' food purchases at non-traditional retailers was also considered. Healthy Eating Index-2010 (HEI-2010) scores were 3.40 points higher for higher-income household shopping trips at SNAP-authorized versus unauthorized retailers. In contrast, HEI-2010 scores did not vary significantly with SNAP retailer authorization for SNAP participants and income-eligible non-participants. A comprehensive policy approach that addresses both supply and demand barriers to healthy food purchases is needed to effectively improve the dietary quality of low-income households.

#### Food and Nutrition Assistance Take-Up

Determinants of food and nutrition assistance program take-up were considered in Project Years 4-5. Results indicate households with young children, in metro areas, and with a college-educated or married respondent participate in fewer programs given eligibility. Program factors that reduce participation stigma and transaction costs are further associated with increased take-up. To improve take-up, policymakers should consider targeted WIC-outreach to eligible households with young children, as well as potential program modifications to overcome participation barriers faced by households with young children.

#### Nutrition Education Evaluation

A body mass index (BMI) cost-benefit analysis (CBA) methodology was developed to provide an objective means to evaluate the economic value generated by nutrition education programs. The developed BMI CBA methodology was applied to the adult Expanded Food and Nutrition Education Program (EFNEP) in Colorado and Washington. BMI CBA results indicate adult EFNEP generates \$9.23 of benefits per \$1.00 of program costs. Study results provide objective evidence that adult EFNEP is an effective use of taxpayer dollars for nutrition education, with program benefits associated with chronic disease prevention exceeding program costs. Results further demonstrate the feasibility and potential value of using biomarkers in future economic evaluations of nutrition education interventions.

**Objective 2 Impact:** Research conducted under Objective 2 has wide-reaching impacts. Results broadly suggest food and nutrition policymakers should avoid food purchase restrictions and instead implement policy changes to improve food access, encourage program take-up, and foster consumer demand for healthy foods. The body mass index (BMI) cost-benefit analysis methodology developed further has the potential to transform economic evaluation of nutrition education interventions by standardizing the use of objective biomarkers for benefit estimation.

#### **Objective 3: Analyze the effect of the food industry's health-related marketing efforts on consumer food purchases and health outcomes. (100% Accomplished)**

Two studies analyzed health-related marketing efforts in the food industry. The first study examined determinants of US household expenditures on fortified fruit juice. Study results indicate fruit-juice fortification is a viable strategy for improving public health among demographic subgroups that are disproportionately vulnerable or at-risk for nutrient deficiencies. Findings suggest that fruit-juice manufacturers' fortification efforts are improving the nutritional intake of toddlers and children, but are less effective at reaching other demographic subgroups with high nutrient-deficiency incidence. Study implications include consideration of targeted marketing and outreach efforts to maximize improvement in dietary quality among fruit-juice consumers.

A second study analyzed whether entrepreneurial assistance programs create value for nascent food industry entrepreneurs through the provision of marketing (health-related labels, etc.), product development, and strategic planning assistance. Results indicate that agri-food EAP assistance prevents untenable business ideas from launching, improves the survival of launched ventures, and develops entrepreneurs' perceived legitimacy with trading partners. Further, results imply targeted EAPs are a viable approach for promoting entrepreneurial activity in the agri-food industry, and they are particularly well suited to assisting nascent entrepreneurs with marketing, product development and strategic planning.

**Objective 3 Impact:** Findings under Objective 3 highlight the need for targeted marketing and outreach efforts in the food industry. Fruit juice manufacturers can expand their market for fortified fruit juice products by targeting two demographic groups with high nutrient-deficiency incidence: rural and minority-headed households. Further, findings indicate EAPs are a viable outreach approach for promoting entrepreneurial activity in the food industry and can support nascent entrepreneurs' execution of health-related marketing strategies.

#### **Briefly describe how your target audience benefited from your project's activities.**

Year 5 project activities were targeted at policymakers, program administrators, and academics. Two presentations at academic conferences and one corresponding submission to a peer-reviewed journal (currently under review) introduced academics and policymakers to: 1) the impacts of the SNAP Online Purchasing Pilot on food sufficiency during the early

COVID-19 pandemic, and 2) the association between the mode of school meal distribution and food security during the pandemic. Two additional journal articles currently under review at peer-reviewed journals further provide: 1) policymakers and academics with insight on the determinants of the number of nutrition assistance programs low-income households with children participate in given multi-program eligibility, and 2) program administrators and academics with an introduction to a biomarker-based cost-benefit analysis methodology for objective nutrition education intervention evaluation.

**Briefly describe how the broader public benefited from your project's activities.**

This study broadly benefited the public by providing insight on how consumers, the food industry, and government can contribute to improving food security and diet quality in the US.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

**Training:** Bridget Bafowaa is seeking an MS degrees in Economics. Her research was supported through this Hatch project and relates to Objective 2. Ms. Bafowaa is analyzing the impact of COVID-19 relief policies on US household food security and food acquisition. During project Year 5, Ms. Bafowaa conducted background research, developed her research methodology, conducted multivariate regression analyses using data from the Household Pulse Survey, and drafted her MS thesis. Her MS thesis will be defended during Spring 2023. In addition to her thesis, Ms. Bafowaa also assisted with data analysis for the study Child Nutrition Program Waivers and Food Security during Covid-19, which was presented at the 2022 AAEA Annual Meeting.

**Dissemination:** Results from this project were disseminated through: three journal articles under review (1 revise & resubmit; 2 initial review) and two presentations at national conferences.

**Products:**

Leschewski A, Aragon MC, Baker S, Weatherspoon D, Barale K, and Auld G. 2022. Expanded food and nutrition education program generates economic value through chronic disease biomarker improvement: a cost-benefit analysis. Journal of Extension. (Under Review).

Leschewski A, and Davis D. 2022. Nutrition assistance program take-up given multi-program eligibility. Journal of the Agricultural and Applied Economics Association. (Revise & Resubmit).

Jones K, Leschewski A, Jones J, and Melo G. 2022. The SNAP online purchasing pilot's impact on food sufficiency during the COVID-19 pandemic. Journal of the Agricultural and Applied Economics Association. (Under Review).

Leschewski A, and Bafowaa B. 2022. Child nutrition program waivers and food security during Covid-19. Agricultural and Applied Economics Association's 2022 Annual Meeting. August 2. Anaheim, CA.

Leschewski A, Jones K, Jones J, and Melo G. 2022. The SNAP online purchasing pilot's impact on food sufficiency during the Covid-19 pandemic. Agricultural and Applied Economics Association's 2022 Annual Meeting. August 2. Anaheim, CA.

**Understanding the drivers and assessing the impacts of technology adoption and diffusion in the food and agribusiness sector**

Project Director

Deepthi Kolady

Organization

South Dakota State University

Accession Number

1012620

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

Sustainable agriculture practices such as no-till, conservation tillage, cover crops, crop-livestock integration, and precision agriculture technologies are promoted by federal and state programs as a way to increase producers' profitability while protecting the environment and providing ecosystem services. Further, technologies such as genetic engineering and genome editing are developed to address producers' concerns related to production and consumers' concerns associated with nutrition, food safety, and health. In this project, we try to understand the factors influencing producers' decision-making with respect to technology adoption, the role of regulations in the adoption of agricultural biotechnologies by producers and consumers, and determinants of consumer preferences for sustainably produced food.

Consumers' preferences for eco-friendly foods and technologies are on the rise. However, adoption rates of agricultural conservation practices and precision agriculture technologies that improve soil health vary from region to region. Although available evidence shows that genetically modified foods are as safe as conventionally bred foods, commercial approval of genetically modified foods varies from country to country. Our understanding of what influences farmers' decisions on technology adoption and the regulator's decisions on technology approval is limited. Similarly, knowledge concerning factors that influence consumers' food preferences is also limited. Without an improved understanding of the determinants of producers' and consumers' decisions, it will be hard to develop programs and policies to scale up the adoption of sustainable agricultural practices and technologies.

This project investigates the determinants of producers' adoption of sustainable agricultural practices and technologies and consumers' preferences for eco-friendly and sustainably produced foods. Further, the project also explores the reasons for the regulatory divergence in the commercial approval of genetically modified foods between countries. Results from the project will inform policymaking and market outreach efforts targeted at the large-scale diffusion of sustainable agricultural production practices and technologies.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1:**

We completed an analysis of farm-level data from eastern South Dakota that focused on the adoption of precision technologies and conservation practices. We used two separate farm-level surveys to collect this information. Findings showed that adoption of embodied knowledge precision technologies such as autosteer was higher (68%) than information-intensive precision technologies such as variable rate application, yield monitors, etc (47%). The study showed that producers who perceive environmental benefits from precision technology adoption and producers with prior knowledge of computer use adopt more precision technologies than their peers. Results highlighted the importance of market outreach programs in scaling up the adoption of information-intensive precision technologies such as yield monitors and variable rate applicators.

Peer effects help reduce the learning costs associated with the adoption of new practices/technologies, as producers can observe the practices on neighbors' fields. If peer effects are important, then extension and outreach programs can be developed to leverage the peer effects to increase the adoption of such practices instead of solely relying on financial incentives, which are costly and controversial at times. Study findings showed the importance of spatially mediated peer effects in the adoption of conservation tillage and diverse crop rotation. However, peer effects were not important in the adoption of cover crops.

Our analysis showed that the adoption of precision technologies and conservation practices is correlated at a statistically significant level ( $r=0.3$ ). The positive and statistically significant correlation implies that certain factors that influence the adoption of conservation practices also influence the adoption of precision technologies. This finding suggests that policies and programs designed to promote the adoption of conservation practices can be leveraged to scale up the adoption of precision technologies.

**Objective 1b: To study the economic, environmental, and social impact of producers' adoption versus non-adoption decisions.**

Another focus of our research was to examine whether the adoption of conservation management practices results in soil resilience and yield stability. We collected soil samples and production data from adopters of conservation practices and non-adopters of conservation practices. The soil samples were sent to Cornell University's Comprehensive Soil Health Testing lab for comprehensive soil testing. Samples were also used for soil microbiome analysis which was conducted at the Center for Biologics and Research at South Dakota State University. The overall soil health score for the conservation fields was 73.4, whereas that for the conventional field was 69.4. The study also collected soil samples from native and restored prairie lands in eastern South Dakota, and the overall soil health scores were 90.0 and 84.0, respectively. We found evidence to support our



hypothesis that, on average, the adoption of conservation practices results in improved soil health. We are currently analyzing whether improved soil health leads to crop yield stability. If the adoption of conservation practices leads to soil resilience and yield stability, our findings will imply that market-based incentives such as crop insurance subsidies can be used to scale up the adoption of conservation practices.

**Objective 1 Impact:** Results from our study provided field-level evidence on the factors influencing farmers' adoption of conservation practices and precision agriculture technologies. The study showed that while peer effects are effective in scaling up the adoption of conservation tillage, cost-share programs are important in scaling up the adoption of cover crops. Our study also showed that soil resiliency due to conservation practices increases with the duration of usage of practice. We have communicated our findings to stakeholders to inform policymaking in this field.

**Objective 2: Objective 2: Study the factors influencing agricultural biotechnology regulations and conduct impact analyses of regulatory policy.**

**Objective 2a: Study how the ethical tensions arising from agricultural biotechnology influence regulations in developed and developing countries.**

There are major differences in the way agriculture biotechnologies are regulated between developed and developing countries. We used U.S. and India as case examples and found overall divergence in policy approaches to agricultural biotechnology. U.S. regulatory agencies address ethical concerns related to environmental and biosafety issues via risk-based environmental impact assessments and food and feed safety assessments and recommend risk management strategies in a timely manner. However, standard political-economic theories, including those of economic interest groups theories alone, cannot fully explain the regulatory uncertainty in India. Poor institutional framework, political interference, and social concerns related to the influence of multinational companies on food sovereignty and environmental concerns contribute to regulatory uncertainty in India. Our analysis showed that types of prevalent ethical concerns, differences in institutional structure, and domestic politics contributed to divergence in policy and regulation of agriculture biotechnology in the U.S. and India. These factors may play an important role in the regulation of new technologies such as genome-edited crops.

**Objective 2b: Conduct impact analyses of technology regulations on social welfare.**

Nothing to report.

**Objective 2 Impact:** Our study highlighted the reasons for discrepancies between agricultural biotechnology regulations between countries and how these divergencies in regulations could affect social welfare. Findings from our study provide insights for addressing any divergence in regulations on emerging new food technologies such as gene editing.

**Objective 3: Study consumer acceptance of emerging technologies and its impacts on niche market development, rural health, and the environment.**

**Objective 3a: Study consumer acceptance of new agricultural technologies such as genome editing and understand the factors influencing their perceptions of alternative labeling options and niche markets.**

We completed a nationally representative consumer survey examining consumer perceptions and willingness to pay for gene-edited crops relative to genetically modified crops and conventional crops. Almost 90% of the survey respondents have heard of genetically modified (GM) crops, while only 43% have heard of gene-edited foods. About 48% of the respondents consumed GM foods during the previous three months. Current consumers of GM foods are more likely to consume gene-edited foods (~50%). Consumers prefer conventional foods (non-GM and non-gene-edited), and providing information on technology increases consumers' willingness to pay for gene-edited foods. Because of the continued activism centered around the corporate conduct and reputation of specific firms involved in developing GM technologies (e.g. Monsanto) consumers prefer gene-edited technology from universities and small domestic start-ups compared to those from multi-nationals.

