

Utah (Utah State University) Annual Report - FY2021

Report Status: Approved as of 09/29/2022

Contributing Organizations

Utah State University

Executive Summary

Overview

Utah State University Extension

Utah State University (USU) Extension delivers relevant information, education, and solutions to individuals, families, and communities across Utah. USU Extension provides research-based education and information on agriculture and natural resources, home gardening, family wellbeing, relationship education, food nutrition and safety, emergency preparedness, community development, and youth programs. USU Extension plays a primary role in helping Utah State University fulfill its land-grant mission. Though more than 100 years old, USU Extension is as important as ever due to the increased diversity and complexity of the issues affecting Utah residents. The integration of teaching, research, and public service enables USU Extension to respond to critical and emerging issues with research-based, unbiased information. USU Extension focuses on seven (7) critical issues, as defined by NIFA, these are (1) Global Food Security and Hunger, (2) Climate Change and Management of Natural Resources, (3) Nutrition and Health, (4) Food Safety, (5) Healthy, Financially Secure Families, (6) Youth Development, and (7) Community Resilience.

Table 1: Summary of Critical Issues

<i>Critical Issue</i>	<i>Description and Objectives</i>
Global Food Security and Hunger	We must develop more stress-resistant crops and ensure an improvement in overall agricultural productivity. The objective of USU Extension is to enhance Utah food security through productive and sustainable agricultural systems.
Climate Change and Management of Natural Resources	Agriculture is climate dependent; any changes in the environment will require that plants and animals adapt to climate change. The objective of USU Extension is to be at the forefront in adapting to new climate realities, as well as mitigating many of the influences of climate change.
Nutrition and Health	Much of the most vulnerable populations, such as young children and aging adults, are subject to food scarcity and poor diets. The objective of USU Extension is to enable a healthy population through education on affordable and nutritious diets and healthy living.
Food Safety	Pathogens can enter the food supply during the production, harvest, processing, and transporting process. The objective of USU Extension is to reduce foodborne illnesses through education on proper food preparation, storage, preservation, and canning.

Healthy, Financially Secure Families	Utah families face high debt loads, rural-urban migration, and high divorce rates. The objective of this of USU Extension is to enhance individual and family resource management. Other aspects include healthy marital and family relationships, and mental health and wellbeing.
Youth Development	Youth development is critical to the future prosperity of Utah. Utah 4-H of USU Extension actively builds the knowledge, skills, and attitude of youth to prepare them for a successful life. The objective of USU Extension is to facilitate positive youth development to ensure a bright future for youth.
Community Resilience	Community resilience and development through economic prosperity and social capital is necessary to strengthen urban and rural communities. The objective of USU Extension is to promote community resilience through sound community planning, youth and adult education, recreation, and family support services.

USU Extension is committed to improving the lives of Utahns through non-formal education. Therefore, it is necessary to continuously monitor and demonstrate our impact on individuals and communities across the state. Outreach programs for each *Critical Issue* are aligned to key social, economic, and/or environmental (SEE) conditions. Program impact is assessed through changes in behavioral indicators that reflects SEE conditions. Statewide program evaluation activities are geared towards measuring changes in individual and community behaviors that correlate to improved quality of lives for Utahns.

Utah Agricultural Experiment Station

The Utah Agricultural Experiment Station supports diverse research programs in six of the eight colleges at Utah State University: the College of Agriculture and Applied Sciences, the Quinney College of Natural Resources, the College of Sciences, the College of Engineering, the Emma Eccles Jones College of Education and Human Services, and the College of Humanities and Social Sciences. In 2021, UAES supported scientists engaged in 92 Hatch Projects, 14 McIntire-Stenis Projects, 3 Animal Health Projects, and 86 State Funded Projects. In addition, USU faculty participated in 37 Hatch Multistate projects. Many of these reserach projects, particularly the projects where the PI is also and Extension Specialist, generate new information that directly informs our Extension Programs.

Critical Issue: Climate Change and Management of Natural Resources

Major Extension Program: Sustainable Natural Resources

Program Goal: To provide non-formal education to residents, stakeholders, and organizations to promote, facilitate, and strengthen environmental stewardship and sustainable natural resource use in Utah. This project primarily focuses on forest management, water conservation, and stewardship of public lands.

Desired Program Outcomes:

1. To equip residents with the competency to effectively engage in natural resource conservation and preservation
2. To facilitate partnerships between community members and public and private stakeholders to strengthen natural resource conservation and enable sustainable resource use.

Notable Results in FY21:

- *Center for Water Efficient Landscaping (CWEL):* The faculty team developed the monthly “Water Well with CWEL” webinar series in 2021.
 - There were 1,376 members on the webinar list serve, 3,430 individuals have registered for events, 2,097 attendees to educational events, and 4,461 YouTube views.
 - In 2021, CWEL saw a 36% increase in registration, 37% increase in attendance, 52% increase in members to the email list serve, and 203% increase in YouTube views. In 2021, 9 webinars were facilitated by CWEL. Of the 765 attendees across the 9 events, 436 were unique viewers.
 - Evaluation results indicated about 86% of the participants acquired resources they can use to promote efficient landscape water use and conservation.

- All respondents reported an increase in knowledge related to landscape water use and conservation after attending the events.
- Most participants (90%) indicated that they gained water conservation ideas they can implement.
- After attending a CWEL educational activity, about 39% of participants adopted best practices for water conservation, and 53% indicated they planned to adopt best practices.

Utah Agricultural Experiment Station

Climate Change and Management of Natural Resources is a major research area for the Utah Agricultural Experiment Station. In 2021 there were 27 active Hatch projects, 14 active McIntire-Stennis projects, plus additional projects funded by state matching funds, that addressed this Critical Issue. Descriptions and results for these research projects are included in the results section of this report.

Critical Issue: Community Resilience

Major Extension Program: Vibrant Communities

Program Goal: To strengthen communities across Utah through facilitated community-focused coalitions and partnerships, entrepreneurship education, and strategic initiatives to facilitate economic and social wellbeing.

Desired Program Outcomes:

1. To connect rural communities to economic opportunities in urban centers through innovative workplace practices (e.g., remote working arrangements),
2. To facilitate educational interventions, and community partnerships and coalitions to reduce substance abuse disorders in rural counties.

Notable Results in FY21:

- *Rural employment:* The Rural Online Initiative (ROI) of USU Extension developed the Master Remote Work Leader (MRWL) certificate course to provide specialized training for organizational leaders on core skills for effectively creating remote work environments and leading hybrid-remote and fully distributed employees.
 - Results showed statistically significant differences between pre-and-post test scores for all seven modules of the MRWL course. As such, organizational leaders demonstrated significant increases in their knowledge of creating a remote work environment.
 - After course completion, participants felt they had better abilities to balance their professional and personal lives, manage their professional and personal productivity, solve problems, communicate digitally, use online technology, engage in teamwork, and manage their careers.
 - Upon course completion, 90% of participants reported they were more likely to create remote work positions in their organization; almost all participants (99%) felt their value as a leader of remote employees improved; and 61% indicated they were more likely to hire qualified residents from rural Utah.
- *Substance Use Disorder Treatment:* The State of Utah and USU Extension began providing para-professional peer support specialist certification in 2010. State-approved Certified Peer Support Specialist (CPSS) programs offer 40-hour trainings to individuals with at least six months of recovery.
 - After the training, post-survey results showed that respondents had higher levels of agreement that peer support specialists are helpful on the road to, and are trained to uplift persons struggling with mental illness and substance abuse disorders.
 - Results indicated a significant increase in participants' knowledge about the requirements of CPSS certification and the job opportunities for a CPSS in the State of Utah.
 - In rural counties with low access to mental health providers, increased CPSS trainings support employment for those who are in recovery while building a treatment workforce.
- *Partnerships in Rural Counties:* USU Extension created a culturally responsive and multi-pronged community approach to tackle Substance Use Disorder (SUD) in Tooele county, Utah. This led to a consortium of stakeholders with a shared vision to address SUD in rural counties.
 - Consortium membership increased in size and diversity – from four (4) organizations to fifteen (15), and a doubling membership of Recovery Community Organizations (RCOs). This resulted in expansion of services such as gas card support for treatment access, and funding the planning phase for a crisis nursery and a methadone clinic.

- The number of Tooele County physicians to treat opioid use disorder with FDA-approved buprenorphine medication increased by 40%.
- The consortium compiled a stigma reduction resource booklet for healthcare providers and community members, which includes evidence-based information on safe opioid use, prescribing guidelines, and treatment and harm reduction resources for people with SUD.
- Survey results from stigma reduction trainings showed increased support for MOUD (methadone and buprenorphine) and harm reduction interventions. Findings show there was a large increase in support from public attendees for harm reduction interventions.
- The USU Extension team distributed 79 naloxone kits directly to community members and 660 naloxone kits to community agencies and consortium partners.

Utah Agricultural Experiment Station

Community Resilience is a minor research area for the Utah Agricultural Experiment Station. In 2021 there were five active Hatch projects, plus additional projects funded by state matching funds, that addressed this Critical Issue. Descriptions and results for these research projects are included in the results section of this report.

Critical Issue: Food Safety

Major Extension Program: Public Food Safety Education

Program Goal: To provide relevant research-based education to Utah residents on best practices to reduce the risk food contamination and foodborne illnesses. Major focus areas of this program are food preservation techniques and household food storage.

Desired Program Outcomes:

1. To reduce the occurrences of foodborne illnesses in Utah through research-based education on food safety practices in households
2. To reduce food contamination in the food supply chain by providing relevant education on best practices to processors and producers.

Notable Results in FY21:

- *Food Preservation:* USU Extension created an online food preservation series. In 2021, a series of five (5) comprehensive canning classes were taught in a live online format.
 - Pre-post evaluation results showed there were a significant increase in participants' knowledge of freeze drying, dehydrating, and pressure canning after completing the series.
 - Participants were confident in their ability to follow safe home food preservation practices, and to share safe food preservation methods with others.
 - Over 80% of participants stated they plan to implement recommendations made by the instructor.

Utah Agricultural Experiment Station

Food Safety is an important research area for the Utah Agricultural Experiment Station. In 2021 there were six active Hatch projects, plus additional projects funded by state matching funds, that addressed this Critical Issue. Descriptions and results for these research projects are included in the results section of this report.

Critical Issue: Global Food Security and Hunger

Major Extension Program: Agriculture and Natural Resources

Program Goal: To meet the needs of traditional agriculture while evolving to meet the needs of developing agricultural industries.

Desired Program Outcomes:

1. To increase the productivity and efficiency of Utah agricultural operations.
2. To promote sustainable natural resource use through relevant education on conservation practices.

Notable Results in FY21:

- *Underserved farmers:* USU Extension facilitated the Beginning Farmer and Rancher program to develop educational opportunities for underserved audiences in agriculture, including women, Hispanics and Native Americans.
 - Post-evaluation results indicated 82% of the participants increased their knowledge of agricultural production practices.
 - For high school (FFA/4H) students, 100% increased their understanding of urban farming systems, and 15-20% plan to complete an urban farm project.
- *Food security:* A team of faculty in Davis County, UT created a community garden and deliver nutrition education to residents living in subsidized housing complex of a community considered food insecure.
 - Post-evaluation results of the community garden and nutrition education activities in Davis County indicated participants increased their understanding in what crops grow best in Davis County, improved skills such as planting a seed and knowing when to harvest fruits and vegetables, increased their consumption of fresh fruits and vegetables, and reported increase in enjoyment in gardening.
 - In the subsidized housing complex where one garden was developed, a participant stated, “this has really brought our community together and I am happy to say, everyone has shown the utmost respect for the project.”
- *Agricultural inputs:* The USU Pesticide Safety Education team spearheaded an effort to provide virtual pesticide training sessions for applicators during COVID-19 due to the cancellation of face-to-face trainings.
 - Evaluation results indicated participants’ knowledge on pesticide safety, law, and use improved after the sessions.
 - Results of a pre-post self-assessment indicated participants experienced a statistically significant increase in their knowledge related to topics covered during the private and commercial applicator events, including mental health self-awareness, state and federal laws, and sprayer calibration.
- *Mental health in agriculture:* A team of faculty at USU Extension developed a research-based outreach course to address stress and mental health in agriculture.
 - Using a pre-post design, results indicated participants had an increase in knowledge related to recognizing, identifying, and responding to mental health issues after completing the course.
 - With respect to intentions, more than half the number of total participants (62%) stated they intended to adopt mental health best practices.
- *Varroa Mites:* Varroa mites and the diseases they carry represent the single biggest challenge facing honey bees in most areas of the world. A USU Extension faculty implemented the Thriving Hive program.
 - There was a 61% increase in the use of Varroa mite monitoring methods by participants after completing the Thriving Hive classes.
 - Evaluation results show 100% of respondents from beginning beekeeping classes intended to use Varroa mite monitoring methods and treat for Varroa mites.

Utah Agricultural Experiment Station

Global Food Security and Hunger is a major research area for the Utah Agricultural Experiment Station. In 2021 there were 45 active Hatch projects, three active Animal Health projects, plus additional projects funded by state matching funds, that addressed this Critical Issue.

Descriptions and results for these research projects are included in the results section of this report.

Critical Issue: Healthy, Financially Secure Families

Major Extension Program: Individual and Family Resource Management

Program Goal: To enhance individual and family resource management (FRM). FRM relates to financial management, family health, healthy marital and family relationships, and mental health and wellbeing.

Desired Program Outcomes:

1. To strengthen family relationships.
2. To improve the economic wellbeing of individuals and families.

Notable Results in FY21:

- *Marital relationships:* A team of faculty implemented the Utah Marriage Celebration to help couples gain knowledge and learn skills to strengthen their relationships.

- A follow-up evaluation indicated most participants agreed that since attending the Marriage Celebration they were “committed to working more” on their marriage (97%), and were more “committed to investing more time together for their marriage” (95%).
- When asked what changes they have seen in their relationship since the Utah Marriage Celebration event, participants said, “Increased connection, more positivity, better communication,” and “renewed commitment to each other.”
- *Financial wellness:* A USU Extension team implemented the Empowering Financial Wellness program (EFW) to provide personal financial management education to counties across Utah.
 - Participants experienced a statistically significant increase in knowledge on personal financial management topics after completing all eight modules of the online certificate course.
 - With respect to skills, over 90% of participants in the course indicated they were confident in their ability to create a SMART financial goal, keep track of their expenditures, and create a zero-based budget.
 - Two months after completing the course, participants reported adoption of best financial management practices; 100% of participants identified their money personalities, 83% created SMART money goals, 71% tracked their expenditures every month, 93% reported positive changes to their credit scores, and 88% established emergency savings.
 - Four months after completing the course, results show positive financial wellness among participants; 95% of participants agreed they could handle a major unexpected expense, 90% agreed they can enjoy life because of the way they managed their money, and 65% agreed they had money left over at the end of the month. Overall, about 75% of participants expressed improved financial wellness.
- *Homeownership:* The USU Extension Homebuyer Education courses are HUD and USDA Rural Housing approved. The courses meet the research-based National Industry Standards for Homeownership Education and Counseling.
 - Three (3) months after completing the Homebuyer course offered by USU Extension, most participants reported they implemented financial management strategies to make informed decisions regarding purchasing a home, and developed confidence and understanding the process home buying process.
 - Findings show participants were able to secure funds from a grant or other financial assistance program to help with their home purchase. These grants ranged from \$5,000 to \$20,000 each. One participant said, “this course has given me information about home buying process that I had no prior information.”

Utah Agricultural Experiment Station

Healthy, Financially Secure Families is a minor research area for the Utah Agricultural Experiment Station. In 2021 there was one active Hatch project, plus additional projects funded by state matching funds, that addressed this Critical Issue. The description and results for this research project are included in the results section of this report.

Critical Issue: Nutrition and Health

Major Extension Program: Public Nutrition and Health Education

Program Goal: To decrease the incidences of chronic diseases and other nutrition-related health issues among residents through non-formal nutrition education. The priorities for this program are to expand nutritional research and education, and to promote healthy dietary habits.

Desired Program Outcomes:

1. To empower residents to make healthy food choices and improve their nutritional intake.
2. To reduce the economic cost of chronic diseases in Utah.

Notable Results in FY21:

- *Access to fresh produce:* Create Better Health of USU Extension developed the Buy Produce for Your Neighbor healthy food drive initiative to address food insecurity and low consumption of fruits and vegetables.
 - The reach of the Buy Produce for Your Neighbor program has expanded since it began, providing donations to one (1) food pantry in 2019, five (5) in 2020, and eleven (11) in 2021.
 - Approximately 381 lbs. of food were donated in 2019, while 6,206 lbs. were donated in 2021. This represents a 1500% increase in the amount of food donated to pantries over a three-year period.
 - A single parent of six children expressed gratitude for the program and its impact on her family after receiving fresh produce from her local food pantry, saying, “This is the only way my family can get fresh fruits and vegetables; we are so grateful for

this program.”

- *Access to fresh produce in rural counties:* USU Extension’s Create Better Health and the Hunger Solutions Institute partnered with the Utah Farm Bureau and Miracle of Agriculture Foundation to develop Farmers Feeding Utah (FFU) campaign to connect food-insecure residents to farmers and ranchers for locally produced food.
 - FFU served over 23,000 Utah families directly through food distribution, with each family receiving approximately \$80 worth of locally grown Utah food.
 - Food pantries (31) were provided with a variety of local fresh foods to stock their shelves.
 - The retail value of food that has been distributed to families and pantries through FFU totaled over \$3.1 million dollars.
 - FFU has also supported 32 Utah farmers and ranchers, including those that raise livestock, vegetables, fruits, and grain.

Utah Agricultural Experiment Station

Nutrition and Health is an important research area for the Utah Agricultural Experiment Station. In 2021 there were seven active Hatch projects, plus additional projects funded by state matching funds, that addressed this Critical Issue. Descriptions and results for these research projects are included in the results section of this report.

Critical Issue: Youth Development

Major Extension Program: Utah 4-H: Positive Youth Development

Program Goal: To empower youth success through hands-on projects in educational areas including science, health, agriculture, and civic engagement. Utah 4-H allows youth to engage in their educational interests in a positive environment where they receive guidance from adult mentors, while also being encouraged to take on proactive leadership roles.

Desired Program Outcomes:

1. To facilitate positive youth development through educational activities that fosters youth competence, character, connection, caring, confidence, and contribution
2. To empower youth to pursue their passion for a successful career and healthy life.

Notable Results in FY21:

- *Career readiness:* The 4-H Portfolios program aims to help youth achieve developmental milestones as they become contributing, successful adults in their communities. Each 4-H Portfolio consists of a cover letter and résumé written by youth in grades 3 – 12 to record developmental milestones and set goals for the future. Faculty introduced a new Portfolio program to increase access to more youth across the state.
 - After restructuring, the new 4-H Portfolio program format led to increased accessibility, streamlined coordination, and real-world job application experience for youth.
 - Results showed 1,190 submissions at the county level (i.e., a 38% increase from the old format last used in 2018).
 - After the revised 4-H Portfolio became a standard application tool for state contests and leadership roles, there were over 600 submissions to state-level events; a whopping 2,122% increase since 2018.
 - Results show that youth benefited from the revised 4-H Portfolio; 89% of participants reported learning to write a cover letter and résumé, and 87% of youth indicated they will use their 4-H experience to make decisions about their future.
 - Youth also reported they intend to use the skills learned through creating 4-H portfolios for job applications (98%), scholarship applications (96%), leadership roles (81%), and college applications (93%).
- *Healthy living:* A USU Extension faculty team utilized the PROSPER delivery framework for a substance prevention program to youth.
 - Evaluation results indicated 7th grade students demonstrated highly positive anti-drug, anti-smoking, and anti-drinking attitudes. Students also expressed strong drug refusal skills.
 - A correlational analysis showed strong positive correlations between all anti-drug sentiments, indicating a youth was likely to exhibit anti-drug, anti-smoking, and anti-drinking attitudes simultaneously after participation in the training.
 - Over 70% of youth participants strongly agreed they would not smoke a cigarette, drink alcohol, smoke marijuana, use cocaine or other drugs, use prescription drugs that were prescribed to others, and vape or smoke an e-cigarette.
- *Social and emotional learning (SEL):* Faculty at USU Extension implemented SEL lessons with elementary-aged afterschool students at four schools in Sanpete County, Utah over a six-week period.

- While initial data indicated 38% of participants were unable to control their anger, post-test results showed only 13.7% of youth reporting trouble controlling their anger after participating in emotion regulation lessons.
- Post-evaluation results showed a 25% reduction in risk behaviors among youth participants.
- About 90% of afterschool educators reported a decrease in impulsivity among youth and an increase in youth applying positive techniques for controlling their emotions, resulting in positive changes in daily school environments.
- *Youth vaping*: Extension faculty from Carbon, Emery, and Grand county implemented an educational train-the-trainer program in communities to combat initiation and use of e-cigarettes among youth.
 - Results indicated a statistically significant increase in teachers' knowledge of the health risks associated with e-cigarettes.
 - There was a statistically significant increase in teachers' confidence to discuss tobacco and vaping specific information with students, incorporate information and discussions about tobacco and vaping into classes.

Utah Agricultural Experiment Station

Youth Development is a minor research area for the Utah Agricultural Experiment Station. In 2021 there was one Hatch project, plus additional projects funded by state matching funds, that addressed this Critical Issue. The description and results for this research project are included in the results section of this report.

