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

This project focuses on identifying individual and contextual factors that influence financial abuse within families, more specifically identity theft perpetrated by family members and financial abuse of older adults by family members. This project is important because the financial, emotional, physical, and relational effects of financial abuse within families can be devastating and long-lasting.

Financial abuse within families is a significant problem affecting both victims and their families. Estimates of such abuse range from 5.2% of elders age 65 and older being victimized by a family member (Acierno, Hernandez-Tejada, Muzzy, & Steve, 2009), and up to 30% of identity theft victims being victimized by a family member (LaDue, 2016). Financial abuse within families can negatively impact victims and families financially, physically, and psychologically. Victims can be denied credit, employment opportunities, be required to pay security deposits for utilities services, have their estate plans thwarted, and experience feelings of distrust, shame, and embarrassment as a result of this problem. The stress of financial abuse within families can also have physical ramifications, such as headaches, insomnia, and malnutrition. Family relationships can be damaged beyond repair. These effects can be long-lasting and challenging to overcome.

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: Objective 1: Understanding the Lived Experiences of Familial Identity Theft Victims 95% accomplished

Two manuscripts were published, based on a qualitative study I completed in 2018. The papers were published in the *Journal of Financial Counseling and Planning* and *Journal of Financial Therapy.* A third manuscript regarding differences in financial, emotional, and physical health consequences of familial identity theft victimization has been accepted for the *Journal of Financial Counseling and Planning*. I am currently recruiting familial identity theft victims for another study.

Objective 1 Impact: Experian, a credit reporting agency, has used the *Journal of Financial Therapy* article to provide education to the public. Moreover, given this publication is in an open access journal, several familial identity theft victims have reached out to me after finding it to share that they see similiaries in their experiences as compared to those reported in the study. This has resulted in these victims feeling less alone in their experiences.

Objective 2: Understanding Perpetrators of Elder Family Financial Exploitation (EFFE): In Years 1 and 2, individual and contextual factors that may contribute to becoming a perpetrator of financial exploitation of an elder relative will be explored as a member of W3191: Elder Financial Exploitation: Family Risk and Protective Factors. The aim of this objective is to identify common characteristics and circumstances that lead to the perpetration of elder family financial exploitation. **100% accomplished**.

W3191 member Marlene Stum and I analyzed interview data from 28 family members who had experienced elder family financial exploitation (EFFE) in their families. We focused on family members' experiences with perpetrators to explore what influences a family member EFFE perpetrator. This data was presented at the 2021 Association for Financial Counseling and Planning Education symposium and published in *Victims and Offenders*.

Objective 2 Impact: This work will be useful for older adults, financial planners, financial counselors, social workers, and adult protective services workers to use in working with clients to prevent or recover from elder family financial exploitation.

Objective 3: : Exploring Risk and Protective Factors Associated with Elder Family Financial Exploitation via POA: In Years 1-5, individual and contextual factors that may lead to or prevent later financial exploitation of an elder by a family member power of attorney agent (POA) will be explored as a member of W3191: Elder Financial Exploitation: Family Risk and Protective Factors. The aim of this project is to identify common individual, family, and social risk factors for elder family financial exploitation via POA. 40% accomplished

It is my understanding that the W3191 multi-state group is inactive since it has not had an annual meeting since 2020. I officially stepped away from this group in March 2021. To wrap-up my work on this project, I published a paper in the *Journal of the National Extension Association of Family and Consumer Sciences* focused the role of financial powers of attorney in preventing financial exploitation of older adults in South Dakota.

Objective 3 Impact: The results of this work can be used to inform local Extension programming on estate planning in South Dakota.

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

Target audiences reached include academic audiences and practitioner audiences in the fields of family and consumer sciences, financial counseling and planning, financial therapy, and criminal justice, along with government employees in relevant agencies (Federal Trade Commission, Consumer Financial Protection Bureau), via presentations at academic conferences, webinars, and journal articles.

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

The broader public benefitted from the project's activities by having access to open access researched-based publications that provide a greater understanding of familial identity theft victims and perpetrators. Moreover, South Dakotans have access to an open access publication focused on preventing elder family financial exploitation via financial powers of attorney.

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.

Plans for next reporting period:

For Objective 1, I will continue to recruit participants for the study on familial identity theft, and submit preliminary findings as an abstract for the 2022 AFCPE symposium.

Objective 2 is complete.

Objective 3 will be addressed in a future Hatch project.

Products:

Betz-Hamilton, A., Stum, M., & Chan, A.C.Y. (2022). Elder family financial exploitation offenders: Examining the complexities of problematic behaviors. *Victims and Offenders*. https://doi.org/10.1080/15564886.2022.2040068

Betz-Hamilton, A., & *Rich, J. (2021). Preventing financial exploitation of older adults in South Dakota by family members: A qualitative pilot study exploring the role of financial powers of attorney. *Journal of the National Extension Association of Family and Consumer Sciences, 16,* 15-20. https://neafcs.memberclicks.net/assets/documents/journal/2021-jneafcs/Preventing%20Financial%20Exploitation%20of%20Older%20Adults%20in%20SD.pdf

Betz-Hamilton, A. (accepted). A comparison of the financial, emotional, and physical consequences of identity theft victimization among familial and non-familial victims. *Journal of Financial Counseling and Planning*.

Betz-Hamilton, A., Stum, M., & Chan, A.* (2021, November). Elder family financial exploitation: Examining the complexities of problematic behaviors. *Proceedings of the 2021 Association for Financial Counseling and Planning Education Symposium*

Other Products:

Activities: Analyzed interview data of 28 concerned family members regarding elder family financial exploitation

Critical Issue

Food Systems, Nutrition, Health, and Well-Being

Extension Strategies Promote Dietary and Lifestyle Changes

Project Director

Ann Schwader

Organization

South Dakota State University

Accession Number

Expanding Physical Activity Opportunities in South Dakota

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

According to 2019 Behavioral Risk Factor Surveillance System data, only 22% of South Dakotans meet the recommended amount of aerobic and muscle strengthening guidelines. Access to physical activity opportunities across the state can also be challenging, as some individuals must travel long distances to access nearest facilities or programming opportunities.

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.

In 2018, South Dakota State University (SDSU) Extension adopted two evidence-based physical activity programs, Walk With Ease and Fit & Strong! to offer statewide. South Dakota adults are the primary target audience for both programs, with an extra emphasis on individuals living with arthritis.

Walk With Ease

Walk With Ease is an evidence-based, six-week walking program developed jointly by the Thurston Arthritis Research Center and the Institute on Aging of the University of North Carolina. The program has been shown to reduce pain and improve overall health in program participants. Whether participants need relief from arthritis or chronic pain, or just want to be active--if they can be on their feet for 10 minutes without
increased pain, participants can find success with Walk With Ease.

Fit & Strong!

Fit & Strong! is an evidence-based physical activity and fall prevention program developed by researchers at the University of Illinois at Chicago. The program is eight or twelve weeks and includes education on a variety of health topics and discusses how physical activity can help manage symptoms and pain. The program covers safe stretching techniques, balance exercises, lower extremity exercises, resistance band exercises,
and aerobics. Participants develop physical activity techniques that are sustainable after the Fit & Strong! program ends. SDSU Extension has implemented the program statewide and is the current license holder.

Both programs are offered in-person and virtually. Public resources created for the programs include an overview of each located on the SDSU Extension's website at https://extension.sdstate.edu/walk-ease and https://extension.sdstate.edu/fit-strong.

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

In 2018, SDSU Extension trained the first two instructors in both Walk With Ease and Fit & Strong!. Since this training, additional funding and program expansion has occurred. Currently, there are over 26 active South Dakota Fit & Strong! leaders and 19 Walk With Ease leaders across the state. Additionally, SDSU Extension has two trained Master Trainers in Fit & Strong!.

During 2021, **Walk with Ease** had 154 participants. Participants indicated a change in confidence managing their joint pain and/or stiffness from 7.6 to 8.0 on a scale of 1-10. During 2021, the program trained 10 volunteers.

During 2021, 88 individuals have participated in **Fit& Strong!** workshops. In 2020, South Dakota was part of the Fit & Strong! @Home pilot program, which helped develop the virtual delivery of the program. Since the pilot, Fit & Strong! @ Home is offered as a virtual opportunity statewide in South Dakota. During 2021, the program trained 12 volunteers.

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

Two evidence-based physical activity programs are offered statewide by SDSU Extension for South Dakota adults with an emphasis on individuals living with arthritis. Walk With Ease is an evidence-based, six-week walking program. The program has been shown to reduce pain and improve overall health in program participants. Fit & Strong! is a physical activity and fall prevention program that lasts eight or twelve weeks and includes education on a variety of health topics and discusses how physical activity can help manage symptoms and pain. The program covers safe stretching techniques, balance exercises, lower extremity exercises, resistance band exercises, and aerobics. Both programs are offered in-person and virtually.

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.

SDSU Extension is continuing to offer and expand both Walk with Ease and Fit & Strong! in the state of South Dakota. They are working closely with their local (i.e. SD Department of Health, trained leaders) and national (i.e. Osteoarthritis Action Alliance, National Council on Aging) partners to plan for sustainability and continued implementation of both programs. These two programs are also part of the overarching umbrella of Better
Choices, Better Health SD Programs©.

Exploring the Role of Diet and Physical Activity in Muscle, Bone, and Joint Health Across the Lifespan.

Project Director
Lee Weidauer
Organization
South Dakota State University
Accession Number
1021292

Year 3 Results 10/01/20-09/30/21:Exploring the Role of Diet and Physical Activity in Muscle, Bone, and Joint Health Across the Lifespan.

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

As a population life expectancy has slowly increased over the past several decades, the number of years spent free from disability and living an active and fulfilling life have not increased to the same extent. A thorough examination into factors leading to diminished quality of life along with interventions to address these factors is critical to allowing older adults to age in place and improve their health span.

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: Determine the role that diet, and physical activity have in the health of musde, bone, and cartilage throughout the lifespan. 70% Accomplished

During the past year, I have been part of a team that completed a needs assessment for older adults and healthcare providers treating older adults. We completed surveys with 1,283 older adults from the general population and 166 health care providers from various fields. Upon completion of this assessment, the team went to work analyzing data and writing manuscripts. It is expected that 7 manuscripts will come from this work. We currently have 5 manuscripts at various stages of development and review:

Peterson, N., Francis, S., Palsgaard, P., Arthur, A., Xu, F, **Weidauer, L.,** Ventura-Marra, M., Sahyoun, N., Monroe-Lord, L. Age-related training needs, barriers, and preferences of health professionals. *Journal of Applied Gerontology* (under review)

Palsgaard, P., Arthur, A., Maino Vieytes, C., Peterson, N., Francis, S., Monroe-Lord, L., Sahyoun, N., Ventura-Marra, M., **Weidauer, L.**, Xu, F. Modeling health professionals' views and knowledge of the aging process. *Journal of Applied Gerontology* (under review)

Weidauer, L., Xu, F., Ventura-Marra, M., Weidauer, L., Arthur, A., Sahyoun, N., Francis, S. Physical Activity Patterns and Preferences in Rural Older Adults. (expected submission, March 2022)

Wong, L., Francis, S., Genschel, U., Kendall, C., Sahyoun., Ventura-Marra, M., Monroe-Lord, L., **Weidauer, L.**, Xu, F., Arthur, A. COVID-19 Impacts on Food Practices, Physical Activity and Stress Levels of Older Adults (expected submission, March 2022)

Carmago, J., Arthur, A., Hamilton-Reeves, J., **Weidauer, L.**, Social determinants of health and multimorbidity among aging adults: An exploratory study paper. (expected submission, March 2022)

Objective 1 Impact: Through the completion of the aforementioned needs assessment, we have gained a sound understanding of the opportunities and threats that are present in the areas of nutrition and physical activity in older adults. Upon publication of these results, the next step will be to develop community based interventions to address these needs. This has the potential to have a vast impact on quality of life for older adults and in the long-term has the possibility of decreasing the burden on the healthcare system through reduced prevalence of chronic disease.