**Objective 3b: Study the impact of consumer acceptance of new technologies on niche market development, rural health, and the environment.**

Implementation of the Veterinary Feed Directive (VFD), which eliminated the use of medically important antibiotics for growth promotion in food animals in the U.S., offers marketing opportunities for livestock producers to differentiate products based on antibiotic use and will contribute to the efforts to reduce the development of antibiotic resistance. In our first post-VFD study, we used data from an online split-design national survey of 660 U.S. consumers conducted during June 2019 and employed a discrete choice experiment to examine U.S. consumers' willingness to pay (WTP) for pork chops from pigs raised without antibiotics and with minimal use of antibiotics for disease treatment. The results showed high premiums for antibiotic-free pork and pork with minimal use of antibiotics relative to regular pork. The results indicated a higher WTP for consumers with information on the non-therapeutic use of antibiotics. The findings imply that U.S. pork producers and firms



can use labeling and market outreach efforts to leverage consumer demand for meat products with reduced use of antibiotics. Policymakers can facilitate product differentiation in the marketplace by developing standards that clearly define labels such as antibiotic-free and therapeutic use of antibiotics. The results have similar implications for other countries with high antibiotic use in animal agriculture.

**Objective 3 Impact:** Our analysis of consumer preference for genome-edited foods showed that consumer preference for genome-editing technology varies based on food types, food processing levels, the information provided, and the type of technology developer. Our study showed that there is consumer demand for pork products with different levels of antibiotic use such as reduced use of antibiotics or sustainable use of antibiotics in addition to the already available antibiotic-free products. Overall, our results showed how consumer preference can influence producers' decisions on management practices (antibiotic use in pork production) and technology use (adoption of genome-editing technology).

**Briefly describe how your target audience benefited from your project's activities.**

Crop and livestock producers, agribusiness firms, academic researchers, and policymakers are our target audience. Our research findings were shared with our target audience through scholarly publications, conference presentations, and outreach articles. Results from our farm-level analysis on determinants of adoption of conservation practices and precision technologies and economics of conservation practices provide insights on developing targeted programs and policies that increase the adoption of sustainable agricultural practices at the farm level. Findings from our analysis of consumers' preferences and WTP for pork produced using different antibiotic use levels and for genome-edited foods show the importance of consumer preferences on producers' decision-making at the farm level.

**Briefly describe how the broader public benefited from your project's activities.**

My research program and publications made significant contributions to the current policy discourse on agricultural technology adoption issues in the state and nation, with positive implications for producers, agribusiness firms, and the ecosystem. I was selected as a 2022-2023 US Fulbright Scholar to continue my research on farmers' adoption of sustainable production practices at Chulalongkorn University in Thailand. I was an invited panelist at the 2022 Congressional panel on climate-smart agriculture organized by the National Academies of Sciences Engineering and Medicine and Scientific American.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

**Training:** Three graduate students were engaged in survey research, applied econometric analysis, and policy analysis. **Bindu Paudel, MS Student, Economics:** Ms. Paudel developed a consumer survey that employed a discrete choice experiment and focused on U.S. consumers' acceptance and willingness to pay for gene-edited foods. She presented papers at the 2021 Western Agricultural Economics Conference (virtual) and 2021 Agricultural and Applied Economics Association Annual Meeting in Austin, Texas. Bindu won the second prize for the best graduate paper award at the 2021 Western Agricultural Economics Conference. Bindu has three journal articles published based on her research. **Md Mahi Uddin, MS Student, Economics:** Analyzed the factors influencing adoption and adoption intensity of precision technologies in South Dakota. He has one publication based on this work. **Alex McLain, MS student, Economics:** Worked on collecting data on adoption of conservation practices and assessing its impact on soil health. He has presented the research findings at the 2021 Southern Agricultural Economics Association Annual Meeting. He also published an extension article based on his research.

**Dissemination:** Scientific community: We generated 10 peer-reviewed journal papers, one book chapter, and 13 conference presentations based on the project. Crop and livestock producers: We published 7 outreach articles based on the project. General public: I conducted six media interviews with outlets such as SD Farm Talk Radio and South Dakota Public Broadcasting. Invited panelist for the Congressional panel on Climate-smart agriculture organized by the National Academies of Sciences Engineering and Medicine and Scientific American.

**Products:**

Paudel\*, B, Kolady\*\*, D. Just, D., Ishaq, M. 2023. Effect of information and innovator reputation on consumers' willingness to pay for genome-edited foods. Food Quality and Preference. <https://doi.org/10.1016/j.foodqual.2023.104825>

Paudel\*, B., **Kolady\*\***, D., Just, D., and Van der Sluis, E. 2023. Determinants of consumer acceptance of gene-edited foods and its implications for innovators and policymakers. *Agribusiness: An International Journal* (forthcoming). DOI: [10.1002/agr.21799](https://doi.org/10.1002/agr.21799)

Annan\*, K, Van der Sluis, E., Fausti, S., and **Kolady**, D. The role of biotechnology and biofuels in U.S. Corn Belt cropping system changes. *Renewable Agriculture and Food Systems*. 2022. <https://www.cambridge.org/core/journals/renewable-agriculture-and-food-systems/article/abs/role-of-biotechnology-and-biofuels-in-us-corn-belt-cropping-system-changes/74D02F699FEC490B1A3CDD92B317F3F4>

Paudel\*, B., **Kolady**, D., Grebitus, C., Ishaq, M. Are consumers willing to pay more for pork produced with reduced levels of antibiotics? [Magazine – Archive | AFMA \(afmaaz.org\)](#).

McLain\*, A., **Kolady**, D. On-farm decisions and outcomes: How management practices affect soil health and crop yields. Southern Agricultural Economics Association Annual Meetings 2022, February 12-13, New Orleans, LA.

#### Other Products:

**Media Interviews:** Interview with DW News Germany’s Janelle Dumalaon. Impact of inflation and shocks on agriculture (10/18/2022). [How inflation and economic policy impact the work of US farmers | DW News - YouTube](#)

Interview with South Dakota Public Broadcasting’s Lori Walsh (In the Moment). War in Ukraine and its pressure on farmers to produce more. Does it affect farm sustainability (4/12/2022). [Deepthi Kolady | SDPB](#)

Interview with Joshua Haiar of SDPB on Conservation Reserve Program (April 19,2022)  
<https://listen.sdpb.org/environment/2022-04-14/crp-conservation-reserve-acres-mostenrolled-since-1990s>

**Congressional Panel:**2022 Science on the Hill panel member for the discussion on climate-smart agriculture (July 15, 2022); [Science on the Hill Climate Smart Agriculture | National Academies](#)

Critical Issue

## Food Systems, Nutrition, Health, and Well-Being

### Identifying Weight Related Behaviors for Obesity Prevention and Wellness

Project Director

Kendra Kattelman

Organization

South Dakota State University

Accession Number

1013769



**Final report: 10/1/17-09/30/22: Identifying Weight Related Behaviors for Obesity Prevention and Wellness**

Final Result

#### **In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

There are limited validated tools used to comprehensively and effectively assess the perception of the environment to support healthful behaviors for chronic disease prevention and weight maintenance. Therefore, research is needed to elucidate the combination of individual and environmental factors associated with unhealthy weight gain among our targeted population of young adults, including those in under-represented, low-income communities. Using the ecological perspective to understand how different factors interact to influence food and physical activity behaviors, this research will inform more tailored interventions that lead to lasting healthful behavior change.

Emerging adulthood, or the transition through late adolescence and young adult years, is a distinct stage of life associated with declines in healthy lifestyle behaviors. Young adults are at risk for unhealthy weight gain and dietary patterns, as well as more sedentary lifestyles. The dramatic changes in living and social situations associated with emerging adulthood have been linked to adverse health outcomes. These outcomes may be further challenged by the escalating cost of higher education and

uncertainty in the global and local economies. Campuses and communities where young adults reside will benefit from timely and personalized information, as well as utilization of evidence-based tools and programs to enhance the health and well-being of this population. The overarching goal of this multistate project is to support campuses and other communities in creating environments and opportunities that embrace young adults' unique barriers to a healthy lifestyle, promote healthier weights, and reduce health disparities among vulnerable members, who are the fastest grown segments within the US.

Determining the mechanisms and interventions to change and support healthy eating and lifestyle behaviors will increase the quality of life, and decrease the burden of chronic illness, and healthcare costs.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1: (95% Accomplished)**

This is an ongoing project to develop a framework to collect data, summarize, and disseminate the outcomes and impacts of community wellness intervention/programs. This tool is designed to guide the user to capture community and health data that is related to the program goals, compile and assemble the data, and provide comparison's to established public health guidelines in an easy to understand report for disseminating to the interested parties in the community. This infographic portrays a community profile and includes the ability to include outcome data from an intervention to share impacts. The tool has been shown to be useful and favorable in two large community-based interventions. The first intervention to use eB4CAST was iCook 4-H, an out-of-school obesity prevention program for youth aged 9–10 years and their primary food preparer founded around "Cooking, Eating, and Playing Together." The Extension educator captured the indirect data that was aligned with the program outcomes from publicly available websites which showcased the justification for the program need. Direct data were collected as part of the measured outcome data from iCook 4-H project and included in the infographic as outcome from the intervention. The infographic was used to disseminate the impact of the programming to the public.

The second project to use eB4CAST was GetFruved, a research project designed to decrease obesity in older adolescents through behavioral intervention and environmental support on college campuses. eB4CAST was used to collect indirect and direct data to create a snapshot of the campus environment and show the need for improvements. Indirect data that aligned with the GetFruved program were collected from both the institution and national websites. Institutional data included number of residence and dining halls on campus, student enrollment, percentage of students living on campus, gender and race breakdowns, percentage instate residency, and student-to-teacher ratio. National websites were used to collect other campus environment data including campus crime, neighborhood crime, weather, housing and transportation affordability, walkability, rurality status, population, food environment, and health. The direct data was collected as part of the GetFruved RCT and shared with eB4CAST researchers to create the infographic report. Direct data included the Healthy Campus Environmental Audit that evaluated campus policy, dining, and recreation, the College Environmental Perceptions Survey that determined student and administrator perceptions of the healthfulness of their campus, Student and Administrator's Readiness to Change which evaluated how ready the campus is to make behavioral and environmental change, Student and Administrator's Priorities that examined the top five priorities for change on campus, and a Wellness Report card which evaluated campus physical activity, fruit, and vegetable consumption, sleep, and stress. eB4CAST was used to report the data for the intervention. To date, 66 college campuses have received eB4CAST infographic to use to disseminate the outcomes and impact on the campuses. **Impact:** The eB4CAST is an easy to use comprehensive tool that is useful in reporting impacts of wellness programming on the community.

**Objective 2: Continue environment and behavioral instrument development, refinement and validation of the Behavior Environment Perceptions Survey (100% accomplished)**

The Behavioral Environment Perception Survey measures the perceptions of the healthfulness of campus environment. The instrument is a 21-item survey that includes perception of the environment to support physical activity, healthful eating, mental health, barriers to healthful eating, and peer influences.

Development of a Healthy Campus Environmental Audit is nearly complete. As part of this audit we have developed easy-to-use validated tools to assess the environment and be used in the Healthy Campus Environmental Audit. A walkability/bikeability assessment of campuses was developed and tested for validity in relation to college students walking behaviors and BMI. The walkability/bikeability audit tool is a 12-item audit and assesses the ease of walking and biking on a campus. A second component of the Healthy Campus Environmental Audit is the assessment of the healthfulness of the food environment. The Full Restaurant Evaluation Supporting a Healthy (FRESH) Dining Environment is a simple tool that was developed and validated to assess cafeterias and restaurants. The impact of a validated and reliable tool to measure the

healthfulness of the campus environment will be the ability to readily assess and develop programming specific to the needs of campus. **Impact:** The Healthy Campus Environmental Audit is an easy to use, comprehensive audit to benchmark the campus environments for support of healthful behaviors.

**Objective 3: Develop and pilot the novel, comprehensive Healthy Community Index on college campuses and test the feasibility in low-income communities. (10% accomplished)**

Work has started on adapting the audits developed for the campus to a low-income community. In-depth interviews are being conducted with nutrition educators in low socioeconomic status communities to gather information about what is considered “healthy” in their community. Focus groups were conducted to capture the changes due to COVID. The focus data is analyzed and a manuscript is in progress to disseminate the outcomes. **Impact:** The impact of this outcome that community leaders will have easy-to-use tools to comprehensively audit the environment for support of healthful behaviors. The outcomes will include information on the impact of pandemic on the environmental supports of healthful behavior.

**Objective 4: Continue exploration of mechanisms of interaction between lifestyle behaviors and environmental factors in influencing healthy behaviors and health status of young adults. (50% accomplished)**

Many college students lack the ability to choose and/or prepare healthy meals, with consequences of convenient, but unhealthy food choices. The objective of this feasibility project was to determine whether cooking classes for college students would improve knowledge and behavior to eat healthfully and practice food safety. A series of 3 cooking classes was provided to students, focusing on simple, healthy recipes with inclusion of food safety and nutrition instruction. Pre- and post-test surveys assessed nutrition knowledge; frequency of healthy eating; confidence, ability, and cooking frequency; and food safety knowledge. Thirty-eight college students participated in the cooking classes. Participants were primarily female (84.2%) and mostly freshman (55.3%). Nutrition knowledge score increased from pre- to postintervention ( $P = .000$ ). Participants reported an increase in cooking confidence ( $P = .026$ ), cooking abilities that require greater skills—putting together ready-made ingredients to make a complete meal ( $P = .016$ ), and preparing dishes from basic ingredients ( $P = .006$ ). There were no differences in ability to cook convenience foods, frequency of cooking, nor changes in any of the food safety behaviors questions from pre- to postintervention. The classes were effective in increasing nutrition knowledge, cooking ability and confidence.

Using data from GetFruved high school student intervention, the association between cooking frequency to prepare and cook a main meal from basic ingredients (CF) with diet quality was explored. We recruited 1,563 high school students from five districts in 4 states (Kansas, Tennessee, Florida, and South Dakota) to complete on-line surveys assessing for age, sex, location, height, weight, CF, and frequency of breakfast and fast food consumption. Additional metrics tracked included fiber, added sugars, ounce equivalents of whole grains per day (WG) using the Dietary Screener Questionnaire, and cup equivalents of fruit and vegetable (FV) using the National Cancer Institute Screener. Multiple linear regression with CF as independent variable and frequency of breakfast, fast food consumption, fiber, sugar, FV, and WG as dependent variables controlling for location, sex, ethnicity, and BMI z-score were performed. There was a significant inverse correlation of cooking a main meal from basic ingredients and the frequency of fast food consumption and added sugar consumption and a positive correlation with intake of fiber, whole grains, and fruit and vegetable consumption. These results support a positive relationship between frequency of preparing a main meal from basic ingredients and diet quality as measured by fiber, WG and FV. **Impact:** The results indicate the need for education on meal preparation and cooking skills in adolescents and young adults to support healthful dietary behavior.