Merit and Scientific Peer Review Processes

Updates

None

Stakeholder Input

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

None

Methods to identify individuals and groups and brief explanation

None

Methods for collecting stakeholder input and brief explanation

None

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

Utah State University Extension

Several state-level and county-level needs assessments were conducted between 2019 and 2021. These include a youth needs assessment, and a research to understand the perceptions of county commissioners on issues affecting residents. Primary data from clientele (youth and adult), county commissioners, and other stakeholders were used to develop, implement, and evaluate Extension programs within the current Plan of Work. Each program was aligned to an identified need, activities were implemented to target the need, and evaluation frameworks were developed to measure progress towards addressing the need. In addition, program teams and working groups utilized formative evaluation methods for continuous program improvement, while also working with target audiences to adjust program components. Therefore, stakeholder input is considered and incorporated in every stage of the program planning and evaluation process at USU Extension.

Utah Agricultural Experiment Station

Faculty, Department Heads, and Utah Agricultural Experiment Station (UAES) Administrators meet with a wide array of stakeholders including commodity groups, industry partners, state agency scientists and administrators, state legislators, and NIFA National Program Leaders on a regular basis. Research priorities are frequently a topic of discussion at these meetings. Faculty members set their research priorities based on discussions with their department head, their dean, their college's associate dean for research, and the Director

and/or Associate Director of the UAES. Faculty members develop their own research objectives for their five-year UAES (Hatch, McIntire-Stennis, Animal Health, or State) research projects. However, these projects are reviewed by their department head, two content experts, and the Associate Director of the UAES, and must align with NIFA Strategic Goals and the USU Critical Issues defined in our Plan of Work.

Highlighted Results by Project or Program

Critical Issue

Climate Change and Management of Natural Resources

[Climate and Parent Material Controls on Soil Development in Western Ecosystems: Understanding the Past and Adapting to the future](#)

Project Director

J Boettinger

Organization

Utah State University

Accession Number

1022936



Climate and Parent Material Controls on Soil Development in Western Ecosystems: Understanding the Past and Adapting to the future

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

The ultimate goal is to characterize pedogenic thresholds in soils over environmental gradients and assess the impacts of these thresholds on ecosystem services. The exact scope of the work will depend in part on the external funding obtained in conjunction with this project. Requested UAES budget will provide the baseline funding for the proposed scope of work. We intend to pursue additional funds when calls for proposals are issued by USDA and other funding agencies.

Objective 1: Investigate the influence of climate and volcanic ash on soil development on basalt lava flows on the western slope of Haleakala, Maui, Hawaii. Land use on Maui shifts from monocultures of sugarcane to livestock grazing and ecotourism, and there is growing interest in sequestering soil carbon and developing markets for niche specialty crops. The results of our work can advance our understanding of soil development while providing useful soil information for land managers. The research should be significant in that it builds on previous research on soil development and pedogenic thresholds on the islands of Hawaii and Kauai. In addition, there is a soil survey update on Maui in progress, and there is opportunity to collaborate and share data with USDA NRCS, while enhancing the progress and added value of the resulting soil survey.

Objective 2: Expand the soils component of a vegetation geo-climatic zonation in the Rocky Mountains of northern Utah. The original work was a coarse-scale vegetation geo-climatic zonation based on vegetation, climate, and soils that provided a framework for a comprehensive ecosystem survey, which was missing in the central Rocky Mountains. The vegetation-geoclimatic zonation explicitly accounted for the influence of the physical environment on the distribution of vegetation within a complex landscape typical of the central Rocky Mountains. Given the diversity of parent materials across this region, there is opportunity to mine existing data to evaluate the influence of climate/elevation, parent material, and vegetation on soil development and pedogenic thresholds.

Objective 3: Investigate coevolution of rare endemic plants, soils, and landscapes in the Colorado Plateau and Great Basin physiographic provinces of Utah. This research will build upon previous work on the soil habitats of rare endemic plants in the Uinta Basin and work in the Bear River Range.

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 island of Maui, and in particular, the western slope of Haleakal?, spans eight soil orders and presents a unique opportunity to study soil diversity over a dramatic climatic gradient in a short distance. However, high variability of volcanic ash deposits as a parent material across the study area complicates the ability to isolate the influence of climate on soil formation. Andic soils (Andisols and andic intergrades of other soil orders), which contain short range order aluminosilicates

and iron oxides resulting in unique soil chemical and physical properties, are challenging to map. Little is documented about the spatial extent of ash deposition, frequency and intensity of volcanic ejecta events, and composition of ash. Using climate data and andic soil property data from 16 pedons sampled in the study area—bulk density, phosphate retention, and aluminum plus 1/2 iron extracted by ammonium oxalate—we applied multiple linear regression and spatial prediction models to predict the areal extent of andic soils of western Haleakalā. Results show that predicted andic soils generally extend beyond the boundary of currently mapped Andisols, with the exception of Andisols mapped on the arid leeward side of the study area. Soils with andic intergrades to other soil orders extend beyond our predictions of the windward study area due to more liberal andic soil property requirements. The majority of our predicted andic soils are used in agriculture and ranching. Therefore, considering the unusual behavior short range order aluminosilicates have on soil chemical and physical properties, reassessing, and potentially redefining, the current extent of these andic soils would directly impact soil conservation and land management plans for land owners. Additionally, this may support the prevention of urban development of prime farmland.

Rangelands provide numerous ecosystem services, including forage for livestock grazing. Effective grazing management requires measuring forage availability, which influences the level of grazing that can be sustained while maintaining healthy ecological conditions. However, spatiotemporal variability makes such determinations of forage quantity difficult, potentially hindering optimal management. These determinations are especially difficult across large, remote areas. To address this, we developed an approach using data from a one-time sampling of vegetation throughout the Uintah and Ouray Reservation in northeast Utah. By associating these data in a random forest model with environmental and climatic covariates that vary annually, we produced yearly predictions of forage availability on a pixel-by-pixel basis for the Reservation and surroundings from 1984 to 2018. This method addresses and quantifies the spatiotemporal variability of available forage. The model confirms that forage availability is highly variable throughout the area. On average, forage availability in Reservation management units declined as much as 32% below median availability in some years and increased 33% above median availability in others. Moreover, some management units experienced large increases in favorable years but less significant declines in unfavorable years, while the opposite was true in others. In comparison to determining a single “typical” forage availability of management units, recognizing this inherent variability and how it differs between units provides a fuller picture of the range of possible forage availability. This can improve grazing management by revealing how forage quantities vary from year to year and may help avoid forage overutilization during unfavorable years such as drought. The model can continue to be used into the future to monitor vegetation trends, though with ongoing climate and vegetation changes periodic recalibration may be necessary. In addition, the modeling method may be applicable to other similar study systems.

Repacked soil columns can be less variable and more easily obtained than undisturbed natural cores, but their hydraulic characteristics may be unnatural due to changes in pore structure. This study was conducted to compare one-step outflow parameters and variance of four types of repacked columns to that from natural cores. Undisturbed cores and bulk soil were obtained from two soils, a sandy loam maintained as irrigated pasture and an uncultivated sandy clay loam. The cores were saturated and outflow recorded as they drained from a pressure head (hp) of -7.6 cm to -133 cm. The cores were sacrificed to obtain the bulk densities of 5-cm layers. Ordinary-packed columns were made by compressing bulk soil to the average bulk density. Layered columns were made by duplicating the bulk density in 5-cm layers. The columns were run freshly packed (New treatment) and after drying (Dry treatment). An outflow model that uses the initial water content (θ_i) and loss of water ($\Delta\theta$) was fit to the data by adjusting an outflow rate parameter T. Layered columns had water content and flow parameters not significantly different from those of natural cores for 58% of the values, in comparison to 25% for ordinary-packed columns. Dried columns were significantly less variable than natural cores for 42% of the values, in comparison to 17% for new columns. Repacked columns of the sandy pasture soil had slower outflow (significantly greater T) than natural cores, possibly due to lack of root-formed pores and insufficient clay to reform aggregates. The uncultivated sandy clay loam outflow parameters were not significantly different from natural cores in 58% of the cases, in comparison to 33% for the pasture columns. Among all columns, layered and dried columns were the most similar to natural cores and least variable.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None

Training and Professional Development -

This project provided opportunities for research training for one doctoral-level graduate student. The project also provided training opportunities in field observation and interpretation of soils for 11 students in PSC 5130/6130, a senior/graduate-level course in Soil Genesis, Morphology, and Classification at Utah State University.

The 2021 Pedology Tour for the Annual Meetings of the Soil Science Society of America was a three-day tour in November that traveled from Salt Lake Valley north and east to Cache Valley, home of Utah State University's main campus in Logan, to explore landscape evolution and soil formation. The travel from Salt Lake City to Cache Valley included a stop at the Bear River Migratory Bird Refuge west of Brigham City to marvel at the vastness of Lake Bonneville at its high stands and the importance of fresh water to wildlife at the margin of the Great Salt Lake, the remnant of Lake Bonneville. Located at the boundary of the Middle Rocky Mountains and the Basin and Range/Great Basin, and surrounded by mountains dominated by calcareous sedimentary rocks, Cache Valley hosts a wide diversity of soils and land uses. We explored a litho-toposequence of soils formed in different particle-size distributions of Pleistocene pluvial Lake Bonneville deposits affected by different depths to a seasonal-high water table, a chronosequence of soils formed in similarly textured deposits in lake sediments vs. younger alluvium, a toposequence of soils in lake deposits affected by a non-saline vs. saline water table, and a toposequence of soils that have been cultivated for dryland wheat for a century in this semiarid and seasonally dry climate.

Dissemination -

Results of the Maui, Hawaii, research were disseminated via a volunteered poster and recorded oral presentation at the annual meetings of the Soil Science Society of America, Crop Science Society of America, and the American Society of Agronomy, held in Salt Lake City in November 2021.

Results of the research on modeling forage availability in range units in the Uintah and Ouray reservation were published in Range Ecology and Management.

Results of the Packed soil column research were presented as a poster at the annual meetings of the Soil Science Society of America, Crop Science Society of America, and the American Society of Agronomy, held in Salt Lake City in November 2021.

Plan of Work -

Prepare an submit for possible publication manuscripts on soil development and distribution in Maui, Hawaii, and on packed soil columns. A paper on the soil sequences of Cache Valley was submitted to the 2022 World Congress of Soil Science, scheduled for summer 2022.

Publications

Other

Hodges, R. C., & Boettinger, J. L. (2022). Predicting the Extent of Andic Soils of Western Haleakala, Maui. Salt Lake City, UT: ASA, CSSA, SSSA International Annual Meeting.

Powelson, D., Boettinger, J. L., & Jacobson, A. (2021). Restructured Soil Columns for Water Transport Studies. Powelson, D., Boettinger, J. L., & Jacobson, A. R. (2021) Restructured Soil Columns for Water Transport Studies [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Salt Lake City, UT: ASA, CSSA, SSSA International Annual Meeting.

Presentations

Hodges, R. (Author Only), Boettinger, J. L. (Author Only), 2020 ASA-CSSA-SSSA International Annual Meeting, "Soil Genesis across a Climo-Lithosequence of Western Haleakal?," American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Virtual. (November 11, 2020 - Present)

Hodges, R. (Author Only), Boettinger, J. L., West Region Cooperative Soil Survey Conference, "Soil genesis across a climo-lithosequence of Western Haleakal?, Hawaii," USDA Natural Resources Conservation Service and New Mexico State University, Virtual. (July 22, 2020)

Developing a skillful multi-year prediction for deluge-drought extremes in the Great Plains

Project Director

Simon Wang

Organization

Utah State University

Accession Number

1022974



Developing a skillful multi-year prediction for deluge-drought extremes in the Great Plains

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

The Great Plains of the U.S. is the breadbasket of the nation. Since 2015, many states in the central U.S. have suffered from consecutive episodes of widespread flooding, each caused by record precipitation from various origins. These storms and flood events damaged agriculture by submerging farmlands and rangelands (Figure 1). In 2019, farmers from Oklahoma to Mississippi faced crop disasters as extensive flooding continued along the Arkansas River and Mississippi River (6/3/2019, <https://www.dtnpf.com/>). In Oklahoma, the rain, floods, tornadoes and hail have reduced the expected winter wheat crop as much as 20% by summer 2019, a drastic loss compared to the forecasted 119 million bushels of wheat crop. To help mitigate the destructive effects of extreme events on crop losses, such as the recent sequential floods in the central U.S. states, this project will develop multi-year predictions that can assess threats of similar water cycle extremes, up to 5 years in advance.

Objective (A): exploration of the physical processes enabling decadal climate prediction

Whereas the atmospheric short-term memory originates from higher-frequency weather disturbances, the large-scale atmospheric variability is modulated by lower-frequency climate variability associated with seasonal-to-decadal ocean memories [Chikamoto et al., 2017]. In addition, many land systems (e.g., soils, groundwater, streamflow, vegetation, and perennial snowpack) can effectively filter out the high-frequency precipitation component and thereby exhibit a longer persistence of variability through naturally integrating the atmospheric signals over time [Chikamoto et al., 2015; Chikamoto et al., 2013]. Consequently, this natural filtering effect can enhance the lower-frequency component of hydroclimate originated from the ocean memory, extracting “signals” from the atmospheric noises. Skillful dynamical predictions in tropical Pacific climate require constant improvement in the knowledge of physical processes alongside performance of climate models. Studies conducted by the PI have linked an energetic 4-6 year frequency of ENSO with a global propagation pattern [Wang et al., 2015a] that is persistent and potentially predictable. However, the conventional ENSO dynamics provide a theoretical upper limit of tropical Pacific climate predictability, up to several seasons only. By utilizing newly found signals originating from the Atlantic and Indian Oceans, a recent framework of inter-basin interactions could enhance the tropical Pacific predictive skill towards the multi-year timescale [Chikamoto et al., 2015]. However, inter-basin interactions can propagate model biases in the Atlantic and Indian Oceans to the tropical Pacific, reducing climate predictability. Therefore, finding the optimal balance among these traits is critical.

Objective (B): analysis of past/future conditions at high resolution for specific crop regions

Any useful prediction information of climate needs to be interpreted to a proper geographical boundary that is meaningful to installation management. To produce physically sound interpretation of extreme climate risks, a dynamically based approach will be used to explicitly represent thunderstorms in high-resolution numerical atmospheric modeling at the kilometer scale. Within the context of these so-called convective-permitting simulations, the statistical characteristics of extreme weather will be evaluated via extreme-value statistical analysis, which considers the statistical behavior of values in the tails of the distribution, and objective tracking of storm-prone atmospheric circulation patterns. Pursuing these two approaches will result in a more physically robust and spatially detailed quantification of multi-year change in severe weather regimes, in a manner that already conforms to the military's operational risk assessment criterion for severe weather. The result will maintain a consistent framing context of operational weather forecasting watch and warning criteria used by the National Weather Service.

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.

Published five peer-reviewed papers about the climate variability and extremes in the western U.S. including the central plains and the associated predictability.

To assess the long-range prediction of extreme precipitation beyond the seasonal timescale, a new simulation framework is proposed that combines global and regional climate models. The Climate Earth System Model (CESM) simulates the complex ocean-atmospheric interactions and captures prolonged climate signals imprinted on the atmosphere. The Weather Research and Forecasting (WRF) model dynamically downscales CESM output over a Texas domain using a convective-permitting resolution to represent storm-level processes on the mesoscale.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

n/a

Training and Professional Development -

Graduate student Jacob Stuienvolt Allen published two papers in the forecastability study about fire weather. Jacob also received the graduate student researcher of the year award from the department.

Dissemination -

Journal articles, press release, and conference presentations.

(The Guardian *June 18, 2021*) 'Potentially the worst drought in 1,200 years': scientists on the scorching US heatwave
(Digital Journal *June 20, 2021*) Drought and extreme heat in the U.S. West – The climate change connection
(TRT World July 8, 2021) Canada, south and west US experienced extreme temperatures - TV interview

Plan of Work -

The remaining question of interest is whether there are values added by convective-permitting modeling to simulate extreme wet or dry anomalies. We consider 2015 and 2011 characterized by anomalous wet and dry late springs. We downscaled 10 members of CESM prediction for each year.

Other Products

Data and Research Material - Press release for the forecast

<https://www.usu.edu/today/story/utah-climate-center-winter-outlook-says-more-precipitation-in-the-north-but-deepening-drought-likely>

Research Publications:

Zhang, W., V. Hari, **S.-Y. Wang**, M. D. LaPlante, G. Garfin, G. Affram, and R. Kumar, 2021: Fewer troughs, not more ridges, have led to a drying trend in the western United States. *Geophysical Research Letters*, in press (PDF)

Gu, H., **S.-Y. Wang**, Y.-H. Lin, J. Meyer, R. R. Gillies, E. Taylor, and B. Pokharel, 2021: Historical trend of probable maximum

precipitation in Utah and associated weather types. *International Journal of Climatology*, DOI:10.1002/joc.7503

Keen, R. M., S. L. Voelker, **S.-Y. Wang**, and Coauthors, 2021: Changes in tree drought sensitivity provided early warning signals to the California drought and forest mortality event. *Global Change Biology*, DOI:10.1111/gcb.15973

Song, F., Z. Feng, L. R. Leung, B. Pokharel, **S.-Y. Wang**, X. Chen, K. Sakaguchi, and C.-C. Wang, 2021: Crucial roles of eastward propagating environments in the summer MCS initiation over the U.S. Great Plains. *Journal of Geophysical Research-A*, DOI:10.1029/2021JD034991

Stuivenvolt Allen, J., **S.-Y. Wang**, M. LaPlante, and J.-H. Yoon, 2020: Three western pacific typhoons strengthened fire weather in the recent northwest U.S. conflagration. *Geophysical Research Letters*, DOI:10.1029/2020GL091430

Modelse https://earth.climate.usu.edu/service/floodingModel.php

The spring flood risk prediction model and an information dissemination system.

Audio or Video - <https://youtu.be/nsM-ZPd-fUM>

Analysis and explanation for the "Miracle Spring" events that impact the Colorado River system with an unpredictable influx of water.

Audio or Video - https://youtu.be/4mSvxzslkkk

Predicting the Flow: USU Researchers Find How to Forecast the Colorado River's Water Supply - on Utah States Today

Audio or Video - https://www.upr.org/post/climate-change-mountain-west-simon-wang-tuesdays-access-utah

A UPR interview for disseminating the research outcome relevant to this project.

Agricultural Climate Change Adaption Strategies for Native American Reservations

Project Director

Kynda Curtis

Organization

Utah State University

Accession Number

1019595



Agricultural Climate Change Adaption Strategies for Native American Reservations

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

This project seeks to improve the economic sustainability of agriculture on Native American reservations in the face of climate change effects such as:

- Less overall water availability, especially late in the season
- Periods of flooding, too much water
- Warmer temperatures, increased growing degree days
- Larger variability in temperatures
- Increased pest pressure
- Reduced productive rangeland
- Increased erosion on range and fallow areas

Sustainable agricultural systems will assist in maintaining tribal social and cultural traditions and enable tribal members to remain on their reservation and participate within their community. Maintaining a strong agricultural economic base on reservations will also build the economic viability of surrounding rural areas dependent on local production adjacent to reservations.

This project has six primary objectives:

1. Examine the primary cropping systems, water availability, and irrigation systems on native American reservations in Utah.
2. Evaluate the potential economic feasibility of alternative cropping systems including low water-use, heat resistant, high CO2 resistant marketable crops and high-value crops on reservations.
3. Evaluate the potential economic feasibility of ag-related enterprises (food product development, food tourism, etc.) on reservations.
4. Assess the economic, social, and cultural benefits and impediments to producer adoption of alternative cropping systems and ag-related enterprises.
5. Assess educational and technical assistance needs.
6. Disseminate study results and information to agricultural producers and policy makers on reservations.

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.

Accomplishments by Project Goal

1. Examine the primary cropping systems, water availability, and irrigation systems on native American reservations in Utah. Data set completed and used in Goal 2 below.
2. Evaluate the potential economic feasibility of alternative cropping systems including low water-use, heat resistant, high CO2 resistant marketable crops and high-value crops on reservations. Partial budget analysis was conducted for three livestock drought management strategies, and cost benefit analysis was conducted for three forage drought management strategies for agricultural production on Native American reservations across four states. Journal articles and Extension factsheets will be written and submitted in 2022 based upon the MS thesis. Three fact sheets were published in 2021 on drought resistant native and non-native plants, grains, grasses, etc. which can be grown in the Southwest.
3. Evaluate the potential economic feasibility of ag-related enterprises (food product development, food tourism, etc.) on reservations. No yet started
4. Assess the economic, social, and cultural benefits and impediments to producer adoption of management strategies/alternative cropping systems and ag-related enterprises. One proceedings article was published 2021. One journal article was published in 2021 and one is under review (R&R). Four fact sheets which discuss the economic impacts of drought on native American reservations were published in 2021. Three fact sheets based upon the drought management preferences of producers across crop/livestock types were published in 2021.
5. Assess educational and technical assistance needs. Started as part of Goals 2 and 4 above.
6. Disseminate study results and information to agricultural producers and policy makers on reservations. See Dissemination below.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None.

Training and Professional Development -

One post-doctoral fellowship in progress. Journal article presented at international conference August 2021.

Dissemination -

Project results were presented in 2021 at an international conference and at a regional water meeting.