Objective 2: To develop, implement and evaluate interventions that preserve or improve health in aging adults living in rural and urban environments. 30% Accomplished

Osteoarthritis is the 4th leading cause of disability in the United States and as rates of obesity continue to rise, so do rates of osteoarthritis. The strong correlation between obesity and osteoarthritis necessitates the need for obesity prevention and treatment programs. Additionally, once an individual has osteoarthritis and the disease progresses to a terminal point requiring joint replacement obesity becomes an even greater issue. Obesity is associated with longer surgical times, increased surgical complications and infections, and poorer long-term post-surgical outcomes. Even with that knowledge, health care systems currently do very little in the area of weight management and lifestyle improvement prior to joint replacement surgery. To address this, I am currently conducting a randomized clinical trial aimed at promoting weight loss and lifestyle improvement in obese older adults prior to and following joint replacement surgery in an effort to improve outcomes. If we determine an optimal program that improves post-surgical outcomes in older adults the impact may be drastic for this population.

Objective 2 Impact: Osteoarthritis is currently a major economic burden in the United States. Significant costs include joint replacement surgery, non-invasive treatment, physical therapy, hospitalizations and stays in swing bed units. These costs are increased significantly when surgical outcomes are suboptimal due to increased hospital stay length and extended

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

In this reporting period I was part of a group that completed a Qualtrics-based needs assessment to determine the wellness and nutrition needs and preferences for adults ages 40 and older. This study was conducted with a sample of adults ages 40 years and older from 7 states: Iowa, Illinois, South Dakota, Washington DC, West Virginia, Maryland, and Rhode Island with a target enrollment of 1,268. An additional Qualtrics-based needs assessment was performed targeting 166 health care professionals. This study assessed nutrition and physical activity training needs and preference for health care professionals ages 18 and older from across the United States.

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

Nothing to report at this time

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.

Similar to the prior reporting period, the primary challenge faced over this reporting period was related to Covid-19. Due to Covid-19, many of my collaborators and I were forced into non-traditional working arrangements which made scheduling of meetings with several collaborators very difficult. However, many of these systems have been improved over time and this past year was far more efficient and should not be a problem moving forward.

Two students seeking a M.S. in Nutrition and Exercise Science were trained and mentored through this project.

They had the opportunity to participate in the following:

Completing CITI training in the responsible conduct of research.

Completing a NCBI webinar covering advanced search techniques in PubMed.

Graduate assistants received training in the interpretation of statistical tests to better assist them in understanding findings in the literature.

Graduate assistants had the opportunity to contribute significantly to the writing of a manuscript from our needs assessment study.

In the past year, the primary means of dissemination has been through manuscripts. Our plan for the next reporting period is to disseminate our published findings to the general public in a non-technical summary format.Over the next reporting period, my plans include dissemination of the findings from our needs assessment. Additionally, a working group has been formed to develop interventions and grant proposals from these results.

Additionally, members of my multistate group and myself are planning to develop and submit an application for funding to test a remotely delivered program for sarcopenia prevention. This study will focus on overcoming barriers to physical activity that are common among rural living older adults. Additionally, a nutritional intervention aimed at providing a non-supplement-based high protein diet to maintain or enhance lean mass in older adults. The goal of this project is to develop long-term sustainable interventions that can be easily implemented in rural communities.

Peterson, N., Francis, S., Palsgaard, P., Arthur, A., Xu, F, **Weidauer, L.,** Ventura-Marra, M., Sahyoun, N., Monroe-Lord, L. Age-related training needs, barriers, and preferences of health professionals. *Journal of Applied Gerontology* (under review)

Palsgaard, P., Arthur, A., Maino Vieytes, C., Peterson, N., Francis, S., Monroe-Lord, L., Sahyoun, N., Ventura-Marra, M., **Weidauer, L.**, Xu, F. Modeling health professionals' views and knowledge of the aging process. *Journal of Applied Gerontology* (under review)

Weidauer, L., Xu, F., Ventura-Marra, M., Weidauer, L., Arthur, A., Sahyoun, N., Francis, S. Physical Activity Patterns and Preferences in Rural Older Adults.

Wong, L., Francis, S., Genschel, U., Kendall, C., Sahyoun., Ventura-Marra, M., Monroe-Lord, L., **Weidauer, L.**, Xu, F., Arthur, A. COVID-19 Impacts on Food Practices, Physical Activity and Stress Levels of Older Adults

Carmago, J., Arthur, A., Hamilton-Reeves, J., **Weidauer, L.**, Social determinants of health and multimorbidity among aging adults: An exploratory study paper.

Other products:

A needs assessment covering nutrition and physical activity was administered to 1,266 adults and 166 health care providers

Identifying Weight Related Behaviors for Obesity Prevention and Wellness

Project Director
Kendra Kattelmann
Organization
South Dakota State University
Accession Number
1013769

Year 4 results 10/01/20-09/30/21-Identifying Weight Related Behaviors for Obesity Prevention and Wellness

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 behaviors1-4. 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 economies1-4. 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 withing the US.

In 2020, over 30 million American adults are between the ages of 18-26 years5. These years of emerging adulthood have long been recognized as a transformative period due to the numerous and significant transitions (e.g., completion of education, leaving the family home, securing full-time employment, living independently, partnering and cohabitation) 4,6,7. The Institute of Medicine and National Research Council published a report in 2014, following changes in the Affordable Care Act, to encourage scientists and policymakers to consider the age group of 18-26 years as a separate demographic with unique social, economic, and policy needs 7. However, attention to and research about this distinct subpopulation is lacking overall; especially as it relates to lifestyle behaviors such as dietary patterns8-20. While United States (U.S.) surveillance systems may include all ages in their sampling protocols, methodologies limit the inclusion of those with transient residency status or young adults living outside traditional households. These data systems frequently combine young adult data with teenagers (e.g., 16-19 years) or older adults (e.g., 18-35 years), which fails to identify this group's unique status adequately.

Today, young adults face unique challenges that differ from their parents and grandparents. For example, regardless of income level, young adults born between 1996-2001 have grown up with ubiquitous access to information (both accurate and misleading) through household computer, tablet or smartphone21 and have spent their entire adolescence navigating the advantages and disadvantages of social media22,23. Today's young adults are more likely to identify as a race other than white (16% in 1976 to 44% in 2017)24, and they are more likely to delay marriage and parenting much later than previous generations25,26. Young adulthood is an established time of psychological vulnerability with data from 2017 suggesting that the prevalence of any mental illness is highest in young adults (25.8%) when compared to older age groups. While previous generations have experienced economic uncertainties and/or global crises, today's young adults report higher rates of anxiety than previous generations27 and now face an unprecedented economic landscape28,29 with the scope, duration, and impact of the global pandemic unknown. The impacts of this pandemic, along with other crises facing our nation's young adults, which we have named influential disruptive factors (IDFs), on long-term health consequences are a much-needed focus of current health-related research.

While young adults experience diverse pathways, they are more likely to attend an institution of higher education post high school than previous generations. Currently, 40% of 18-24 year-old individuals enroll in a degree-granting postsecondary institution, representing an 11% increase since 200726,30. This increase is largely attributable to the rising number of first-generation college students, a group more vulnerable to health disparities31-36. Despite the benefits of earning an advanced degree, today's college students face higher dropout rates24, high rates of food insecurity10,11,37-46, and difficulties repaying student debt47 as compared to previous cohorts. In 2015-16, the average student had borrowed $24,480 by the time of degree completion compared to $14,260 in 1999-200030. The influence of the additional debt facing college graduates on long-term health is unclear; however, college students with higher credit card debt are less likely to participate in healthier behaviors and more likely to have a higher Body Mass Index (BMI)48.

The emerging adult years are linked to declines in healthy behaviors and high rates of weight gain, yet existing interventions and assessment tools have not adequately addressed this population's unique needs and challenges49. These individuals were born in a global obesity epidemic that has failed to wane. Nationally, 18% of young adults 18-24 years old report weight status that would be classified as obese50. Like all age groups, young adults have experienced rising rates of overweight/obesity; however, young adults gain weight faster than any other period of adulthood51, and a majority (60%) of college students report weight gain (7.5 lbs) in their first year of college attendance52. Young adults who experience excessive weight gain are at an increased risk of developing diet-related diseases, including obesity, heart disease, hypertension, and type 2 diabetes. Obesity alone currently affects 93.3 million adults in the United States (US), with an estimated cost of $315.8 billion50.

Obesity prevention programs have largely overlooked young adults and may not adequately consider their attitudes, motivations, and perceptions14,49,53,54. Emerging adulthood is a critical period for developing healthful weight management behaviors but unfortunately, most obesity prevention programs have focused on changing individual behaviors and/or knowledge with limited attention on the environment. Environments with limited access to healthy foods, such as fruits and vegetables, or opportunities for physical activity make it difficult for individuals to engage in healthful behaviors. An individual's perception (subjectivity) of the environment and resources available may differ from the actual (objective) environment, individuals may be unable to recognize opportunities that could support healthful behaviors. Therefore, investigating young adults' eating behaviors and lifestyle choices as well as their perceptions has never been more important nor more urgent to reduce the burden of illness, increase the quality of life, and improve societal impact from obesity.

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: Implement a new model (eB4CAST) to benchmark community, wellness-programing efforts for their effectiveness and sustainability.95% Accomplished.

This is an ongoing project to develop an instrument to benchmark community wellness programs. The impact of having this instrument is that those leading community wellness programs and interventions will have a comprehensive, easy to use tool to provide outcome impact of programing on the community. The tool has been shown to be useful and favorable in two large community-based interventions.

The intent of the tool is to have it automated with easy customization to the respective wellness intervention and community. We are still exploring how to automate this tool for wider dissemination.

Objective 1 Impact: The impact of having an instrument to easily benchmark community wellness is that those leading community wellness programs and interventions will have a comprehensive, easy to use tool to provide outcome impact of programing on and to the community.

Objective 2: Continue environment and behavioral instrument development, refinement and validation of the Behavior Environment Perceptions Survey for college campuses and the Healthy Campus Environmental Audit. 90% 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 Health 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 programing specific to the needs of campus.

We are still working on developing the overall scoring for the Healthy Campus Environmental Audit. Work on this objective was halted due to COVID 19 as we need additional campuses to increase the sample size.

Objective 2 Impact: The impact of having an Healthy Campus Environmental Audit will be to have simple 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.

Objective 3 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.

The exploration of mechanisms of interaction between lifestyle behaviors and environmental factors in influencing health behaviors and health status of young adults was included as an objective in the renewal for the multi-state and work continues.

Data from a previous study was analyzed to determine the relationship between parenting styles (including authoritative, authoritarian, indulgent, and uninvolved), food parenting practices (within Structure, Coercive Control, and Autonomy Support constructs) and dietary intakes of preschoolers. Children aged 3–5 years and their parents were recruited from preschools/daycare centers and parents completed the surveys (n = 166). Dietary intakes were collected using the Harvard Service Food Frequency Questionnaire (HSFFQ), parenting style was assessed using the Parenting Dimensions Inventory-Short Version (PDI-S), and food parenting practices were measured using Comprehensive Home Environment Survey (CHES). The results showed that food parenting practices had a higher number of specific significant findings on children's nutrient and food group intakes than parenting styles. Correlation analyses showed positive parenting practices within Structure were significantly related to healthier children's intakes (e.g., vegetables, iron, and folate) and less unhealthy dietary intakes (e.g., sweets and total fats). Regression models show that children with authoritative parents consumed more fruits compared to children with authoritarian parents and indulgent parents.

Objective 4 Impact: The results addressed the importance of parental influences for preschoolers' healthy dietary intakes, which suggested that future interventions and educational programs could enhance parenting practices to impact child diet.

Objective 5. Exploratory work with the influence of the diet on the microbiome in Native Americans. 95% 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 statistically significant correlations in microbiome diversity measures and gender, self-reported ulcer or stomach disease, antibiotic use, and participation in wellness programs. There were no significant correlations with any of the individual nutrients measured and the microbiome diversity. When evaluating the diet by food group types, there was a significant correlation in microbiome diversity and intake of legumes. A manuscript is in preparation with the outcomes.

Objective 5 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.

Nothing to report at this time

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: 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 were trained to complete focus groups and complete the environmental assessments.

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

Plans for next reporting period:

Objective 2. Work will continue to refine the Healthy Campus Environmental Audit.

Objective 3. Qualitative work will be completed as the first step in determining the feasibility of the Healthy Campus Audit in low-income communities.