**Objective 5. Exploratory work with the influence of the diet on the microbiome in Native Americans. (100% accomplished)**

Stool samples, dietary data, and socioeconomic data were collected from 50 Native American adults. The dietary data and microbiota data from stool samples was analyzed. There were no significant correlations with any of the individual nutrients measured and the microbiome diversity. When evaluating the diet by food group types, microbiome diversity was positively correlated with dietary intake of legumes. **Impact:** This data will add to the emerging body of knowledge of the correlation of dietary intake on microbiota of the gut and relationship to prevention of chronic disease.

**Briefly describe how your target audience benefited from your project's activities.**

The target audience of 18-24 year olds on college campuses benefit from the benchmarking. To advocate for change, one must have a baseline to measure improvement.

Native American adults can benefit from the exploratory work of diet and influence on the microbiome. Although, there was not a significant correlation with nutrient intake and gut microbiome, there was a significant positive relationship to gut microbiome diversity and legume intake. This outcome is aligned with the 2025 Dietary Guidelines to increase dietary intake of legumes.

**Briefly describe how the broader public benefited from your project's activities.**

The broader public benefit of this project activities include the benchmarking of the communities to support healthful behaviors. Healthful behaviors are important for chronic disease prevention.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

**Changes/Problems:** I have had delays due to COVID. We put the environmental assessment on hold during this time. We plan to continue with those assessments next year.

**Training:** Two graduate students (Alison Kuch, PhD student, 25% time and Kady Harris, MS student, 25% time) were trained to complete focus groups and the environmental assessments, qualitative and quantitative data analysis, and dissemination of results.

**Dissemination:** The results have been disseminated through peer reviewed journal articles and poster presentations at national meetings.

**Products:**

#### **Published manuscripts**

1. Kunicki, Z.J., Kattelman, K.K., Olfert, M.D., Franzen-Castle, L., Colby, S., Mathews, D.R., White, A.A. 2022. Dyadic analysis of a self-report physical activity measure for adult-youth dyads. *Child Psychiatry Hum Dev.* 53, 440–447. <https://doi.org/10.1007/s10578-021-01144-3>.
2. Chen, B., Kattelman, K., Comstock, C., Wey, H., Bowne M., Meendering, J. 2022. Identifying food parenting practices from comprehensive home environment survey. *Journal of Nutrition Education and Behavior.* 54(6), 557-564. <https://doi.org/10.1016/j.jneb.2022.02.010>.

#### **Astracts/Proceedings (\* mentored students)**

1. Varela, E., Zeldman, J., Kuch, A., Wang, Y., Hall, E., McNamara, J., Morrell, J., Tolar-Peterson, T., Brown, O., Olfert, M., Franzen-Castle, L., Kidd, T., Colby, S., Kattelman, K., Greene, G., Shelnut, K. 2022. The impact of COVID-19 on perceived barriers and facilitators to the healthfulness of communities with low-income. *J. Nutr. Educ. Behav.* 54:S7.
2. Varela, E., Zeldman, J., Hall, E., Wang, Y., Kuch, A., Olfert, M., Kidd, T., Kattelman, K., Greene, G., Shelnut, K. 2021. Perceived healthfulness of the environment of communities with low income by community stakeholders. *J. Nutr. Educ. Behav.* 53:S7.

#### **Process interventions for enhancing microbial quality, safety, and nutrition of dairy foods.**

Project Director

Sanjeev Anand

Organization

South Dakota State University

Accession Number

1012795



**Final Result: Process interventions for enhancing microbial quality, safety, and nutrition of dairy foods**

Final Result

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

The project addressed the control of sporeformers and environmental *Listeria* to improve the quality and safety of dairy products. Experiments were also completed to successfully entrap probiotics in whey protein hydrolysates to enhance bioactivities of dairy proteins.

Due to public health concerns it is important to be able to monitor *Listeria* levels in the dairy industry and to control populations to improve the quality and safety of dairy products.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1:** Our work demonstrated the presence of different types of spores in samples of Whey Protein Concentrate (WPC) and Non-Fat Dried Milk powders (NFDM). Samples were enumerated for 3 types of endospores after heating at 80°C/12 min for regular spores (SP), 100°C/30 min for high-heat resistant spores (HHRS), and 106°C/30 min for specially thermoresistant spores (STS). For each sample, 11 g was reconstituted in 99 mL of phosphate buffer saline, and a desired serial dilution was plated on tryptic soy agar. Under aerobic conditions, the plates were incubated for 24 h at 37°C for mesophiles and 55°C for thermophiles. Several spore-forming species were identified based on colony morphology followed by MALDI-TOF. In WPC the samples containing the mesophilic spores were 64% SP, 20% HHRS, and 16% STS. Similarly, the samples containing thermophilic spores were 73% SP, 14% HHRS, and 13% STS. In NFDM the samples containing the mesophilic spores were 95% SP and 5% HHRS. Similarly, the samples containing thermophilic spores were 60% SP and 40% HHRS. STS was not present in NFDM samples. Based on the percent distribution, SP was the most prominent heat treatment spore-category.

In the sampling variability study, evaluated the influence of sample volume, sampling frequency, and sampling methods for whole milk, skim milk, and whey. We used an experimental High-Temperature-Short-Time (HTST) pasteurization unit in the Davis Dairy Plant. Samples were inoculated with *Bacillus licheniformis* at 4.0 logs and pasteurized uninterruptedly for 12 h at 72°C/16secs. Raw and pasteurized milk represented high and low-count milk, respectively. At 0, 4, 8, and 12-h individual samples of 10mL and 100 mL were drawn from the low and high-count sides of the pasteurizer. Two continuous composite samples of the 12 h run were also drawn separately from the low and high-count sides. Standard Plate Counts (SPC) were enumerated using tryptic soy agar incubating the plates at 32°C for 48 h. The study demonstrated that sample volume does not influence the SPC. The zero hour counts in low counts milk were Log 1.48 and 1.56 for 10 and 100mL samples, respectively. Thus, 10 and 100 mL can be equally effective for microbiological analysis of low and high count samples of milk and whey. We found that the SPC varied with sampling interval. Counts were Log 1.48 and 1.98 for the samples collected at 0 and 12 h, respectively. Extended process runs of 12 h or more, sampling at multiple intervals could be more representative of the entire process. Composite samples collected during the 12-h run could provide an indication of the overall microbial counts in extended process runs, which might help to draw an inference on the entire process. Further studies may be needed to evaluate the influence of any other factors on the composite sampling over a period of time.

**Objective 2:** *Listeria monocytogenes* (Lm) is a prevalent foodborne pathogen that forms biofilms on floors in dairy processing facilities and can potentially cross-contaminate products. Despite the fact that these facilities have effective floor cleaning systems, Lm is still isolated sporadically. As a result, we conducted a study to assess the performance of a typical floor cleaning protocol utilized in a commercial dairy facility. For this study, we used an industrial Lm isolate to develop biofilms on clay brick tiles (a common flooring material used in dairy plants) of 1x1 square inch dimensions for 24, 48, and 72h using 7.0LogCFU/mL Lm spiked dairy effluent and incubation at 37°C for the specific duration. The dairy effluent was procured from a dairy facility and analyzed for pH, carbohydrate, fat, and protein content. The typical floor cleaning steps were then sequentially simulated on the biofilm-formed clay brick tiles. We then used 3M quick swabs containing 1mL letheen broth to take pre-and post-treatment counts. The results showed 24h old biofilms were most susceptible to cleaning, resulting in the highest log reduction of 3.18±0.26. Meanwhile, the 72h old biofilms had a log reduction of 2.5±0.18, and 48h old biofilms had a log reduction of 2.0±0.00. The fewest Lm survivors were observed when the cleaning procedures were conducted on 24h old biofilms. Thus, dairy plants should incorporate a 24h cleaning regime, when appropriate, to remove *Listeria* biofilms from dairy plants more effectively. The second part of the study was directed towards the *Listeria* species such as *L. monocytogenes* (Lm), *L. innocua* (Li) and *L. welshimeri* (Lw) that are routinely found in dairy processing environments. Common phenotypic traits (colonization and biofilm formation) were used to differentiate these species. We also used genomic tools to assess whether specific genetic determinants could be linked to their persistent or sporadic nature. Whole-genome sequencing (WGS) of six industrial *Listeria* isolates (3 Li, 2 Lw, and 1 Lm isolates) sourced from a dairy plant was performed using two approaches, viz. MiSeq (MS) and Nanopore sequencing (NPS). The Wizard DNA extraction kit was used to extract DNA from individual isolates. Following that, libraries were created using PCR amplification (for MS) and gDNA sequencing kit (for NPS) and fed into the Illumina and Minlon platforms. The MS assemblies were constructed using the CLC Genomic Workbench, while Flye was used for NPS. In addition, Nanopolish and Racon were used to polish the constructed assemblies for NPS. Finally, using the RAST server, annotations were developed for both methods. The improved contiguity seen through NPS helped in the completeness of the *Listeria* genome. The MS results revealed alleles in the isolates linked to 13 phenotypical traits. These alleles differed in the strain and species level. The following responses were found to play a role



in persistence: cell signaling and attachment (NAG-IIA, NAG-IIB), osmotic (CadA), and oxidative (YRKL) stress resistance. Lm was found positive for all these attributes, while Lw and Li lacked genes for motility (ActA), biofilm formation (AgD), and acid tolerance (AdiA), rendering them less resilient. The NPS results revealed additional gene variants in the isolates not identified before by MS. Motility, cell attachment, antibiotic, osmotic shock, and toxic compound resistance are the phenotypic expressions for those genes.

**Objective 3:** Developing value-added functional foods is a growing research interest, however, maintaining the viability of bioactive ingredients like probiotics and their interactions with the product matrix are major challenges. Previous studies in our lab developed a bioactive whey protein hydrolysate-probiotic encapsulant containing *Bifidobacterium animalis* ssp. *lactis* and *Lactobacillus acidophilus* exhibiting high viable probiotic counts (8.98 log10CFU/g) and enhanced bioactive properties including antioxidant, anti-microbial and anti-hypertensive properties. Further studies were conducted to incorporate WPH-probiotic encapsulant in whipped cream and butter matrices as the potential carriers, followed by storage stability studies at 4±1°C for 12 and 28 days, respectively. Batches (200 g) of pasteurized cream were whipped and churned followed by spiking encapsulant at 0.1% and 1.0% levels. For the probiotic whipped cream, viable counts were enumerated with De Man, Rogosa, and Sharpe Agar using a gaspak anaerobic system (37°C, 72 h) along with physicochemical and microstructural analysis at a 4-day interval for probiotic butter. For WPH-probiotic butter, analysis was carried out at a 7-day interval. Three trials were conducted in triplicates, and means were compared using one-way ANOVA.

The 1% probiotic whipped cream showed significantly higher viable probiotic counts (7.28±1.56log CFU/g), storage and loss modulus (14585.73±5.07 Pa, 3004.32±6.54 Pa) with lower serum loss (12.07±0.47%) as compared to 0.1% probiotic whipped cream. The 1% probiotic whipped cream also showed viability of more than 6 logs up to 12 days of storage. Micro images provided evidence of the adsorption of proteins at the O/W surface around the air cells that led to these improved characteristics. In the case of probiotic butter, 1% probiotic showed significantly higher viable probiotics (5.25±1.23 logCFU/g) as compared to 0.1% formulation, with an enhanced rheological and textural profile indicating a strong viscoelastic network. The WPH-probiotic butter could retain up to 5 logs CFU/g up to 28 days of storage at refrigerated conditions.

**Overall Impact:** New information was generated on the types of sporeformers in US dairy ingredients. This information is critical in expanding export markets for dairy ingredients, and also to improve processes for quality and safety improvement. The second study involved understanding the sampling variability in monitoring microbiological quality of dairy products in real time during the processing operations. This information is critical for developing more robust statistical process controls measures. The study related to environmental *L. monocytogenes* provided unique perspective of comparing various environmental isolates of *Listeria* based on whole genome sequencing. Our ability to develop more robust risk assessment models regarding the resident nature of high risk pathogens such as *Listeria* was enhanced by these findings and will help develop more effective the risk management strategies for environmental *Listeria* control. In the last objective, technology was standardized to create novel whipped cream and butter applications by incorporating encapsulated probiotics in conjugated whey protein hydrolysates. The findings of this part of the study could lead to expanding the role of health attributes of dairy products and consumer acceptance.

### **Briefly describe how your target audience benefited from your project's activities.**

The target audience for this project included dairy processors, dairy equipment manufacturing companies, and dairy separation membrane users. The research outcomes were shared with industry personnel and academia, in addition to inclusion in the teaching and instructional content for undergraduate and graduate students in the Dairy and Food Science Department.

### **Briefly describe how the broader public benefited from your project's activities.**

The overall objectives of this project included studies to safeguard consumer health by providing them dairy products with better quality and safety and with enhanced health benefits beyond basic nutrition.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

**Training:** The project provided opportunities to train 6 Ph.D., 6 MS, and 10 undergraduate students on advanced microbiological and dairy processing techniques. All these students were mentored on day-to-day basis by providing them opportunities to work with the faculty advisor. The graduate students were also provided professional development opportunities by supporting their participation in regional and national conferences and professional meetings.



**Ratul Kalita, M.S.** 2022. Studied the factors influencing sampling variability on microbiological analysis of milk and whey.

**Shayanti Minj, Ph.D.** 2021. Developed whey protein encapsulated probiotics and evaluated environmental *Listeria* using whole-genome sequencing.