Dr. Curtis was a featured speaker on the national radio show Native American Calling discussing the impacts of drought on tribal agriculture June 22,2021.

All project outputs were posted to the project website at: <https://extension.usu.edu/apec/tribalagriculturedrought>. The website was visited by 180 individuals in 2021.

Project outputs were also posted on the Native Waters – Arid Lands project website at: <https://nativewaters-aridlands.com/resources/tribal-agriculture-drought/>

Extension Factsheets published under this project have been viewed 544 times since publication.

Plan of Work -

Plan of Work by Project Goal

1. Examine the primary cropping systems, water availability, and irrigation systems on native American reservations in Utah. Completed.

2. Evaluate the potential economic feasibility of alternative cropping systems including low water-use, heat resistant, high CO2 resistant marketable crops and high-value crops on reservations.

Draft journal articles and fact sheets based upon completed MS thesis.

Submit papers for presentation at conferences in 2022.

3. Evaluate the potential economic feasibility of ag-related enterprises (food product development, food tourism, etc.) on reservations.

Start literature review, data collection and analysis.

4. Assess the economic, social, and cultural benefits and impediments to producer adoption of management strategies/alternative cropping systems and ag-related enterprises.

Continue to publish one journal article currently under review (R&R).

5. Assess educational and technical assistance needs.

Continue assessment

6. Disseminate study results and information to agricultural producers and policy makers on reservations.

Present results from Goals 1-4 at national, regional, and state producer meetings and Indian agricultural conferences.

Create outreach materials for use with target audience.

Begin project impact assessment and draft assessment tools.

Publications

Conference Proceedings

Curtis, K., Drugova, T., & Ward, R. A. (2020). Producer Response to Drought Policy in the West. (1st ed., vol. 51, pp. 17-25). Journal of Food Distribution Research.

Drugova, T., Curtis, K., & Kim, M.-K. (2021). The Economic Impacts of Drought on Navajo Nation. (1st ed., vol. 52, pp. 31-38). Journal of Food Distribution Research.

Refereed Journal Articles

Drugova, T., Curtis, K., & Kim, M.-K. The Economic Impacts of Drought on SW Tribal Economies. *Journal of American Water Resources Association*.

Drugova, T., Curtis, K., & Ward, R. A. (2021, October). Producer Preferences for Drought Management Strategies in the Arid West. *Renewable Agriculture and Food Systems, Online*(Forthcoming print).

Other

Curtis, K., Drugova, T., & Ward, R. A. (2021). Utah Fresh Produce Grower Preferred Drought Management Strategies. (Applied Economics 2021-01pr ed.). Logan, UT: USU Extension.

Curtis, K., Drugova, T., & Ward, R. A. (2021). Utah Hay and Forage Grower Preferred Drought Management Strategies. (Applied Economics 2021-03pr ed.). Logan, UT: USU Extension.

Curtis, K., Drugova, T., & Ward, R. A. (2021). Utah Livestock Producer Preferred Drought Management Strategies. (Applied Economics 2021-02pr ed.). Logan, UT: USU Extension.

Drugova, T., Curtis, K., & Kim, M.-K. (2020). Impacts of Drought on Tribal Economies in Arizona. (Applied Economics/2020-04pr ed.). Logan, UT: USU Extension.

Drugova, T., Curtis, K., & Kim, M.-K. (2020). Impacts of Drought on Tribal Economies in Nevada. (Applied Economics/2020-02pr ed.). Logan, UT: USU Extension.

Drugova, T., Curtis, K., & Kim, M.-K. (2020). Impacts of Drought on Tribal Economies in New Mexico. (Applied Economics/2020-03pr ed.). Logan, UT: USU Extension.

Drugova, T., Curtis, K., & Kim, M.-K. (2020). Impacts of Drought on Tribal Economies in Utah. (Applied Economics/2020-01pr ed.). Logan, UT: USU Extension.

Rice, E., & Curtis, K. (2021). Drought Tolerant Options for Southwest Agriculture: Edible Produce. (Applied Economics 2021-05pr ed.). Logan, UT: USU Extension.

Rice, E., & Curtis, K. (2021). Drought Tolerant Options for Southwest Agriculture: Grasses, Grains and Legumes. (Applied Economics 2021-04pr ed.). Logan, UT: USU Extension.

Rice, E., & Curtis, K. (2021). Drought Tolerant Options for Southwest Agriculture: Ornamentals, Herbs, and Cosmetics. (Applied Economics 2021-06pr ed.). Logan, UT: USU Extension.

Presentations

Drugova, T. (Author Only), Curtis, K. (Presenter & Author), Kim, M.-K. (Author Only), Agricultural and Applied Economics Association Annual Conference, "Drought Impacts on Tribal Economies in the US Southwest," Austin, TX. (August 2021)

Curtis, K. (Presenter & Author), Drugova, T. (Author Only), Kim, M.-K. (Author Only), Food Distribution Research Society Annual Meeting, "Impacts of Drought on Tribal Economies," Online. (October 2020)

Curtis, K. (Presenter & Author), Drugova, T. (Author Only), Australian Agricultural and Resource Economics Society Annual Meeting, "Agricultural Producer Adaptation to Drought in Utah: An Experimental Study," Perth, Australia. (February 2020)

Curtis, K. (Presenter & Author), Drugova, T. (Author Only), Ward, R. A. (Author Only), Food Distribution Research Society Annual Meeting, "Producer Response to Drought Policy in the West," Seattle, WA. (October 2019)

Curtis, K. (Presenter & Author), Drugova, T. (Author Only), Native Waters on Arid Lands 2019 Tribal Summit, "Farmer and Rancher Response to Drought in the West," Reno, NV. (October 2019)

Curtis, K. (Presenter & Author), Native Waters on Arid Lands 2018 Tribal Summit, "Improving the Economic Sustainability of American Indian Agriculture," Reno, NV. (October 2018)

Other Products

Databases - Data set of current cropping systems, water availability, and irrigation systems.

Data and Research Material - Data from economic experiments on producer preferred drought management strategies.

Closing Out (end date 09/07/2023)

[Integrating location and individual based perspectives to understand and predict wildlife migration](#)

Project Director

Tal Avgar

Organization

Utah State University

Accession Number

1018520



Integrating location and individual based perspectives to understand and predict wildlife migration

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

Terrestrial migratory connectivity is an important factor in determining population health in big game species, a factor that may be particularly vulnerable to climate and land-use changes. Understanding the drivers of wildlife space-use patterns, and particularly migration, in the context of managed landscapes, is thus a crucial component for the effective sustainable management of these natural resources, and is thus highly compatible with NIFA's objectives.

Patterns of space-use behavior of individual animals, and the density of animals on the landscape, are intrinsically linked. Spatial and temporal variation in density are important drivers of individual movement and resource selection. Many species exhibit between-individual attraction (aggregation or collective motion) or repulsion (e.g., dispersal or territoriality) as a function of predation risk and resource availability. The ability to predict population-level patterns from individual traits and behaviors, and vice versa, is the ultimate test of the validity of our scientific understanding. In the context of animal space-use behavior, evaluating this predictive capacity requires contrasting model projections against location-focused population-density data across space and time. Combining individual-focused and location-focused space-use data is thus an exciting and promising research frontier.

Utah's Division of Wildlife Resources (UDWR) has recently launched a state-wide GPS-collaring project, termed The Migration Initiative, where >1000 individual cougars, mule deer, elk, bighorn sheep, and pronghorn antelopes, are being tracked at high spatiotemporal resolution over a four-year period. The aim of my proposed research program is to couple this unprecedentedly extensive individual-focused initiative with location-focused information about local population and community dynamics and composition. Combined, these complementary perspectives will allow my lab to address the following themes over the next five years:

- Evaluate the utility of individual-focused vs. location-focused approaches to modelling and predicting migratory wildlife space-use and abundance patterns.
- Understand the role of density-dependent processes in driving individual habitat-use and migratory behaviors across multiple interacting species and spatial scales.
- Examine potential antagonistic interactions between different species (e.g., competition or predation), and the potential effects such interactions may have on space-use behavior, by examining patterns of species co-occurrences through space and time.

Ultimately, I expect the knowledge gained through this research program will be used to inform management actions, such as habitat restoration, dynamic harvest allocations, and placement of highway-crossing structures, to ensure the sustainable persistence of migratory-game populations in Utah.

GOALS

I. Identify individual- and population-level drivers of big game migratory patterns across multiple scales, including forage spatiotemporal dynamics (linking ground-truthed measurements with climatic, topographic, and remote-sensed variables), conspecific and heterospecific densities, anthropogenic landscape disturbances, and land ownership and use.

II. Construct species-specific individual-based and population-based predictive space-use models.

III. Use best predictive models to provide species- and range-specific quantitative management recommendations with respect to anthropogenic movement barriers, conflict with landowners, harvest allocations, and habitat restoration, all in the context of projected climatic conditions.

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.

Major activities completed

Since May 2019, we are collecting approximately 10,000 photos per month using motion-triggered cameras across over 100 sites in the Diamond Fork area, covering a total study area of 41,000 ha across an elevation gradient ranging from 5,300 to 8,400 feet. These cameras are set to take continuous photos as long as they are triggered, and are maintained regularly so that they operate year-round. Photos are being classified using a combination of an AI algorithm and trained technicians. So far, approximately 70% of the photos were classified. The graduate student that has been leading this project over the first two years has defended her thesis last December. Her thesis, focusing on the project's objective for mule deer, will soon be submitted for publication. In addition, an undergraduate researcher on the project is in final stage of completing here analysis, which is expected to result in a publication in the next few months. A new graduate student has taken her place in

January 2021, supported by funding from Mississippi State University. Further, with financial support from UDWR, the project has been extended into 40 new camera sites to monitor areas that were burned in 2018, with a focus on elk and aspen.

Significant results achieved, including major findings, developments, or conclusions

Quantifying the abundance and distribution of animal populations is critical for effective wildlife research and management. Due to their cost-effectiveness, wildlife cameras have become an increasingly popular tool for estimating population densities. Previously, this technique relied on 'capture-recapture' models that utilized re-sightings of individually marked animals, but in recent years methods have been developed to estimate the population densities of unmarked animals. One such method is the random encounter and staying time (REST) technique, which does this by assuming that the cumulative time animals stay within the view of the camera scales linearly with the number of individuals. This allows for a density estimate without the need to determine individual identity. To evaluate the accuracy and precision of the REST method, we compared cattle density estimates based on trail-camera photos to the actual number of cattle stocked on a U.S. Forest Service (USFS) grazing allotment. Photos were collected across 96 motion-activated cameras distributed across a single grazing allotment in Spanish Fork, Utah. Based on the USFS grazing plan, the allotment operated under a rest-rotation grazing system, and therefore was divided into three pastures, only one of which held cattle at any given time in the year. Based on this plan cattle numbers also varied throughout the year according to a set schedule. For each stocking period and pasture, we generated REST-based abundance estimates, including empirical confidence bounds derived using either spatial or temporal averaging. Our results indicate very poor agreement between REST-based estimates and USFS stocking rates, where, at the allotment level, the former are typically 50-150% higher than the latter. Whether this indicates REST-based estimates are biased or inaccurate is hard to say; there is no doubt our cameras had detected cows (sometimes a lot of cows) in places and times that no cows should have been in based on USFS records. We thus have little confidence in the reliability of these records. As for precision, coefficient of variation values for our estimates ranged between 0.5 and 0.2 (depending on the number of active camera days used to calculate the estimate, and on whether densities were averaged across space or across time). This indicates that REST-based estimates are at least precise enough to be reasonably consistent across time (and to the a lesser degree, space), and may hence be a valuable tool at the hand of wildlife managers.

Many temperate ungulate populations follow seasonal migration patterns, residing in low-elevation regions during winter and travelling to high-elevation locations in the summer. Plant phenology follows a similar pattern, with lower elevations undergoing earlier spring green-up. Previous research has demonstrated that, at the individual level, ungulate migration often coincides with this green-up, a behavior that is hypothesized to optimize energy uptake by following peak forage quality across the landscape. However, it is still unknown whether these individual-level patterns scale up to the population level nor what is the relative effects of biomass quantity versus quality. We obtained finely resolved estimates of mule deer relative densities across space and time using camera traps placed across a wide elevation gradient. We then tested the hypothesis that population-level migration is driven by spring vegetation green up, measured using remotely-sensed indices of biomass availability. Our results indicate that migration in our study area is driven by both forage quantity and quality, and that the wave of vegetation regrowth is closely tracked by a wave of peak deer densities. We thus provide not only a novel technique to quantify wildlife density dynamics at high spatiotemporal resolution, but also the first demonstration of population-level green-wave surfing.

Key impacts or other accomplishments realized

This project has so far been the basis for research conducted by three MS students (one has already graduated and the other two are expected to graduate in Spring 2023) and three undergraduate students (all URCO recipients). The project provided necessary leverage for successfully securing two contracts with external funding agencies (worth approximately \$300000), and three URCO grants.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

Photo tagging is incredibly resource-demanding; we are trying our best to find creative solutions for accomplishing the task within a very limited budget.

Training and Professional Development -

So far, this project contributed to the training of three graduate students and seven undergraduate students.

Dissemination -

So far, results emerging from this project have been presented in the following conferences:

TWS (national; 2019)

TWS (Utah; 2020)

USU's Fall Student Research Symposium (2020 and 2021)

Plan of Work -

We are continuing to move forward, focusing most time and resources on photo tagging, analysis, and writing manuscripts

Presentations

Avgar, T. (Author Only), Del Bosco, T. (Presenter & Author), TWS National Annual Conference, "Towards a population perspective on green-wave surfing," Utah State University, Reno, Nevada. (September 29, 2019 - October 3, 2019)

Other Products

Data and Research Material - Vegetation surveys conducted across 106 camera sites.

App. 0.5 million photos collected.

App 10% of these photos have been classified and entered into our database.

A scientific poster describing the research was presented by the graduate student at the national TWS conference

Leveraging the NADP network to fill critical dust deposition data and knowledge gaps

Project Director

Janice Brahney

Organization

Utah State University

Accession Number

1015140



Leveraging the NADP network to fill critical dust deposition data and knowledge gaps

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

Our overarching hypothesis is that biogeoclimate and land-use affect emission rates and composition of dust, which in turn influence a) aquatic ecosystems, and b) human health. Ecosystem impacts have been demonstrated by our previous work that showed a high degree of correlation between deposition and lake water chemistry (Brahney et al. 2014, 2015a, 2015b), and data from 1000's of waterbodies across the country that indicate phosphorus concentrations are increasing in remote locations (Figure 2; Stoddard et al. 2016). Public health impacts are supported by findings of the Center for Disease Control that incidents of Valley Fever, contracted by inhaling soil borne-pathogens, are increasing in the southern states (CDC 2013). Further, drought has been linked to the production and transport of aeroallergens and irritants (Takaro et al. 2013), and studies in the Middle East have showed cyanotoxin persistence in eroded soils (Richer et al. 2015) that may be linked to a variety of diseases (Takser et al. 2016). By measuring total mass of deposition at a high spatiotemporal resolution, we can quantify ecosystem impacts across different aquatic environments, determine potential human exposure to pathogens, and identify prominent dust producing areas. We plan to test our central hypothesis by pursuing the following two specific objectives:

Objective 1: Demonstrate that deposition of the full range of dust can be implemented at a regional scale by using novel deposition samplers deployed at existing NADP stations. We hypothesize that variation in dust deposition and composition is driven by biogeoclimate and land-use activity across space. We will use a combination of back trajectory models and genomic and isotopic signatures to trace unique regional sources and identify where dust originates.

Objective 2: Determine direct ecological impacts of dust deposition on lake ecosystems. Our working hypothesis is that variation in dust composition and deposition input rates affect nutrient availability, species composition, and productivity of plankton in recipient lakes. To test this hypothesis, we will perform leaching experiments and bioassays using dust collected from Objective 1 to quantify bioavailability of dust-derived nutrients.

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 year 2, an additional 10 dry deposition sites were established, and one site was terminated. At present, there are 20 sites fully operational across the western USA with contiguous data. To date, 547 dust samples have been collected, and an additional 60 dust samples have been acquired from NEON. All dust samples have been weighed, processed, and stored in temperature-controlled environments at Utah State University. Non-destructive analyses are being performed in advance of destructive techniques on both samples collected through this study and NEON samples.

To date, mass deposition rates and plastic content have been completed for both years, while pH, metal chemistry, extractable phosphorus and nitrogen, and bioassays have been completed for year 1 and are in progress for year 2. We added a new metric, charcoal concentration, due to the unprecedented fire years in the western USA over the past two summers. Ash often contains higher concentrations of bioavailable phosphorus, and is thus relevant to our goals. Experiments at two of the four lakes chosen for bioassay studies have been completed, including Castle Lake, CA, and The Loch, CO. Two additional lakes in the Uintas and southern CO will be chosen for the upcoming year. With respect to source attribution, air mass back trajectory data is being generated and smoke data layers are being used to establish fire contribution to particulate deposition.

Dust microbial analyses began in the Fall of 2020. DNA extraction procedures have been tested to determine minimum dust sample requirements. BacLight viability and flow cytometry methods have been finalized to determine the number of viable organisms within each sample. Despite establishing the techniques, a wide range of samples have not yet been analyzed at BYU and we anticipate these results in the coming year. In a preliminary subset of sites (five), we found the relative frequency of microbial species varied substantively.

Due to the global pandemic, we took the opportunity to measure particulate samples for SARS-CoV-2.

Our results to date have identified a seasonality in both total mass deposition rates as well as dust composition. As we hypothesized, dust deposition rates increase through the spring at most sites but reach their peak during the summer months. The 2020-2021 dust year was substantively higher than the preceding years. These patterns are repeated at all 11 field sites with multiple years of data. Higher summer deposition suggests that annual dust deposition rates may be frequently underestimated since one of the most common methods for estimating annual dust deposition rates is through dust on snow collection. Dust deposition rates vary by an order of magnitude across the American west (Figure 1) Synchronized with changes in mass deposition rates are significant changes in dust composition. Through the summer, dust carbon isotopes are largely consistent with organic matter from soil and vegetation sources. At least one Arizona sample is a clear outlier with carbon isotopes closer to values consistent with C4 desert grasses. Through the cooler months, $\delta^{13}C$ values migrate towards more depleted isotopic values more consistent with atmospheric methane and perhaps other yet unidentified sources. Nitrogen isotopes (not shown) also show seasonal signals reflecting shifting atmospheric aerosol sources. Dust pH is markedly lower and more acidic in winter months and trend towards more alkaline values in the mid-summer. Of particular relevance to this study are the distinct seasonal changes in phosphorus concentrations as measured by XRF, which dip to the lowest values in the winter months. Lower winter P concentrations combined with dust-on-snow based deposition rates suggest that previous estimates of P deposition may be considerably underestimated

Total phosphorus deposition rates ranged from 4 to 60 mg m⁻² yr⁻¹. Bioavailability ranged from 37 to 70% (Figure 2). Bioavailability was greater in the winter months for arid regions, but greater during the summer for semi-arid and mountain landscapes. Preliminarily, bioavailability appears to vary with organic content in the summer and combustion sources in the winter. Here we define the bioavailable fraction as the water-soluble plus exchangeable plus the organic fraction of the NaOH extract. Given an average wet plus dry dust deposition rate at UT95 (the East McKee site) of 10.13 g m⁻² year⁻¹ and a bioavailable P concentration of 1.09 mg g⁻¹ of dust, we arrive at a bioavailable P deposition rate of 11 mg P m⁻² year⁻¹. This is potentially an underestimate given the higher P concentrations observed through the summer. Nevertheless, for a lake that is

0.5 km² in area with an epilimnion depth between 5 and 10 m, direct dust deposition to the lake surface could account for a 1.1-2.2 ug P L-1 increase in water column nutrients. This approximation does not account for catchment focussing; Though not yet evaluated for our field stations, previous work has shown that up to 30% of the dust deposited to a catchment could end up with the lake basin (Brahney et al. 2015). These back-of-the-envelope calculations indicated that dust could be a significant driver of ecosystem change, which we have tested through field and laboratory bioassays. Finally, we found a significant positive relationship between charcoal concentration and phosphorus deposition rates, and bioavailability (Figure 3).

An additional interesting and somewhat unexpected result is the positive association of organic matter, total phosphorus, and bioavailable/organic phosphorus content with elevation (Figure 4), perhaps reflecting a shift in aerosol size fractions with elevation. This hypothesis is yet to be tested and grain size analyses should provide some insights.

Field bioassays have shown a positive relationship between dust additions and chlorophyll-a content, but a negative relationship to net primary production (Figure 5). At Castle Lake, significant differences in final chlorophyll-a concentration were observed across all treatments, through the lowest dust addition was not markedly different from the control. However, in vivo fluorescence showed statistically significant differences between the control and the lowest dust deposition as the lowest dust treatment showed a positive slope while the control did not (Figure 5). We hypothesize that the contrast between chlorophyll concentration and primary production is a result of low dust additions stimulating large phytoplankton species, while higher dust treatments stimulate smaller-sized phytoplankton. A negative relationship between production and the relative contribution of small cells exists, supporting this notion. This hypothesis will be further tested in this upcoming year through community composition and size distribution analyses of the preserved bioassay samples. Laboratory assays have revealed a strong positive relationship between dust additions and the planktonic growth rate of a single species (*Scenedesmus obliquus*). The results were moderated by the initial condition, including pH and temperature. Lower pH and high temperatures led to a greater effect of dust on the phytoplankton growth rate, suggesting that in the future the effect of dust deposition on lake systems may be amplified. Subsequent analyses will examine the effect of dust additions and pH on the stoichiometry of algal cells. With respect to microbial community composition, we found substantive differences in the operational taxonomic units between five samples collected at four sites. These results suggest that dust source controls microbial community composition (Figure 6).