Objective 4. Work will continue on the exploration of mechanisms of interaction between lifestyle behaviors and environmental factors in influencing healthy behaviors and health status of young adults. With the change in funding focus from obesity prevention to sustainable agriculture, a grant was submitted focusing on improving dietary behavior through sustainable agriculture practices. If funded, those objectives will be incorporated into the research agenda.

Products:

Bunde K, Gjesvold D, Kattelmann KK, McCormack LA, Vukovich MD. Increased frequency of nutritional counseling improves weight status and lipids in renal transplant recipients. Topics in Clinical Nutrition. 36(1): 3-12, 2021. DOI: 10.1097/TIN.0000000000000231

Chen, B.; Kattelmann, K.; Comstock, C.; McCormack, L.; Wey, H.; Meendering, J. Parenting Styles, Food Parenting Practices and Dietary Intakes of Preschoolers. Nutrients 2021, 13, 3630. https://doi.org/ 10.3390/nu13103630.

Chen B., Kattelmann K., Comstock, C., ey McCormack, L., Weys H., Bowne M., Meendering J. Identifying Food Parenting Practices from Comprehensive Home Environment Survey (CHES), Accepted Journal of Nutrition Education and Behavior, Feb 14, 2022

Critical Issue

Natural Resources and Environmental Systems

Understanding past and present fish responses to habitat change to effectively manage and conserve populations

Project Director

Alison Coulter

Organization

South Dakota State University

Accession Number

1026183

Year 1 Results:03/30/20-09/30/21: Understanding past and present fish responses to habitat change to effectively manage and conserve populations

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

Humans have made critical changes to aquatic habitats, including altering habitat quality, quantity, and connectivity through activities such as urbanization, farming, and dam construction. These changes have contributed to declines in many fish populations that are ecologically or economically valuable. This research will improve the management and conservation of

fish populations by understanding how fishes have responded to past environmental change and how they are currently being impacted by habitat change.

3.1 Key Problem/Issue: This research will improve the management and conservation of fish populations, both sportfish and nongame species, by developing a deeper understanding of how fish interact with their environment and respond to current and past disturbances (e.g., agricultural nutrient runoff, shoreline development, introduced species).

Fishing is a popular commercial and recreational activity, with millions of dollars each year spent on fishing related equipment and travel in South Dakota alone. Humans have made critical changes to aquatic habitats which have altered fish production and distributions. This work will improve the management and conservation of fishes through increased knowledge of how fishes have responded to past changes and how they are using current habitat.

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: Quantify multispecies responses to aquatic environmental change (5% Accomplished)

We have gathered, formatted, and combining data on sportfish length, age, and abundance in South Dakota Glacial lakes. Initial analyses of sportfish responses to past environmental change will focus on Lake Kampeska (Watertown, SD). Initial analysis of this dataset will occur in 2022 followed by expansion of analyses to additional glacial lakes in subsequent years. Data for predictors of fish change are also being collected, including past land use in watershed, water quality, and species introductions.

Objective 1 Impact: Recreational fishing is a valuable economic driver in South Dakota but human activities may reduce sportfishing opportunities. Results of this analyses will reveal how past changes in fish populations are related to past environmental change in order to better understand how fish may respond to future change.

Objective 2: Examine how fish distribution and behavior are influenced by habitat diversity, quality, and connectivity (10% Accomplished)

Initial work under this objective has focused on Lake Kampeska (Watertown, SD) where humans have impacted sportfishes through nutrient loading (removal of vegetation buffers, agricultural land use in watershed), species introductions (Smallmouth Bass, zebra mussels), and partial disconnection of valuable wetland habitat via weir construction (fish can pass through one small ~2 ft wide opening of weir).

This objective has two main projects that have begun. The first project evaluates the impacts of wetland disconnection on the most valuable sportfish in Lake Kampeska, Walleye. This will involve evaluating Walleye diets as well as the prey availability in both the lake and wetland. Additionally, Walleye use of the partially disconnected wetland vs. lake habitats will be tracked using acoustic telemetry. All of this information will help identify how Walleye have been impacted by human disconnection or loss of wetland habitats. Many lakes in South Dakota have experienced similar reductions in habitat diversity due to human activities.

The second project under this objective is examining competition of a human-introduced sportfish, Smallmouth Bass, with other sportfishes, Walleye and Northern Pike, via resource overlap. This project will also evaluate seasonal changes in resource overlap among these species in order to understand when potential competition with an introduced fish may have the greatest impact on native sportfishes. Many waters in South Dakota have increasing populations of Smallmouth Bass and declines in other sportfish, especially Walleye. This study will help document potential influences of a human-introduced fish on sportfish and how effects may vary through time. **This project is led by undergraduate student Lauren Allex.

Project 1: Impacts of wetland disconnection on Walleye

Collection of Walleye for diet analysis was done using DC boat electrofishing and short-term (<2 hours) gill net sets. 36 Walleye were collected in summer 2021 (24 lake, 12 wetland) and 37 in fall 2021 (22 lake, 15 wetland) for diet analyses. All diets collected so far can items identified to the lowest taxa possible (e.g., order, family) and mass of diet items was determined. Initial results show that Walleye collected in the lake were more likely to have an empty stomach (40% empty in lake; <30% empty in wetland) and that mass of stomach contents was greater in fish in the wetland (mean 15 g in wetland vs. mean 7 g in lake [Scheirer-Ray-Hare test indicated significant different between habitats and seasons]). Additionally, Walleye were consuming more in the fall than during the summer despite prey availability being lower in the fall.

Possible Walleye diet items abundance and diversity was determined within each season and habitat using benthic samples (Ekman dredge) to sample invertebrates and mini fyke nets to target preyfish. Initial results show that prey diversity is much higher in the wetland habitat than in the lake (e.g., Shannon Diversity 0.8 in wetland, <0.2 in lake). Combined with the Walleye diet results, this indicates that the wetland habitat is likely an important source for a variety of food items for those Walleye that pass through the weir into the wetland.

Movements of Walleye between the lake and wetland will help determine 1) how many Walleye exploit the wetland habitat where prey is seemingly more abundant and 2) what proportion of time is spent in the wetland relative to the lake. In fall 2021, 18 Walleye were implanted with acoustic telemetry tags. An additional 32 tags will be deployed spring 2022. Acoustic receivers were deployed in fall 2021 to monitor Walleye movements near the weir separating the wetlands from the lake. Work on this project is expected to continue through spring of 2023.

Project 2: Evaluating resource overlap of introduced Smallmouth Bass with other sportfish

Smallmouth Bass, Northern Pike, and Walleye will be collected via boat electrofishing and gill netting from Lake Kampeska. At least 25 individuals per species will be collected in each season from summer 2021 through summer 2022 (excluding winter) to evaluate seasonal changes in resource overlap. Fishes have already been collected for both summer and fall 2021. To quantify overlap, two methods will be used to examine short-term (daily) overlap and overlap in a slightly longer timeframe (1-2 months). Short-term resource overlap will be quantified by examining fish diets for similarity. Diets from summer and fall 2021 have already been processed and show Smallmouth Bass eating mostly crayfish while Walleye and Northern Pike consume preyfishes. Longer term resource overlap will be assessed via stable carbon and nitrogen isotopes ratios. White muscle plugs will be taken from a subset of 15 fish per species. White muscle typically represents an integrated signature of resource use (diet and habitat) over the previous 1-2 months. Muscle samples from Smallmouth Bass and Walleye from summer and fall 2021 have already been analyzed and show these species feeding at similar trophic positions (indicated by similar nitrogen stable isotope ratios). However, Walleye carbon stable isotope ratios indicated that they were feeding more pelagically while Smallmouth Bass were feeding more nearshore. Analyses of additional samples will continue through 2022 and 2023.

Objective 2 Impact: Humans have directly impacted fish habitats and ecosystems through activities such as species introductions and wetland loss or disconnection. Results of this project will reveal how humans have impacted fish environments and habitats and provide guidance for management and restoration activities. Results will also demonstrate the value of wetland habitats for fishes and help inform future wetland and habitat restoration efforts.

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

The target audience for this project includes the general public, especially land owners. Another target audience is natural resource managers. The research community is another target audience.

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

Nothing to report at this time

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.

Main challenges so far have been limited access to wetland habitat by boat due to 2021 drought and collecting the targeted number of Walleye in each habitat and within each season. We have engaged in additional consultation with SD Game, Fish, and Parks staff that works in this system to identify locations for Walleye collection. SDGFP staff have also offered to help collect Walleye in 2022.

A change in the approved IACUC proposal was obtained to switch the type of anesthesia used on Walleye during acoustic telemetry tag implantation surgeries in order to reduce Walleye handling times. Initial anesthesia approved was carbon dioxide and was switched to electrosedation via TENS (transcutaneous electrical nerve stimulation) unit. This change was approved prior to any acoustic telemetry surgeries.

Logan Cutler (MS)e- Logan is seeking an MS degree in Wildlife and Fisheries, fisheries specialization. Logan began in May 2021 and spent 20 hours per week during school year and 40 hours per week during summer working on both objectives of this project. He learned how to sample fish via boat electrofishing, gill nets, and mini fyke nets; how to design research; how to plan and conduct surgeries for an acoustic telemetry study. Logan is also refining his skills as a mentor by working with multiple undergraduate students. Logan also has established collaborations with SD Game, Fish, and Parks in order to secure data for Objective 1.

Hannah Mulligan (MS)e- Hannah is seeking an MS degree in Wildlife and Fisheries, fisheries specialization, beginning in August 2021. Hannah spent 5 hours per week working on Objective 2 of this project in August and September of 2021. Hannah learned about South Dakota ecosystems and how to sample fish via boat electrofishing, gill nets, and mini fyke nets.

Lauren Allex (UG)e- Lauren is seeking a BS degree in Wildlife and Fisheries and Ecology and Environmental Sciences and began working on the project in May 2021. Lauren spent 40 hours per week during summer and 10 hours per week during the semester. Lauren has learned about literature review, experimental design, and how to coordinate field work by planning and starting her own undergraduate research project. Lauren has learned how to sample fish via boat electrofishing, gill nets, and mini fyke nets, collect fish diets, remove otoliths for aging, identify diet items, and process muscle samples for stable isotope analysis.

Elise Anderson (UG)e- Elise is seeking a BS degree in Wildlife and Fisheries and began work on the project in August 2021. Elise worked 30 hours total on the project learning how to sample fish via boat electrofishing, gill nets, and mini fyke nets, collect fish diets, remove otoliths for aging, identify diet items, and process muscle samples for stable isotope analysis.

Brady Cardwell (UG)e Brady is seeking a BS degree in Wildlife and Fisheries and began work on the project in August 2021. Brady worked 10 total hours (on the project learning how to sample fish via boat electrofishing, gill nets, and mini fyke nets, collect fish diets, remove otoliths for aging, identify diet items, and process muscle samples for stable isotope analysis.

Maria Erceg (MS)e Maria is seeking an MS degree in Wildlife and Fisheries, fisheries specialization, and began work on the project in August 2021. Maria worked 10 hours total on the project learning how to sample fish via boat electrofishing, gill nets, and mini fyke nets, collect fish diets, remove otoliths for aging, identify diet items, and process muscle samples for stable isotope analysis.

SDSU undergraduate students (n=150) learned skills used to evaluate fish habitat use and the same methods used under Objective 2 of this research (acoustic telemetry) as part of NRM 230: Natural Resource Management Techniques (summer 2021). An additional 60 SDSU undergraduate students were taught a module in WL 367: Ichthyology (fall 2021) on the importance of fish habitat and human impacts on habitat using initial results from Objective 2 as an example.

Objective 1. Quantify multispecies responses to aquatic environmental change.

Begin analyses of collected data to evaluate sportfish population responses to past environmental change. Present results at minimum of one conference and share initial results directly with SD Game, Fish, and Parks.

Objective 2. Examine how fish distribution and behavior are influenced by habitat diversity, quality, and connectivity.

Other Products

Dataset: For all fish collected, information (length, weight) provided to SD Game, Fish, and Parks as requirement of scientific collector's permit

Continue to collect diet and preyfish data. Acoustically tag 32 additional Walleye and download data on movements. Present results at minimum of two conferences and share directly with SD Game, Fish, and Parks staff. Involve at least 2 additional undergraduate students in research.