**Kaavya Rathnakumar, Ph.D.** 2021. Conducted milk phospholipids extraction using switchable solvents (Co-Advised).

**Pratishtha Verma, M.S.** 2020. Assessed a natural antimicrobial from *Bacillus subtilis* as a biosanitizer for resilient membrane biofilms.

**Nancy Awasti, Ph.D.** 2019. Studied the influence of sporulation and germination behavior of *Bacillus licheniformis* on microbial quality of skim milk powder.

**Pratibha Chaudhary, M.S.** 2019. Assessed hydrodynamic cavitation as an in-line process to control common dairy sporeformers.

**Neha, N. Ph.D.** 2019. Assessed *Listeria* risk during different stages of ice cream manufacturing and storage.

**Steve Beckman, Ph.D.** Likely completion, Fall 2023. Studied the quality of dairy ingredients as influenced by membrane processes.

**Taghreed Almalki, Ph.D.** Likely completion, Spring 2023. Assessed microbial biofilm formation on stainless-steel contact surfaces and weldments.

**Sheetal Jha, MS.** Likely completion, Spring 2023. Developed a natural bio sanitizer for dairy plants.

**Kritika Gaba, MS.** Likely completion, Spring 2023. Developed fat rich dairy products with encapsulated probiotics.

**Bhaswati Chowdhury, MS.** Likely completion, Spring 2023. Studied control of environmental *Listeria* isolates in dairy plants.

**Wyatt Seagren**, 2022 (Human Biology, Sophomore, SDSU). 'Project Title: Culturing and identification of *Listeria* and evaluating its biofilm forming potential on dairy floors.'

**Nolan Lee**, 2022 (Community Public Health, EHS, SDSU). 'Project Title: Influence of a typical CIP protocol on surface roughness of gaskets and biofilm.'

**Jacoby Theodore**, undergraduate, 2021 (Dairy Manufacturing, SDSU). 'Influence of microbial contaminants on whey protein quality.' Undergraduate research project to complete the requirements of Dairy science.

**Allison Haltli**, 2020 (Biology, SDSU). 'Comparing *Listeria* species to form biofilms on different dairy floor types.'

**Taylor Gilmore**, 2020 (Dairy Production, SDSU). 'Developing a novel whipped cream formulation containing WPH hydrolysate-encapsulated probiotics.'

**Dani Rinehart**, 2019, (BS Animal Science/ Biotechnology, Oklahoma State University). 'Genomic forensics for improving food safety.' Funding: Summer training program in precision livestock production, USDA, REEU undergraduate training program.

**Belma Husic**, undergraduate, 2018. 'Hydrodynamic Cavitation for High Heat Resistant Spore (HHRS) Control in Dairy Industry.' Capstone research project to complete the requirements of Human Biology/ Pre-Medicine major.

**Jene Martin**, undergraduate, 2018, (Microbiology Major, University of California, San Diego), 'Genomic forensics for improving food safety.' Funding: Summer training program in precision livestock production, USDA, REEU undergraduate training program.

**Marie Zander**, undergraduate, 2018. 'Standardizing a non-thermal process for controlling spore formers.' Funding: DMI ongoing research grant. To meet the requirements of Honors College Independent Study. J. F. Nelson Award 2018 for undergraduate research.

**Maggie Becher**, undergraduate, 2018. 'Conducting risk assessment study for *Staphylococcus aureus* in dairy products.' Funding: MDFRC ongoing research grant plus Schreiber Foods (\$1,650). To meet the requirements of Honors College Independent Study. J. F. Nelson Award for undergraduate research (\$2,500)

**Training:** In all, 20 peer reviewed research articles, 63 conference and workshop presentations, and 4 book/encyclopedia papers were published.

## Natural Resources and Environmental Systems

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### Conservation and Management of Natural Resources

Project Director

Ann Schwader

Organization

South Dakota State University

Accession Number

7001897



### Quality Surface Water a Priority in South Dakota

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**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

South Dakota has 10,094 miles of perennial rivers and streams and 584 lakes and reservoirs with specific aquatic life and beneficial uses. Department of Agriculture and Natural Resources reported that 78% of the rivers and streams and 84 lakes do not meet one or more designated beneficial uses, such as fish propagation, livestock drinking water, and recreation. Non-point source pollution from agricultural lands (usually runoff of farm chemicals, fertilizers, and sediment) is the main cause of water quality impairment. Impairments can include high levels of fecal coliform bacteria from grazing livestock which can cause serious illness if swallowed, high levels of nutrients like phosphorous and nitrogen leading to algae bloom outbreaks, and high levels of suspended and dissolved solids which cause low water clarity and lower dissolved oxygen content for fish propagation. Improving the quality of South Dakota's surface water resources is a top priority for the enjoyment of its citizens, but also lowers the cost of municipal water purification systems for human consumption.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

SDSU Extension created educational programs and activities to address surface water quality and quantity issues to increase the knowledge and awareness of South Dakota residents.

- **Riparian Restoration**

This program utilized beaver dam analogues and low-cost, low-tech tools for riparian restoration. This Extension activity involved developing the Western South Dakota Stream Guide, setting up demonstration sites, and teaching producers and land managers about riparian systems through workshop/schools. The SDSU Extension team delivered the Professional's Range Camp focusing on riparian restoration and management with 40 adult participants attending.

- **Conservation Tile Drainage**

Through this program, Extension faculty, staff, and students worked with nine farmers along the Interstate 29 corridor to determine nutrient loss and help farmers develop strategies to reduce nutrient loss. This involved sampling 34 tile drainage outlets weekly (when water was flowing) and analyzing samples for nitrate and ortho-phosphate. A report will be generated for the farmers. Preliminary results and information about potential nutrient loss in tile drainage was presented at two field days (Ag PhD Field Day, Boadwine Farms Field Tour) and a farm show (Dakotafest). A demonstration project will be installed in 2023 for automated controlled drainage. Conservation drainage starts in the field with improved soil structure and function. A watershed scale project focused on assessing the impact of conservation practices on water management. During this program, SDSU Extension worked with nine farmers to assess soil moisture dynamics throughout the growing season for 23 fields in a HUC-12 watershed northwest of Sioux Falls. Results from this program were also presented at two field days and a farm show.

- **Eastern South Dakota Water Conference and South Dakota Student Water Conference**

The Eastern South Dakota Water Conference is held annually in Brookings, SD and features presentations from universities; industry; local, state and federal government agencies; non-profits; and other stakeholder groups. The conference covers the latest strategies and research for water managers and water users on the Northern Great Plains. This program focused on challenges related to phosphorus. An invited panel of five experts presented on phosphorus at the soil, field, reach, watershed and global scales. The program also featured local projects focused on phosphorus (Lake Mitchell). The second annual South Dakota Student Water Conference was held the day prior and featured 44 student presentations from 7 states. The program also included professional development and an opportunity for students to interact with professionals from a range of water careers.

- **SD Watershed Academy**

The SD Watershed Academy provided participants with tools to increase their knowledge of water resources issues, measure water quality parameters, and design and implement management practices to improve water quality and quantity to meet desired beneficial uses under the Clean Water Act. The SDSU Extension team delivered the first ever school with 10 adult participants attending.

- **Western South Dakota Stream Guide**

A Western South Dakota Stream Guide was developed during 2022 and was published through a partnership of SDSU Extension, the Nature Conservancy, and the Natural Resources Conservation Service. It will be available as a free digital download in 2023. The Stream Guide describes four common stream types found in the prairie habitats of western South Dakota, provides instructions on assessing stream type and condition, and explains management options to restore or protect streams in working rangelands. The guide has four primary goals:

1. Educate readers on why prairie stream and riparian health are important.
2. Helping readers identify the type of streams in their area and assess their health and functionality.
3. Provide recommendations for management according to stream type and condition, with a focus on adaptive management.
4. To inspire readers about the potential to improve stream and riparian health in western South Dakota.

Quality surface water programming was implemented during three radio interviews, and 25 presentations at 15 scientific and stakeholder meetings.

During 2022, ten SDSU Extension website articles were published related to quality surface water in South Dakota:

- **Online Eastern South Dakota Water Conference set for Oct. 20** <https://extension.sdstate.edu/news/online-eastern-south-dakota-water-conference-set-oct-20>
- **What is a Hydrologic Unit Code (HUC)?** <https://extension.sdstate.edu/what-hydrologic-unit-code-huc>

- Spring Storms Help Bureau of Reclamation Reservoirs in Northwestern South Dakota <https://extension.sdstate.edu/spring-storms-help-bureau-reclamation-reservoirs-northwestern-south-dakota>
- The Trophic State Index <https://extension.sdstate.edu/trophic-state-index>
- SDSU Extension Hosts First South Dakota Watershed Academy <https://extension.sdstate.edu/sdsu-extension-hosts-first-south-dakota-watershed-academy>
- Registration Open for the 2022 Eastern South Dakota Water Conference <https://extension.sdstate.edu/news/registration-open-2022-eastern-south-dakota-water-conference>
- Liebig's Law of the Minimum and Phosphorus in South Dakota Surface Waters <https://extension.sdstate.edu/liebigs-law-minimum-and-phosphorus-south-dakota-surface-waters>
- Managing Water with Soil Health <https://extension.sdstate.edu/streamlines-episode-14-managing-water-soil-health>
- Conservation Drainage Complexities Part 1 <https://extension.sdstate.edu/streamlines-episode-1-conservation-drainage-complexities-part-1>
- Conservation Drainage Complexities Part 2 <https://extension.sdstate.edu/streamlines-episode-2-conservation-drainage-complexities-part-2>

**Briefly describe how your target audience benefited from your project's activities.**

SDSU Extension created educational activities and programs to address surface water quality and quantity issues to increase the knowledge of South Dakota producers, state and federal agencies, and non-governmental organizations concerned about surface water not meeting their designated uses. They benefit from the project by increasing their awareness of water quality issues and understanding of how to install best management practices to improve them.

**Briefly describe how the broader public benefited from your project's activities.**

South Dakota benefits by having more citizens, producers, and natural resource managers aware of the surface water quality issues in South Dakota and potential best management practices to improve them to meet the desired beneficial uses established by the Clean Water Act. South Dakotan benefits from a better trained technical service provider workforce and a future student trained workforce. Improving the management of surface water flow using newer conservation practice technologies ultimately increases profitability of agricultural producers while simultaneously protecting and enhancing environmental benefits such as wildlife and fish habitat, water quality, and hydrologic function.

**Agricultural Best Management Practices on Subsurface-Drained (Tiled) Land for Reduction of Nutrient and Pesticide Loading into Receiving Water Bodies**

Project Director

John McMaine

Organization

South Dakota State University

Accession Number

1015618

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

Excess nutrients in outflow from agricultural fields contributes to both economic loss for the producer as well as downstream environmental degradation. In eastern South Dakota, where subsurface (tile) drainage has rapidly expanded in recent decades, the magnitude of nitrate loss through tile drainage has not been significantly measured, nor have mitigation tools been extensively researched. This project uses grab sampling across a wide range of fields to assess baseline nitrate concentration and flow from tile drainage systems in eastern South Dakota, as well as researching established (woodchip denitrifying bioreactors) and new (automated controlled drainage) tools for mitigation of downstream nitrate loss.

Water quality affects local and downstream stakeholders. Understanding of how water quality is impaired, as well as tools that can mitigate negative water quality, are critical for reducing environmental risk, maintaining recreation opportunities, and protecting human health.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1: Developing and enhancing in-field and edge-of-field water management technologies. (100% Accomplished)**

In 2021, weekly sampling began to establish baseline nitrate concentrations. Samples were collected from 23 outlets (while tile was flowing) concentrated around five areas in Eastern South Dakota. To date, around 352 samples have been collected and analyzed. Of the samples that have been analyzed (160), the average nitrate-N concentration was 12.4 mg/L, maximum was 48 mg/L, and minimum was 0.2 mg/L. There was limited variability within each site, with the exception of site 18 (average standard deviation of the remaining 22 sites was 2.60), but significant variability across the entire population (standard deviation with site 18 included was 7.06, standard deviation without site 18 included was 6.10). In general, during the study period, flow was relatively low with no samples collected when normalized depth was greater than 0.4 and the majority collected when normalized depth was 0.16 or below. Unfortunately, this decreases the accuracy of any load calculation because standard flow equations are not reliable at this low of a normalized depth. Visually, the frequency of occurrence for concentration followed somewhat of a bimodal distribution with a significant number of samples between 8 and 10 mg L-1 and a significant number of samples between 15 and 17 mg L-1. The majority of samples were below 25 mg L-1, with 195 samples above and 157 below the drinking water standard of 10 mg L-1. It should also be noted that there was no significant correlation between the nitrate-nitrogen concentration and the normalized depth of water recorded in the tile outlet.

The long-term performance of woodchip bioreactors was assessed as well as failure mechanisms and potential long-term maintenance strategies for woodchip bioreactors. A bioreactor that had seen reduction in performance was excavated and woodchips were analyzed.

When compared along the length, bulk density was highest in the cross-sections closest to the inlet. When compared across depth, the bottom layer had the highest bulk density. This is in contrast to portions at the top of the bioreactor that were less dense along with the portions in the middle and nearer to the outlet of the bioreactor, therefore sedimentation affected the front of the bioreactor the most with much of it settling to the bottom of the bioreactor. While the water level near the inlet will be set according to the inflow control structure, the inflow manifold was near the bottom of the bioreactor. This likely partially explains the high amount of sediment present near this location. This also significantly impedes flow into the remainder of the bioreactor.

Drainable porosity was highest in the middle of the bioreactor and lowest at the upstream end. The front and back ends of the bioreactor have the highest fraction of the smallest particle size (bottom pan) which contributes to a low drainable porosity. The bulk density indicates that the upstream end of the bioreactor has more sediment, and the downstream end has less sediment but more small woodchips particles. This indicates that even though the bioreactor likely failed due to sedimentation at the front end of the bioreactor, there are likely still potential issues with clogging at the downstream end of the bioreactor but due to woodchip breakdown instead of sediment. For long-term maintenance implications, the middle of the bioreactor may maintain performance, but the upstream and downstream ends of the bioreactor may be impaired due to sedimentation and woodchip breakdown respectively.