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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

Changes / Problems -

COVID-19 Delays: The onset of the COVID-19 pandemic shortly after the inception of the study has created some unforeseen and new challenges. With respect to student activities, there has been limited or restricted access to laboratories within USU and external labs and the international PhD student involved was unable to acquire a drivers license through the summer period as local facilities were closed. The establishment of sites has been slowed and significantly delayed as the engineering facility that produces the samplers (and the external manufacturers of parts) have undergone intermittent closure. The organization was shut down entirely for a period of time as the workers in the facility contracted COVID-19. As a result, only a small portion of our requested samplers have been delivered to date. This lack of samplers has limited the spatial scope of the study but will not impact the data generated from the sites that we are able to establish. We do not anticipate changing our approach.

Training and Professional Development -

A total of five diverse students, one postdoc, and one technician have been hired and trained through various aspects of this project. All students participate in virtual lab meetings as a group, with collaborators, and with Brahney one-on-one where research results are presented and research papers discussed. Jiahao Wen, an international MS student was hired to work on

dust nutrient bioavailability with Brahney. Detiara Leifi was hired to analyse the microbial community composition of dusts with Zach Aanderud (Major Advisor) and Bonnie Waring (External Advisor). Three undergraduate students, Audree Provard, Katie Siesel, Margaret Hallerud, and one technician, Eric Heim, were hired with Brahney to assist with project operations. Molly Blakowski is a PhD student working with Brahney who is interested in education and outreach, Molly is assisting with the development of materials for high school students.

Students have been trained on various aspects of laboratory, analytical, and statistical procedures, though access to field work has been curtailed through the pandemic. Margaret Hallerud (undergraduate) and Eric Heim (MS level technician) have also participated in the publication of research results to date in the journal *Science*.

Dissemination -

Twenty-two invited and an additional four talks on the results of the research to date have been presented. International conferences included the American Geophysical Union, the European Geophysical Union, the Global Microplastic Symposium, Ocean conservancy's Trash Free Seas Alliance, and the Group of Experts on the Scientific Aspects of Marine Environmental Protection meeting in November of 2020. Local and regional presentations took place at the Utah Air Quality Science for Solutions conference in 2020 and 2021, the National Atmospheric Deposition Program's network operations fall meeting, university seminar series, documentary showings and conservation groups. Brahney also presented at the California Assemblies hearing on Environmental Safety in March, 2021.

Two papers have been published to date, one in *Science* and a second in *Proceedings of the National Academy of Sciences*. Brahney has written two lay articles, one for the *Science Breaker* and a second opinion piece published in *The New York Times* (06/26/2020). One chapter has been published in the *Encyclopedia of Inland Waters*, entitled "Dust and Fog effects on Inland Waters", by Brahney, Reche, and Weathers.

Brahney has given additional interviews on microplastic deposition through 2021 from ongoing attention related to the *Science* publication as well as the new publication in *PNAS*. Both papers were widely reported in news agencies such as *The New York Times*, *The Washington Post*, *The Guardian*, *Scientific American*, *National Geographic*, *Bloomberg*, *Wired*, *CNN*, *USA Today*, and *Newsweek*. Most recently Brahney was interviewed several times for a feature upcoming article in *Popular Science* about increasing dust emissions in the American West. Brahney has given several interviews for broadcast news including Gerta Van Susteren's 'Voice of America' and 'Full Court Press' and was featured on several podcasts including the *Ocean Protect Podcast*, *Quirks and Quarks (CBC)*, and *Big Picture Science Podcast*. Brahney has also worked with several agencies to create educational content for kids (*Science World Magazine*, *Newsforkids.net*) as well as for the general public including an interactive website by Pentagram Design and *Google Arts and Culture* and an animation through *Vox Answers*.

A new chapter for the textbook "Encyclopedia of Limnology", published by Academic Press, Elsevier, has been published. The chapter is titled "Dust and Fog effects on Inland Waters" by Brahney, J., Weathers, K., Reche, I. The chapter outlines our current understanding of dust composition and the capacity for dust to fertilize inland water bodies and influence pH and alkalinity. The state of knowledge on the capacity for dust to influence microbial and algal community composition is provided along with the significant knowledge gaps. The chapter is currently under review.

Curricula for our high-school program is being developed by Brahney and PhD student, Molly Blakowski, and our new extension specialist at USU, Dr. Erin Rivers. Due to the onset of the COVID-19 pandemic, the educational materials are being developed to focus on experiments students can do at home as well as the high school in question.

Plan of Work -

This project is in the last phases and we will continue to analyze the samples as above and expect to produce several additional publications on the composition of dust. Papers will focus on bioavailable nutrient deposition.

Other Products

Other - Code to calculate wind dispersion sources

<https://github.com/mhallerud/WindDispersionSources>

Audio or Video - Vox Answers: How does plastic from everyday items get swept into the air?

<https://twitter.com/voxdotcom/status/1289321212569559040?lang=en>

Physical Collections - We have >400 samples collected from 15 sites around the American west

Instruments or Equipment We have produced 30 samplers, 24 are still in operation.

Data and Research Material - We have produced and analyzed data for two publications. 1) on the physical functioning of our sampler for dust collections 2) on dust plastic composition, and 3) over 600 back trajectory models.

Protocols - We have developed protocols surrounding the use and recovery of our dust samples

Physical Collections - We have 120 samples collected from 15 sites around the American west

[Diversity and functions of bacterial symbionts in adelgids \(Hemiptera: Sternorrhyncha: Adelgidae\)](#)⁶

Project Director

Carol Von Dohlen

Organization

Utah State University

Accession Number

1012829



Diversity and functions of bacterial symbionts in adelgids (Hemiptera: Sternorrhyncha: Adelgidae)

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

Plant-sap-sucking insects are serious pests of agriculture and forests resources. Introduced and invasive species pose the greater threats. With growing concerns over pesticide use and insect resistance, alternative methods for control are needed. Adelgidae are aphidoids that feed solely on conifers. Native adelgid species cause significant economic losses in spruce seed orchards in the U.S. Invasive, introduced adelgids have become serious pests in North America. Hemlock woolly adelgid (HWA) introduced from Japan has nearly eliminated hemlocks in the eastern U.S, dramatically changing the ecology of eastern forests. Balsam woolly adelgid (BWA) introduced from Europe causes significant damage and mortality to true firs across the U.S. and Canada. Tens of millions of tax dollars have been spent to control these pests, without appreciable success. Problems will only intensify as a warming climate promotes more rapid insect reproduction and geographic range expansion.

Most sap-sucking insects harbor bacterial symbionts. Some bacteria are required (obligate) partners that supplement nutrient-poor plant-sap diets, while others are non-required (facultative) symbionts with other, protective roles. Because symbionts are intimate partners essential or beneficial to insect ecology and survival, such microbiota represent a potential alternative to insecticides and predators for control. Microbes have much simpler biology than their hosts, and are more easily manipulated. In addition, any direct effects of microbes on host trees could be negated by focused treatments aimed at toxic substances introduced by microbes, if they can be identified. Before information from microbes could be used to combat pests, however, we must have information about their identities and functions. In contrast to other sap-feeding insects, adelgid symbionts are understudied. Nothing is known about the roles or functions of these symbionts, aside from the preliminary data my laboratory has collected.

The overall goal of this project is to characterize the full diversity of bacterial symbionts that form functional associations with adelgid insects. Based on our preliminary survey and genomic data, we hypothesize that obligate symbionts of adelgids are likely nutritional partners, but may have other roles. We also hypothesize that facultative symbionts in certain adelgids may contribute to their invasive status and to their negative impacts on host plants. In this project, we will survey a broad sample of adelgid species to catalog the diversity and incidence of facultative symbionts, which may have functions in insect-plant interactions, and/or contribute to invasiveness through mediation of environmental stressors or even insecticide resistance. In addition, we will characterize the complete metabolic capabilities of obligate symbionts in two invasive pest adelgids, to determine whether they contribute specific products involved in toxicity to host plants. In these same two adelgids, we will characterize the host-insect products that potentially interact with symbionts regarding metabolic pathways.

Specific objectives are as follows:

1. Identify and inventory obligate and facultative bacterial associates of diverse adelgid species.
2. Finalize genome assembly and annotations of *Pseudomonas*, *Annandia*, and *Serratia* symbionts of hemlock woolly adelgid.
3. Assemble and annotate complete genomes of *Ecksteinia* and *Steffania* symbionts of balsam woolly adelgid.
4. Sequence, assemble, and annotate transcriptomes of three populations of hemlock woolly adelgid (HWA).

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

Objective 1. We completed a manuscript describing and comparing the 10 symbiont genomes from five Adelgidae species.

Objective 2. We have continued genome assembly work on the new sample of *Adelges tsugae* from *Tsuga heterophylla*. The assembly of the *Pseudomonas* symbiont is fragmented and needs more work. We have several strategies in progress to improve it. In addition, through a collaborator we have obtained a sample of *A. tsugae* from Bhutan, which is almost certainly host-alternating. We will sequence the symbiont genomes from this sample to compare to our other populations, to test for differences related to a life cycle containing a more nutrient-rich phase (the gall).

Objective 4. This year we scouted for more Douglas fir populations and found two productive sampling localities found (Logan Canyon and White Pine campground, ID.) Collaborators from Georgia spent a week at my lab in June and we dissected bacteriomes from adelgids from Douglas-fir needle generations. Collaborators extracted RNA for transcriptome analysis, but unfortunately the RNA was too degraded to be used. We have adjusted our methods to mitigate this when we sample again in June 2022. We have also conducted microscopy studies of bacteriomes on these samples and others from the gall generation. Transmission electron microscopy and light microscopy show that there are two cell types in the bacteriome. The smaller cells sometimes contained bacteria and usually contained strange vacuoles that might be symbiosomal membranes containing degenerated bacteria. The larger cells contained either a single bacterial type or a mixture of types. There were fewer small cells in these bacteriomes and more larger cells. Our hypothesis is that the galling adelgids have more, smaller, empty bacteriocytes and are mainly filled with *Vallotia*, the more abundant symbiont. In needle-feeding adelgids more bacteriocytes are used to house symbionts and the abundance of *Profftia* symbionts is increased.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None.

Training and Professional Development -

This project provided training for two PhD graduate students, who gained experience in general molecular biology laboratory skills, computer analysis, and bioinformatics. Specifically, the students gained experience in purifying genomic DNA and RNA and bioinformatic assembly of whole bacterial genomes from Illumina next-generation sequencing.

Dissemination -

This project provided opportunities for one Native American student from the Blanding statewide campus to learn about insect-bacterial symbioses and to participate in in-person laboratory research for one week.

Plan of Work -

Objectives 2. Purify DNA, send for Illumina sequencing, and conduct bioinformatics work to detect and assemble the symbiont genomes from the Bhutan *A. tsugae* strain. Finalize genome assemblies and annotations for symbionts of all *A. tsugae* strains.

Objective 4. Monitor *A. cooleyi* populations at Douglas-fir field sites for maturing nymphs to harvest for bacteriome dissection and transcriptomics (RNAseq). Dissect bacteriomes of 4th-instar nymphs for transcriptomics. Purify RNA and send for RNAseq. Conduct additional microscopy studies on fresh material from both life cycle phases of *A. cooleyi* to test the hypothesis of symbiont investment across different host plant diets.

Publications

Dederich, A., Halbert, S., & von Dohlen, C. D. (2022). Description of a new species of Hamamelistes forming galls on Fothergilla spp. (Hamamelidaceae) and the generic limits of Hormaphidini (Sternorrhyncha: Aphididae: Hormaphidinae). *To appear in Zootaxa*.

Dial, D. T., Weglarz, K. M., Aremu, A. O., Havill, N. P., Pearson, T. A., Burke, G. R., & von Dohlen, C. D. (2021, January 01). Transitional genomes and nutritional role reversals identified for dual symbionts of adelgids (Aphidoidea: Adelgidae). *ISME Journal*, epub 20210910.

Mech, A. M., Harper, S. J., Havill, N. P., von Dohlen, C. D., & Burke, G. R. (2017, December). Ecological factors influencing the beneficial endosymbionts of the Hemlock Woolly Adelgid (Hemiptera: Adelgidae). *Insect Science*.

Nieto Nafria, J. M., von Dohlen, C. D., Moreno-Gonzalez, V., Ortego, J., & Mier Durante, M. P. (2019). The species of Uroleucon (Hemiptera: Aphididae) living on Adesmia (Fabaceae) in Argentina, with the description of a new species. *Zootaxa*, 4555(4), 561–572.

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Ortego, J., Licht, M., Mier Durante, M. Pilar, & Nieto Nafria, J. (2022). Blanchardaphis poikila syn. n. to B. capitophoroides and Blanchardaphis syn. n. to Lambersius (Hemiptera, Aphididae, Aphidinae, Macrosiphini, Uroleucon). *To appear in Zootaxa*.

Weglarz, K. M., Havill, N. P., Burke, G. R., & von Dohlen, C. D. (2018, June 01). Partnering with a pest: Genomes of hemlock woolly adelgid symbionts reveal atypical nutritional provisioning patterns in dual-obligate bacteria. *Genome Biology and Evolution*, 10(6), 1607-1621.

von Dohlen, C. D., Spaulding, U., Patch, K., Weglarz, K. M., Footitt, R. G., Havill, N. P., & Burke, G. R. (2017, June). Dynamic acquisition and loss of dual-obligate symbionts in the plant-sap-feeding Adelgidae (Hemiptera: Sternorrhyncha: Aphidoidea). *Frontiers in Microbiology*, 8, 1-15.

Presentations

Brunet, B. (Presenter & Author), Burke, G. (Author Only), Footitt, R. (Author Only), Havill, N. (Author Only), Johnston, S. (Author Only), von Dohlen, C. D. (Author Only), ICE 2022, "Building a Phylogeny for the Adelgidae using Shotgun Phylogenomics," International Congress of Entomology, Helsinki, Finland. (July 19, 2022 - July 24, 2022)

Licht, M. (Presenter & Author), von Dohlen, C. D. (Author Only), ICE 2022, "PACH-ed with Species: Parsing a Cryptic Species Complex (Pachysylla: Psylloidea: Hemiptera)," International Congress of Entomology, Helsinki, Finland. (July 19, 2022 - July 24, 2022)

Dederich, A. (Presenter & Author), von Dohlen, C. D. (Author Only), Annual Meeting of the Entomological Society of America, "Consequences of host life cycles for symbiont genome evolution," Entomological Society of America, Denver, CO. (November 2021)

Dial, D. (Presenter & Author), Weglarz, K. (Author Only), von Dohlen, C. D. (Author Only), Havill, N. (Author Only), Burke, G. (Author Only), Joint Eastern & Southeastern Branch Meeting of the Entomological Society of America, "Differential division of labor in the ancient symbionts of sap-sucking insects (Sternorrhyncha: Adelgidae)," Entomological Society of America, Mobile, AL. (March 2020)

Dial, D. (Presenter & Author), Burke, G. (Author Only), von Dohlen, C. D. (Author Only), Weglarz, K. (Author Only), Havill, N. (Author Only), Annual Meeting of the Entomological Society of America, "Differential division of labor in the ancient symbionts of sap-sucking insects (Sternorrhyncha: Adelgidae)," Entomological Society of America, St Louis, MO. (November 2019)

Dial, D. T. (Presenter & Author), Burke, G. R. (Author Only), Weglarz, K. M. (Author Only), Havill, N. P. (Author Only), von Dohlen, C. D. (Author Only), Gordon Research Seminar: Symbiotic Tipping Points: Evolutionary Forces Driving Symbiotic Interactions, "Differential division of labor in the ancient symbionts of sap-sucking insects (Sternorrhyncha: Adelgidae)," Gordon Research Seminar, Mount Snow, Vermont. (June 2019)

Dial, D. (Presenter & Author), Burke, G. (Author Only), Weglarz, K. (Author Only), Havill, N. (Author Only), von Dohlen, C. D. (Author Only), Southeastern Branch Meeting of the Entomological Society of America, "Differential division of labor in the ancient symbionts of sap-sucking insects (Sternorrhyncha: Adelgidae)," Entomological Society of America, Mobile, AL. (March

2019)

Licht, M. (Presenter & Author), Nieto Nafria, J. (Author Only), Jaime, O. (Author Only), von Dohlen, C. D. (Author Only), Annual Meeting of the Entomological Society of America, "Going Native: Aphid Colonization of South America," Entomological Society of America, Vancouver, BC, Canada. (November 2018)

Burke, G. (Invited Lecture), Weglarz, K. (Author Only), Havill, N. (Author Only), von Dohlen, C. D. (Invited Lecture), Annual Meeting of the Entomological Society of America, "Chefs and sous-chefs in the adelgid kitchen: Differential division of labor in the ancient symbionts of sap-sucking insects (Sternorrhyncha: Adelgidae)," Entomological Society of America, Denver, CO. (November 2017)

Burke, G. (Invited Lecture), Weglarz, K. (Author Only), Havill, N. (Author Only), von Dohlen, C. D. (Invited Lecture), Annual Meeting of the Entomological Society of America, "Passing the torch: an obligate adelgid symbiont steps back from its role as the primary producer," Entomological Society of America, Denver, CO. (November 2017)

Weglarz, K. (Presenter & Author), Burke, G. (Author Only), Havill, N. (Author Only), von Dohlen, C. D. (Author Only), Annual Meeting of the Entomological Society of America, "Vacillating Vallotia: does a switch in metabolic role influence the course of symbiont genome decay in adelgids (Hemiptera: Sternorrhyncha: Adelgidae)?," Entomological Society of America, Denver, CO. (November 2017)

Other Products

Data and Research Material - Purified RNA from gall generations of *Adelges cooleyi*.

Data and Research Material - Dissected bacteriomes from gall generations of *Adelges cooleyi*.

Data and Research Material - Insect samples in ethanol of *Adelges tsugae* from Bhutan.

Data and Research Material - Partial genomes assemblies for two endosymbionts of one strain of Hemlock Woolly Adelgid (*Adelges tsugae*) from *Tsuga heterophylla* from Washington state.

Data and Research Material - Purified genomic DNA for Hemlock Woolly Adelgid (*Adelges tsugae*) from *Tsuga heterophylla* from Washington state.

Data and Research Material - Purified genomic DNA for 8 species of adelgids (Hemiptera: Adelgidae)

Data and Research Material - Complete, annotated genomes for dual symbionts of three strains of hemlock woolly adelgid (*Adelges tsugae*) and four other *Adelges* species.

Data and Research Material - Complete, annotated genomes for dual symbionts of *Pineus similis*, *Adelges cooleyi*, *Adelges lariciatus*, and *Adelges piceae* (Hemiptera: Sternorrhyncha: Adelgidae).

Data and Research Material - Specific PCR data on presence/absence of *Serratia* symbionts across diverse species of adelgids.

Data and Research Material - 16S sequences of *Serratia* symbionts from specific PCR products generated from adelgid species.

Data and Research Material - Complete, annotated genomes for *Annandia* and *Pseudomonas* symbionts of hemlock woolly adelgid (*Adelges tsugae*) from eastern North America.

Data and Research Material - Genomic data for *Annandia*, *Pseudomonas*, and *Serratia symbiotica* symbionts of hemlock woolly adelgid (*Adelges tsugae*) from *Tsuga sieboldii* from Japan.

Data and Research Material - 16S sequence data for symbionts and other microbial associates of ~20 populations/species of adelgids.

Identifying biotic and abiotic controls of plant regeneration to advance sagebrush steppe conservation and restoration

Project Director

P Adler

Organization

Utah State University

Accession Number



Identifying biotic and abiotic controls of plant regeneration to advance sagebrush steppe conservation and restoration

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

1. Determine how plant-soil feedbacks influence the establishment of native perennials in the sagebrush steppe
2. Determine how climate change will alter impacts of the cheatgrass invasion

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: How do plant-soil feedbacks influence the establishment of native perennials in the sagebrush steppe?

Field work for this objective is now complete. Former post-doc Anny Chung and I are working together to disseminate the results. We have one manuscript in the second round of review at Ecology, and a second manuscript, an invited Opinion piece for Trends in Ecology and Evolution, is in preparation

Objective 2: How will climate change alter impacts of the cheatgrass invasion?

Most of our work this year focused on this objective, carried out in coordination with our NSF "Bromecast" award.

Successful completion of pilot common garden experiment

In spring 2021, we completed our pilot common garden experiments at the Cheyenne, WY, Dubois, ID and Boise, ID sites. Our primary goal was to test our colored gravel "albedo" treatment for manipulating soil temperature. We had originally planned to use open top chambers to increase temperatures, but we were concerned about a number of unintended environmental side-effects that OTCs introduce. The results of our pilot study have given us confidence to proceed with the colored gravel alternative. At all three sites, black gravel increased soil temperatures at least 2 degrees C above the white gravel treatment. The difference in temperature also translated into differences in plant phenology and growth, with more rapid phenology and increased growth on black gravel. Surprisingly, we observed greater growth in the high density than the low density planting treatments, indicating some sort of intraspecific facilitation. Finally, we learned valuable lessons about how to apply the gravel, glue seeds to toothpicks and plant them, and monitor plant responses. These lessons helped us implement the full-scale common garden experiments this summer and fall. We are now working on a short manuscript to document these methods, led by post-doc Toby Maxwell (USGS Boise).