[Conservation and Management of Natural Resources]

Project Director

Ann Schwader

Organization

South Dakota State University

Accession Number

7001897

Improving Water Quality and Quantity Resilience Through In-Field and Edge-of-Field Practices for Agricultural Water Management

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

In South Dakota and throughout the Midwest, agriculture is one of the most significant economic contributors, but is under the magnifying glass for potential impacts to water. While agriculture can negatively impact water quality, it can also be part of the solution for improved local and downstream resilience. There are many tools to improve water resilience, including in-field (cover crops, no-till, etc.) and edge-of-field best management practices (BMPs), which include constructed wetlands, saturated buffers, riparian buffers, etc.

For water quality, tile drainage has become a hot-button issue in South Dakota with very strong pro- and anti-tile voices. Much of the debate is rooted in emotion and not based on actual measurements from tiling systems.

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.

Water Quantity

Through the support of an $870,000 South Dakota NRCS Conservation Collaboration Grant (CCG), the largest ever CCG granted by the South Dakota Natural Resources Conservation Services (NRCS), a South Dakota Extension Specialist-Water Management Engineer is leading a multidisciplinary watershed project, established to create a roadmap to water resilience.

Water Quality

Through the support of a $200,000 grant from the South Dakota Nurtient Research and Education Council, a South Dakota Extension Specialist-Water Management Engineer is leading a project to provide an unbiased assessment of the potential impact of tile drainage systems to water quality.

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

The water quantity project brings together 13 different organizations from across the agricultural/environmental spectrum, as well as research and extension from five disciplines within SDSU, to work directly with local farmers to determine impacts of a range of agricultural management practices on soil moisture management in approximately 20 fields. The project will be used as a foundation and model for conservation implementation across South Dakota and beyond.

The water quality team is working with farmers to collect weekly drainage samples from 20-25 tile outlets to investigate nitrate and phosphorus loss and potential risk factors.

Three separate extension products were developed to equip producers with tools needed to reduce impacts of agriculture on water quality:

1. A new podcast was created in collaboration between SDSU Extension and the South Dakota Water Resources Institute. The first season focused on conservation drainage and 14 episodes were produced. The podcast has been accessed over 1,000 times from stakeholders across six different states. A second season is being financially sponsored by the South Dakota Nurtient Research and Education Council.

2. A conservation drainage video series was developed. The video series was supported with grant dollars from a USDA NIFA project for conservation drainage and consists of three overview videos produced in collaboration with a professional animator.

3. The nutrient loss calculator web app was created as an online tool developed to enable farmers, agronomists, or other ag or conservation professionals to quickly determine the loss of nutrients from a tile drainage system, using a few measurements from the tile drain itself. The tool has generated interest and use from both individuals and companies such as Prinsco (tile manufacturer).

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

Improved soil health results in an improved ability of a soil to capture and hold water during wet times and move water through the soil profile during dry times. Improved water management at the field scale can also potentially reduce flooding downstream. The water quantity project will be used as a foundation and model for conservation implementation across South Dakota and beyond. Understanding the potential risk of nutrient loss and risk factors enables targeted conservation and an understanding by farmers of potential economic loss and downstream impacts of nutrient loss.

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.

Extension is often not well known as a career path for undergraduates and there is insufficient training for extension available to undergraduate students. The South Dakota Extension Specialist-Water Management Engineer is leading a regional extension internship program that will both equip undergraduate students with skills needed to pursue meaningful careers in extension, as well as ignite the passion to do so. This program is generously supported by a competitive $500,000 USDA NIFA REEU grant and is innovative in its approach through a regional virtual cohort. Seven states are involved with 12 mentors from across the Upper Midwest. This approach will provide students with many perspectives, skills, and regional network of future colleagues. Water issues are complex and require skilled, passionate professionals for success. This program will create a regional workforce equipped to tackle challenges facing water resources across the region.

Maintaining and Improving South Dakota's Rangelands

Project Director
Ann Schwader
Organization
South Dakota State University
Accession Number
7001898

SDSU Extension RREA Program Increases Producer Knowledge of Range Management Strategies

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

Native range and pasture lands account for over 50% of South Dakota's total land mass of 48 million acres. Over 17,000 family-owned and operated ranches depend on these lands to provide grazing for 4.05 million beef cattle and 255,000 sheep. Livestock production is critical to our state's economy, accounting for $3.2 billion in total cash receipts (according to Census of Ag NASS, 2017). Land managers need tools and techniques to help monitor rangeland condition, improve utilization of rangeland resources, control invasive species, and develop management plans to respond to climate challenges. The South Dakota RREA program addresses these natural resource issues through landowner/operator educational programming.

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.

Despite a second year of working through Covid-19, SDSU Extension was able to offer several research-based, educational opportunities during FY2021. The overal objectives of the project are to increase producer knowledge of range management strategies and increase adoption of practices that will improve overall range condition and increase economic benefits from enterprises depending on the rangeland resource.

- **Women on the Range**: This program was offered for the first time in 2021, with efforts led by the project director and a range field specialist. Topics covered during rangeland ecology, plant identification, forage production, and rangeland health. Women on the Range will be a continuing program.

- **SD Rangeland & Soils Day**: Due to Covid-19, two venues were selected to hold this program, instead of holding it in one traditional location. A total of 60 youth participants attended the program and participated in rangeland and soils judging.

- **15 Workshops** were held for 425 agency professionals and producers, covering the topics of grass management, grazing practices, women in agriculture, dormant season wildfire impacts, and marketing.

Twenty-six articles were published by educators for the SDSU Extension website that focus on rangeland management, monitoring, wildlife habitat, prescribed fire, and native species development.

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

Nine women participated in the Women on the Range program by attending a one-day, in person workshop. Participants learned about plant community development, pasture management, and soil health. Participants also gained perspective on the impacts of drought and sheep nutrition, as well as developed relationships with like-minded women who are interested in range management. One participant remarked, "I really enjoyed this workshop and learned more than I ever thought I would! I liked that we went to the field and that it was very interactive."

Sixty range judging students (youth) learned to judge habitat suitability for beef cattle and prairie grouse, in addition to learning more about plant indentification and morphology. Soil judging students learned about soils, topics such as determining soil texture and type, interpreting soil limiting factors and determining land capability with management recommendations.

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

With approximately 22 million acres of South Dakota's rangeland under private ownership, it is critical that landowners and managers have a thorough understanding of best management practices to improve long-term rangeland health, utilization, and productivity.South Dakota State Uiversity Extension's RREA program promoted grazing land management and best management practices through a variety of educational events and activities including workshops, rangeland and soils judging for youth, and numerous research-based articles published on the SDSU Extension website.

Managing saline/sodic soils in South Dakota

Project Director
David Clay
Organization
South Dakota State University
Accession Number
1023104

Year 1 results: 10/02/20-09/30/21:Managing saline/sodic soils in South Dakota

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

In the Northern Great Plains (NGP), increasing temperatures and spring rainfall are leading to rising water tables and the capillary transport of subsurface salts to the soil surface. Salts transported to the soil surface can decrease seed germination and growth if their concentrations are high, whereas Na+ can lead to soil dispersion. Salt risks are reported as the soil electrical conductivity (EC) and sodium risks are reported as the exchangeable sodium percent (ESP). Sodium dispersion risks can be reduced by increasing the EC. Within a landscape, salts first appear in low elevations and as time progresses, they move upslope. This phenomenon is occurring on millions of ha worldwide including in North Dakota, South Dakota, Montana, Minnesota, Canada, and Australia. In salt affected soil zones, crop yields and profits decrease as soil electrical conductivity (EC) increases. For example, corn is a moderately salt-sensitive plant, with grain yields starting to decrease at ECe values > 1.7 dS/m, and additional losses of 12% for each additional 1 dS/m increase in the soil ECe. In addition to low yields, these zones have very high N2O-N emissions, especially if N is applied. Research is being conducted to address these concerns.

The expanding Northern Great Plains (NGP) soil salinity and sodicity problems result from increasing rainfall, which elevates the risk of capillary movement of sodium and other salts from underlying marine sediments to the soil surface. This situation has placed many otherwise highly productive soils at the tipping point of sustainability. Disturbingly, following traditional saline remediation strategies of installing tile drainage, applying gypsum, and leaching with "good" quality water exacerbate this problem. The objectives are to: 1) determine the change in ecosystem services (GHG emissions, pollinator habitat, nutrient cycling, and carbon sequestration) associated with switching from traditional saline/sodic soil remediation to an innovative vegetative remediation strategy; and 2) create decision support tools that provide options to restore ecosystem services on salt-affected lands.

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: Determine the change in ecosystem services (GHG emissions, pollinator habitat, nutrient cycling, and carbon sequestration) associated with switching from traditional saline/sodic soil remediation to an innovative vegetative remediation strategy (50% Accomplished)

Although salinity and sodicity are global problems, information on greenhouse gas emissions from agricultural salt-affected soils is scarce. CO2-C and N2O-N emissions were quantified from three zones intertwined within a single Northern Great Plains USA field: 1) a highly productive zone (EC 1:1 = 0.4 dS m-1; SAR= 1.8), 2) a transition zone (moderately salt-affected, EC1:1=1.6 dS m-1; SAR = 4.99), and 3) a saline/sodic zone (EC1:1 = 3.9 dS m-1; SAR = 22). These zones were seeded with corn. In each zone, emissions were measured every 4 h for 7 days in 4 randomly placed chambers that were treated with 2 N rates (0 and 224 kg N ha-1). The experiment was conducted in 2018 and 2019 during similar seasonal periods. Soil samples taken from treatments after GHG measurement were analyzed for soil inorganic N, and microbial biomass from different communities was quantified using phospholipid fatty acid analysis (PFLA). Real-time PCR was used to quantify the number of copies of some specific denitrification functional genes.

The productive zone had the highest CO2-C and lowest N2O-N emissions, and the greatest microbial biomass, whereas the saline/sodic zone had the lowest CO2-C and highest N2O-N emissions, and the lowest microbial biomass. Within a zone, urea application did not influence CO2-C emissions, however, N2O-N emissions from the urea-treated saline/sodic zone were 84 and 57% higher than the urea-treated productive zone in 2018 and 2019, respectively. The copy number of the nitrite reductase gene, nirS, was 42-fold higher in the saline/sodic than the productive soil, suggesting that the saline/sodic soil had a high potential for denitrification. These findings suggest N2O-N emissions could be reduced by not applying N to saline/sodic zones.

Drainage

Increased rainfall is increasing the risk of the capillary movement of sodium and other salts from buried marine sediments to the soil surface in the North America's northern Great Plains. These salts reduce productivity and resilience, while adversely affecting the environment. Understanding the interactions among management, climate, cropping system, and soil is the first step toward implementing effective management plans. This study determined the influence of soil depth on hydraulic conductivity and changes in soil Na+ (mg Na+/kg soil) to EC1:1 (dS/m) ratio following high spring rainfall in 2019 in three soils. The landscape positions included in the study were a well-drained shoulder, moderately well drained backslope, and a poorly drained toeslope soil. Based on the soil classification, shoulder and backslope subsoils were not predicted to be salt affected, while the toe-slope soil was predicted to contain a natric soil horizon. The crop rotation at the site was corn followed by soybeans. Rainfall in 2018, 2019, and 2020 was 46, 76, and 37 cm, respectively, and soil cores were collected prior to and following the 2019 high rainfall. Samples from 2018 were analyzed for soil electrical conductivity (EC1;1), pH, ammonium acetate extractable cations, soil particle size, available water at field capacity, drainable porosity, soil bulk density, and saturated hydraulic conductivity. Samples from 2019 were analyzed for EC1:1 and ammonium acetate extractable Na+.

Across the sampling sites, shoulder and backslope soils had higher saturated hydraulic conductivities than the toe-slope soils. Saturated hydraulic conductivities were negatively correlated to pH (r=-0.55, p<0.01), the Na+ to EC1;1 ratio (r= -0.66, p<0.01), extractable Na+ (r= -0.56, p<0.01), and sand content (r = -0.66, p<0.01), and positively correlated to the silt content (r=0.65, p<0.01). A comparison between the saturated hydraulic conductivity and the Na+ to EC1:1 ratio suggests that saturated conductivities approached 0 cm h-1 when the Na+ to EC1:1 ratio exceeded 600 (mg Na/kg)(dS/m).-1 The high rainfall in 2019 increased the risk of soil dispersion in the lower soil depths (>82.5 cm). For example, in the shoulder soil at the 105- to 112.5 cm depth, EC1:1 decreased 0.936 ± 0.254 dS/m from 2018 to 2019, whereas the exchangeable Na+ increased 688 ±283 mg/kg soil. Our findings suggest that a climate change-induced shift in rainfall patterns can increase salinity and socidicy risks in northern Great Plains subsurface soils. Salinity and sodicity risks are expanding into zones not previously identified as at risk, and improving the productivity of these soils requires careful planning.