**Objective 1 Impact:**

These results indicates that not every tile drain is likely to lose significant nitrate but there is certainly risk of nitrate loss. It also indicates that there are likely variables such as field characteristics or management that are driving loss. Of the variables assessed at the time of this report, tillage, season, drainage area, flow rate, and pipe size did not significantly correlate with concentration. Additional factors such as antecedent rainfall, timing of nitrogen application, soil texture, cation exchange capacity, organic matter will be assessed in the future to determine any significant risk factors.

The work with the aged bioreactor was very important to determine future management and maintenance protocol for bioreactors. After approximately nine years, significant changes were observed in the structure and performance of a denitrifying woodchip bioreactor near Hartford, SD. Reduction of performance was assessed through analysis of materials excavated throughout the bioreactor. Woodchip degradation and sedimentation are believed to be the two main mechanisms of failure within this drainage system. These mechanisms can drastically change lead to reduced pore sizes in affected areas changing the hydraulic properties within the bioreactor.

The woodchips in the middle of the Hartford bioreactor are still in relatively intact condition with only a minimal amount of very small particles and could continue to serve as a carbon source and allow adequate flow, but as the performance of the bioreactor has been diminished due to issues on either end of the bioreactor, the middle of the bioreactor is serving little to no function. To reduce recharge costs, a modular system might be used in the future to save areas that in good condition, and only recharge the areas that have declined.

## **Objective 2: Communicating and transfer of water management technologies (100% Accomplished)**

Throughout the period of COVID-19, new approaches were needed for connecting with stakeholders and transferring knowledge and affecting behaviour change. Translating research into practice doesn't happen by accident, it requires careful, deliberate steps to engage, educate, and empower stakeholder groups. "Streamlines" is a new interview-based podcast co-hosted by Dr. John McMaine and Anthony Bly and produced by Keely Moriarty. The podcast features interviews from subject matter experts and in-depth discussion by the co-hosts. The current season explores conservation drainage topics such as controlled drainage, saturated buffers, and drainage water recycling.

Also, three new partner videos were produced about saturated buffers, controlled drainage or drainage water management, and drainage water recycling. These are available on the SDSU Extension Youtube Channel. Finally, a web-based nutrient loss calculator app was developed and launched and is available on the SDSU Extension website. This is a great conversation starter and provides data points to farmers who wonder how much nutrient loss there is from their tile. Once they see how easy it is to take these measurements, they are more likely to take measurements to see if there are differences in the kind of farming practices they use. This allows an entry point to talk about nutrient loss because mass (pounds of nitrate for example) is a relatable value, especially when the economic value of that nutrient is included. At farm shows, we handed out a flyer about the tool along with nitrate testing strips to give farmers a ballpark starting point. If their nitrate loss is higher than they want, then they follow up to see what they can do about it. Once they have implemented changes, they can continue to monitor to see if there were any differences.

**Objective 2 Impact:** Outreach and communication by Dr. McMaine and Dr. McMaine's team directly reached over 2,500 individuals over the 5 years of the project. Indirectly (videos, podcasts, tweets, webpages), Dr. McMaine has reached many more. Communication was crafted in a way to help stakeholders see the positive impact they can have on environment and water quality as well profitability through practice implementation.

## **Briefly describe how your target audience benefited from your project's activities.**

The target audience is crop farmers who are interested in sustainable nutrient management practices, researchers and technicians that work in this field, and agricultural professionals who work with producers to implement water management practices. This research and outreach project will aid farmers with a range of knowledge levels regarding nutrient management. Farmers with limited knowledge will be exposed to new systems for nutrient management through research farm field days, as well as farm shows. Farmers with some knowledge will increase in knowledge and understanding of how to implement changes through targeted workshops. Finally, farmers with advanced knowledge will benefit from additional understanding of how practices function so then they can continue to optimize practices based on the specific characteristics of their operation.

## **Briefly describe how the broader public benefited from your project's activities.**

During the project period, several podcast were launched. "Streamlines" is a new interview-based podcast co-hosted by Dr. John McMaine and Anthony Bly and produced by Keely Moriarty. The podcast features expert interviews from subject matter experts and in-depth discussion by the co-hosts. The current season explores conservation drainage topics such as controlled drainage, saturated buffers, and drainage water recycling.

Also, three new partner videos were produced about saturated buffers, controlled drainage or drainage water management, and drainage water recycling. These are available on the SDSU Extension Youtube Channel. Finally, a web-based nutrient loss calculator app was developed and launched and is available on the SDSU Extension website. This is a great conversation

starter and provides data points to farmers who wonder how much nutrient loss there is from their tile. Once they see how easy it is to take these measurements, they are more likely to take measurements to see if there are differences in what kind of farming practices they use. This allows an entry point to talk about nutrient loss because mass, pounds of nitrate for example, is a relatable value, especially when the economic value of that nutrient is included. At farm shows, we handed out a flyer about the tool, along with nitrate testing strips to give farmers a ballpark starting point. If their nitrate loss is higher than they want, then they follow up to see what they can do about it. Once they have implemented changes, they can continue to monitor to see if there were any differences.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

**Changes/Problems:** COVID-19 presented delays in field sampling due to restrictions of research. Sampling was planned to begin in 2020 but began in earnest in early 2021 and continued through 2022.

#### **Training:**

**Shelby Duncan**, an **MS student** assisted on this project, has been trained on experimental design; sieve analysis; measurement of drainable and total porosity; soil sampling and analysis; water sampling; project management; literature review; developing and presenting technical presentations; and presenting to non-technical audiences.

**Morghen Hurst**, an **MS student** assisted on this project, has been trained on experimental design; soil sampling and analysis; project management; water sampling; literature review; developing and presenting technical presentations; and presenting to non-technical audiences.

**Marcella Reese**, an **undergraduate student** worked on this project, was trained on sampling; poster preparation; and communicating with stakeholders.

**Myranda Hentges**, an **undergraduate student** worked on this project, was trained on sampling; poster preparation; and communicating with stakeholders.

**Dissemination:** In addition to traditional methods of outreach and dissemination (workshops, field days, peer-reviewed manuscripts), steps were taken to reach other groups. To reach communities of interest not usually aware of these research activities, a podcast was developed, as well as a Twitter campaign for National Water Quality Month. This engages stakeholders and points them to other research and extension resources which increases visibility and engagement in addition to increasing knowledge. These tweets resulted in 42,359 impressions during the month of August 2021 and 1,322 engagements (link clicks, likes, retweets). This group of Twitter threads increased awareness of current research with 71 new followers in August 2021 and 50 in September 2021. Each new follower increases visibility of outreach products and efforts. The number of engagements also suggests that the content and links to resources were being utilized.

#### **Products:**

Tran, K., Zhang, H., McMaine, J., Zhang, X., Luo, D. 2022. 10 m rop type mapping using Sentinel-2 reflectance and 30 m cropland data layer product. International Journal of Applied Earth Observation and Geoinformation. 107.

<https://doi.org/10.1016/j.jag.2022.102692>

Gardezi, M., Prutzer, E., Rizzo, D., Emery, M., Merrill, S., Ryan, B., Oikonomou, P., Alvez, J., Adereti, D., Almen, K., Anjum, R., Badireddy, A., Bhattarai, D., Brugler, S., Cheney, N., Clay, D., Clay, S., Dadkhah, A., Faulkner, J., Joshi, D., Koliba, C., McMaine, J., Michael, S., Musayev, S., O'Neil-Dunne, J., Pinder, G., Ricketts, T., Schneebeil, S., Schroth, A., Turnbull, S., Zia, A. 2023. Rethinking 'responsibility' in precision agriculture innovation: Lessons from an interdisciplinary research team. Journal of Responsible Innovation. (under review).

Adereti, D., Gardezi, M., McMaine, J., Wang, T., May, C. 2023. Understanding farmers' engagement with intelligent agricultural decision support systems. Precision Agriculture. (under review).

Saha, A., McMaine, J. 2023. Impact of soil health practices on field hydrology: How sensitive is the Soil-Plant-AirWater (SPAW) model to changes in soil properties?. Journal of ASABE. (under review).

Other Products:

**Oral Presentations**



McMaine, J., Kringen, D.. 2022. Managing soil moisture. Webinar. Crop Hour with SDSU Extension. March 1. 40 participants.

McMaine, J. 2022. Understand the other ET: Evapotranspiration on terra firma. Kentucky Vegetable Growers Association Annual Meeting. Bowling Green, KY. January 4. 30 participants.

McMaine, J. 2022. Water challenges for produce growers: Quantity and quality. Kentucky Vegetable Growers Association Annual Meeting. Bowling Green, KY. January 4. 6 participants.

McMaine, J. 2022. Rainwater harvesting for high tunnels. Kentucky Vegetable Growers Association Annual Meeting. Bowling Green, KY. January 4. 20 participants.

McMaine, J., Almen, K., Blann, K., Adaliku, P., Kringen, D., Bly, A., Koladi, D., Gardezi, M. 2022. Every practice counts: Willow Creek watershed project. Eastern South Dakota Water Conference. Brookings, SD. October 20.

Saha, A. K., McMaine, J.T. 2022. Impact of conservation agriculture and different management on field hydrology: How sensitive is the soil plant atmosphere water (SPAW) model to changes in soil properties? First Annual South Dakota Student Water Conference. Brookings, SD. October 19.

Duncan, S., McMaine, J.T. 2022. Efficiency of an aged denitrifying woodchip bioreactor: Hydraulic performance after nine years. First Annual South Dakota Student Water Conference. Brookings, SD. October 19.

### Poster Presentations

Ghosh, S., McMaine, J.. 2021. An integration of three-dimensional investigation and remote sensing application to detect total algae mass in a freshwater environment. First Annual South Dakota Student Water Conference. Brookings, SD. October 19. 50 participants

Aydogdu, M., McMaine, J. 2022. Demonstration of rain water harvesting (RWH) techniques for Eastern South Dakota. First Annual South Dakota Student Water Conference. Brookings, SD. October 19. 50 participants

Butterbaugh, R., Perkins, L., McMaine, J., Bergstrom, J. 2022. Installation of a bioretention garden for demonstration and hydrologic monitoring. First Annual South Dakota Student Water Conference. Brookings, SD. October 19. 50 participants

Hurst, M., McMaine, J., Almen, K. 2022. Nitrate nitrogen in tile drainage. First Annual South Dakota Student Water Conference. Brookings, SD. October 19. 50 participants

Javed, U., McMaine, J. 2022. Electric resistivity survey: A potential method to geophysically investigate groundwater strata. First Annual South Dakota Student Water Conference. Brookings, SD. October 19. 50 participants

Critical Issue

## Regenerative Agronomic Systems

### Diagnosis of and developing management strategies for diseases of broadleaf crops in South Dakota

Project Director

Febina Mathew

Organization

South Dakota State University

Accession Number

1019299



**Diagnosis of and developing management strategies for diseases of broadleaf crops in South Dakota Final report 10/1/19-09/30/2022**

Final Result

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

Plant diseases can affect the yield potential and economic benefit of field crops in South Dakota. Consequently, it is critical that disease management strategies be developed for farmers to save the crop from yield and economic losses.

We anticipate that this research will generate effective disease management recommendations in soybean, sunflower, and pulse crops which includes yield benefit information to incorporate into a decision-support tool for farmers in South Dakota.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1: Developing disease management strategies for established diseases of broadleaf crops that are effective. (100% Accomplished)**

On sunflower, foliar fungicide trials were conducted in multiple locations in MN, NE, ND, and SD between 2019 and 2021 for a total of 87 location-years, which included either university farms or farmer fields with history of *Phomopsis* stem canker. Each field trial was conducted in a randomized complete block design with at least three replicates (plots) and a no-fungicide treated control (NTC) was included in all trials. All field trials were planted to medium-early maturing commercial hybrids (susceptible or partially-resistant to fungi causing *Phomopsis* stem canker) and harvested as according to standard production practices in MN, NE, ND, and SD. All fungicides were sprayed at the recommended rates on the manufacturer's label and at multiple application timings [V8 (eight true leaves), R1 and R5, and sequential applications (i.e., V8+R1, R1+R5, V8+R5, V8+R1+R5)] using a CO<sub>2</sub>-pressurized backpack sprayer or a highboy sprayer. About four to six weeks after the fungicides were sprayed, at least 10 plants were visually rated for disease severity using a 0-to-4 (Debaeke et al. 2003) or 0-to-5 disease rating scale (Mathew et al. 2015) and converted into the disease severity index (DSI) (Chiang et al. 2017). The center two rows of each plot in all field trials were harvested and the yield was adjusted to 10% moisture (Duffeck et al. 2020). We performed meta-analysis to determine which active ingredient was effective against fungi causing *Phomopsis* stem canker. For the data analyses, each field trial was considered an independent study.

We observed that only fungicides applied at R1 were associated with a significant reduction in disease severity index (Hedges'  $g=-0.57$ ) and significant increase in yield ( $g=0.33$ ) when compared to NTC. In addition, we observed that the fungicides containing pyraclostrobin had a significantly small to large effect in reducing DSI {fluxapyroxad + pyraclostrobin [ $g=-0.55$ ;  $p<0.048$ ], mefentrifluconazole + pyraclostrobin + fluxapyroxad [ $g=-2.23$ ;  $p<0.015$ ], and pyraclostrobin [ $g=-0.65$ ;  $p<0.0001$ ]} and increasing yield {fluxapyroxad + pyraclostrobin [ $g=0.36$ ;  $p=0.0227$ ], mefentrifluconazole + pyraclostrobin + fluxapyroxad [ $g=0.85$ ;  $p=0.0428$ ], and pyraclostrobin [ $g=0.43$ ;  $p=0.0001$ ]} when compared to NTC.