Implementation of full common garden experiments

We began implementing a larger-scale common garden experiment in the spring of 2021 across four sites in the Intermountain West (two sites near Boise, ID; one in Dubois, ID; one in Cheyenne, WY). We established denuded plots using a 2 x 2 factorial design of cheatgrass density (low vs high) and plot temperature (white vs black gravel). Every site contains 40 plots (10 replicates of each density x temperature treatment in a randomized block design) each planted with 100 cheatgrass seeds from 95 different genotypes for a total of 16,000 planted seeds across all sites. Before planting, we glued all cheatgrass seeds to toothpicks and labeled toothpicks of different genotypes with unique color combinations to more effectively track individual seeds in randomized planted grids and monitor source population demography and growth. We planted 10 toothpicks of 18 genotypes (180 seeds total) in additional grid rows to destructively sample plants and measure morphological and physiological traits in high elevation white plots and low elevation black plots (to produce the greatest variability in traits).

In addition to seed planting, we covered plots with black or white gravel to change surface albedo and monitor the effect of simulated warming on cheatgrass demography and growth. We installed four replicates of Decagon 5TM VWC and temperature sensors in low density black and white plots (a total of eight sensors) to quantify differences in these abiotic characteristics between temperature treatments. A denuded plot planted with cheatgrass at low density and two 5TMs installed serves as a control plot. An ambient plot with intact vegetation and four sensors (two thermocouple and two Decagon ECH2O sensors) installed at depth (20 and 50 cm) will help configure temperature and moisture regimes.

We have already completed our first, post-emergence census at all sites, and are encouraged by the high emergence rates (well over 90%) and already apparent treatment effects (more rapid growth on black gravel).

Implementation of satellite site experiments

We have recruited volunteers to conduct the distributed, satellite experiments across western North America from British Columbia, Canada to Arizona. This year, we have about 40 sites planned, involving about 40 Bromecast participants (some sites have multiple volunteers). Approximately 25 of these sites have confirmed their fall 2021 planting. A total of 150 cheatgrass seeds are planted on toothpicks in every site in either control or vegetation removal treatments to measure the effects of interspecific interactions on cheatgrass demography. We will also monitor plant species composition and ground cover and soil-surface characteristics during spring surveys to extend the inference of environmental covariates on cheatgrass demography beyond the common garden sites, and to test model predictions.

Genomic analyses (led by collaborators at Penn State University)

In Fall 2020, we extracted DNA from six representative genotypes that were sent for sequencing at 50X coverage to the DOE Joint Genome Institute and used for making preliminary genome assemblies. In Fall 2020-Spring 2021 we bulked over 200 cheatgrass genotypes from the native (54) and invaded (149) range in a growth chamber with controlled conditions. We planted 5 replicates per genotype, two of which were used for DNA extraction and sequencing. Extracted DNA was sent to the Texas A&M sequencing facility to be sequenced at ~4.4X coverage. The other three replicates were vernalized after ~20 days after germination for 10 weeks in a cold room at 4°C, and subsequently were placed back in a growth chamber (13°C night and 20°C day with a 12h photoperiod). We used these three replicates to estimate vegetative and reproductive height, number of tillers and approximate number of leaves, total number of inflorescences produced, flowering time, fresh aboveground mass, and fecundity (approximate seed number based on the weight of 20 seeds per plant). Fecundity measures are still ongoing. We received all sequences back in Fall 2021 and we're currently performing the bioinformatics for calling genetic variants. Taken together, this data will allow us to dissect the genetic basis of variation in life history strategies, and how strategies differ or not between the native and invaded range.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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.

Training and Professional Development -

The UAES project has supported four undergraduate research assistants over the calendar year. They received training in plant propagation (greenhouse experiments), field data collection, sample processing, data entry, and data quality control and assurance. The project also provided partial support for a post-doc working with Bromecast Co-PI Germino in Boise, who helped conduct the pilot common garden experiment, and designed and implemented the main common garden experiments.

Dissemination -

Under Objective #1, plant-soil feedbacks, we have one manuscript in review and a second in preparation.

Under Objective #2, cheatgrass, our NSF project involves a public outreach component lead by the Denver Botanic Garden. They are working with Idaho Botanical Garden (in Boise) and Red Butte Botanic Garden (in Salt Lake). They fabricated fiberglass hexagon chambers and shipped them to the two other sites. Due to shut downs from Covid, they were quite

delayed in getting the chambers set up, but were able to get all the chambers set up at all 3 sites (the above 2 plus Denver Botanic Gardens) this year and begin data collection. They have 5 plots (paired with a control plot) set up at each site. They decided to focus on phenology for data collection since all sites have public programs linked to NPN so it is easy for everyone (staff, volunteers, visitors) to collect data on the NPN app (Nature's Notebook). They used this year primarily to figure out how things would work at each site and troubleshoot site-specific issues (high winds requiring larger ground staples to hold some in place; unintended mowing of a control plot) and plan to initiate more rigorous public outreach and data collection starting in the spring. Each site will focus on incorporating the chambers into their existing programs which vary by site but include school programs such as field trips and camps and docent-led tours. The interpretation and engagement staff at Denver Botanic Gardens are planning the interpretation development around plants and climate change. Each of the other sites completed an interpretation survey for the Denver staff so they could better understand the needs and capacity at each site so that materials developed will be useful and usable.

Plan of Work -

We will continue working on the Bromecast project until the rapidly approaching end of this project.

Publications

Refereed Journal Articles

Adler, P., White, E., & Cortez, M. (2020). Matching the forecast horizon with the relevant spatial and temporal processes and data sources. *Ecography*, *43*(11), 1729-1739.

Adler, P., Kleinhesselink, A. R., Hooker, G., Taylor, J. B., Teller, B., & Ellner, S. (2018). Weak interspecific interactions in a sagebrush steppe: evidence from observations, models, and experiments. *Ecology*, *99*, 1621-1632. 1073,

Anderson, T. M., al, e., & Adler, P. (2018). Herbivory and eutrophication mediate grassland plant nutrient responses across a global climatic gradient. *Ecology*, *99*, 822-831.

Chung, Y. A., Monaco, T., Taylor, J. B., & Adler, P. Do plant-soil feedbacks maintain coexistence in a sagebrush steppe?

Hautier, Y., al, e., & Adler, P. (2018). Local loss and spatial homogenization of plant diversity reduce ecosystem multifunctionality. *Nature Ecology and Evolution*, *2*, 50-56.

Hodapp, D., al, e., & Adler, P. (2018). Spatial heterogeneity in species composition constrains plant community responses to herbivory and fertilisation. *Ecology Letters*, *21*, 1364-1371.

Kleinhesselink, A. R., & Adler, P. (2018). The response of big sagebrush (*Artemisia tridentata*) to interannual climate variation changes across its range. *Ecology*, *99*, 1139-1149.

Kulmatiski, A., Adler, P., & Foley, K. M. (2020). Hydrologic niches explain species coexistence and abundance in a shrub-steppe system. *Journal of Ecology*, *108*(3), 998-1008.

Lasky, J. R., Hooten, M. B., & Adler, P. (2020, December). What processes must we understand to forecast regional-scale population dynamics? *Proceedings of the Royal Society B: Biological Sciences*, *287*(1940), 20202219.

Laughlin, D., Strahan, R., Adler, P., & Moore, M. (2018). Survival rates indicate that correlations between community-weighted mean traits and environments are unreliable estimates of the adaptive value of traits. *Ecology Letters*, *21*, 411-421.

Renwick, K., Curtis, C., Kleinhesselink, A. R., Schlaepfer, D., Bradley, B., Aldridge, C., Poulter, B., & Adler, P. (2018). Multi-model comparison highlights consistency in predicted effect of warming on a semi-arid shrub. *Global Change Biology*, *24*, 424-438.

Tredennick, A., Kleinhesselink, A. R., Taylor, J. B., & Adler, P. (2018). Ecosystem functional response across precipitation extremes in a sagebrush steppe. *PeerJ*, *6*, e4485.

Tredennick, A., Adler, P., Hooker, G., & Ellner, S. (2018). Size-by-environment interactions: a neglected dimension of species' responses to environmental variation. *Ecology Letters*, *21*, 1757-1770.

Presentations

Terry, T. J., Adler, P., Ecological Society of America Annual Meeting, "Climate drives dryland plant response to disturbance: A lesson from natural gas pipeline corridors." (2021e Present)

Adler, P., Western Drought Resilience Workshop, "Ranching, rangelands, and resilience: ensuring adaptive capacity in an increasingly variable climate," USDA Southwest Climate Science Hub. (2020 - Present)

Chung, A. (Author Only), Monaco, T. (Author Only), Taylor, J. B. (Author Only), Adler, P., Ecological Society of America Annual Meeting, "From phenomenon to mechanism: Are plant-soil feedbacks maintaining coexistence in the sagebrush steppe?," Ecological Society of America, Salt Lake City. (2020)

Adler, P., Lasky, J. (Author Only), Hooten, M. (Author Only), Ecological Society of America Annual Meeting, "What processes must we understand to forecast the impact of global change on species distribution and abundance?," Ecological Society of America, Salt Lake City, UT. (2020)

Other Products

Other - We have created a project website (<https://bromecast.wixsite.com/home>) to recruit participants to the Bromecast network, share protocols and data with them, and share our research with the broader research community.

Sustainable Natural Resources Education

Project Director

Lendel Narine

Organization

Utah State University

Accession Number

7001909



Landscape Water Conservation

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

Utah is the second driest state in the nation; landscape irrigation efficiency and water conservation are ongoing focus areas for the Sustainable Natural Resource program at USU Extension. Utah receives only 13 inches of precipitation annually. Residential and commercial landscape irrigation is one of the largest drivers of water consumption, particularly in urban settings. Several state and national agencies have developed certification programs to educate professionals on efficient landscape water use and conservation. However, two major challenges for professionals are (a) maintaining a professional certification, and (b) completing the required continuing education units (CEU's) needed to keep the certification current.

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

To address these issues and share the latest best practices and research related to efficient landscape water use and conservation, the Center for Water Efficient Landscaping (CWEL) developed the monthly "Water Well with CWEL" webinar series. To date, CWEL delivered educational sessions to Extension outreach professionals, conservation program managers, state & federal employees, horticulturist, master gardeners, landscape professionals, homeowners and students across 38 states. In addition to the live events, each webinar is available on CWEL's YouTube channel. In December 2021, there were 1,376 members on the webinar list serve, 3,430 individuals have registered for events, 2,097 attendees to educational events, and 4,461 YouTube views. In 2021, CWEL saw a 36% increase in registration, 37% increase in attendance, 52% increase in members to the email list serve, and 203% increase in YouTube views. In 2021, 9 webinars were facilitated by CWEL. Of the 765 attendees across the 9 events, 436 were unique viewers.

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

In 2021, there was significant growth in participation to CWEL educational events on water conservation. Post-evaluation results indicated about 86% of the participants acquired resources they can use to promote efficient landscape water use and conservation. All respondents reported an increase in knowledge related to landscape water use and conservation after attending the events. Most participants (90%) indicated that they gained water conservation ideas they can implement. In a follow-up evaluation, about 39% of participants had adopted best practices for water conservation, and 53% indicated they planned to adopt best practices soon. Some practices implemented by participants to improve water efficiency were

increased use of native and drought tolerant plants, improved irrigation systems and irrigation scheduling, installation of green roofs, utilization of smart technologies to manage landscape water use, incorporation of rainwater harvesting systems, and water-wise landscape principals into landscape designs.

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

While landscape irrigation efficiency alone will not provide all the water needed to sustain Utah's population growth, it remains the most feasible areas of intervention to protect the state's water supply. USU Extension will continue to expand landscape irrigation education to residents to facilitate efficient water use. The CWEL targets programming to gardeners and homeowners across Utah with a long-term goal is sustainable water use and protect our water supply in times of climate change and population growth.



Public Natural Resource Education

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

Many communities lack the opportunity to engage with science education in public forums to discuss issues related to natural resources. With three national parks, including Arches, natural resource tourism is a major contributor to economic growth in Grand County Utah. The large number of year-round visitors impacts the daily lives of community members. This is especially relevant to the town of Moab in Grand County that receives over 3 million visitors a year. While sustainable tourism requires input from all community members, some individuals may lack unbiased knowledge of issues relating to their natural resources to contribute to meaningful decision-making on important policies.

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 response, K. Young and team developed an Extension program to address relevant issues and disseminate unbiased information to residents on natural resources. The Public Science program included the Science Moab radio podcast, and the School-to-Science series. K. Young and team co-produced 24 episodes of the Science Moab radio show in 2021. Each episode averaged 1,000 listeners. In addition, they developed and facilitated the launch of the School-to-Science program that pairs Grand County High School students with scientists for job shadows and internships.

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

In 2021, 100% (N = 17) of participants in the School to Science program indicated an increase in scientific knowledge and college and career readiness skills after participating in the program. All participants indicated an increase in understanding of desert ecosystems and in ability to convey scientific concepts.

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

The Public Science program aims to bridge the gap between public science education and tourism policy discussions. Tourism in Grand county has a direct impact on residents, and non-biased information provided by Extension can help residents engage meaningfully with policymakers and stakeholders. The program, while in its early stages, focuses on disseminating information to adults through the podcast, and to youth through school-based interventions. As the program grows, residents of Grand county will have access to program services and activities to help them participate in the ongoing discussions of natural resources, policy, and tourism.

Critical Issue

Community Resilience

[Climate Change, Media Coverage, and Societal Responses in Utah and the Intermountain West.](#)

Project Director

Jennifer Givens

Organization



Climate Change, Media Coverage, and Societal Responses in Utah and the Intermountain West.

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

The overarching goals of this project are to contribute to our understanding of and assess: how the media is covering and communicating climate change, how this varies across place and time, in terms of scale, and by social, political, economic, and environmental contexts, and how this is associated with activities in response to climate change.

The specific objectives are to:

1. Collect empirical data on media coverage of climate change in Utah and the Intermountain West, including how this varies across locations and if it has changed over time.
2. Analyze statistically how variations in coverage are associated with different temporal, geographic, social, political, economic, and environmental contexts.
3. Collect data on response to climate change and test if there is a relationship between media coverage of climate change and response to climate change.
4. Develop a finer grained understanding of the determinants of and relationships between media coverage of climate change, social, political, economic, and environmental context, and response to climate change by conducting an in-depth case analysis of three local communities.

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

A manuscript submitted to a journal based on my former Master's student's successfully defended USU master's thesis in Sociology. He and I have received a revise and resubmit and are currently revising. The key contribution is a comparison of local to national media coverage of climate change, and a finding that the two differ by context on one key component of framing, the "human interest" component. Results also indicate increasing politicization of climate change coverage in the media.

(Objectives 1, 2, and 4)

My current graduate student successfully defended her Master's Thesis Proposal. This project compares media coverage of climate change in three media outlets and two communities. This is an in-depth qualitative case analysis of differing coverage in two communities, one Native American/Indigenous and one not. Under my guidance and the guidance of her thesis committee, she has completed data collection, which consisted of developing a sampling frame, compiling articles to code, and developing a coding frame. We are now coding and beginning data analysis. Based on this analysis we will be able to discuss relationships between media coverage of climate change and views and proposed actions on climate change as it varies by community.

(Objectives 1, 2, 3 and 4)

The following article, which came out online in 2020 and was included in my 2020 report, came out in print in 2021. Givens, Jennifer E., Shawn K. Olson Hazboun, Michael D. Briscoe, Richard S. Krannich. 2021. "Climate Change Views, Energy Policy Support, and Personal Action in the Intermountain West: The Anti-Reflexivity Effect." *Society & Natural Resources*. Available online May 28, 2020. <https://doi.org/10.1080/08941920.2020.1769782> (2020 Impact Factor 2.050)] This article was a collaboration and publication in the peer-reviewed journal *Society and Natural Resources*, a leading journal in my field. I am first author, and I took the lead on the paper, including the literature review and the analysis. Key findings include the importance of political views in shaping views on climate change. This improves knowledge and informs our understanding of media coverage in terms of determinants of views and politicization. This work arose from a collaboration with several other researchers who gave me access to new survey data on responses to climate change, including concern and views, policy support related to energy sources, and behavior change in five states in the Intermountain West (Utah, Colorado, Wyoming, Montana, and Idaho).

(Objective 2 and 3)

An ongoing collaboration related to COVID and other environmental issues in Utah related to media coverage. (Objectives 2 and 3)

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

While there were no major changes or problems this year, COVID-19 may have affected progress and impacted dissemination of results at conferences and to broader audiences.

Training and Professional Development -

I am training my second Master's student in Sociology supported by this funding. As with the first M.S. student, I am chairing her thesis and mentoring her through the research process. I closely mentor students one-on-one in developing research questions about media coverage of climate change in different social contexts, writing thesis proposals, data collection and analysis, and preparation of results for thesis projects and peer-reviewed publications. I also emphasize training students how to work as a research team. I successfully mentored my current M.S. student in applying for a USU College of Humanities and Social Sciences (CHaSS) Creative Activity and Research Enhancement (CARE) grant to hire an undergraduate research assistant to assist with coding. This also gives the M.S. student experience with grant writing and mentoring. I also mentored her through submitting our research to present at a conference to be held in 2022.

In addition, although my former MS student has graduated, I am continuing to mentor him to get the paper we crafted from his thesis published in a peer-reviewed journal.

Dissemination -

Submission of an article, co-authored with my former M.S. student to a peer-reviewed journal.

Submission of a presentation to a conference scheduled to be held in 2022.

Plan of Work -

Objective 1, continue analysis of data my second M.S. student has collected of media coverage of climate change specifically related to indigenous peoples and native nations and communities in Utah and the West compared to national coverage.

Objective 2, continue analysis of data collected on media coverage and social context.

Objective 3, continue qualitative analysis in two communities with current M.S. student and continue analysis of previously collected survey data, including data on media.

Objective 4, continue analysis of media coverage of climate change in local contexts.

Publications

Refereed Journal Articles

Givens, J., Hazboun, S. O., Briscoe, M. D., & Krannich, R. S. (2021). Climate Change Views, Energy Policy Support, and Personal Action in the Intermountain West: The Anti-Reflexivity Effect. *Society & Natural Resources*.

Hazboun, S. O., Howe, P., Coppock, D. D., & Givens, J. (2020). The Politics of Decarbonization: Examining Conservative Partisanship and Differential Support for Climate Change Science and Renewable Energy in Utah. *Energy Research & Social Science*.

Presentations

Givens, J. (Presenter & Author), Society for Human Ecology (SHE) Annual Meeting, Brazil, Virtual Meeting, "Inequality, Emissions, and Well-being, and the Desiccation of the Great Salt Lake in Utah." (October 21, 2021)

Givens, J. (Presenter & Author), Schad, J., American Sociological Association (ASA) Annual Meeting, Chicago, Virtual Meeting, "Views on Three Environmental Issues and COVID-19 in Utah: Political Polarization and Hope for Social Change." (August 10, 2021)

Givens, J. (Presenter & Author), Knight, K. (Author Only), International Sociological Association IV ISA Forum of Sociology, Porto Alegre, Brazil, Virtual Meeting, "Democratic Values and Climate Change Views: A Cross-National Multilevel Analysis." (February 25, 2021)

Spradlin, T. (Presenter & Author), Givens, J. (Presenter & Author), American Sociological Association (ASA) Annual Meeting, "Framing Climate Change: National and Local Newspaper Coverage of Climate Change," (Note: this session was cancelled due to COVID.). (August 2020)

Givens, J. (Presenter & Author), Howe, P. D. (Author Only), Spradlin, T. (Presenter & Author), Coppock, D. L. (Author Only), International Symposium on Society and Resource Management (ISSRM), "Environmental Concern, Action, and Risk Perception in Utah, 2017: Views about the Environment, Climate Change, and Air Pollution," Snowbird, UT. (June 17, 2018 - June 21, 2018)

Other Products

Other - Journal Article under review with revise and resubmit - by Tyler Spradlin, MS Sociology USU, and Jennifer Givens, PhD

Other - Successful Master's Thesis Proposal Defense, and Thesis in progress, by Gina McCrackin in Sociology at USU; I, Jennifer Givens, am her thesis committee chair

Other - Master's Thesis, by Tyler Spradlin, MS Sociology. Successfully defended April 2020. Available at <https://digitalcommons.usu.edu/etd/7907/>

Data and Research Materiale Compiled a database of newspaper coverage of climate change in three mountain towns in the Western US (in Utah, Colorado, and Wyoming), at two time points (2011 and 2016), and a companion database of newspaper coverage of climate change in two national prestige press newspapers (The New York Times and Washington Post) for the same two years for comparisons at the local versus national scale.

Data and Research Materiale Building a database of newspaper coverage of climate change in three mountain towns in the Western US, 2000-2016 and a database of newspaper coverage of climate change in Utah in 2016

Databases - Building a database of newspaper coverage of climate change in three mountain towns in the Western US, 2000-2016.

Data and Research Materiale Collected survey data on public views on climate change, other environmental issues, and individual responses, in Utah, 2017.