Reseeding with perennial plants

A field study, conducted between 2017 and 2021, investigated the effect of phytoremediation on soil and plant health in a landscape containing productive, transition, and saline/sodic soils. Phytoremediation treatments included corn (Zea mays) and 2 perennial grass mixes that were planted and compared with a no-plant control treatment across three soil zones. Perennial grasses were dormant seeded in the winter 2017 and 2018 and corn was grown in 2018, 2019, and 2020. Soil samples (0- to 15-cm) were collected on 24 July 2018, 23 July 2019, 24 July 2020, and 15 April 2021. Across years (2018, 2019, and 2020) total corn biomass in the saline sodic soil was 2794 ±2012 kg/ha, whereas perennial grass yields were 4733 ±1385 kg/ha. In the good soil, total corn biomass produced was 7927 ±2353, whereas the perennial grass production was 6454 ±1566. Across soil zones, total corn biomass was 5,990, 3,900, and 6,150 kg ha-1 in 2018, 2019, and 2020, respectively, whereas perennial grass biomass yields averaged 1,220, 9,065, and 7,375 kg ha-1 in 2018, 2019, and 2020, respectively. In 2019, the depth to the water table EC1:1 (-0.83 ±0.149 dS/m) and exchangeable Na+ (-656 ±220) decreased in all treatments. With drier conditions from the fall of 2019 through the spring 2021, the depth to groundwater increased, the EC1:1 decreased in the transition soil but increased in the saline/sodic soil (p=0.001). In conclusion, this and related work showed that phytoremediation, when combined with high natural rainfall, reduced soil EC1;1 and the exchangeable Na+ in all soils. However these benefits may be short lived and as the water tables dropped in 2020, EC1:1 increased in the saline/sodic zones. Growing plants reduced the risk of soil dispersion and reduced erosion, while improving soil health. Producers should consider planting saline/sodic soils with perennial salt tolerant plants.

Objective 1 Impact:

Based on our research, the SD progam “Every Acre Counts” was created to help farmers return salt effected soils to perenial grasses.

Objective 2: create decision support tools that provide options to restore ecosystem services on salt-affected lands (20% Accomplished)

The data has been collected and we are in the process of developing and using AI techniques to identify problem soils. To date we have learned that the traditional treatment of applying chemical amendments such as gypsum are ineffective. In addition, tile drainage is often not effective in northern Great Plains saline/sodic soils, and dispersed saline sodic soils have GHG emissions that are orders of magnitude higher than surrounding soils. The work also showed that high rainfall only provides a temporary respite from high salt concentrations, and that reseeding saline sodic with perennial plants may require several years

Objective 2 Impact:

None at this time.

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

The target audience includes scientists, students, farmers, and agricultural specialists. We are beginning to understand the complexity of these problems. SDSU is working with a group of national and international scientists to create a text book focus on this problem. The text book will extend the audience to students and agricultural professional worldwide.

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

Salts transported to the soil surface can decrease seed germination and growth if their concentrations are high, whereas Na+ can lead to soil dispersion. Salt risks are reported as the soil electrical conductivity (EC) and sodium risks are reported as the exchangeable sodium percent (ESP). Sodium dispersion risks can be reduced by increasing the EC. Our work has shown that

traditional chemical amendment are not effective in these soils and that greenhouse gas emissions can be 50% higher than productive soils. Returning these zones to perential grasses can reduce environomental risks while improving farm profit ability.

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 opportunities: During the past year, **5 MS students in Agronomy (Achnal Neupane, Sam Thies, Andrew Engle, Abigail Pranchard, and Doug Fiedler)** conducted research on this topic. They received one-on-one training with a mentor, as well as regular meetings with the project team leader. For professional development they were involved in a salinity study group and producer workshop. Several of these students have graduated (Sam Thies, Doug Fiedler, Abigail Pranchard) and are working in industry or NRCS.

Dissemination: During the last year we held a workshop that was attended by approximately 50 farmers and made a presentation. In addition, topics have been routinely presented to our soil health work group, in classes, and webinars. Over the last year we made several presentations to the NRCS technical committee meeting and we are in the writing stage of a a new salinity/sodicity textbook. This book was approved by the ASA/CSA/SSSA book committee and we are busy writing chapters. A number of draft chapters have been prepared.

Plans for next reporting period:

Over the next year we will work on a text book designed for undergraduate students and agricultural professionals. The focus of the book is to provide scientific answers to difficult problems

Objective 1: Determine the change in ecosystem services (GHG emissions, pollinator habitat, nutrient cycling, and carbon sequestration) associated with switching from traditional saline/sodic soil remediation to an innovative vegetative remediation strategy

Over the next year we will determine the effect of the chemical amendments on soil structural stability and write a research paper on changes in the plant community at the site.

Objective 2: Create decision support tools that provide options to restore ecosystem services on salt-affected lands

Over the next year we will continue our discussion how to interpret soil test results and classify salt effected soils. In addition we will conytinue working a text book where the dicision tools will be posted.

Products:

Fiedler, D.J., S.A. Clay, D. Joshi, S. Westhoff, C.L. Reese, S.L. Bruggeman, J. Moriles-Miller-, L.B. Perkins, D.R. Joshi, S.Y. Marzano, and D.E. Clay. 2022. Phytoremediation and rainfall combine to improve soil and plant health in a North America Northern Great Plains saline sodic soil. J. Soil Water Conservation (in press).

Budak, M.E., D.E. Clay, S.A. Clay, C.L. Reese, S. Westhoff, R.K. Owens, G. Birru, Z. Wang, and Y. He. 2022. Increased rainfall may place saline/sodic soils on the tipping point of sustainability. Soil Water Conservation (in press).

Other Products:

Event: Saline and Sodic Soil Management Workshop and Field Tour. 30 June 2021, Carpenter SD. Attendance 50.

Critical Issue

Regenerative Agronomic Systems

Management of Emerging Insect Pests and Insecticide Resistance in South Dakota

Project Director

Ann Schwader

Organization
South Dakota State University
Accession Number
7000090

SDSU Integrated Pest Management Assists Stakeholders in Making Informed Decisions

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

The South Dakota Integrated Pest Management (SDIPM) program emphasizes providing professional agronomists and land managers up-to-date IPM training, developing a regional resource for insect, plant disease and weed management guidelines to address pesticide resistance management, and developing alternative pest management strategies. Improved knowledge of pest biology, impacts of environmental factors, pest forecasts, and communication that includes available technology, landowners, and managers can prevent unacceptable levels of pest damage by economical means, while posing the least possible risk to people, property, resources, and the environment.

The SDIPM program encourages stakeholders to make informed decisions for pest management to reduce input costs and environmental impacts of pesticides through the reduction of unnecessary and inappropriate applications. The SDIPM program is implemented by SDSU Extension Specialists who provide education and information on the biology of pests, impacts of pesticides, environmental factors that influence pests, and pest forecasts. The project has three goals:

1. The first goal is to develop applied research projects that will be used for demonstration and outreach programs in collaboration with SDSU Extension agronomy and agronomy-related specialists in South Dakota.

2. The second goal is to deliver IPM resources through the development and deployment of Extension programs for South Dakota stakeholders (i.e., residents, producers, consultants, and additional members of the agricultural community.)

3. The third goal of this project is to prepare and publish electronic and hard copies of Extension materials that will provide accurate pest updates, pest information and pest forecasts.

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 methods for reaching the target audience were both in-person and virtual. In 2021, demonstration plots were planted and managed by SDSU extension personnel for educational purposes at all four research farms: Volga Research Farm, Southeast Research Farm, Northeast Research Farm, and West River Research Farm. These plots were used both for in-person field days and for recording video demonstrations for the virtual IPM Field School. The plots consisted of weed management demonstrations, cover crop demonstrations, insect resistant host plant demonstrations, insect scouting demonstrations, and disease management demonstrations for corn, soybean, and wheat.

Extension personnel hosted and presented educational information at four field days and recorded demonstrations for one virtual
field school. The purpose of these meetings was to disseminate information obtained from research in South Dakota and surrounding states. Extension personnel also participated in one agricultural tradeshow and the South Dakota State Fair. The total contacts made at these events was approximately 12,000 stakeholders. In addition, extension personnel presented integrated pest management information to regional agricultural magazines and radio shows. The estimated contacts for these efforts were 200,000 stakeholders in both South Dakota and neighboring states. Along with in-person resources, extension personnel expanded our virtual outreach as well. The weekly/monthly Pest and Crop Newsletter had approximately 30,865 stakeholders reached per article per quarter. Our Crop Hour held from January to March had a total of 2,528 unique viewers during the live presentations and currently has 2,710 views on YouTube.

Pest management guides, identification guides, fact sheets, and newsletter articles were developed and published both in hard-copy and digital pdf during the on-going Covid-19 pandemic. These publications were handed out at in-person events and are available for download from the SDSU Extension website and the virtual IPM Field School.

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

Through these efforts, the SDIPM has helped stakeholders throughout South Dakota prevent pests from reaching economically damaging levels while also minimizing economic inputs and potential risks associated with human, property, and
environmental impacts of the pesticides. The SDIPM program is recognized by stakeholders as a primary source for pest management expertise and up-to-date resources. Extension agronomy personnel use applied IPM research to explore current and alternative pest management strategies to optimize agricultural production in South Dakota while minimizing economic and
environmental impacts.

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

The SDIPM program emphasizes providing professional agronomists and land managers up-to-date IPM training, developing a regional resource for insect, plant disease and weed management guidelines to address pesticide resistance management, and developing alternative pest management strategies. Improved knowledge of pest biology, impacts of environmental factors, pest forecasts, and communication that includes available technology, landowners, and managers can prevent unacceptable levels of pest damage by economical means, while posing the least possible risk to people, property, resources, and the environment.

Developing Processing Technologies for Advanced Utilization of Agricultural Commodities

Project Director
Bishnu Karki
Organization
South Dakota State University
Accession Number
1025481

Year 1 results: 12/31/20-09/30/21: Developing Processing Technologies for Advanced Utilization of Agricultural Commodities

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

The yellow pea protein has few challenges preventing products from entering food markets, including fiber contamination, off-flavors/smells, and low protein solubility. Saponins, the secondary metabolites produced in response to pathogens or environmental stress, are known to be the cause of off-flavors in the peas. Fungal fermentation has the potential to improve quality and broaden the applications of pea proteins in food markets.

This project will lead to the production of new and improved proteins of plant origin, specifically underutilized crops like pulse and lentils. While “using fermentation to produce high protein concentrates for feed use” has been around for many years, the novelty lies in approaching fermentation as a tool to enhance protein extractability and functional characteristics for food use.

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: Optimize fungal fermentation processes to improve the nutritional qualities of pulse products. (15% Accomplished)

This study evaluated the effects of 6 fungal organisms (Aspergillus niger, Aspergillus oryzae, Aureobasidium pullulans, Neurospora crassa, Rhizopus microspores var. oligosporus, Trichoderma reesei) in the fermentation of dry-processed pea proteins (DPP) for 120 h. Air classified DPP with 52% protein (dry basis) was obtained from AGT foods (Bismark, ND). The submerged fermentation was performed in 500 mL Erlenmeyer flasks at a 300 mL working volume. Moisture content of DPP was determined, and 30 g of DPP by dry basis was added to each flask (0.1 g/g solid loading rate). Heat sterilized slurries were then inoculated with 48 h inoculum of respective microbes using 0.1 mL/mL of working volume and incubated at 120 h at 30

℃ and 150 RPM. Starting at 0 h, 3 flasks were harvested every 24 h with the final samples being taken at 120 h (6 sample points total). Sampling procedure included centrifugation of fermented meal at 10,000xg for 10 min. Immediately after centrifugation, supernatant was decanted from the solids and mass of both fractions were recorded. Fermented material was analyzed for total phenolic content (TPC), saponin profile, mass balance, soluble and insoluble dietary fibers, and crude protein.