**Objective 1 Impact:** Our results generated fungicide recommendations for farmers to protect their crop from fungi causing *Phomopsis* stem canker. Based on the sunflower grain prices ranging from \$0.15/kg (\$6.89/cwt) to \$0.64/kg (\$29.1/cwt) between 2000 and 2020 (sunflowernsa.com), we observed the probability of not recovering the fungicide application cost associated with pyraclostrobin fungicides was less than <0.20.

**Objective 2: Providing support in plant pathology to broadleaf crop breeding programs to help breeders develop crop varieties with improved disease resistance and yield potential for growers. (100% Accomplished)**

*Phomopsis* stem canker is a major sunflower disease in South Dakota and other sunflower producing U.S. states that can compromise yield up to 40%. To improve the resistance of sunflower to the fungi causing *Phomopsis* stem canker, accessions from eight countries (Argentina, Austria, Russia, Kazakhstan, Germany, Hungary, Bulgaria, and the U.S.) were evaluated for their resistance to *D. gulyae* and *D. helianthi* under greenhouse conditions.

**Sub-objective 2.1. Evaluate the USDA collection of cultivated sunflower accessions for resistance to *D. gulyae* and *D. helianthi* in the greenhouse.**

In the greenhouse, 213 cultivated sunflower accessions were screened in separate experiments using single isolates of either *D. gulyae* and *D. helianthi*. The confection inbred 'HA 288' (PI552934) was used as the susceptible check in all experiments. For each accession, six seeds were planted in three pots (2 seeds per pot) containing moist potting mix and the pots were placed at between 20-25°C and under a 16 h light/ 8 h dark cycle in the greenhouse. The experiment was performed twice for *D. gulyae* and *D. helianthi* in a completely randomized design with six replications (pots). Four weeks after planting, the plants were inoculated using the mycelial-contact inoculation method (Thompson et al. 2011), in which one agar plug infested with *D. gulyae* or *D. helianthi* was placed between the third and fourth nodes of the plants. Fourteen days (*D. gulyae*) and 30 days (*D. helianthi*) after inoculation, disease severity was assessed visually using a 0 (no discoloration) to 5 (plant lodging or dead) rating scale (Mathew et al. 2015). The disease severity data was ordinal and was converted as relative treatment effects (RTE) using non-parameteric analyses (Shah and Madden 2004). The RTEs associated with the accessions were compared using 95% confidence intervals. For *D. gulyae*, 39 accessions had significantly lower RTE ( $p<0.0001$ ) when compared to 'HA 288'. For *D. helianthi*, a significant effect of accessions was not observed on RTE ( $p=0.06$ ).

**Sub-objective 2.2. Identify quantitative trait loci (QTLs) and common putative candidate genes associated with resistance to *D. gulyae* and *D. helianthi*.**

The sequence data of the 213 accessions used for disease phenotyping were aligned to the sunflower reference assembly, Ha412-HOV2 reference genome (<https://sunflowergenome.org/>) to call for variants. The final data set contained 3,647,853 bi-allelic variants, which were used for genome-wide association studies (GWAS). Between *D. gulyae* and *D. helianthi*, 31 common SNPs were identified in GWAS, which are in 28 common overlapping QTLs (13 full length and 15 partially overlapped) and located on 7 common chromosomes (Chr 3, 4, 8, 9, 11, 12, and 16). To determine the putative candidate genes, the nucleotide sequences were extracted from HA412-HOV2 genome and were BLASTp searched in the non-redundant database of National Center for Biotechnology Information (NCBI) database. A total of 63 and 189 genes were significantly associated with resistance in sunflower to *D. gulyae* and *D. helianthi*, respectively. Among these genes, 24 genes overlapped between the two fungi, five of which have predicted functions associated with plant-pathogen interactions.

**Objective 2 Impact:** Our results have identified accessions with resistance to the causal fungi of Phomopsis stem canker that can be used as parental materials in the public (USDA-ARS) and private breeding programs to develop commercial disease resistant hybrids for farmers. Additionally, we identified putative candidate genes associated with resistance to *D. gulyae* and/or *D. helianthi* that will help develop resources for genomics-assisted breeding.

### **Objective 3: Diagnosing disease and evaluating causal organisms associated with new diseases of broadleaf crops. (100% Accomplished)**

We monitored for new diseases on broadleaf crops during this reporting period, however no new diseases were observed in South Dakota.

#### **Briefly describe how your target audience benefited from your project's activities.**

**Target audiences** include researchers and students at SDSU and other institutions, USDA-ARS and state labs, chemical and seed industry, agricultural professionals, stakeholders, and public, both in and outside the United States.

**Efforts** include presentations at scientific, stakeholder, university, and industry meetings. We also developed research manuscripts, extension/outreach publications, presentations for classroom lecturers, and workshops.

#### **Briefly describe how the broader public benefited from your project's activities.**

Results obtained from research were used to explain and demonstrate basic concepts in plant disease management to students taking the course (PS 433/533 – Field Crops Diseases and Management) at SDSU. The students benefit from the information generated by my research projects and improved their intellectual thinking to join the competitive workforce

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

#### **Training:**

**Four Ph.D. students (Renan Guidini, Ruchika Kashyap, Nabin Dangal, Karthika Mohan), and one M.S. student (Bijula Sureshababu)** were trained in plant pathology through my research. **Guidini, Kashyap, Dangal, Mohan, and Sureshababu** were trained in soybean and sunflower diseases, which included identifying effective foliar fungicides and fungicide seed treatments, their application rates, precision agriculture, fungicide resistance, identification of fungal pathogenic endophytes, and screening accessions for disease resistance. The five students prepared presentations (oral and poster) to disseminate research results at the stakeholder meetings (National Sunflower Association) and scientific meetings (American Phytopathological Society).

Additionally, the research provided training opportunities in precision agriculture to the PI, as well as use the results to teach the course PS 433/533 (Field Crops Diseases and Management) to undergraduate and graduate students.

**Dissemination:** Results from my research program were disseminated through manuscripts in peer-reviewed journals published by the American Phytopathological Society (Plant Disease, Plant Health Progress); classroom instruction at SDSU (PS 433/ 533 - Field Crop Diseases and Management; oral and poster presentations at scientific conferences (international, national); stakeholder meetings; and stakeholder magazines (The Sunflower).

- Sureshababu, B. M., Subramanian, S., Braun, N., Kontz, B., and 2022. Effect of foliar fungicides on pathogenic fungal endophytes in soybean (*Glycine max* L.). American Phytopathological Society Annual Meeting, Pittsburgh, PA. August 2-6.
- Mohan, K., Markell, S., Harveson, R., Braun, N., Rekabdarkolaee, H. M., and 2022. Resistance to azoxystrobin (Qol) Fungicide in *Diaporthe* species from sunflower (*Helianthus annuus*) in the Northern Great Plains. American Phytopathological Society North Central Division Meeting, Lincoln, NE. June 21-23.
- Sureshababu, B. M., Mohan, K., Allen, T., Bergstrom, G., Bissonnette, K., Bradley, C., Buck, J., Chilvers, M., Kelly, H., Kleczewski, N., Koehler, A., Malvick, D., Markell, S., Mueller, D., Smith, D., Subramanian, S., Markell, S., Telenko, D., Wise, K., and 2022. Sensitivity of *Diaporthe aspalathi*, *D. caulivora* and *D. longicolla* causing soybean disease to azoxystrobin fungicide. American Phytopathological Society North Central Division Meeting, Lincoln, NE. June 21-23.
- Kashyap, R., Markell, S., Harveson, R., Underwood, W., Thompson, S., Ryley, M., and 2021. Sensitivity of *Diaporthe gulyae* causing Phomopsis stem canker of sunflower to fluxapyroxad, pyraclostrobin, and tebuconazole. Australasian Plant Pathology Society Conference 2021 (Virtual). November 23-26.
- Guidini, R., Marek, L. F., Rieseberg, L., Jahani, M., and 2021. Five accessions have resistance to *Diaporthe helianthi* and *D. gulyae* in sunflower. American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America International Annual Meeting, Salt Lake City, UT. November 7-10.
- Sureshababu, B. M., Braun, N., Kontz, B., Subramanian, S., and 2021. Evaluating the effect of fungicide on endophytes in soybean (*Glycine max* L.). The Bean Improvement Cooperative (BIC) and the North American Pulse Improvement Association (NAPIA) Annual Meeting (Virtual). November 2-4.
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- Guidini, R., Jahani, M., Huang, K., Rieseberg, L., and 2022. Genome wide association mapping in sunflower (*Helianthus annuus* L.) reveals common loci and putative candidate genes for resistance to *Diaporthe gulyae* and *D. helianthi* causing Phomopsis stem canker. Plant Dis. <https://doi.org/10.1094/PDIS-05-22-1209-RE>.
- , Harveson, R., Gulya, T., Thompson, S., Block, C., and Markell, S. Spanish translation by Andres Zambelli, 2022 (Accepted 3/24/2022). Phomopsis stem canker of sunflower. The Plant Health Instructor. <https://doi.org/10.1094/PHI-I-2018-1103-01>
- Kashyap, R., Rekabdarkolaee, H. M., Markell, S., Harveson, R., Underwood, W., and 2022. Sensitivity of Phomopsis species to fluapyroxad, pyraclostrobin, and tebuconazole fungicides. Proceedings of the 44th Annual Sunflower Research Forum, Fargo, ND. January 12-13.
- Dangal, N., Rekabdarkolaee, H. M., Markell, S., Harveson, R., and 2022. Are fungicides effective against Phomopsis stem canker? Proceedings of the 44th Annual Sunflower Research Forum, Fargo, ND. January 12-13.
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, Markell, S., Dangal, N., Kashyap, R., and Harveson, R. 2022. Fungicides work against Phomopsis stem canker. The Sunflower; Published March.

2022. Fungicide Resistance in Diaporthe/Phomopsis causing crop disease. American Society for Microbiology (ASM) Microbe 2022, Washington, D.C. June 10.

2022. Sunflower Phomopsis. National Sunflower Association Board Meeting. (Virtual). February 24.

2022. Triazole sensitivity issues in Diaporthe species causing Phomopsis stem canker of sunflower. Corteva, Indianapolis, IN (Virtual). February 23.

2022. Isolate-genotype interaction for resistance to Diaporthe species. 2022 Virtual Soybean Breeders Workshop. February 14-16.

2022. Evaluating the effect of foliar fungicides on fungal endophytes in soybean (Glycine max L.). Guest Seminar, Fusarium Working Group, Iowa State University, Ames, IA. February 8.

Mohan, K., 2022. Assessment of Diaporthe species infecting sunflower for their sensitivity to tebuconazole fungicide in the greenhouse. GPDN Webinar Series (Virtual). February 9.

2022. Crop Hour (Sunflower Diseases). SDSU Extension Service (Virtual). January 25.

2021. Sunflower Phomopsis fungicide research. 2021 CROPLAN DFC Virtual Training Series: Canola, Wheat, Sunflowers (Pierre, SD). December 21.

2021. Sunflower Phomopsis fungicide research. 2021 CROPLAN DFC Virtual Training Series: Canola, Wheat, Sunflowers (Bismarck, ND). December 20.

Critical Issue

## Regenerative Livestock Systems

### Sustaining and Enhancing Growth in Dairy Production

Project Director

Ann Schwader

Organization

South Dakota State University

Accession Number

7001896



**SDSU Extension Strategies Boost South Dakota's Dairies**

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

South Dakota is listed among the 16 leading dairy states, contributing 13% (26.7 million pounds) of U.S. milk production (USDA, 2020). The dairy industry in South Dakota has more than doubled the number of milk cows since its historic low in 2004. In 2019, 4.2% (37,400) of the population in South Dakota were of Hispanic origin, and since 2000 this demographic group has nearly tripled (U.S. Census Bureau, 2019). This increase in milk cows in South Dakota and the surrounding region, creates a unique opportunity to produce high quality milk, dairy beef calves, and creates a vibrant work force opportunity. Resources and training across production, farm management, dairy beef production, and employee development are top priorities to meet these growing farm expectations.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

A team comprised of SDSU Extension field specialists and state specialists provided research-based information and resources to boost the health, production and profits of South Dakota's dairies. The team collaborates with stakeholders to provide essential certification trainings and as a member of the I-29 Moo University Collaboration, SDSU Extension connects South Dakota's producers with peers and industry experts across a five-state region.

To reach Hispanic employees and farm managers, customized farm employee trainings were delivered to more than 16 farms in the region reaching approximately 500 employees and managers, representing over 68,000 cows. Additionally, a Spanish in-person seminar offered two days at Central Plains Dairy Expo reaching 50 Hispanic dairy farm participants each day from the I-29 region. SDSU Extension provided two Spanish in-person 1-hour sessions (World Dairy Expo-Madison, WI and National Mastitis Meeting - San Diego, CA) that were televised internationally covering employee motivation strategies for dairies and dry cow therapies. These two sessions reached 85 in-person attendees and immeasurable international attendees both live and watching recordings.

A needs assessment was distributed statewide in July 2022 to determine the education program and resource needs regarding common reproductive management practices on South Dakota dairies. Results from the survey represent 33,878 cows and show how the producers are using assisted reproductive technologies to improve the genetic gain and profitability of the dairy farms (89.5% use AI, 31.65% follow an *in vitro* embryo transfer and genetic testing practice in their reproductive program). Producers are asking for on-farm trainings (theoretical and practical) to improve employee skills associated with a reduction in management and production issues on farm. This activity will direct future SDSU Extension efforts regarding reproductive management.

SDSU Extension along with its university extension collaborators from Minnesota, Iowa, and Nebraska created the I-29 Moo University. To reach dairy beef feeders, the I-29 Moo University conducts a 1-day Dairy Beef Short Course prior to the Central Plains Dairy Expo that has been a growing audience since 2016. Attendance in 2022 reached 87 participants from 7 states at the short course. Other I-29 Moo University activities reach dairymen and industry professionals through two Winter Workshops (59 participants), regular webinars (50+ live participants and 325 views), and a total of 18 podcasts, which have received 2,882 total downloads. I-29 Moo University efforts are highlighted in numerous radio interviews, and presentations at producer meetings.