[The Rural Community Environment and Individuals with Disabilities' Social Integration](#)

Project Director

K Christensen

Organization

Utah State University

Accession Number

1012951



The Rural Community Environment and Individuals with Disabilities' Social Integration

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

The purpose of this research effort is to explore the role environmental context plays in relation to individuals with disabilities' social integration in a community.

There are numerous research questions to be explored, such as to what extent the characteristics of an individual with disabilities' environment is related with their opportunities for social interaction, quality of their social interactions, quality of their social support, self-efficacy, and perception of their quality of life. To do so the specific objectives of the research plan include:

1. Model individuals with disabilities' social environment.
2. Model individuals with disabilities' physical environment.
3. Develop an integrated framework describing the socio-ecologic environment of individuals with disabilities.
4. Describe the relationship between individuals with disabilities' physical and social environments.

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 research project involves four objectives, to be completed over 5 years; (objective 1) model individuals with disabilities' social environment, (objective 2) model individuals with disabilities' physical environment, (objective 3) develop an integrated framework describing the socio-ecologic environment of individuals with disabilities, and (objective 4) describe the relationship between individuals with disabilities' physical and social environments.

The first objective occurred over the first two project years (beginning July 1st, 2017 through June 30th, 2019). These activities represented an ongoing review of the literature necessary to develop the social and behavioral survey instruments, and IRB protocol development necessary to accomplish this first project objective. The literature review, and other efforts, led to a successful and significant external funding award to support expanded project activities. The remaining activities of the original first objective have evolved to meet the expanded objectives, which will continue to take place according to the timeline of the new research award/effort beginning September 29, 2019 through September 28, 2024. The three coordinated survey instruments, and fourth COVID-19 focused synthesis instrument, have been developed and piloted, as described in the Products section of this report. And IRB approval for their use has been obtained.

The project's original data collection activities are delayed at present due to COVID-19 pandemic impacts on individuals with disabilities' activities of daily community living. The participation of individuals with disabilities in activities of daily community living are significantly impacted by the conditions associated with responses to COVID-19. As our research team intends to collect data regarding individuals with disabilities' activities of daily community living this is a significant issue, which we need to return to 'normal' before collecting data. In the meantime, an exploratory study was developed and conducted to assess individuals with disabilities' activities of daily community living during the COVID-19 pandemic conditions compared with those of the general population. This data, measured using an abbreviated version of the activities of daily community living instruments, both (1) informs our understanding of pandemic condition impacts (which is largely unknown at present), and (2) is being used to determine lasting impacts which may influence the project's planned data collection activities when they resume in 2022, to maintain the fidelity of the instruments. This exploratory research effort concluded mid-December 2021 and have been submitted for peer-review publication.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

Completion of the project activities is expanded as a result of the external funding award; A Socio-Ecologic Framework Supporting Individuals with Disabilities' Community Living and Participation, funded by the National Institute on Disability, Independent Living, and Rehabilitation Research, Research (NIDILRR) as a Disability and Rehabilitation Research Projects (DRRP) focused on Community Living and Participation of Individuals with Disabilities. Time commitments and timeline of the objectives have been shifted to address this expanded effort beyond the ending of this UAES project.

The UAES project's original data collection activities are delayed due to COVID-19 pandemic impacts on individuals with disabilities activities of daily community living. The participation of individuals with disabilities in activities of daily community living are significantly impacted by the conditions associated with responses to COVID-19. As our research team intends to collect data regarding individuals with disabilities' activities of daily community living this is a significant issue, which we need to return to 'normal' before collecting data.

Steps continue to be taken to minimize overall project delay as a result of COVID-19 delays. The work plan has been revised somewhat to emphasize other project objectives during the delay. The data collection instruments have been developed, piloted, with the intention of proceeding with pre-model development, as per Objectives 1 through 3, using the extrapolated data from piloting. These efforts will facilitate the research team's recruitment and data collection efforts to proceed quickly once the COVID-19 impacts sufficiently subside, and then quickly be integrated into the initial model development.

Additionally, and importantly, the research team initiated an exploratory study to assess individuals with disabilities' activities of daily community living during the COVID-19 pandemic conditions compared with those of the general population. This exploratory research effort has been published.

Training and Professional Development -

Under the PIs supervision two LAEP graduate student were recruited to meet the project's initial objectives. The graduate student worked actively with the PI to increase their understanding of individuals with disabilities' social networks, as well as meeting the projects objectives. A PhD student was recruited in the department of Social Work to assist in the development of the assessment instruments, including working with an advisory board of individuals with disabilities to pilot the survey instruments and work towards ensuring that these instruments reflect the characteristics and needs of the participant population of individuals with disabilities. And a PhD student in Civil Engineering participated in the project, to contribute to objective 2 through the development of an UrbanSim computational model of individuals with disabilities' community environment context, particularly in initiating the stable instance running within the project's research environment and examining the data flows among the model components.

The research team for the new funding award has recruited an additional 3 PhD students to assist in the expanded project objectives over the course of the next 3-4 years. As part of this expanded effort, training and technical assistance activities of the effort comprise dissemination of community-scale planning policies and practices, and tools. Instruments to assess the inclusion of individuals with disabilities in activities of daily community living, including transportation which is a critical aspect of such, represent one of these important tools. Sharing of developed resources and tools, such as these instruments, is important to improving the community living and participation of individuals with disabilities.

Dissemination -

Dissemination has not yet taken place regarding aspects of this research project which have been delayed due to the COVID-19 pandemic. However, the exploratory studies developed and conducted to assess individuals with disabilities' activities of daily community living during the COVID-19 pandemic conditions compared with those of the general population, has been completed and disseminated; A Double Jeopardy: COVID-19 impacts on people with disabilities' travel behavior and community living. *Transportation Research Part A: Policy and Practice*, (156): 24-35. As have other exploratory work to establish the foundation for the research; Impacts of disability on daily travel behavior: A systematic review. *Transport Reviews*.

A number of other articles are either in review or preparation, regarding the social sustainability of community place types, disability theory for planners, and disability-focused community policy analysis.

Plan of Work -

The expanded objectives related to the new award will continue beyond the ending of this project, and involve including individuals with disabilities in the computational models used in community planning and development to examine the relationships between people, housing, employment, public accommodation and services (Objective 1), and transportation (Objective 3). In a socio-ecologic framework which recognizes the link between the physical environment and the social environment (Objective 4), **we will combine these models with models of the social networks (family, friends, and acquaintances) and activities of daily community living measured through surveys with individuals with disabilities (Objective**

2 – which is the original Objective 1 of the UAES project). Using this complex socio-ecologic model we will test whether existing community planning practices and policies (Objective 5) improve individuals with disabilities' social networks and ability to complete activities of daily living (Objective 6). Similarly, the research team will be able to develop new community planning practices. So doing will allow the research team to identify and share community planning practices and policies (Objective 8) which are likely to improve individuals with disabilities' community living and participation. The research team will conduct training and technical assistance activities to raise awareness of the available resources and assist communities in identifying those policies and practices which they may implement (Objective 9). As the socio-ecologic computational model and social networks data needed to meet the research and development objectives of this project is beyond the resources of most communities, the research team will also develop and share a user-centered socio-ecologic community infrastructure planning tool (Objective 7) which communities can use to better understand how well they currently support individuals with disabilities' community living and participation, and the effect of proposed changes in community planning practices and policies.

Vibrant Communities

Project Director

Lendel Narine

Organization

Utah State University

Accession Number

7001915



Rural Employment

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

Remote work is the ability to work from any location other than a central office (Siha & Monroe, 2006). With advances in technology and internet speeds, remote work is increasingly popular as an alternative workplace arrangement (Katz & Krueger, 2016). The availability of enhanced mobile and internet connections at affordable rates further enables remote work opportunities within organizations (Allen et al., 2015). The Utah Legislature viewed remote work as an economic development priority to reduce rural unemployment and rural-urban migration. While one aspect of this focuses on training employees on remote work best practices, another emphasizes managing remote workers and creating remote work environments and policies.

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 Rural Online Initiative (ROI) of USU Extension developed the Master Remote Work Leader (MRWL) certificate course to provide specialized training for organizational leaders on core skills for effectively creating remote work environments and leading hybrid-remote and fully distributed employees. The ROI created and delivered an educational online course targeting remote work leadership skills to encourage the creation of remote work environments and employment of remote workers from rural Utah. The MRWL course is currently offered in odd-numbered months. Through remote skills leadership training, the course helps organizational leaders understand the challenges associated with managing remote employees, as well as, facilitating a remote work culture within their organizations. Through seven modules, leaders develop a capstone remote work plan that can be formulated into an operational policy. Course modules are accompanied by interactive core content, assigned quizzes, knowledge checks, and self-assessment activities. Participants engage with their cohort via live weekly Zoom workshops and the group's Slack channel. Participants must earn an average score of 80% or higher to graduate. ROI's Program Coordinators conduct additional seminars where participants (i.e., organizational leaders) pitch available remote job opportunities in their companies. The intended audience for the MRWL certificate course is organizational leaders with businesses located along the Wasatch Front region, or companies approved by the Governor's Office of Economic Development's Center for Rural Economic Development incentive program. This was the target group for the course because this area has the highest job growth and lowest unemployment numbers. Given these circumstances, the market for talent is competitive and helping businesses connect with talent in rural areas would help increase job opportunities for rural Utah residents.

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

A total of 120 participants completed the MRWL course since it began in February 2020. An evaluation of short-term outcomes captured changes in participants' knowledge, attitudes, skills, and aspirations toward creating remote work environments. Most participants (98%) believed remote work was important to the future of talent acquisition, and all participants believed the creation of a remote work environment was important in their organization.

For knowledge, results showed statistically significant differences between pre-and-post test scores for all seven modules of the MRWL course; culture ($t = 12.75, p < .001$); vision ($t = 12.58, p < .001$); change management ($t = 12.48, p < .001$); conflict management ($t = 10.31, p < .001$); learning and development ($t = 10.30, p < .001$); performance management ($t = 6.54, p < .001$); and communication ($t = 5.31, p < .001$). As such, participants demonstrated significant increases in their knowledge of creating a remote work environment.

Overall, participants had high overall mean scores across all skills; culture ($M = 4.73, SD = 0.33$); communication ($M = 4.73, SD = 0.37$); vision ($M = 4.68, SD = 0.45$); change management ($M = 4.65, SD = 0.45$); performance management ($M = 4.64, SD = 0.45$); learning and development ($M = 4.60, SD = 0.54$); and conflict management ($M = 4.56, SD = 0.50$). After course completion, participants felt they had better abilities to balance their professional and personal lives, manage their professional and personal productivity, solve problems, communicate digitally, use online technology, engage in teamwork, and manage their careers.

Upon course completion, 90% of participants reported they were more likely to create remote work positions in their organization; almost all participants (99%) felt their value as a leader of remote employees improved; and 61% indicated they were more likely to hire qualified residents from rural Utah.

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

The MRWL course showed progress in meeting short-term outcomes with increases in knowledge, favorable attitudes, improved skills, and positive intentions to create remote work environments. With the ability to effectively manage remote employees, organizational leaders were willing to create remote work environments in their organizations. These results suggest participants value remote work as an option for business continuity and employment opportunities in rural Utah communities. In the long-run, this ultimately helps reduce rural unemployment and rural-urban migration. The Rural Online Initiative (ROI) of USU Extension is actively creating opportunities and implementing programs to enhance rural competitiveness and promote economic development across Utah.



Strengthening Partnerships in Rural Counties

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

Substance Use Disorder (SUD) is a persistent problem in Tooele County, Utah. Tooele county's drug overdose death rate between 2015 and 2019 was 21 per 100,000 people, which is higher the statewide rate of approximately 20 per 100,000 people (Centers for Disease Control and Prevention, 2020). In addition to high fatal and non-fatal overdose rates, Tooele County lacks a adequately specialized trained workforce necessary for meeting SUD treatment needs and recovery support services to reduce harms associated with opioid use disorder (OUD) and other substance use issues (DasGupta, et al., 2020; Canary et al., 2017).

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.

M. Voss and team designed a culturally responsive and multi-pronged community approach to tackle SUD in Tooele county. We focused on stigma reduction (i.e., community awareness campaigns and harm reduction trainings for professionals), expanded SUD work-force capacity (i.e., para-professional certifications and funding), and increased community-level support for persons in recovery (i.e., shared community events, economic aid, and naloxone distribution). The multi-pronged approach served several target populations. Community members and professionals impacted by stigma received substance use education and harm reduction trainings. Individuals in recovery with insufficient support received access to emergency recovery financial aid for treatment costs, transportation, childcare, and housing expenses. Agencies with an inadequate workforce received access to coalition resources, professional development support, and para-professional workforce funding.

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

During the first 24 months of project implementation, multiple activities provided sustained *prevention, treatment and recovery services*. The outcomes of the consortium include an increase in collaboration, care providers focused on SUDs, and stigma reduction.

Increase in Collaboration: Consortium membership increased in size and diversity- from four (4) organizations to fifteen (15), and a doubling membership of Recovery Community Organizations (RCOs). This resulted in expansion of services such as gas card support for treatment access, and funding the planning phase for a crisis nursery and a methadone clinic. Enhanced collaboration was evidenced throughout consortium activities. For example, community recovery event sponsorship increased from 10 in year one, to 30 community agencies in year two.

Increase in Care Providers Addressing SUDs: The number of Tooele County physicians to treat opioid use disorder with FDA-approved buprenorphine medication increased by 40% (from 5 to 7) during the first year of the project with a \$200 federally funded training stipend. Additionally, Voss and team created a database of 105 opioid prescribing providers, which will be used to promote controlled substance database (CSD) utilization and pain management training.

Stigma Reduction: The consortium compiled a stigma reduction resource booklet for healthcare providers and community members, which includes evidence-based information on safe opioid use, prescribing guidelines, and treatment and harm reduction resources for people with SUD/OD. Stigma reduction trainings were held at 11 community agencies and 1,100 resource guides have been distributed at 25 training and community events. Survey results from stigma reduction trainings showed increased support for MOUD (methadone and buprenorphine) and harm reduction interventions. Findings show there was a large increase in support from public attendees for harm reduction interventions.

Increase in Naloxone Access: Voss and team distributed 79 naloxone kits directly to community members and 660 naloxone kits to community agencies and consortium partners. They also surveyed local pharmacies and found that the majority of Tooele pharmacies carry naloxone and sell it without requiring a prescription. About half of pharmacy staff reported willingness to receive additional training on opioid overdose reversal.

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

The community partnership approach created by M. Voss and team led to a space for Tooele County providers and community members to collaborate on building a recovery-ready community. Coordination and collaboration have resulted in improved access to, and availability of services for people with SUDs in Tooele County. These efforts are necessary in reducing the harms and mortality associated with SUDs. However, stigma towards people with SUDs, by both the general public and health care providers, remains a substantial barrier. M. Voss and team will continue to work to develop a professional workforce trained in harm reduction, and to create bridges to services for Tooele community members. Future efforts include bringing new partners into the consortium, such as faith-based organizations, criminal justice and law enforcement, and the local mental health authority.



Substance Use Disorder Treatment

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

There is growing evidence that the use of peer support in mental health and substance use disorder (SUD) treatment has positive impacts on recovery (Tracy & Wallace, 2016). For example, Alcoholics Anonymous is a popular evidence-based model using peer support volunteers. Research and existing interventions demonstrate the effectiveness of peers in formal SUD treatments (Fallin-Bennett et al., 2020; Myrick & Del Vecchio, 2016; Tracy & Wallace, 2016). The State of Utah began providing para-professional peer support specialist certification in 2010. State-approved Certified Peer Support Specialist (CPSS) programs offer 40-hour trainings to individuals with at least six months of recovery (DSAMH, n.d.).

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 CPSS certification is a pathway to steady employment as a treatment professional. CPSS's services are Medicaid-reimbursable and include one-to-one treatments, patient advocacy, and support in accessing community resources. Until 2020, CPSS training programs were offered in-person only, which created barriers to participation during COVID 19. To address potential barriers to CPSS training, USU Extension was created a hybrid course to reduce the amount of in-person training time required to become a CPSS. Extension county faculty acquired grant funding and worked with state specialists, community representatives, and CPSS trainers to adapt the curriculum and develop evaluation measures to monitor and

assess program effectiveness and outcomes. The adapted hybrid course includes one three-hour synchronous broadcast class as an introduction to the course, independent work on 16 modules of online content completed over approximately a 30-day period, two days of in-person training, and a final certification exam. Participants of the hybrid CPSS program were Utah residents who were at least six months in recovery and had approved applications from Utah's Division of Substance Abuse and Mental Health (DSAMH). The target population for the trainings included residents from Carbon, Duchesne, Emery, Tooele, Salt Lake, and Weber counties. Targeted areas have a shortage of mental health providers (HPSA Find, n.d.). All counties except Salt Lake and Weber are considered rural and are more likely to lack the necessary resources to support individuals affected by SUD.

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

Program participants were in recovery for an average of 3.75 years, and most participants identified as female (69%). A pretest indicated respondents had favorable attitudes towards the role of CPSS training. They also agreed that healing and recovery are possible and attainable (M = 4.88). However, respondents had lower levels of agreement about their understanding of the requirements to become certified (M = 3.94), maintain certification (M = 3.32), and the job responsibilities of a CPSS (M = 3.44). After the training, post-survey results showed that respondents had higher levels of agreement that peer support specialists are helpful on the road to recovery (M = 4.75), and are trained to uplift persons struggling with mental illness and substance abuse disorders (M = 4.69). In addition, results indicated a significant increase in participants' knowledge about the requirements of CPSS certification and the job opportunities for a CPSS in the State of Utah. Qualitative interviews found an appreciation of the online learning format and a desire to have more check-ins. Compared to the online learning component, the in-person training allowed for more personal connection, easier learning, greater details on instruction, and increased perspective from shared experiences. One participant stated, "It was nice to connect with the people that were in the class and get different perspectives on things from people that [are] from different walks of life". Disadvantages included some disorganization in activities and a desire for less role-playing and repetitive questions.

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

The adapted hybrid pilot program resulted in increased accessibility of the CPSS training during COVID 19. Evaluation results indicated the hybrid model was effective with evidence of knowledge gain in several critical topic areas. As the evidence base grows to encourage the use of peer support in mental health and SUD treatment, there will be an increased need for accessible pathways to accreditation. Mental health and substance use disorders are major concerns for Utah. In rural counties with low access to mental health providers, increased CPSS trainings support employment for those who are in recovery while building a treatment workforce. USU Extension will continue to update instructional content and increase hybrid trainings for affected and vulnerable populations in Utah.

Critical Issue

Food Safety

Public Food Safety Education

Project Director

Lendel Narine

Organization

Utah State University

Accession Number

7001910



Food Preservation and Storage

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

According to the CDC, each year 1 in 6 Americans fall ill due to consuming contaminated foods or beverages, and approximately 3,000 individuals die from foodborne illnesses. It is estimated that foodborne illnesses cost more than \$15.6 billion each year. Health departments and other state agencies are charged with following USDA regulations for systems of managing food, including education and certification for restaurants and other food services. However, home food safety practices education is not in the jurisdiction of health departments.

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.

USU Extension utilizes science-based information to teach home food safety practices to prevent incidences of foodborne illness, hospitalizations, and death. As people reacted to the COVID-19 pandemic in unique ways, one prominent theme in Utah emerged – the desire to preserve and store food. However, M. Jewkes and a team at USU Extension was concerned over the use of misinformation and non-research-based procedures, which could lead to foodborne illness. To provide safe food preservation techniques, Extension faculty created an online food preservation series. In 2021, a series of five (5) comprehensive canning classes were taught in a live, online Zoom format. Each workshop included lecture with visual aids and live canning demonstrations in kitchens. In total, 287 participants joined the webinars live and another 381 watched or downloaded the videos after the course.

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

Pre-post evaluation results showed there were a significant increase in participants' knowledge of freeze drying, dehydrating, and pressure canning after completing the series. In addition, participants were confident in their ability to follow safe home food preservation practices, and to share safe food preservation methods with others. With respect to intentions, over 80% of participants stated they plan to implement recommendations made by the instructor. In particular, participants planned to use food preservation resources, explore information on USU Extension's website, follow research-based directions provided by USU Extension and the USDA, preserve food more often at home, share what they learned with other people, and test their pressure canner dial gauge.

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

Positive evaluation results suggest the food preservation education provided by USU Extension will prevent food-borne illnesses. USU Extension will continue providing these classes to residents across the state in an effort to improve the health and wellbeing of individuals and reduce the economic burden of foodborne illnesses.

Improvement of butter functionality to use as a laminating fat

Project Director

Silvana Martini

Organization

Utah State University

Accession Number

1022989



Improvement of butter functionality to use as a laminating fat

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

The overall objective of this project is to improve water retention in butter during the lamination process by adding a high-melting point fraction of milk fat during butter manufacture. Results from this project will allow dairy producers to manufacture high-quality butter that is sold at a premium price for lamination applications.

Specific objectives:

1. Obtain anhydrous milk fat (AMF) and high melting fractions (HMF) of milk fat from cream
2. Characterize various butter and margarine products currently in the market for their physical properties and their water retention
3. Evaluate the effect of fat content on butter quality for lamination uses.
4. Incorporate the HMF in cream and evaluate butter quality.
5. Incorporate HMF in the working step and evaluate butter quality.