Results indicate that pea protein can support the growth of all fungi tested. Except for *A. pullulans*, protein titers of fermented solid fractions increased significantly with maximum of 69% with *N. crassa* treated samples. Significant increases in supernatant protein over 120 h were seen in *A. niger*, *A. pullulans,* and to a lesser degree with *R. oligosporus,* suggesting a solubilizing effect of fungal metabolism. No significant changes were observed in supernatant protein for other microorganism treatments. Fermentation of DPP with different microbes led to the significant loss in total solids (2.8–20.7% loss depending on fermentation time). The highest solid loss was seen with *T. reesei* with a loss of 20.7% solids. This loss in total solids can be attributed to the fungal metabolization of carbohydrates and fiber into carbon dioxide. Total saponin content of fermented peas were relatively higher than that of unprocessed peas (total saponin of 0.86, 0.70, 1.87 g/g db for raw, control and A. pullulan fermented DPP, respectively), however the increase was not statistically significant. But, when comparing treatments, *A. pullulans*, and *T. reesei* treatments were statistically different than the mean of the group. This indicates that organism treatments may facilitate extraction of saponins. It is predicted that hydrolytic enzymes of microbes likely caused the breakdown of DPP cell wall matrix and subsequently improved the saponin extractability resulting in a higher level of saponin content than raw and control samples.

A. pullulans and *A. niger* provided a significant increase in TPC as compared to the raw samples with an average of about 9 and 14 mg gallic acid equivalents (GAE) per gram of fermented material, respectively by 120 h. The other 4 organisms yielded similar maximum TPC measurements of 5–6 mg GAE per gram of fermented material which was not significantly higher than the raw samples. This clear distinction between *A. niger and A. pullulans* compared to other organisms indicates that TPC can be increased with fungal fermentation, but all organisms are not capable of these alterations.

Objective 1 Impact:

Overall, these results demonstrate potential benefits of microbial fermentation processes for new and improved plant protein sources, specifically in underutilized crops like yellow peas.

Objective 2: Compare the protein extraction yields and purity of fermented pulse proteins with unfermented pulse proteins. (1% Accomplished)

Currently, work is in progress to determine the extractability of the fermented pea proteins.

Objective 2 Impact: n/a

Objective 3. Characterize the impact of fermentation and subsequent alkaline extraction on protein structure and functionalities. (% Accomplished)

We needed to first develop the fermentation process for the peas, hence no work was done in year 1. This work will begin towards the end of this year when progress is made on objective 2.

Objective 3 Impact: n/a

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

Nothing to report at this time due to the short reporting period

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

Nothing to report at this time due to the short reporting period

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 opportunities:

An **undergraduate student** who worked on the project included: **Javi, Adividya,** (Microbiology). Javi learned microbial techniques (culture preparation, media sterilization, aspectic inoculation and sampling processes, microbe identification via plating and gram staining, cell count etc.), and other sample processing techniques by assisting the graduate student in the project.

An **MS student** who worked on the project included: **Camille Massmann, (Microbiology)**. As a part of MS thesis research, Camille learned several technical (experimental design, operating scientific protocols, data analysis and interpretation), communication (manuscript writing, oral presentation at scientific meetings), and mentoring skills by participating in this project.

A PhD student who worked on the project included: **Ahmad Alhomodi, (Microbiology).** Ahmad mentored both the undergradatue and MS student working in the project.

Dissemination:

Research findings have been shared through journal articles, conference presentations, theses and dissertations.

Plans for next reporting period:

Objective 1: Optimize fungal fermentation processes to improve the nutritional qualities of pulse products.

Work is currently underway to determine the feasibility of fungal processing on the dehulled peas

We are also exploring the different enzymatic activities of the microbes during fermentation of pea proteins.

Objective 2: Compare the protein extraction yields and purity of fermented pulse proteins with unfermented pulse proteins.

Experiments to determine the protein extractability of the fermented pea protein is currently underway

Objective 3. Characterize the impact of fermentation and subsequent alkaline extraction on protein structure and functionalities.

Work in this objective is dependent on progress in objectives 1 and 2.

Products:

Massmann, C., Berhow, M., Gibbons, W.R., Karki, B. 2021. Fungal fermentation: Exploring potential benefits for pea proteins. American Oil Chemists Society Annual Meeting and Industry Showcases. Virtual Meeting. May 3-14.

Massmann, C., Berhow, M., Gibbons, W.R., Karki, B. 2022. The effects of fungal bioprocessing on air-classified pea protein concentrates. LWT, 154, 112686.

Cover Crops, Intercropping, and Double-Cropping for Improving Profitability and Environmental Sustainability in the Northern Great Plains

Project Director
Thandiwe Nleya
Organization
South Dakota State University
Accession Number
1023151

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

Lack of soil cover and intensive tillage in the production of oilseed crops cause soil erosion, nutrient leaching, and water pollution from runoff. Lack of crop diversity poses risks to pollinators and health of the soil microbiome. In recent years, research and adoption of cover crops has increased nationwide and in the Northern Great Plains (NGP). Most of the acres reported as using a cover crop are in corn, soybean, or wheat rotations, while the adoption of cover crops in other crops is very limited. The lack of adoption is likely due to insufficient investment into research and therefore lack of science-based information about cover crops choices, establishment, termination, and benefits in these cropping systems.

In addition to the three main crops, corn (Zea mays L.), soybean (Glycine max L.), and wheat (Triticum aestivum L.), the Northern Great Plains (NGP) produces a wide range of crops that are important to the region and to the nation. For example, more than 85% of total U.S. production of sunflower, flax, and canola occurs in North Dakota, South Dakota, and Minnesota (NASS, 2018). These three crops are not only critical for farmers in the NGP, but also make essential contributions to food security in the country. Lack of soil cover and intensive tillage in the production of these crops causes soil erosion, nutrient leaching, and water pollution from runoff. Lack of crop diversity poses risks to pollinators and health of the soil microbiome. Increasing concentrations of salts at the soil surface due to capillary rise of water tables has created multiple problems that include soil structure degradation, reduced microbial activity, and an inability to sustain plant growth. Sodic and saline soils are impacting current, and will impact future, regional agroecosystems. Salt impacts to soil are very difficult to reverse. These changes occur gradually, but steadily worsen over time unless management practices are changed. Most row crops, including corn and soybeans, are sensitive to sodic or saline soils.

In recent years, research and adoption of cover crops has increased nationwide and in the NGP. Most of the acres reported as using a cover crop are in corn, soybean, or wheat rotations, while the adoption of cover crops in other crops is very limited. The lack of adoption is likely due to insufficient investment into research, and therefore a lack of science-based information about cover crops choices, establishment, termination, and benefits in these cropping systems. Winter crops as cash or cover crops can provide ground cover protecting the soil from wind and water erosion, sequester carbon, lower greenhouse gas emissions, and provide food source for pollinators. Double-cropping winter oilseeds for biofuel with a food crop such as sunflower would allow for production of biofuel and food crop on the same land, alleviating food versus fuel crop concerns. Intercropping can provide ecosystem services and reduce pest and disease pressure. The evaluation of cover crops and oilseed crops in slightly to moderately saline soils is needed to identify potential means to bring both productivity and biological activity back to marginal soils.

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: Integrate cover crops, intercropping, and relay cropping into various cropping systems to improve profitability and environmental sustainability. (20% Accomplished)

A field study was conducted at the Aurora Research Farm near Brookings, SD during 2021 to investigate the potential of canola, pea, and flax in intercropping versus monoculture systems. The three crops were grown at four seeding rates: 1) full rates (recommended seeding rate) in each monocrop, 2) full rates in each intercrop combination, 3) one-third/two-thirds rates intercrop combination, and 4) two-thirds/one-third intercrop combination of canola/pea, canola/flax and pea/flax. The experimental design was a randomized complete block (RCBD) with treatments replicated four times. Individual plot size 30 ft. long and 5 ft. wide with seven rows, 7 inches apart. The study was planted on 18 May 2021. Measurements included plant stands, days to flowering, canopy cover using the normalized difference vegetation index (NDVI), and yield advantage assessed with the land equivalent ratio (LER).

Data analysis is still in progress, but preliminary analysis of the canola/pea intercrop trial suggests that at the full seeding rate the combined pea and canola yield was 39% greater than the canola monocrop yield and was 261% greater than the pea monocrop yield. Pea yields in monocrop were lower due to the prevalence of white mold disease. This shows that intercrops can potentially reduce disease pressure. At the seeding rate of one-third canola and two-thirds pea, the combined yield was 30% lower than canola monocrop yield but 82% greater than pea monocrop yield. When the intercrop combination was two-thirds canola and one-third pea, the combined intercrop yield was 14.8% lower than the canola monocrop but more than double the monocrop pea yield (121% greater).

Similarly, LER was always greater (>1) under intercrops compared to monocrops indicating that intercrops were more productive than monocrops. However, it is important to note that pea yields in the intercrop were much lower that the canola yields, except where intercrops were seeded at the full seeding rate. For example, at a seeding rate of one-third canola and two-thirds pea, the intercrop yield of canola was 1,071 lb/ac and that of pea was 566 lb/ac. When the intercrop seeding rate was two-thirds canola and one-third pea, the yield of canola rose to 1,567 lb/ac whereas the pea yield was 408 lb/ac. This is compared to monocrop yields of 2,319 lb/ac for canola and 893 lb/ac for pea. NDVI data are still being analyzed, but trends are for greater NDVI (canopy cover) with intercrops as compared to monocrops.

Flax data is still being analyzed, to results on flax/canola and flax/pea combinations will be included in the next report.

Objective 1 Impact: These findings, though preliminary, suggest that canola-pea intercrops might yield greater that monocrops for each crop. In addition, intercrops provide better ground cover so they are valuable as means of protecting the soil from wind and water erosion thus enhance environmental sustainability.

Objective 2 Evaluate nutrient cycling and soil health to enhance environmental sustainability and long-term productivity (15% Accomplished)

A greenhouse experiment was conducted to evaluate a three crop/cover crop combination (barley, kernza wheat, and Florida broadleaf mustard) for performance under saline-sodic soils. We collected saline soil samples from a high salinity (> 4 dS ma-1) site near Clark, SD in the summer of 2021. A control soil sample was collected where there was normal plant growth near the same site. Sixty seeds of each crop were planted in cones eight inches in diameter and five inches tall filled with either of the two soil types (three with saline and three non-saline) and replicated two times. In addition, un-planted controls for each soil type were included for greenhouse gas (GHG) emission comparison with planted soils. Plant measurements included number of days to emergence, number of emerged plants 3 weeks after planting, and fresh and dry weight of plants 6 weeks after planting. Additionally, GHG emissions were monitored for three gases (carbon dioxide, methane, and nitrous oxide) according to the LI-COR protocol. The experiment will be repeated with two more replications. Data collection is still in progress but initial indications are that barley might be more tolerant to saline-sodic soils that kernza wheat and mustard.

Objective 2 Impact: This is an ongoing study. We hope to identify crops (cash or cover crops) that are tolerant to saline sodic soils and therefore can provide vegetation cover and bring back productivity in impacted soils.

Objective 3. Monitor effects on soil microbiome diversity and activity (5% Accomplished)

Soils were collected from different treatments in intercrop plots. These soils are currently stored in the freezer before sending them to Ward Laboratories Inc. for microbial diversity and activity analysis. The results will be presented in the next progress report.

Objective 3 Impact: N/A

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

Scientific community, farmers, extension personnel, and students.

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

Nothing to report at this time

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: Nothing to report at this time

Training and Professional Development:

Two graduate students were trained on the project.

Unius Arinaitwe, MS student, September 2019 to October 2021. 49% research assistantship. Assisted with field work and learned skills in experimental design and field experiments layout.

Deepak Josh, PhD student, January 2022 to present. 49% research assistantship. Assisted with greenhouse research and learned skills in experimental design and field experiment layout. Deepak is also monitoring GHG emissions from different treatments in the greenhouse study.

Dissemination: Nothing to report at this time

Plans for next reporting period:

Objective 1. Integrate cover crops, intercropping, and relay cropping into various cropping systems to improve profitability and environmental sustainability.

Repeat the intercrop study at the Brookings location.