Another unique opportunity for SDSU Extension is teaching SDSU dairy science students about the National Dairy FARM Animal Care program and animal handling. Three courses (Dairy Farm Operation and Management, Introduction to Dairy Science, and Physiology of Lactation) each received 50-minute seminars and 2-hr hands-on labs that focused on real-world best management practices for dairy's animal well-being program (FARM AC); approximately 75 students were trained. These

students represent the region's next generation of dairy farmers and industry professionals (90% are from dairy farms). Several of the region's co-op and processor representatives have commented positively about graduates having the FARM AC background and making them more desirable as hires.

During FY2022, seven SDSU Extension website articles were published related to dairies in South Dakota:

- **Managing Stress in Dairy Cows** <https://extension.sdstate.edu/managing-stress-dairy-cows>
- **Emergency Preparedness on Dairies** <https://extension.sdstate.edu/emergency-preparedness-dairies>
- **Fly Population Management on Dairies** <https://extension.sdstate.edu/fly-population-management-dairies>
- **Dressing for the Job on Dairies Year-Round** <https://extension.sdstate.edu/dressing-job-dairies-year-round>
- **I-29 Moo University Annual Dairy Beef Short Course to be Held on March 29** <https://extension.sdstate.edu/news/i-29-moo-university-annual-dairy-beef-short-course-be-held-march-29>
- **New Sensor Technology to Estimate Feed Intake in Lactating Dairy Cows** <https://extension.sdstate.edu/new-sensor-technology-estimate-feed-intake-lactating-dairy-cows>
- **Winter Preparedness on the Dairy Farm** <https://extension.sdstate.edu/winter-preparedness-dairy-farm>

**Briefly describe how your target audience benefited from your project's activities.**

The SDSU Extension team developed resources and activities for the benefit of South Dakota and surrounding states' dairy producers, employees, and allied industries. The resources are customized for English and Hispanic audiences depending on needs and goals (milker trainings, dairy beef short course, farm protocol trainings, and cow handling). They benefit from the resources and activities by increasing milk quality, overall profitability (decrease employee turnover and increase pounds of milk), and risk management.

**Briefly describe how the broader public benefited from your project's activities.**

Due to the research-based resources and educational activities developed by SDSU Extension, South Dakota dairies have boosted health, production and profits. South Dakota and the region benefit by having more profitable dairy farms with an engaged well-trained workforce to sustainably care for the cows while providing a steady supply of high-quality milk and dairy beef. Dairy manufacturing industry growth in Lake Norden and Milbank, South Dakota is a direct response to the increase supply chain leading to local, high paying job creation while meeting high-quality food demands of a growing U.S. population.



★ **year 3 results: 10/1/21-09/30/22:Applied management strategies in ruminant systems: Effects on animal performance and meat quality**

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

The growing global demand for high quality animal protein will require farmers and ranchers to seek methods to enhance production efficiency. While many current practices and new technologies make it possible to 'produce more with less' it is critical that product quality is maintained. It is also important to consider the influence of management practices and/or technologies on the entire productive life of an animal. By improving our knowledge of pre-harvest management on the production of beef and bison we will support producers in providing high quality protein to a growing consumer population.

According to the United Nations, the global population will need 100 percent more food by 2050 without increasing the number of acres in farm and ranch land. Development of new strategies and technologies to enhance the efficiency and yield of food production is fundamental to meeting this challenge. However product quality must also be monitored to ensure consumer satisfaction. With the ever-increasing costs associated with beef and bison production, it is critical to evaluate the effects of current and novel management strategies on the composition and quality of the end product.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

Low stress weaning strategies are utilized in the beef industry to divide the weaning process into two stages: 1) physical separation from dams and 2) separation from milk as a nutritional source. It is suggested that two-stage methods decrease the degree of changes in behavior as opposed to simultaneous social and nutritional separation from dams. However, studies investigating the impact of low stress weaning methods on long-term feedlot performance and carcass characteristics of beef cattle are limited. The objective of this study was to compare the influence of two low stress weaning methods with conventional weaning on post-weaning performance and carcass characteristics of beef steers. Steer calves (n = 89) were allocated into three treatment groups (n = 29 or 30 steers/treatment): ABRUPT (calves isolated from dams on the day of weaning), FENCE (calves separated from dams via a fence for 7 d prior to completely weaning), and NOSE (anti-suckling nose-flap inserted and calves remained with dams for 7 d prior to completely weaning). At d +7 post-weaning calves were transported to a commercial feedlot where they received a standard finishing rations typical for a Northern Plains feedlot. Body weights were recorded on study d -7 (PreTreat), 0 (Weaning), 7 (PostWean), 26 (Receiving), 175 (Ultrasound), and 238 or 268 (Final) and average daily gains (ADG) were calculated for each time period. Blood samples were collected via coccygeal venipuncture at d -7 (PreTreat), 0 (Weaning), and +7 (PostWean) from a subsample of calves (n = 10 per treatment) and analyzed for haptoglobin (acute-phase stress protein) concentrations. On d 175, ultrasound fat thickness and intramuscular fat were determined and utilized to project marketing dates when steers reached 1.27 cm of backfat (d 238 or 268). Carcass measurements were recorded at the time of harvest.

Weaning method interacted ( $P = 0.0001$ ) with time period for ADG. Calf ADG was 96% greater in the NOSE treatment than ABRUPT, and 69% greater in the NOSE than FENCE during PreTreat to Weaning while ABRUPT and FENCE calves had similar ( $P = 0.9927$ ) ADG. This suggested that physical separation by a fence negatively affected ADG compared to NOSE calves that were prevented from suckling but had close association with dams. In the Weaning to PostWean period, the FENCE calves had greater ( $P \leq 0.0006$ ) ADG than ABRUPT and NOSE. During the Postwean to Receiving period ADG was greater ( $P = 0.0444$ ) for ABRUPT compared to FENCE and NOSE. Calf ADG was similar ( $P > 0.9999$ ) among treatments for the remainder of the feeding period. Calf body weight did not differ among treatments ( $P > 0.9999$ ) at all times of weighing. Haptoglobin was undetectable in all samples except two samples collected on d -7 suggesting that the calves in this study may not have experienced detectable stress during weaning regardless of treatment. Weaning method did not influence ( $P \geq 0.1214$ ) carcass measurements.

**Objective 1 Impact:** Results suggest that low stress weaning methods do not significantly improve post-weaning growth performance or carcass characteristics compared to using conventional methods despite minor, short-term alterations in average daily gain during the weaning period. It may be efficacious for producers to take into consideration and implement low stress weaning methods for improved performance at weaning or during early backgrounding phases if calves are to be marketed during those time periods. Alternatively, if calves will not be marketed during or immediately after weaning, these data suggest producers can expect overall performance and economic returns to be unaffected by weaning method.

**Objective 2: Understand the impact of manipulating maternal nutrition on offspring growth performance, composition, and beef quality. (90% Accomplished)**

Maternal nutrient restriction in beef cows can impact developmental processes in the fetus that may influence lifetime performance. If feed is limited a maternal deficiency in protein and/or energy can occur. As a result, the fetus may receive inadequate levels of nutrients, potentially altering fetal development. We conducted a study to investigate the impacts of metabolizable protein (MP) restriction in first-calf heifers during mid- and/or late-gestation on progeny performance and carcass characteristics. Heifers were allocated to 12 pens in a randomized complete block design. The factorial treatment structure included 2 stages of gestation (mid- and late-) and 2 levels of dietary protein (control [CON]; ~101% of MP requirements and restricted [RES]; ~80% of MP requirements). Half of the pens on each treatment were randomly reassigned to the other treatment at the end of mid-gestation. Progeny were finished and carcass measurements were collected. Gestation treatment x time interactions indicated that MP restriction negatively influenced heifer body weight, body condition score, and loin muscle area ( $P < 0.05$ ), but not fat thickness ( $P > 0.05$ ). Treatment did not affect feeding period initial or final body weight, dry matter intake, or average daily gain of progeny ( $P > 0.05$ ). Progeny of dams on the RES treatment in late gestation had greater loin muscle area ( $P = 0.04$ ), but not when adjusted on a hot carcass weight basis ( $P > 0.10$ ).

**Objective 2 Impact:** This study demonstrates that metabolizable protein-restricted heifers mobilized lean tissue mass at the time the restriction was imposed. However, metabolizable protein restriction did not impact calf birth or weaning body weight, nor did it substantially influence feedlot performance or carcass characteristics of progeny suggesting that offspring may be buffered from the metabolizable protein restriction.

**Objective 3: Evaluate the effects of pre- and post-weaning management on resultant feedlot performance, carcass traits, and meat quality. (40% Accomplished)**

A study was initiated to evaluate the influence of finishing system (grass-finished vs. grain-finished) on carcass and meat quality characteristics of bison bulls and proximate and fatty acid compositions of bison steaks. At 26 mo of age bison bulls were randomly assigned to either grain-finishing ( $n = 98$ ; in an open lot with ad libitum access to prairie hay, alfalfa hay and corn for 95 days prior to slaughter) or grass-finishing ( $n = 98$ , on pasture until slaughter). Bulls were slaughtered at approximately 29 months of age. Carcass data, lean color of the exposed ribeye, and the external fat color, were recorded for each carcass. Strip loins were collected from a subsample of carcasses ( $n=30$  carcasses closest to the treatment average hot carcass weight) for compositional analyses. Ultimate pH was recorded, and strip loins were cut into 2.5-cm steaks. One steak was designated for fatty acid and cholesterol analysis and another steak was used for determining proximate composition.

Grain-finished bulls had greater ( $P < 0.01$ ) live (16% greater) and hot carcass weights (25% greater), dressing percentage (4% greater), ribeye area (9% greater), backfat thickness (264% greater), kidney fat (164% greater, and marbling scores (76% greater) compared to grass-finished bulls. A greater proportion ( $P < 0.001$ ) of grain-finished carcasses had moderately bright red lean color, whereas a greater proportion ( $P < 0.001$ ) of grass-finished carcasses had moderately yellow fat color. Finishing system did not influence ( $P > 0.05$ ) ultimate pH of bison striploins. Steaks from grain-finished bulls had an increased percentage of ( $P < 0.01$ ) crude protein, fat, and ash content but less moisture than grass-finished bulls. Steaks from grain-finished bulls had more ( $P < 0.01$ ) cholesterol, palmitic, stearic, oleic, linoleic, and arachidonic acids, in addition to more total fatty acids (mg/g of wet tissue). However, when normalized by total fatty acids, grass-finished steaks had a greater ( $P < 0.01$ ) proportion of polyunsaturated fatty acids (11.9% vs. 17.47% for grain- and grass-finished, respectively).

A study was also initiated to evaluate the influence of 2 bull production systems (Young bulls slaughtered at 29 months of age and not utilized in the breeding herd or Mature bulls slaughtered at 36 months of age following use in the breeding herd) on carcass traits, meat quality, and sensory characteristics. Bulls were harvested, carcass measurements were recorded, and striploins were collected from a subsample of carcasses. Laboratory assays and statistical analysis are ongoing for this study.

**Objective 3 Impact:** Data indicate that the bison finishing system influences nutrient content and fatty acid composition, which may have consumer health implications, as grass-finished bison steaks exhibited a decreased cholesterol content, percent fat, and n6 to n3 fatty acid ratio when compared to grain-finished bison steaks. With these changes to carcass characteristics, composition, and nutrient profile, it could be beneficial for bison producers to recognize the influence of finishing system on product traits and use these differences to market desirable attributes of bison meat accordingly.

**Briefly describe how your target audience benefited from your project's activities.**

Beef and Bison Producers - Beef and bison producers were targeted because they will be the end users of this research. They are ultimately the audience that will apply the findings of this research to their operations. Producers were targeted through Extension and outreach activities.

Personnel supporting the beef and bison industries - Professionals that work to support the beef and bison industries were targeted because they can benefit from the knowledge generated by this project and can assist in disseminating the findings to producers. Industry professionals were targeting through Extension and outreach activities.

**Briefly describe how the broader public benefited from your project's activities.**

Research Community - Specifically we are targeting Animal Scientists and Meat Scientists because the findings of this research will help move the entire body of scientific knowledge forward. Scientists were targeted through peer-reviewed publications and presentations at scientific meetings.

Students - Many undergraduate and graduate students will choose careers in the beef, bison, and meat industries. Students were targeted through formal and informal instruction.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

– July 2020 to August 2022. 49% graduate research assistantship. Learned skills in laboratory techniques, research methods, bison management, carcass data collection, meat quality assays, and data analysis. Thesis was successfully completed in 2022. Presented research findings at the 75th Reciprocal Meat Conference and abstract selected as one of two “Chairman Selected” abstracts.

– April 2021 – present. 49% graduate research assistantship. Learned skills in laboratory techniques, research methods, bison management, carcass data collection, meat quality assays, sensory analyses, western blotting, and data analysis. Presented research findings at the 75th Reciprocal Meat Conference.

– July 2022 – present. 49% graduate research assistantship. Learned skills in laboratory techniques, research methods, and western blotting.

Research Community: We have published 1 peer-reviewed manuscript and have 1 additional accepted for publication. Four abstracts were presented at national meetings. One M.S. student has completed their thesis. One M.S. and one Ph.D. student are currently working toward completing their thesis/dissertation projects. Beef and Bison Producers, Allied Industry Professionals and Consumers: We have published 4 popular press articles, contributed to 4 podcasts, provided 1 presentation to a national producer group as well as a proceedings paper, 1 presentation to a local foods conference, 2 Beef Day Reports, and delivered one demonstration program to meat industry professionals and two workshops to beef producers.

We plan to initiate one project to assess the amount of beef produced and carcass economic value per unit of methane emitted by stocker cattle as affected by vegetative composition and diversity driven by grazing history. We plan to initiate one project to determine the influence of including an encapsulated oregano-based essential oil to beef finishing diets on growth performance, carcass characteristics, and meat quality. We also plan to publish one peer-reviewed manuscript that highlights the effect of different beef production systems utilizing additive combinations of growth promotant technologies on beef quality attributes including meat color, composition, tenderness, and mechanisms regulating the aging process.