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

A MS student, Annalisa Jones worked on this project through 2021. She characterized the physical properties of commercial butters to understand which of these properties affect water loss during butter lamination. She wrote the paper which has been returned for corrections. She is planning to re-submit the revised version in December 2021. Annalisa also evaluated the effect of fat content on the physical properties of butters and she is writing a manuscript with this data.

During her research Annalisa showed that water content is the only characteristic that was identified to significantly effect water loss in the butter. To better understand the product a correlation analysis was performed for the high fat content butters (greater than 83% butterfat) and for the regular fat content butters (less than 83% butterfat). The water loss in high fat products had a negative correlation with G' and G'' and a positive correlation with solid fat content at 5°C, 10°C, and 15°C. The regular fat content group had a positive correlation with hardness, water droplet size, and SFC at 30°C. While correlations between butter and physical properties as a whole were not significant, the fat content in combination with the physical properties does show significant correlations that can be used to predict water loss.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None

Training and Professional Development -

This project provided training to one MS student (Annalisa Jones) in 2021. Annalisa gained knowledge in common laboratory techniques and in more sophisticated ones such as rheology, differential scanning calorimetry, pulsed nuclear magnetic resonance, and texture profile analysis. She also gained experience in the design and execution of experiments, in the analysis and interpretation of the results, and in writing a manuscript for publication in a peer-reviewed journal.

Dissemination -

Results were presented in local, regional, and international conference such as the BUILD Dairy Annual meeting and the Annual Meeting and Expo of the American Oil Chemists' Society (international).

Plan of Work -

Annalisa will finish writing her second manuscript that we estimate to submit it by the end of Spring 2021. She will start with the third objective which is to add fractionate milk fat and to add these fractions to the cream during the butter making process.

Presentations -

Jones, A. (Presenter & Author), Martini, S. (Author Only), 112th AOCS Annual Meeting and Expo, "Relationship Between Butter Physical Properties and Water Loss in a Laminated Pastry Model System," American Oil Chemists' Society. (May 2021)

Other Products

Data and Research Material

Optimizing inputs for forages and field crops in Utah

Project Director

J. Creech

Organization

Utah State University

Accession Number

1023108



Optimizing inputs for forages and field crops in Utah

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

1. Small grains: determine the effect of one-time compost applications and cover crops on dryland organic wheat yield and quality.
2. Oilseeds: determine the seeding rate necessary to establish optimal dormant-seeded safflower stands and further refine chemical options for weed control in dormant seeded safflower.
3. Corn: determine the effect of row spacing and seeding rate on grain corn hybrids.
4. Forages: determine the management practices to avoid glyphosate injury to glyphosate resistant alfalfa.

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.

Small grains: determine the effect of one-time compost applications and cover crops on dryland organic wheat yield and quality

In 2021, graduate student Michael Deakin completed his MS thesis on work to directly address this objective. A new PhD student, Brad Davis, began work on the project this year. The field research experiments continued on a USU farm in Blue Creek, UT and on a producers farm in Snowville, UT. An additional location was established near Monticello, UT in 2021. Data was collected on cover crop, weed growth, and wheat yield and yield components in 2021. Wheat yields at all locations appear to be responding positively to compost. Cover crops appear to consistently decrease wheat yield. Blue Creek was in the wheat phase in 2021, as well. Little to no yield difference was noted. Measurement of wheat quality in the laboratory is ongoing. Wheat was planted this fall for harvest in 2022.

Progress towards the successful completion of this objective will lead to the development of new management recommendations for organic dryland wheat growers that will increase soil fertility and health, soil moisture storage, and wheat yields in organic dryland wheat systems. Understanding differences in crop response to compost among sites will enable us to predict when it is economically viable to apply compost and when it is not.

Oilseeds: determine the seeding rate necessary to establish optimal dormant-seeded safflower stands and further refine chemical options for weed control in dormant seeded safflower

Graduate student Rodney Nelson continued his work on this project in 2022. Experiments in Kaysville, Blue Creek, Clarkston, and Millville, UT were harvested. Analysis of data collected in the field is ongoing. Seed quality analysis is also underway. Dormant trials for harvest in 2023 were planted in 2022. Mr. Nelson plans to complete his thesis and graduate in late 2022 or early 2023.

Progress towards the successful completion of this objective will lead to the development of new management recommendations for safflower growers that will increase safflower yields and improve the economic sustainability of dryland farms. Understanding differences in seeding rates will enable us to make recommendations that will produce viable crop stands for maximum yields. Furthermore, knowledge of herbicide options for weed control will give farmers options to prevent yield loss due to weed competition.

Corn: determine the effect of row spacing and seeding rate on grain corn hybrids

Work is scheduled to begin on this objective in 2022 with the recruitment of a new graduate student.

Forages: determine the management practices to avoid glyphosate injury to glyphosate resistant alfalfa.

Field work on this objective has finished, student Chet Loveland has graduated, and a manuscript is in preparation for

publication in early 2023. Progress towards the successful completion of this objective has led to the development of management strategies for glyphosate resistant alfalfa to avoid crop injury due to the interaction between freezing temperatures and alfalfa growth when treated with glyphosate.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None to report at this time.

Training and Professional Development -

In 2021, the project provided 11 graduate students (Michael Deakin, Michael Laca, Carson Roberts, Bailey Shaffer, Megan Getz, Rodney Nelson, Brad Davis, Dani Thiemann, Michael Greenland, Benson Israelsen, and Kyle Forsyth) with training in field plot establishment and maintenance, and data collection techniques. Mr. Deakin, Mr. Laca, Mr. Roberts, and Mr. Shaffer all graduated with MS degrees in 2021.

Dissemination -

To date, dissemination has consisted primarily of presentations at national and regional conferences, field days, and Extension meetings. During the reporting period and directly related to my AES project, graduate students and I made 16 presentations at national and regional conferences and published 8 manuscripts in refereed journals. Research from my AES project was also presented at 25 Extension meetings and field days in Utah and across the western US and in 27 field tours of my research plots with small groups of Extension personnel, industry representatives, and agricultural producers.

Plan of Work -

Continue to collect data through the 2022 growing season. Analyze data from previous years in preparation for publication and thesis defense for three MS and one PhD student in 2022. Host field days and field tours of research and demonstration plots. Speak at conferences and winter crop school meetings on the research conducted as part of this AES project.

Publications

Conference Proceedings

Creech, J. E., Loveland, C., Yost, M., Ransom, C., & Putnam, D. (2020). How to Avoid Glyphosate Injury in Glyphosate-Resistant Alfalfa. (vol. 73, pp. 72). Proceedings of the Western Society of Weed Science.

Refereed Journal Articles

Adeleke, K., Atoloye, I., Creech, J. E., Dai, X., & Reeve, J. (2021, June). Nutritive and non-nutritive effects of compost on organic dryland wheat in Utah. *Agronomy Journal*, 113, 3518-3531.

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Hadfield, J., Waldron, B. L., Isom, S., Creech, J. E., Rose, M. F., Long, J., Miller, R. L., Rood, K. A., Young, A., Stott, R. D., Sweat, A., & Thornton-Kurth, K. (2021). The effects of grass and grass-legume pastures on organic dairy heifer development: Heifer growth and performance. *Journal of Dairy Science*, *104*(10), 10863-10878.

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Rose, M. F., Waldron, B. L., Isom, S. C., Peel, M. D., Thornton-Kurth, K., Miller, R. L., Rood, K. A., Hadfield, J. A., Long, J., Henderson, B., & Creech, J. E. (2021). The effects of organic grass and grass-birdsfoot trefoil pastures on Jersey heifer development: Herbage characteristics affecting intake. *Journal of Dairy Science*, *104*(10), 10879-10895.

Waldron, B., Bingham, T., Creech, J. E., Peel, M., Miller, R. L., Jensen, K., Zobell, D., Eun, J.-S., Heaton, K., & Snyder, D. L. (2020). Binary mixtures of alfalfa and birdsfoot trefoil with tall fescue: herbage traits associated with the improved growth performance of beef steers. *Grassland Science*, *66*, 74-87.

Waldron, B., Sagers, J., Peel, M., Rigby, C., Bugbee, B. G., & Creech, J. E. (2020). Salinity reduces the forage quality of forage kochia: a halophytic Chenopodiaceae shrub. *Rangeland Ecology and Management*, *73*, 384-393.

Yost, M., Pound, C., Kitchen, B. M., Creech, J. E., Cardon, G., Gale, J. A., Heaton, K., Price, S., Pace, M., & Wilde, T. (2021). Nitrogen Fertilizer Needs of First-Year Small Grain Forages Following Alfalfa. *Agronomy Journal*, *113*, 2006-2017.

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Other

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Getz, M., & Creech, J. E. (2020). Targeting late flowering time and forage quality association study within a segregating orchardgrass population. Western Society of Crop Science Annual Meeting.

Holt, J., Yost, M., Creech, J. E., Allen, L., & Winward, D. (2020). Agricultural water optimization with advanced sprinkler packages for pivots. ASA, CSSA, SSSA annual meeting.

Roberts, C., Yost, M., Ransom, C., & Creech, J. E. (2020). The impacts of irrigation, herbicide, and oat companion crop on spring-seed alfalfa. Western Society of Crop Science annual meeting.

Rose, M., Creech, J. E., Waldron, B., Isom, S., Peel, M., Thornton-Kurth, K., Hadfield, J., & Rood, K. (2020). Pasture Management to Improve Dry Matter Intake. (https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3118&context=extension_curall ed.). Logan, Utah: Utah State University.

Sullivan, T., Yost, M., Creech, J. E., Allen, L., & Kitchen, B. M. (2020). How a management stacking environment affects yield of silage corn. ASA, CSSA, SSSA annual meeting.

Sullivan, T., Yost, M., Creech, J. E., Allen, L., & Kitchen, B. M. (2020). The effects of stacking water management factors on forage quality. ASA, CSSA, SSSA annual meeting.

Yost, M., Sullivan, T., Westmoreland, M., Bugbee, B. G., & Creech, J. E. (2020). Impacts of irrigation, cultivar, and nutrient management on hemp yield and quality. ASA, CSSA, SSSA annual meeting.

Yost, M., Creech, J. E., & Allen, L. (2020). Irrigation strategies that make sense. *Progressive Forage*.

Yost, M., Allen, L., Creech, J. E., Putnam, D. H., Gale, J. A., & Shewmaker, G. (2020). Ten Reasons Why Alfalfa is Highly Suitable for the West. USU Extension.

Yost, M., Cardon, G., Allen, L., Sorenson, B., Egbert, K., Creech, J.Æ., Ransom, C., & Ramirez, R. (2020). Chemigation guide. USU Extension.

Yost, M., Powell, C., Creech, J. E., Cardon, G., Gale, J. A., Pace, M., Kitchen, B. M., Price, S., Heaton, K., Nelson, R. M., Wilde, T., & Russell, K. (2020). Nitrogen Fertilizer Guide for First-Year Small Grains Following Alfalfa. (pp. 1-7).

[Sustainable microbial biocontrol of plant pathogens](#)

Project Director

Robert Schaeffer

Organization

Utah State University

Accession Number

1020158



Sustainable microbial biocontrol of plant pathogens

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

The overarching goal of this project is to identify a sustainable means of biocontrol for fire blight. More specifically, the following objectives will be addressed. First, diverse microbial taxa will be screened for their effectiveness at limiting *Erwinia amylovora*. Second, isolates tested will be screened metabolically to determine how resource use and other competition related traits inform patterns identified in Objective 1. Third, floral microbiomes of pome fruits will be surveyed to identify consortia design. Fourth, trials will be performed to determine their effectiveness both in the lab and field. Finally, the influence of consortia on vectors of biocontrol strains and *Erwinia* alike will also be tested.

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.

Pear disease management – A significant research aim in the Schaeffer lab is centered on identification of sustainable strategies for disease control in pear. Pear is threatened by a number of bacterial and fungal pathogens, pre- and post-harvest. Of primary concern is *Erwinia amylovora*, the causal agent of fire blight, which also afflicts apple and other Rosaceous hosts. Current control measures for this bacterial pathogen, namely application of antibiotics, is not sustainable and alternative approaches are needed. To address this need, our research group has been conducting the following, complementary studies.

First, prior to joining USU, Schaeffer collected flowers samples from pear orchards in the Wenatchee region of central Washington. These samples were collected from orchards that varied in their IPM scheme (conventional, organic, and bio-based), as well as context (e.g., surrounding landscape cover). Since arriving to USU, these samples have been sequenced, and over the past year analyzed to investigate links between local orchard management practices, landscape cover, climate, and flower microbiome structure. Briefly, we found that bacteria and fungi respond differently to IPM schemes. Organic orchards had higher fungal and lower bacterial diversity in flowers than conventional or bio-based IPM orchards. Moreover, geographic distance among orchards was a poor predictor of alpha diversity, but patterns of bacterial and fungal diversity were affected by IPM scheme, surrounding land cover, and climatic factors. IPM scheme best predicted the distribution of several bacterial and fungal genera important for disease and disease suppression, with organic and bio-based IPM best explaining the distribution of bacterial and fungal genera respectively. Finally, IPM scheme was a primary factor influencing bacterial community similarity across sites, as well fruit orchard cultivation in the surrounding landscape. Geographic distance, climatic factors, management, and the amount of forest or pear produced in the surrounding landscape influenced fungal community turnover across sites. Taken together, these analyses reveal local- and landscape-level drivers of floral microbiome structure, providing insights that can potentially inform microbiome management and links to host health and yield quality. A manuscript stemming from these findings was published this fall in the journal *Applied and Environmental Microbiology*.

Second, microbes represent a promising alternative to synthetic chemicals for disease control. Currently, two microbiological products are used by pear and apple growers for management of fire blight. Active ingredients in these two products include *Bacillus subtilis* (bacterium) and *Aureobasidium pullulans* (yeast). Both have shown promise for fire blight control, but effectiveness can be variable, with the latter also on occasion causing russetting of fresh fruits. Alternative species, as well as species mixtures, may provide better control, without side effects that can affect the marketability of fresh fruit. Using diverse

bacteria and fungi collected from agricultural and wild flower hosts, we've screened 50+ species for their potential in suppressing *Erwinia in-vitro* across different nectar environments, as well as *in-vivo*. Beyond measures of growth suppression, we are also analyzing effects of each antagonist species on nectar traits, including pH and sugar and amino acid content. These three nectar traits can play an important role in structuring microbe-microbe interactions in the hypanthium, and ultimately *Erwinia* success, as this is the primary site for infection. We are currently finishing nectar chemistry work and data analyses, with a manuscript planned for submission this upcoming spring (March 2022).

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

N/A

Training and Professional Development -

A training and professional development opportunity was provided to one undergraduate student. Alondra Arroyo-Flores, an undergraduate from the University of Puerto Rico, joined our lab this past summer through the NSF Plant Health STEM program at USU. During her internship in the lab, Alondra contributed to nectar chemistry analyses for the *Erwinia* biocontrol project. She presented some of the preliminary findings at the SACNAS Annual Conference this fall.

Dissemination -

Pear disease management – A manuscript on the pear flower microbiome has been published in the journal *Applied and Environmental Microbiology*. A second manuscript evaluating the effectiveness of different microbial isolates on fire blight incidence, as well as mechanisms involved, is in preparation and will be submitted by March 2022 for publication. Finally, a graduate student and myself are currently working on an invited perspective for the *Journal of Agricultural and Food Chemistry* on sustainable management of the floral microbiome. This will be submitted by the end of January 2022.

Plan of Work -

Pear disease management – We will continue our assays to assess effectiveness of microbial consortia in suppressing *Erwinia*. We are also exploring pollination assays in spring 2022, to measure how addition of microbes to flowers may affect pollinator attraction, fruit yield and quality.

Alfalfa pest management- In 2020, the lab initiated a new project aimed at belowground pest interactions in alfalfa. Alfalfa is attacked by clover root curculio (CRC; *Sitona hispidulus*), an emergent pest that targets roots during the larval stage. Larvae feed on rhizobia nodules, which are critical for nitrogen access for the host. Beyond nitrogen stress, root damage can also facilitate secondary attack by fungal root rot pathogens. How larvae navigate through the soil to identify nodules for feeding, as well as mechanisms underlying facilitation of fungal root rot remains unclear. To begin to address these issues, we performed a survey of alfalfa fields throughout northern Utah for CRC. During this survey, we also sampled soil to characterize microbial diversity and rhizobia abundance. Rhizobia isolated from fields will be screened for volatiles, in effort to identify bioactive compounds that mediate CRC attraction, both larvae and adults. Using eggs collected this fall, we will perform behavior assays to assess CRC attraction to rhizobia isolates, as well as the volatile compounds involved. In fall 2022, we will collect gravid females and test their attraction to these same isolates, both in-vitro and in-plantae. By identifying microbial cues important for CRC attraction, we can begin to identify strategies that can disrupt these behaviors and improve alfalfa health and yields.

Publications

Refereed Journal Articles

Schaeffer, R. (2021, July 13). Orchard management and landscape context mediate the floral microbiome of pear. *Applied and Environmental Microbiology*.

Presentations

Arroyo-Flores, A. (Presenter & Author), Freundlich, G. (Author Only), Pathak, H. (Author Only), Vannette, R. (Author Only), Schaeffer, R. (Author Only), SACNAS Annual Conference, "Sustainable microbial biocontrol of fire blight," SACNAS, Virtual. (October 25, 2021e October 29, 2021)

Other Products

Data and Research Material - Pear flower microbiome structure and diversity

Data and Research Material Data on pear flower microbiome structure and diversity in central Washington.

Data and Research Material Data on biocontrol potential of flower microbes for fire blight suppression.

Data and Research Material Data on rhizobia abundance and diversity in alfalfa fields in northern Utah.

Data and Research Material Data on microbial abundance and diversity associated with flowers and seeds of onion, *Allium cepa*. These data were collected from fields dedicated to onion production in southwestern Idaho.

[Measurements and Models of Evapotranspiration of Irrigated Vineyards in California and Forage Crops in the Upper Colorado River Basin](#)

Project Director

Lawrence Hipps

Organization

Utah State University

Accession Number

1020205



Measurements and Models of Evapotranspiration of Irrigated Vineyards in California and Forage Crops in the Upper Colorado River Basin

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

The general goal is to address measurements and models of evapotranspiration (ET) for irrigated agriculture, and further development of methodology to improve precision of irrigation and quantify water use by key crops of the Utah and the Intermountain Region and several high value irrigated crops in California. Also, to develop methodology to simulate how warming summer temperatures will increase the demand for irrigation. The ET and the processes which control its value will be studied in two distinctly different agricultural regions of the western US, with very different climates, crops, and agroeconomics.

One case involves irrigated forage lands in the upper Colorado River Basin of Utah, Wyoming, Colorado and New Mexico. An existing project by the PI to monitor ET of these lands is already funded by the Bureau of Reclamation.

The other case deals with irrigated vineyards for wine production in California, where spatial distribution of ET is a critical need for optimizing water resources and product quality. The PI is already part of a current study of using remote sensing information to assess ET of vineyards, funded by NASA, USDA and Gallo Vineyards.

Specific objectives include:

Document the turbulence exchanges, microclimate and ET of irrigated vineyards. Use the findings to improve the remote sensing models of vineyard ET.

Use ET measurements of sites in the Upper Colorado Basin region to test and validate several ET models.

Develop a diagnostic model to simulate the changes on ET of irrigated lands in these cases with increases in summer

temperatures that are already observed and predicted to increase. Also, use this approach to fill in gaps of ET data for both remote sensing models and validation measurements.

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.

Research continued that involves several externally funded studies on quantifying the water use by irrigated crops including: NASA study of evapotranspiration (ET), microclimate and use of remote sensing-based models in vineyards; and Bureau of Reclamation (BOR) project to measure the ET of irrigated lands at four sites in the Upper Colorado River Basin; a Colorado-based study on effects of irrigation reductions on ET sometimes called demand management; and the ET of irrigated turfgrass at a golf course, and use of remote sensing-based models.

The main activity related to the NASA project of vineyard ET was a study of the influence of advection of warm, dry air from the surrounding dry lands. A drone copter system with a high-quality set of meteorological sensors measured vertical profiles of air temperature and humidity to a height of about 600 m above the surface, at the upwind edge of the irrigated vineyards, and at a location about 1 km downwind. The profiles are analyzed to determine the amount of depth of layer modified by the downwind vineyard, and the amount of heat extracted from the layer of air, which is a measure of the advection. These findings will be integrated with a set of eddy covariance measurements of sensible heat flux and ET along a transect over the vineyards. The result will be an estimate of the portion of actual water use caused by this advection.

Microclimate measurements were again made inside the vineyards. Results to date show that the air inside the vineyard crown is on average substantially cooler and more humid than the air above the canopy. However, the values in the canopy were variable in time, showing intermittent mixing with the air above. Periods of low turbulence allows the air in the canopy to become cooler and more humid. Occasional turbulence events are strong enough to create significant exchanges and partially mix out the canopy air. The typical time average of temperature and humidity in the canopy, does not represent what one would initially think under these conditions. These findings have implications for understanding the microclimate dynamics in the vineyard, and how ET actually happens there.

The BOR funded study of the ET of irrigated crops at four locations in the Upper Colorado River Basin (one in each of the states of Utah, Colorado, Wyoming, and New Mexico) continued. The New Mexico site was purchased by new owners and planted with alfalfa. The station was moved to reflect this. The daily and seasonal ET values at each site, are used by the BOR test multiple ET models. Results show differences among the models in their ability to simulate the ET, that vary from year to year. This demonstrates the need for long term measurements to provide continuous validation points for the models.