Objective 2. Evaluate nutrient cycling and soil health to enhance environmental sustainability and long-term productivity

Complete the greenhouse study on evaluating cover crops growth on saline-sodic soils. Identify crop(s) that are more tolerant to saline-sodic soils and evaluate them under field conditions. Publish greenhouse study results.

Objective 3. Monitor effects on soil microbiome diversity and activity.

Analyze soils collected from the intercrop study treatments in the field and soil samples taken from treatments after GHG measurements in the greenhouse for microbial biomass and community structure.

No products or other products to report

Critical Issue

Regenerative Livestock Systems

Regenerative Livestock Systems
Project Director
Ann Schwader
Organization
South Dakota State University
Accession Number
7001895

Calf Value Discovery Program

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

In South Dakota, due to varied agro-ecologies associated with soil type and precipitation and temperature patterns, cow-calf systems are quite variable, ranging from extensive rangeland based systems in the west to integrated, mixed crop-livestock systems in the east, although these systems are not geographically exclusive. The success of a cow-calf operation is determined by the marketing strategy employed by the producer. Retained ownership is a program that allows producers the opportunity to start with as few as five of their own calves and pool them with other calves to see how they perform in a feedlot. Retained ownership can provide the greatest opportunity to realize the true value of cattle, but it can also have increased economic risks.

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 coordinated the Calf Value Discovery Program, a retained ownership program in which 14 cow-calf operations participated with 194 calves. Steers were vaccinated and dewormed by the producers prior to enrolling into the CVD program. Upon arriving at the CVD location steers were individually identified, weighed, and implanted. They were consigned to a local feed yard where they were fed in a single pen, visually evaluated and sold in semi-load lots (three loads/harvest time).

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

Cow-calf operation producers received feedback on feeding performance and carcass characteristics of calves. The data provides a benchmark for comparison with cattle from other operations and provides useful guidelines for making selection and marketing decisions in the future.

The Calf Value Discover program realized success as follows:

- Average feeding costs were $451.62 per animal. Load #1 averaged $398.06, load #2 averaged $459.18, and load #3 averaged $488.88.
- Average feedlot total costs were $620.38 per animal. Load #1 averaged $544.09, load #2 averaged $619.23, and load #3 averaged $672.06.
- As expected, steers in load #1 (3.85 pounds/day) gained faster compared to load #2 (3.67 pounds/day) and load #3 (3.26 pounds/day)
- Carcass value averaged $1,711.94 with the range from $1,265.58 to 1,971.45 (grid marketing basis).

Animals reaching the harvest date earlier returned more dollar in carcass value:

- Carcass value of steers harvested at 181 days on feed (load #1) were $1,724.49 compared to steers harvested at 216 days on feed (load #2) $1,715.73 and steers fed for 245 days were $1,699.76 (load #3). Seasonality prices normally start higher in May and decrease throughout the summer; however, summer of 2021 was not a normal pattern with average price per hundred pounds being $190.60/cwt for loads #1 and #2 and load #3 was $197.93.
- Steers harvested 64 days earlier returned $24.73 more per carcass, however, with the additional cost saving from feedlot expenses such as feed and yardage. The difference between load #1 and #3 allowed owners of steers harvested in load #1 to receive $177.40 more per head.

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

The Calf Value Discovery Program, a retained ownership program was coordinated by SDSU Extension to allow producers the opportunity to start with as few as five of their own calves and pool them with other calves to see how they perform in a feedlot. Several producers are using the data to influence their breeding program and some producers are using the data to market their calves for a higher price.

Development of a cost-effective environmental monitoring system for swine and dairy operations

Project Director

Xufei Yang

Organization

South Dakota State University

Accession Number
1021667

Year 2Results: 10/1/20-09/30/21:Development of a cost-effective environmental monitoring system for swine and dairy operations

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

The livestock industry is a powerhouse of the U.S. agricultural economy, with the total production (including cattle, milk, swine, sheep, and goats) valued at $108 billion. Despite its small population, South Dakota is a leading state of beef cattle and swine production. Beef, dairy, and pork together accounted for a gross income of $3.3 billion in the state. Along with many other Great Plains states, South Dakota has witnessed continual expansion and concentration of livestock operations. This, however, has spurred environmental concerns among the public. To achieve sustainable livestock development, efforts must be made to address relevant environmental issues.

One of the most critical environmental issues is impaired air quality caused by air contaminant emissions from livestock operations. These air contaminants not only deteriorate the environment but also compromise the health and welfare of animals and caretakers. The latter problem is particularly prevalent in confinement production systems where animals are housed at a high stock density. Maintaining good air quality in livestock housing environments is therefore of critical importance from both production and environmental perspectives. However, no regular monitoring of air quality parameters has yet been available.

The proposed monitoring system will address the environmental management demand by enabling livestock producers to access air quality information in a timely, automated, and affordable manner. The livestock industry in the U.S. is shifting from the traditional to the precision livestock farming (PLF) paradigm. As a big data-driven methodology, PLF demands the gathering of air quality and other livestock environmental data to support decision making for environmental control. For years only temperature has been routinely measured in livestock barns, even though other environmental parameters, such as humidity, particulates, and NH3, have a significant impact on animal growth and welfare, occupational health, and the environment. This project aims to develop an IoT-based monitoring system that measures several key air quality parameters in livestock barns and delivers the acquired real-time data to livestock producers and other authorized users via the Internet. With that, the producers will be able to precisely control the livestock environment to improve economic productivity while ensuring good environmental stewardship. The system, along with those monitoring the production performance and operating parameters in livestock barns, will enable a solid data foundation for the development of next-generation PLF 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: Assess the performance of low-cost particulate matter (PM) and gas sensors through lab and field experiments. (35% Accomplished)

Last year our work on sensor performance assessment comprised two tasks: 1) calibrating bench-scale, research-grade gas analyzers; and 2) testing low-cost particulate matter (PM) sensors in a university swine barn. Because the student (Mr. Zhisheng Cen) who was assigned to work on this project abruptly quit his Ph.D., no significant progress was made last year.

Regarding gas analyzer calibration, the newly established Air Quality Lab in the Raven Precision Ag Center allowed us to take all gas analyzers back from farm or storage sites for a thorough inspection, maintenance, and calibration. Given a large number of gas analyzers (e.g., 33 Honeywell single point monitors [SPM's]) were inherited from previous PI's, we have finished only half of the instruments. The work is time-consuming since there are various gas analyzers and many of the instruments have not been used for years.

Regarding PM sensor assessment, two replicate monitoring systems were deployed in a wean-to-finish swine barn. Each system (as reported in the 2020 report) consisted of seven low-cost PM sensors: Plantower PMS5003, Plantower PMS7003, Sharp GP2Y1010, DFROBOT Gravity, Shinyei PPD42, Nova SDS011, and Grove HM3301. Their monitoring data, along with timestamp (date and time), was saved to an SD card. The two systems were co-located with a Grimm 11-D Aerosol Spectrometer, with the latter serving as a reference. Two field sampling campaigns were made and each campaign lasted for one week. The testing time was shorter than planned (two weeks) because two brands of sensors (Sharp GP2Y1010 and DFROBOT) stopped working (which compromised the data acquisition of the entire system).

Based on the existing testing results, no low-cost PM sensors could accurately monitor PM concentrations in swine barns. Compared with the Grimm 11-D spectrometer, all the sensors significantly underestimated PM concentrations, especially the Plantower PMS7003 and Grove HM3301. Their measurement data correlated poorly ($R^2<0.61$) with the data derived from Grimm 11-D. All these low-cost PM sensors were based on light scattering. We speculated that for livestock environments with exceptionally high PM concentrations, light transmission-based PM analyzers or sensors (e.g., aethalometer) may perform better. We thoroughly reviewed the existing optical PM monitors and their detection principles. A journal manuscript was submitted.

Objective 1 Impact:

Our work on sensor assessment helped further resolve a key question relevant to future livestock environmental management, that is, the applicability of low-cost PM and gas sensors to the livestock environment. Last year, our research effort continued to focus on PM sensors. From that, some key findings were achieved. For example, the insuitablity of light scattering PM sensors for PM monitoring in livestock barns. In efforts to analyze the sensors' detection principle and compare them with regular, more expensive PM monitors, a comprehensive literature review paper was drafted. This long literature review report (>68k words, excluding references) is expected to profound our understanding of PM origins, properties, measurement, and migitation in confined swine facilities.

Objective 2: Develop a low-cost, photoacoustic ammonia sensor. (20% Accomplished)

Little progress was made. A visiting scholar with relevant experience did not come. Last year our efforts continued to focus on literature review and preparation work. Several essential tools and instruments were purchased and set up in the Air Quality Lab, including a programmable DC power supply, a benchtop multimeter, a benchtop signal generator, an oscilloscope, and a soldering microscope. We also had discussions with several photoacoustics researchers from institutions such as Desert Research Institute and the University of Texas-Austin. Upon their suggestion, we researched quartz-enhanced photoacoustic gas analyzers in the literature.

Objective 2 Impact:

Ammonia emission from livestock agriculture is anticipated to be regulated by the U.S. EPA in the near future. A low-cost, photoacoustic ammonia sensor will significantly improve our management of ammonia, a major noxious gas, in and released from livestock facilities. Our work on ammonia sensors last year had no immediate impact on this goal. However, the refining of sensor design and the acquisition of essential equipment have enabled us to move further forward towards prototype sensors.

Objective 3: Develop an Internet-of-things (IoT) based monitoring system. (45% Accomplished)

Our work last year focused on the development of prototype IoT systems. Three such systems were developed: (1) a low-cost IoT system for remote monitoring of thermal environments and manure levels in swine barns; (2) a low-cost, open-source smart scale system for cattle management; and (3) a rangeland water tank remote monitoring system. The first system was built by two undergraduate students (Audree Berreth and Hunter Koolstra) under the PI's mentoring. Commercial LoRaWAN IoT parts were used. The system was tested on a university swine farm. With the system (~$300), farm workers were able to track the thermal environments and manure buildup inside the swine barn. The results were overall encouraging. Excluding a few outliers, the data generated showed clearly the diurnal and monthly variations in in-barn air temperature and humidity, thereby helping producers improve livestock environmental management. The project has been completed. It resulted in one extension article (further broadcasted by swineweb.com) and several industrial inquiries.

The second system (smart scale) integrated load bars (for livestock weighing), EID readers (for scanning ear tag ID), WIFI modules (for wireless data transmission), SD modules (for local data storage), approaching sensors (for identifying the presence of animals) and microcontrollers into an IoT sensor node. Since the node used WIFI, the data was submitted to the Internet via a regular WIFI router. The measurement data (livestock ID and weight) were then stored and visualized using myDevices Cayenne. It is noteworthy that commercial smart scale products are available. However, they are expensive in terms of both one-time and service costs. The purpose of the project was to develop a low-cost, open-source smart scale solution to better serve cost-conscious livestock producers. The project was a collaboration with Dakota Lakes Farm in Pierre, SD and it is still ongoing.

The third project (rangeland water tanks) was the continuation of a project reported in 2020. It was a collaboration with Dr. Jameson Brennan from the SDSU's West River Extension Station. Last year we focused on 1) field assessment of the prototype system; and 2) migration of IoT and application servers. Specifically, three prototype systems were set up and tested on a cattle ranch near the West River Extension Station. Overall the systems worked well. Unreliable water temperature and level readings were occasionally seen possibly because of challenging weather conditions. Ms. Mengling Ding assisted Dr. Brennan

and the PI in server migration. Specifically, we migrated all LoRaWAN sensor nodes and gateways from The Things Network (TTN; an IoT server) version 2.0 to TTN version 3.0; and migrated the application server from myDevices Cayenne to Amazon Web Service (AWS IoT). New dashboards were created using Node-Red, an open-source programming tool initially developed by IBM. The project has been completed. A presentation was given during the ASABE 2021 Annual Meeting. The framework (TTN 3.0 + AWS IoT + Node-Red) can be used as a general platform for future IoT research/extension efforts at SDSU.

Objective 3 Impact:

Our work on IoT monitoring systems facilitated the implementation of IoT technologies for precision livestock farming. Through the first project, two undergraduate students were training and gained essential research and extension experience. An extension article was published and broadcasted on an International news channel. The second and the third projects expanded the research scope of the PI's group, from livestock environmental monitoring to other livestock-related monitoring efforts. The platform created through the research will be useful for future Ag IoT research/extension efforts at SDSU.