We plan to initiate a study to identify changes in offspring carcass characteristics, meat quality, and value resulting from maternal nutrient restriction during mid-gestation. This project will also aid in identifying changes in adipose tissue gene expression in offspring resulting from maternal nutrient restriction during mid-gestation.

We plan to complete data analysis on a study investigating the influence of bull production systems on carcass and meat quality attributes of bison bulls. We plan to publish one manuscript describing the influence of finishing systems (grass and grain) on carcass characteristics, meat quality and consumer preference of meat from bison bulls. We plan to publish one

manuscript describing the influence of harvest system on the stress response of bison heifers, carcass characteristics, meat quality of bison heifers, and consumer preference for bison steaks.

Bakker, C.E., L.M. Hite, K.R. Underwood, A.D. Blair, H.R. Rode-Atkins, J.K. Grubbs. 2022. Product yield and color of fresh beef transported at different refrigerated temperatures. Meat and Muscle Biology. Accepted.

Block, J.J., M.J. Webb, K.R. Underwood, M.G. Gonda, A.A. Harty, R.R. Salverson, R.N. Funston, K.C. Olson, and A.D. Blair. 2022. Influence of maternal protein restriction in primiparous beef heifers during mid- and/or late-gestation on progeny feedlot performance and carcass characteristics. Animals. 12(5): 588. doi: 10.3390/ani12050588

McFadden, L.J., H. Menendez, J. Brennan, K. Olson, K. Ehlert, A. Blair. 2022. Developing a dry matter intake prediction equation for grazing animals based on real-time enteric emissions measurements. American Society of Animal Science: Western Section. Park City, UT. September 21.

McFadden, L.J., H. Menendez, J. Brennan, K. Olson, K. Ehlert, A. Blair. 2022. Using precision technology to measure cattle methane emissions and intake on western South Dakota rangelands. American Society of Animal Science: Western Section. Park City, UT. September 21.

Newton, C.J., L.M. Hite, C.E. Bakker, J.K. Grubbs, K.R. Underwood, K.M. Cammack, T. Dinh, and A.D. Blair. 2022. Effect of finishing system on carcass characteristics, proximate composition, and fatty acid profile of bison bulls. 75th Reciprocal Meat Conference. Des Moines, IA. June 12-15.

Hite, L.M., K.R. Underwood, A.D. Blair, H.R. Rode-Atkins, J.K. Grubbs, C.E. Bakker. 2022. Influence of temperature during transport on product yield and quality of beef. 75th Reciprocal Meat Conference. Des Moines, IA. June 12-15.

Blair, A.D. and C.E. Bakker. 2021. Direct marketing beef: Management considerations for enhancing carcass quality and cutability. Proceedings of The Range Beef Cow Symposium XXVII. Rapid City, SD. p 18-27.

DeHaan, T., L. Hite, E. Gubbels, C. Bakker, A. Blair, J. Grubbs, K. Underwood. 2022. Influence of beef carcass chilling rates on steak case life and quality traits. SDSU Beef Day 2022 Summary Publication.  
[https://openprairie.sdstate.edu/sd\\_beefday\\_2022/](https://openprairie.sdstate.edu/sd_beefday_2022/)

McFadden, L.J., H. Menendez, J. Brennan, K. Olson, K. Ehlert, A. Blair. 2022. Using precision technology to measure cattle methane emissions and intake on western South Dakota rangelands. SDSU Beef Day 2022 Summary Publication.  
[https://openprairie.sdstate.edu/sd\\_beefday\\_2022/](https://openprairie.sdstate.edu/sd_beefday_2022/)

Blair, A.D. and C.E. Bakker. 2021. Direct marketing beef: Management considerations for enhancing carcass quality and cutability. Range Beef Cow Symposium. Rapid City, SD. Nov 16-17.

Blair, A.D. 2022. Maternal nutrition and meat quality of progeny. University of Arizona Departmental Seminar series. Webinar. Feb. 21.

Blair, A.D. 2021. Enhancing producer resources to build small meat processing capacity and local meat demand. South Dakota Local Foods Conference. Virtual meeting. Nov. 4-6.

## Improving Sustainability of Northern Plains Beef Production Systems

Project Director

Kenneth Olson

Organization

South Dakota State University

Accession Number

1018860



**year 4 results: 10/1/21-09/30/22: Improving Sustainability of Northern Plains Beef Production Systems**

**In 2-3 sentences, briefly describe the issue or problem that your project addresses.**

Beef cattle producers face numerous challenges to sustainability. Important among these is economic sustainability. To maintain profitability, beef cattle producers have to ensure that management practices add value to their market products (cattle or meat) at a greater rate than they increase cost of production. Beef cattle producers need increased opportunities to add value to beef cattle progeny.

Beef cattle producers face numerous challenges to sustainability. Important among these is economic sustainability. To maintain profitability, beef cattle producers have to ensure that management practices add value to their market products (cattle or meat) at a greater rate than they increase cost of production. Beef cattle producers need increased opportunities to add value to beef cattle progeny.

Recent research indicates that the nutrient status of gestating cows can have various long-term implications on progeny in terms of growth, feed intake and efficiency, body composition, carcass characteristics, health, and reproductive traits (Funston et al., 2012). For example, in the first two months following conception in the ruminant, the embryo initiates differentiation of fat cells (adipocytes), structural cells (fibroblasts), and skeletal muscle cells from mesenchymal stem cells (Du et al., 2010). Development of marbling, or intramuscular fat, is of great economic importance to the beef industry. The fetal stage may be the most important in terms of nutritional impacts of the dam on eventual marbling potential of the offspring. Adipogenesis is initiated around the fourth month of gestation, partially overlapping with the second wave of myogenesis or the formation of muscle tissue. Therefore, under-nutrition of the dam during early to mid-gestation can negatively impact muscle development and increase fat deposition in the fetus (Du et al., 2010). After 250 d of age (potentially mid- to late gestation), marbling is enhanced only through the growth of pre-existing adipocytes, and nutritional influences have little chance of increasing adipocyte development (Du et al., 2010). Therefore, nutritional stimuli that optimize muscle adipocyte differentiation during fetal development theoretically could enhance marbling in beef calves. Smith and Crouse (1984) reported that different regulatory processes control fatty acid synthesis in intramuscular and subcutaneous adipose tissue, indicating that it may be possible to increase marbling without proportional increases in backfat that could negatively impact yield grade. Thus, the fetal stage (mid to late gestation) may be the most important in terms of nutritional impacts of the dam on overall carcass quality of offspring.

The concept that the maternal environment during fetal development can create long-term implications on progeny is referred to as fetal programming. While recent research has demonstrated that gestating cow nutrition can impact progeny health and performance, little is known about the physiologic and metabolic mechanisms that drive the process. Additionally, much of the research has considered nutrition in general (e.g. differences in feed intake) and little is known about when the sensitive time periods during gestation occur and which specific nutrients are key. Therefore, the goal of this project is to elucidate when and how alterations in nutrient supply or source that influence metabolic substrates available to beef cows during gestation affect health and performance of progeny.

**Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.**

**Objective 1: Evaluate maternal nutritional treatment effects on cow and replacement heifer performance to ensure unintended consequences do not occur in other segments of the beef cattle production system. (70% Accomplished)**

No new progress was accomplished in year 4 on this objective.

**Objective 1 Impact:**

This objective provided evidence that a least-cost ration developed to meet energy and protein requirements using alternative feedstuffs can be used to meet beef cow nutritional requirements with no negative influence on cow performance. This supports the opportunity for producers to minimize input costs without negative impacts on productivity.

**Objective 2: Determine the effects of maternal energy source (forage vs. grain) during mid-gestation on offspring body composition, post-weaning performance, carcass characteristics and meat quality. (100% Accomplished)**

Research toward this objective was completed with publication of the results (Gubbels et al. 2001) in year 3.

**Objective 2 Impact:**

These data suggest variation in maternal diets applied in this study during mid- and late-gestation has limited influence on progeny performance. They further suggest the diet provided to cows during mid- and late-gestation differentially influenced deposition of subcutaneous fat without compromising marbling score or tenderness. Provided that nutrient requirements are

met, it appears that utilizing alternative diets for the beef cow herd does not significantly influence progeny performance and beef product quality. Based on this study, cattle producers have flexibility to feed their gestating cows available carbohydrate sources during drought and/or variable growing conditions without concern for offspring performance or carcass traits.

**Briefly describe how your target audience benefited from your project's activities.**

The audience for this project includes the scientific community, beef cattle producers and rangeland managers in South Dakota and throughout the Northern Great Plains, and Native American beef cattle producers and rangeland managers in South Dakota and throughout the Northern Great Plains.

**Briefly describe how the broader public benefited from your project's activities.**

Broader public benefit from this project would be assurance that sustainable beef production practices evaluated in this research contribute to a supply of high quality beef products that meet or exceed consumer demand.

**Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.**

**Changes:**

**Objective 3 was added: Evaluate the efficacy of precision livestock management technologies for utilization by Northern Plains beef cattle producers to improve sustainability of beef cattle production systems.** Research was initiated with weaned, replacement beef heifers to evaluate the utilization of precision supplement delivery equipment (C-Lock SmartFeed Pro) to measure amount and variation in supplement intake among individuals in a group of heifers (n = 30) vs. a control group wherein a similar group of control heifers (n = 30) were group-fed in a conventional feed bunk. The first year of field work and data collection were completed from November 2021 to May 2022. Heifers were stratified into two groups with groups assigned to control (supplement hand delivered) or precision (supplement delivered via the Smart-Feed precision feeder) supplementation treatments. Daily supplement intake was recorded for each heifer in the precision treatment. Heifer BW were measured using the Smart-Scales weighing system. Heifers were estrus-synchronized and time bred by AI. Data analysis has not been initiated.

**Training:** Training was provided for 1 graduate student in livestock research activities. The graduate student was **Anna Dagel (MS in Animal Science)**. She received training in low-stress livestock handling and livestock research data collection, proposal writing, data management, statistical analysis, and scientific writing.

**Dissemination:** We published 2 peer-reviewed articles, 1 abstract, 2 oral presentations, and 3 Extension fact sheets.

**Next reporting period: Objective 1: Evaluate maternal nutritional treatment effects on cow and replacement heifer performance to ensure unintended consequences do not occur in other segments of the beef cattle production system.** We plan to complete data analysis and publish results.

**Objective 2. Determine the effects of maternal energy source (forage vs. grain) during mid-gestation on offspring body composition, post-weaning performance, carcass characteristics and meat quality.** Erin Gubbels will submit one additional manuscript for peer review. We plan to submit one manuscript for peer-review from a previous experiment about use of growth promoting technologies in beef cattle production.

**Objective 3. Evaluate the efficacy of precision livestock management technologies for utilization by Northern Plains beef cattle producers to improve sustainability of beef cattle production systems.** Anna Dagel will continue the precision supplementation research project for a second year of data collection.

We plan to publish one peer-reviewed manuscripts from a previous experiment about maternal metabolizable protein restriction on fetal and postnatal progeny growth and carcass characteristics. Erin Gubbels will prepare one additional manuscript for peer-review from her thesis.

**Products:**

Journal Articles Published:



Block, J.J., M.J. Webb, K.R. Underwood, M.G. Gonda, A.A. Harty, R.R. Salverson, R.N. Funston, K.C. Olson, and A.D. Blair. 2022. Influence of maternal protein restriction in primiparous beef heifers during mid- and/or late-gestation on progeny feedlot performance and carcass characteristics. *Animals*. 12:588. <https://doi.org/10.3390/ani12050588>

Blair, A.D., E.R. Gubbels, J.J. Block, K.C. Olson, J.K. Grubbs, and K.R. Underwood. 2021. Maternal nutrition and meat quality of progeny. *Meat and Muscle Biology*. 5:6. <https://doi.org/10.22175/mmb.12990>

Abstracts Published:

McFadden, L.J., H.M. Menendez, K. Olson, J.R. Brennan, K. Ehlert, and A. Blair. 2022. Developing a dry matter intake prediction equation for grazing animals based on real-time enteric emissions measurements. Abstract, Western Section, American Society of Animal Science. Park City, Utah. September 21. *J. Anim. Sci.* 100, Suppl 4: 1. <https://doi.org/10.1093/jas/skac313.000>.

Conference Papers or Posters Presented, Invited Lectures:

McFadden, L.J., H.M. Menendez, K. Olson, J.R. Brennan, K. Ehlert, and A. Blair. 2022. Developing a dry matter intake prediction equation for grazing animals based on real-time enteric emissions measurements. Western Section, American Society of Animal Science. Park City, UT. September 21.

Olson, K. 2022. Does cow size matter in cow-calf production systems? Cow size, nutrient requirements, and forage resources. Invited Lecture, Australian Wagyu Association. Melbourne, Australia. April 27.

Extension Publications:

Brennan, J., H. Menendez, K. Ehlert, and K. Olson. 2022. South Dakota grazing readiness spring turnout map. <https://extension.sdstate.edu/south-dakota-grazing-readiness-spring-turnout-map>.

Olson, K., K. Ehlert, and S. Hadrick. 2022. beefSD Class 6. <https://extension.sdstate.edu/beefsd-class-6>

McFadden, L.J., K. Olson, K. Ehlert, J. Brennan, A. Blair, and H. Menendez III. 2022 Using precision technology to measure cattle methane emissions and intake on western South Dakota rangelands. SDSU Beef Day Summary Publication. [https://openprairie.sdstate.edu/cgi/viewcontent.cgi?article=1016&context=sd\\_beefday\\_2022](https://openprairie.sdstate.edu/cgi/viewcontent.cgi?article=1016&context=sd_beefday_2022)

Type	Projects / Programs
<b>Projects / Programs without a Critical Issue</b>	<b>0</b>
Not Provided	