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

Livestock producers and industry partners. Livestock producers and industry partners were targeted because they would be the end-users of the proposed monitoring systems. They also help identify and prioritize the research needs. Last year, the PI reached out to 140 livestock producers, barn builders, and equipment suppliers in South Dakota and neighboring states through farm visits, in-person, and virtual extension workshops. The PI is currently collaborating with three companies/farms on sensors and IoT systems.

Academia. Last year the PI continued his collaboration with SDSU researchers from the departments of Agricultural and Biosystems Engineering, Animal Science, and Electrical Engineering and Computer Science. He also initiated a partnership with Dakota Lakes Research Farm in developing precision livestock farming systems. Beyond South Dakota, the collaborators included researchers from the University of Minnesota and the University of Georgia.

Students. Undergraduate students were targeted through the PI's Agricultural Waste Management course. A new lecture named "Application of IoT for Livestock Farming" was incorporated into the course. Last year, 28 undergraduate students took the course and they came primarily from Dairy Production and Agricultural System Technology programs. Most students intended to work in the livestock industry after graduation. Three undergraduate students conducted research under the PI's mentoring. The PI advised four graduate students, offering professional training and guidance.

General public. The general public was targeted because their perception of livestock environments will have a significant impact on the future of livestock farming. Meanwhile, the quick development and deployment of smart home technology have spurred the public interest in precision livestock farming. Last year, we disseminate the findings from this research project to the general public through publications, campus visits, conference presentations, and extension/outreach events.

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

Livestock producers learned about the PI's research through his extension and outreach acitivity as a state extension agent. Two livestock producers were involved in livestock IoT system development. One leading livestock producer contacted the PI for further information about LoRaWAN IoT systems. Other stakeholders were also benefited from the PI's research. For instance, one water infrastructure company contacted the PI for future collaboration in promoting the development of IoT infrastructure in rural areas in upper Midwest.

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: The covid-19 pandemic continues to adversely impact student recruitment, professional conferences, and extension activities. As an example, the American Society of Agricultural and Biological Engineers (ASABE) 2021 Annual Meeting was still held online. Mr. Zhisheng Cen, the Ph.D. student hired to work on this project, abruptly left the PI group. This also exerts an adverse impact on the project's progress. The Agricultural and Biological Engineering Department moved to a new building. No experimental work was done for two months (mid-June to mid-August) because of the relocation.

Training: The project provided great opportunities for undergraduate and graduate students from diverse backgrounds to exchange research ideas, work as a team, and learn Internet-of-Things (IoT), and sensor technologies. Through the project, three undergraduate students and four graduate students (including part-time ones) were advised/mentored. Because IoT and sensors are new to most students, the PI has spent on average 8 hours per week advising/mentoring the students. The students' work has resulted in one journal manuscript, two conference presentations, and three prototype products.

The students involved or trained in this project are listed below:

Zhisheng Cen was a **Ph.D. student in ABE** (Aug 2020–May 2021). With a background in applied chemistry and agricultural and biosystems engineering, he was recruited to develop low-cost ammonia sensors and IoT environmental monitoring systems. He assisted the PI and undergraduate students in installing and testing IoT networks at a university research farm. He quit his Ph.D. in May 2021 citing his loss of interest in academia and decision to pursue an industrial career.

Noor Haleem is a current **Ph.D. student in Biological Science (ABE option)** (Aug 2021–Present). With a background in chemistry and environmental science, Noor was a new hire and a replacement for Mr. Zhisheng Cen. He has little experience with electronic circuits and instrumentation development. He is receiving training about monitoring systems, sensors, and circuits.

Augustina Osabutey is a current **Ph.D. student in ABME** (Jan 2020–Present). With a background in mechanical engineering and environmental engineering, Augustina assisted the PI in testing and comparing low-cost gas and particulate matter (PM) in animal confinement buildings.

Mengling Ding is an **M.S. student in Computer Science** working as a part-time student for this project (Jun 2021-Aug 2021). Mengling helped the PI accomplish three IoT-related tasks 1) migrating devices from The Things Network (TTN) version 2 to TTN version 3; 2) migrating the application servers from myDevices Cayenne to Amazon Web Service (AWS) IoT; and 3) developing new dashboards using Node-Red.

Audree Berreth is an **undergraduate student in Animal Science and Pre-Vet.** Audree and Hunter developed and deployed a low-cost IoT system for monitoring manure pit conditions and air temperature and humidity in animal confinement buildings. The system allows for improved assessment and control of air pollutants.

Hunter Koolstra is an **undergraduate student in Agricultural Science and Precision Agriculture.** Under the PI's mentoring, Hunter and Audree teamed together to develop a low-cost IoT system for monitoring manure pit conditions and air temperature and humidity in animal confinement buildings.

Harsh Dubey was an **undergraduate student in electrical engineering and computer science.** He came back to SDSU for makeup credits and helped the PI to further polish the farm monitoring system dashboards in Jan 2021. He is now employed by Intel.

Dissemination: Two conference presentations were given last year. One journal article was submitted. One extension article was published on the SDSU Extension iGrow website. It was broadcasted by swineweb.com, an International news-press channel, as a featured article under technology advancement. We also gave presentations through the SDSU extension program to promote the awareness of IoT-based environmental management among extension specialists, livestock facility builders, and producers. In addition, the PI visited about ten livestock farms and had in-person conversations with producers who were interested in precision livestock farming technologies.

Plans for next reporting period: The PI will continue to explore collaboration opportunities with academia and industry in developing cost-effective solutions for environmental monitoring in swine and dairy facilities. He will maintain an intimate partnership with field extension specialists and livestock producers to identify research needs and disseminate the knowledge and products derived from the research project to end-users. In addition, the PI intends to work with researchers from the Agronomy, Horticulture, and Plant Science (AHPS), and the Natural Resource Management (NRM) departments to facilitate the implementation of IoT technology for greenhouses, crop production, and natural resource conservation and to promote the idea of open-source smart farming.

Objective 1: Assess the performance of low-cost particulate matter (PM) and gas sensors through lab and field experiments.

We will try to acquire or build a simple aethalometer and assess its applicability for PM measurement in dusty livestock barn environments. Meanwhile, we will modify the air inlet and optical chamber of PMS5003 sensors to improve their transfer efficiency and detection sensitivity for coarse particulates. We will test low-cost gas (H_2S, VOCs, and CO_2) sensors against reference research-grade gas analyzers to identify the best-performing ones for livestock environmental applications.

Objective 2: Develop a low-cost, photoacoustic ammonia sensor.

We will finish the design and fabrication of a prototype ammonia sensor, in collaboration with the new Automation Engineer and Biosensor faculty members in the Agricultural and Biosystems Engineering Department. We will challenge the prototype sensor with different NH3 concentrations and humidity levels to determine key design and operating parameters such as zero drift, sensitivity, linearity, reproducibility, detection range, and method detection limit. A detailed design document will be drafted.

Objective 3: Develop an Internet-of-things (IoT) based monitoring system.

We will work closely with Dakota Lakes Farm and finish the lab and field testing of the prototype smart scale system. We will start the design and development of a LoRaWAN IoT-based LiDAR system for tracking feed usage in feed bins (and grain in storage bins). For the prototype IoT-based environmental monitoring system, we plan to revisit its design and make it more modularized. Meanwhile, we will continue to polish the farm monitoring system dashboards and finish the migration of the application server (including the dashboards) from a local HTTP server to AWS IoT.

Products:

Yang, X., Haleem, N., Osabutey, A., Cen, Z., Albert, K. L. 2022. Particulate matter in swine barns: A comprehensive review. Animals. (under review).

Cen, Z., Brennan, J., Ding, M., **Yang, X.** 2021. An IoT-based system for remote monitoring of water levels in rangeland water tanks. ASABE 2021 Annual Meeting. (virtual). July 14.

Cortus, E. L., Samuel, R. S., **Yang, X.**, Thaler, R. C., Hetchler, B. P. 2021. Evaluating gas and particulate matter emissions and downwind concentration impacts using the EPI air filter wall system. 2021 ASABE 2021 Annual Meeting. (virtual). July 14. Paper No. 2100656.

Yang, Thaler, R. Samuel. R. 2021. A low-cost solution to remote monitoring of animal facility thermal environments. SDSU Extension. Accessed at: https://extension.sdstate.edu/low-cost-solution-remote-monitoring-animal-facility-thermal-environments

Yang, X., Ding, M., Thaler, R. Samuel. R. 2021. Web SDOFT

Other Products:

Event: Dec 11, 2020. South Dakota CAFO Environmental Training Workshop, Huron, SD

Event: Mar 4, 2021. South Dakota CAFO Environmental Training Workshop, Huron, SD

Event: May 20-21, 2021. Multistate Research Project S1074 Annual Meeting (virtual)

Event: Jun 28, 2020, South Dakota CAFO Environmental Training Workshop, Huron, SD

Event: Feb 25, Mar 4, Mar 11 & Mar 25, 2021, Minnkota Annual Meeting (virtual)

Event: Nov 3, 2020, SD Swine Day, Brookings, SD

Event: Jul 29, 2021, Ag Ph.D. Field Day, Baltic, SD

Event: Aug 19, 2021, Dakota Fest, Huron, SD

Product: A prototype IoT monitoring system for monitoring water levels and temperatures in livestock water tanks

Product: A prototype IoT monitoring system for monitoring pit manure levels and thermal environments in swine barns

Product: A prototype low-cost, open-source smart scale for cattle ranches/farms

Water intake of growing beef bulls

Project Director

Cody Wright

Organization

South Dakota State University
Accession Number
1012985

Year 4 results 10/01/20-09/30/21: Water intake of growing beef bulls

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

Currently available water requirements for beef cattle were developed over 60 years ago, and while the data generated at that time was of excellent quality, the animals used in those experiments are not necessarily representative of the beef cattle of today. Understanding the water needs of cattle and how the weather impacts those needs is essential to meeting their demands for optimal production and minimizing any negative impacts on the environment.

Currently available water intake requirements of beef cattle have not been updated for changes in animal size and level of production, and may not accurately represent the needs of the animal. Furthermore, the effect of the ambient environment on water requirements is not well understood, particularly in colder climates.

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: Determine the effects of weather, body weight, and dry matter intake on the water consumption of growing beef bulls. (80% Accomplished)

During the reporting period the fourth year of feed and water intake data were collected. Angus (n=14) and SimAngus (n=17) bulls (average starting body weight = 290.2 ± 31.5 kg) were housed in a partially covered pen and fed a common diet consisting of corn silage, high-moisture corn, alfalfa hay, soybean meal, and dried distillers grains plus solubles. The composition of this diet was 42.9% dry matter; 14% crude protein; and 1.15 Mcal NEg/kg DM. Feed was offered twice daily to approximate ad libitum intake. Any feed refusals were discarded. Feed and water disappearance were measured using the Insentec RIC system. Data were checked for errors and summarized for each animal. Weights were collected monthly on all of the animals. We did not have a student interested in summarizing the data for this reporting period. As such, the data were recorded and stored for future use. After collection of the year 4 data, climatic data will be gathered from the South Dakota MESONET system, combined with the feed and water intake and animal body weight, then analyzed as a complete 4-year project. The results will be reported at either the Midwest Section or National American Society of Animal Science annual meeting, and published in a peer-reviewed journal.

Objective 1 Impact:

Collection and analysis of this data will inform facility design, allow for accurate estimation of water requirements, and more accurately predict water usage of beef cattle. These data were collected on intact growing bulls, however, extrapolation to other classes of beef cattle merits investigation.

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

The ultimate target audience for this project is beef producers that raise bulls. However, in order to reach that audience effectively, other audiences must be engaged. Extension personnel will be the first target audience to help facilitate the direct dissemination process to beef producers. Industry consultants, nutritionists, and veterinarians will also be targeted because of their direct impact on the best management practices utilized by beef producers. Each of these audiences will be reached using a combination of dissemination strategies including peer-reviewed journal articles, Extension publications, professional meetings, continuing educational opportunities, and popular press.

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

The broader public benefit of this research will be a more thorough and accurate understanding of the water needs of growing beef cattle. Such knowledge will allow for optimization of animal production while minimizing the environmental impact of livestock production.

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