We made seasonal ET measurements with eddy covariance for a project funded by several entities in the State of Colorado and Trout Unlimited. The study is to document voluntary reductions of irrigation in locations in Colorado on the production and water resources. The ET estimates were made are being supplied to the entire project to study the effects of demand management irrigation on water use in that study region.

Another related project is funded by PacifiCorp to use eddy covariance estimates of ET in three agricultural fields for scheduling irrigation with saline waste-water from a power plant. These results are integrated with soil moisture and precipitation to determine irrigation applications to ensure that saline water does not reach the groundwater.

Finally, a set of ET and energy balance measurements was made over a golf course in northern Utah. Periodic remote sensing data was acquired from multiple satellites and a USU instrumented UAV. These data will be used to test the application of a remote sensing model for ET.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

No significant changes.

Training and Professional Development -

Several remote workshops with university, federal scientists and scientists with private companies. These covered technical aspects of measurements and analyses.

Dissemination -

Key results were delivered directly to funding sources, Bureau of reclamation, NASA etc.. In the case of the vineyard research, results were also shared with the private corporation (Gallo Inc.) that is a research partner in the NASA funded grant. The findings for the golf course ET and weather data were shared with the local golf course and the US Golf Association.

Plan of Work -

The NASA project of water use by irrigated vineyards will continue in the summer. First, the simultaneous measurements of temperature and humidity inside the canopy (microclimate) and their connections with the properties of the air above data will be analyzed. These involve various advanced time series analyses to document the scales of space and time that govern the exchanges of air in and out of the canopy, and the changes in microclimate that result. A new set of drone-based atmospheric profiles will be obtained for upwind and down locations in the vineyard. The locations and heights will be modified somewhat from last year to reflect what the earlier results showed.

The four towers funded by Bureau of Reclamation (BOR) will continue to be operated. The location in Wyoming is likely to be moved. The reasons include the nonoptimal situation of the current site being flooded much of the summer, and the landowner's uncertainty at continuing to host the site. Another location has been tentatively identified only about 20 km away. This project is now funded through 2026.

The graduate student who works under the joint direction of Dr. Lawrence Hipps and Dr. Alfonso Torres, will continue her research on ET of turfgrass. She will collect another season of data for ET at the golf course site, run and validate the remote sensing model, and examine how the ET values are affected by changes in weather and climate.

The project related to demand management irrigation in Colorado will be officially extended for two more years. We will continue to run the eddy covariance station, analyze the data, and provide the daily, monthly and seasonal ET values to the entire interdisciplinary group.

Publications

Refereed Journal Articles

Zahn, E., Bou-Zeid, E., Good, S. P., Katul, G. G., Thomas, C. K., Ghannam, K., Smith, J. A., Chamecki, M., Dias, N., Fuentes, J. D., Alfieri, J. G., Kwon, H., Caylor, K. K., Gao, Z., Soderberg, K., Bambach, N. E., Hipps, L. E., Prueger, J. H., & Kustas, W. P. Direct partitioning of eddy-covariance water and carbon dioxide fluxes into ground and plant components. *Agricultural and Forest Meteorology*, 315(<https://doi.org/10.1016/j.agrformet.2021.108790>).

van Opstal, J. D., Neale, C. M.U., & Hipps, L. E. (2022). Evaluating the adaptability of an irrigation district to seasonal water availability using a decade of remotely sensed evapotranspiration estimates. *Agricultural Water Management*, 261.

Other Products

Databases - Data and calculated products from vineyard research delivered the NASA funded project. Water use data from forage crops delivered to Bureau of Reclamation.

[The Economics of Specialized Agricultural Products: Contracting, Uncertainty, and the Value of Waiting](#)

Project Director

Tanner McCarty

Organization



The Economics of Specialized Agricultural Products: Contracting, Uncertainty, and the Value of Waiting

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

There has been an ongoing shift in many agricultural markets from the production of homogeneous goods to products that are increasingly differentiated (Adjemian, et al., 2016, Crespi, et al., 2012, Saitone and Sexton, 2010, Sexton, 2012). Agricultural product attributes such as organic certification, sustainable production practices, locally grown, and animal welfare are increasingly considered in a consumer's decision making process at the grocery store. Agricultural markets have also experienced a declining number of, but increasing size in, processors who turn raw agricultural products into final food products over time. These two previously mentioned factors have led to agricultural markets that are more thinly traded (fewer options for farmer's to sell their agricultural products to), require more upfront investment cost, and are inherently more volatile than markets for traditional undifferentiated agricultural products. These three previously mentioned attributes of specialized agricultural product markets have non-trivial implications for how they function. More specifically, the thinning of certain agricultural markets over time has shifted relationships between farmers and processors away from buying and selling at a spot price from anyone willing to trade at a given point in time, to relationships with a higher degree of coordination. More specifically, processors either vertically integrate to produce their own specialized agricultural product to add value to or choose specific farmers to sign contracts with ahead of when they need the product delivered (Adjemian, et al., 2016, Crespi, et al., 2012, Sexton, 2012). The investment cost required to produce a specialized agricultural product can be considerable. Organic certifications, specialized harvesting equipment, and investments required to change operations to accommodate animal welfare present the farmer with substantial upfront cost that are often higher and more specialized than the investment cost required to grow homogeneous agricultural products. Farmers often lack the resources necessary to make these large often irreversible investments. The size and irreversibility of these investments can both act as an impediment to investment into an otherwise profitable agricultural sector. Access to this sector is particularly important for small and mid-size farmers whom don't often have the farm size necessary to be competitive in undifferentiated crop production. Finally specialized agricultural products have the potential to be more volatile in their future returns than undifferentiated agricultural products; thin markets generally behave more erratically than markets with large numbers of buyers and sellers. Consumer's willingness to pay for a product with multiple attributes not only changes over time for the product itself but also the demand of a particular attribute. A GMO free tomato for instance has value to certain consumers for both the tomato itself but also for its property of not being genetically modified. Factors of supply and demand will change the value of the tomato itself over time but people's changing attitudes towards GMOs over time will additionally affect the value they place on that attribute. This additional source of volatility makes farmers income, processors input cost, and consumers cost of food less predictable than in an undifferentiated market. All of the previously mentioned factors market thinness, irreversibility, and uncertainty affect how agricultural products are traded between farmers and processors, which in turn affects the costs and prices that farmers, processors, and ultimately consumers are exposed to. This dictates how well off each are. Despite the growth of this market structure in agriculture there is much about it that is not well understood. Understanding the similarities and differences between how traditional markets for undifferentiated products and specialized agricultural product markets function is imperative for effective policy aimed at promoting economic prosperity in rural America, keeping food affordable, and the United States maintaining its edge in global agriculture.

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.

Activities and Objectives:

This year I furthered my second goal of "measuring the effect of these changing relationship structures on risk and return distribution throughout the vertical supply chain in various markets". I also contributed to my third goal of "use the understanding of these relationships to more richly analyze policy aimed at improving agricultural outcomes in the United States." This year I have pivoted my research effort from journal publication quantity to journal publication quality. This has paid off with recently receiving a revise and resubmit invitation from the American Journal of Agricultural Economics with a second article to be submitted there within the week. Both of these articles support my third and final goal of "Use the understanding of these (farmer-processor) relationships to more richly analyze policy aimed at improving agricultural outcomes within the United States." I will list the titles of each of these articles and discuss how they support the aforementioned goal.

"Adapting Network Theory to Fit Spatial Network Externalities in Agriculture: A Case Study on Hemp-Cross Pollination". This

article supports my third goal in two key ways. The first is that it quantifies problem of cross-pollination across different hemp cultivars to inform agricultural policy interventions within this market. Additionally, I wish to explore hemp contracting but need to fully understand the empirical characteristics of this market. Since pollination is such a large determinant for floral hemp farmer's success, it warranted two papers. This paper used two novel datasets to estimate the geographic network that ties various farmers together and calculate the cost effectiveness of reducing pollination in hemp plants across various policies.

"The Economics of Specialized Agricultural Products: Contract Farming Under Uncertainty and Sunk Costs". I have spent a lot of time on this article since starting this project. I wanted to get it just right as I feel it is a very important topic and the heart of my research. I have completed this paper and am waiting on a final round of edits from my co-author to submit it. This article uses my developed contractual framework for specialized agricultural products to examine how transactional attributes such as degree of moral hazard or relative degree of price risk versus yield risk determined optimal contract structure for specialized agricultural products. It also models how these contract structures are affected through policies that limit specific contract mechanisms and how this resulting structure affects farmer, processor and societal welfare.

Results:

Article 1: We find that network structure is an important factor in externality size and cost-effective policy response for spatial agricultural network problems. We also find that policy implemented early and proactively is more likely to be successful and cost-effective than policy implemented retroactively. Finally, we find that in our application of limiting the cross-pollination damage high-cannabinoid hemp growers experience from fiber and seed hemp growers, the most cost-effective policy is to establish a regional quota on non-floral production combined with intertemporal cultivar spacing. This policy response will likely change across time and region as economic and network variables evolve.

Article 2: We kept our analysis general and tested a wide range of assumptions to come up with qualitative insights for a wide range of specialized agricultural products. Once we understood how contracting operates in the absence of regulation we modeled the impact of imposing popularly discussed contracting constraints to examine how they affected equilibrium contract structure, farmer welfare, processor welfare and overall welfare. We find that limiting contractual mechanisms such as indexing payments and production contracts benefit the farmer at the cost of the processor but do not have any meaningful impact on total surplus between the two. In other words, these contract mechanisms affect how the economic pie gets divided not its size. The policy implications for this are considerable.

Key impacts or Other Accomplishments Realized:

Both articles focused heavily on finding the best policies for dealing with inefficiencies in existing markets for specialized agricultural products. For regulators grappling with cross-pollination negatively affecting cannabinoid "floral" hemp producers, we find that under our parameter assumptions, the most cost effective policy tool to fix this problem is establishing a quote system for floral and fiber producers. We also develop a flexible framework that can be easily updated as parameters evolve and change. This framework has use for other spatially based agricultural network externalities such as herbicide drift or GMO contamination in organic seed.

The knowledge obtained in the second article is general enough to be applied to a wide range of specialized agricultural product markets. Numerous articles have explored the claim that specific contractual payments could be used by agricultural processors to exacerbate their own market power. This claim led to the exploration of legally limiting these contractual payments. Indexing payments and production contracts received the most attention. All other research had focused on the effects of the overall market and not on the relationship between a farmer and producer. We now have an improved understanding of how the optimal contract structure itself changes between a farmer and processor when contractual constraints are implemented. This matters because it allows us to estimate surplus of each group and surplus as a whole under various policy interventions. The fact that regulation doesn't affect total surplus should be particularly interesting to policy makers. As limiting production contracts and indexing payments has no meaningful first order effect on efficiency despite shifting surplus away from the processor to the farmer.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

Overall this past year went pretty smoothly. Any barrier I came across while carrying out my research I was able to solve and continue my progress.

Training and Professional Development -

Conferences and workshops:

This past year I presented teaching research based upon coordinated course projects at the WERA-72 conference, "Coordinating Across Courses: Can Fewer, Larger Class Projects Increase Graduate Student Publications?". This presentation received positive feedback. I also attended this conference and learned valuable tools to be more effective in the classroom. This matters for this project because I try to bring my research into the classroom, especially for my master's students. My primary role is teaching so students make up a large part of my intended audience and I learned tools for more effectively teaching them about specialized agricultural products, contracting, and agricultural policy.

Dissemination -

Extension Outreach for the Past Year:

I presented some of my research at the Utah's Hemp Seminar. Hemp is a specialized farm product I have spent a lot of time researching so I was in a unique position to present on it to various stakeholders within the state. I primarily focused on risk management strategies for floral hemp producers within Utah and discussed where prices may be headed in the future.

Plan of Work -

This year has been a year of transition. Everything from my first half of this project got published 12-15 months ago. After that happened I decided that I wanted to focus my attention on higher tier journals and accept fewer articles in return for a larger audience per article. In addition to the previous work I mentioned in section one here are the other projects I have started on this past year. These are all at various stages and should be under review within the next 1-18 months.

I have a case study that I wrote from a class project I assigned in my Masters of Agribusiness, firm strategy course. The class worked with a local ranch to determine whether a small to mid-scale beef processing plant made economic sense. It made for a great class project but also provided some low hanging fruit to convert into a case study. The case is already written, I am receiving final edits from my co-authors before I submit it to the *Applied Economics Teaching Resources Journal*. I am excited about this case study since it links the research done in support of this project, the ranch is trying to market a specialty product with stringent grades for animal welfare and beef grading, with what I do in the classroom.

Earlier this year I was contacted by a researcher at Kansas State, Terry Griffin and Sarah Lancaster, about collaborating on a project for soybeans and Dicamba drift. They reached out to me because of one of my previous publications dealing with spatially based agricultural network externalities for hemp pollen. I adapted my modeling to fit their problem. They specifically wanted to see if certain farmer's were getting forced to adopt Dicamba resistant seed to avoid their fields getting burned by Dicamba herbicide. This paper is getting close to rough draft form. I have organized the data, achieved results, and written a preliminary results and conclusions section. My co-authors are currently incorporating that into the document. While this does not have a large contracting component to it, it does synergize well with my third objective of conducting analysis aimed at improving agricultural outcomes within the United States

I plan on ultimately getting two papers out of this Dicamba research. The aforementioned paper is more about conceptualizing the problem. I am in the early stages of a second paper on the topic that explores potential interaction between these network effects and market power for input suppliers. The working hypothesis is that with agricultural input suppliers already so consolidated, pushing more farmers into adopting a particular seed may make market power even worse.

I also have started work doing a techno-economic analysis for various phosphorus abatement technologies. I was approached about this project by a former classmate, Francisco Scott who now works at the Federal Reserve. Our collaborators have recovered the necessary data. It is up to us to run comparative statics on it and identify the most cost-effective technology for phosphorus abatement. A techno-economic analysis by itself does not fit perfectly within this project but it would lay the groundwork for policy analysis or the exploration of incentives to adopt a particular technology.

Publications

Refereed Journal Articles

Gibbons, G., & McCarty, T. (2020, October). System Design and Co-Product Streams: Does Technological Choice Matter for Aquaponic Profitability? *Journal of Agribusiness*.

McCarty, T., & Sesmero, J. (2020, November). Contracting for Perennial Energy Crops and the Cost-Effectiveness of the Biomass Crop Assistance Program. *Energy Policy*, 112018.

McCarty, T. (2019, December). What Regional Economic Factors Drive Feedstock Cost for Cannabinoid Hemp Processors in the United States? *Journal of Agricultural Hemp Research*, 1(1).

McCarty, T., & Young, J. Hemp Production Network Effects: Are Producers Tipped Towards Sub-Optimal Varietal Selection by Their Neighbors? *Journal of Applied Farm Research*.

Young, J., & McCarty, T. Adapting Network Theory for Spatial Network Externalities in Agriculture: A Case Study on Hemp Cross-Pollination. *American Journal of Agricultural Economics*.

Closing Out (end date 09/07/2023)

POTENTIAL FOR DIETARY SHIFTS IN A COSMOPOLITAN PEST OF GRAIN LEGUMES

Project Director

F Messina

Organization

Utah State University

Accession Number

1015989



POTENTIAL FOR DIETARY SHIFTS IN A COSMOPOLITAN PEST OF GRAIN LEGUMES

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

Many insect pests have greatly expanded their geographic ranges as a result of human transport. Some of these now-cosmopolitan pests consist of distinct genetic “biotypes” that can vary in agriculturally important traits, including the range of crops or cultivars that the pest can attack. Biotypic variation can thus alter pest management strategies in different regions. The research proposed here will use selection experiments and fitness assays to determine the population responses of a highly destructive stored-product pest from different geographic regions to four novel grain legumes (pulses). Our overarching goal is to generate foundational knowledge of plant-insect interactions and to translate this information into a predictive and actionable framework for combating the origin and spread of crop pests. The short-term goal is to identify factors that either promote or constrain host use in the *C. maculatus*/grain-legume system. The specific objectives are:

- 1) To establish the baseline (pre-selection) performance of four beetle populations (from Africa, Asia, North America and South America) on four novel legume hosts that differ in their initial susceptibility. We will use a series of assays to quantify initial larval performance and adult oviposition behavior (host acceptance) on each legume species.
- 2) To use selection experiments to estimate the rate of adaptation (and cross-adaptation) to grain legumes that initially confer poor beetle performance. A subset of lines from each geographic population will be switched to the poorest novel hosts or maintained on the ancestral host. Periodic assays will determine the degree to which selection has occurred. By comparison with the pre-selection assay determined in Objective 1, and will identify which traits are most responsible for improved insect performance.
- 3) To assess whether admixtures of different geographic populations enhance the rate of colonization of a marginal host. Successful colonization of novel, harsh environments may be more likely if genetic variants are combined from different geographic populations, especially if the source populations have different recent evolutionary histories.
- 4) To extend our assays to measure population variation in the response to resistant cultivars of a normally susceptible,

ancestral host (cowpea). We will use a newly developed set of recombinant inbred lines of cowpea to identify map genetic variants and traits associated with resistance to *C. maculatus*. These data will also allow us to ask whether genetic variants associated with resistance to seed beetles overlap with genes conferring resistance to other cowpea pests.

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 2021, we concentrated on Objectives 2 and 4.

Objective 1: We previously quantified variation among beetle populations from four continents in their ability to infest a variety of grain-legume hosts, including cowpea, lentil, pea, chickpea, and mung bean. Documentation of these “biotype” differences continued in 2021 in collaboration with two graduate students working with Dr. Zach Gompert. With Amy Springer, we published a paper illustrating how population differences translate to differential effects on inbreeding on the ability to use a generally poor host for *C. maculatus*, common pea. This work appeared in late 2020 in the journal *Evolutionary Applications*. Results showed that the effects of the two forms of environmental stress, but not inbreeding depression, varied strongly among beetle populations, which would in turn affect the probability of population persistence on a novel host. Other goals originally listed in this Objective were reached in the earliest years of this project.

Objective 2: In 2021 we initiated a new set of experiments to re-examine the potential for “cross-adaptation” in *C. maculatus*, i.e., whether rapid adaptation to a very poor host (lentil) increased insect performance on other novel hosts, including grain legumes more closely related to lentil than to the ancestral host, mung bean. First, we asked whether colonization of a novel host reduces performance (larval survival or host acceptance) on the ancestral host, perhaps because of genetic trade-offs between hosts. Such trade-offs could account for the narrow host ranges of insect herbivores. Second, we asked whether adaptation to a new host causes cross-adaptation to other, never-encountered hosts, and thus could lead to a general expansion of the insect’s host range and increased pest status. Experiments were initiated with three lentil lines and two mung bean (control) lines. We primarily used pea to examine cross-adaptation in larval performance, and compared larval survival in pea, lentil, and mung bean. Here, we asked whether genetic and physiological changes that caused survival in lentil to increase from 2% to >90% would simultaneously increase survival in pea above the baseline level of 40%. To examine cross-adaptation in terms of oviposition (host acceptance), we tested eight lines on four hosts: mung bean, lentil, chickpea, and an artificial host (glass beads). The latter two hosts were used to ask whether the five-fold increased acceptance of lentil in the lentil lines was due to an overall decline in the oviposition threshold. These experiments will be completed and analyzed in 2022.

Objective 3: We previously demonstrated, in work published in 2020, that genetic admixture can strongly affect the pest’s ability to colonize initially poor hosts (in this case, lentil and pea). For *C. maculatus*, such admixture could be mediated by long-distance human transport of infested seeds. We established three replicates of four parental lines from four different continents, along with two hybrid lines (Africa x N.A and Africa x S.A.). Performance on lentil was highest in the Africa x N.A. hybrid, which produced far more adults than either parental line. The Africa x S.A. hybrid also exceeded lentil infestation rates of both parental lines. On pea, the Africa x N.A. line also exhibited the highest survival of any hybrid or purebred line. Our results are best explained by transgressive segregation, in which combining alleles from populations with different genetic histories generates novel phenotypes better able to infest a marginal host. More specific genetic mechanisms are now being investigated at the genomic level by graduate student, Amy Springer, and Dr. Zach Gompert.

Objective 4: Most of our efforts in 2021 involved successful completion of this objective. We conducted the final large-scale experiment to identify the genomic basis of resistance to seed beetles in cowpea. We used 300 recombinant inbred lines (RILs) that were derived from cowpea geneticists at the University of California-Riverside. The RILs each possessed a different mosaic of the eight parental genomes. We used three separate assays in order to get a more robust estimate of the genomic basis of resistance. In particular, we examined whether the results depended on 1) experimental protocol – whether larvae developed with or without competition, and 2) beetle population – we used two populations from the U.S. and India known to differ in several life-history and host-use traits. Using polygenic genome-wide association mapping models, we found that the cowpea RILs harbored substantial additive-genetic variation for several resistance measures. Together, the three experiments demonstrated that genes conferring resistance to *C. maculatus* were located mainly on cowpea chromosomes 5 (for larval development time and survival) and 8 (for larval retention within the host seed). Neither of these genomic regions had been previously known to be associated with resistance to seed beetles. This work was published in 2021 in *Theoretical and Applied Genetics*.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

Although our experiments were delayed and interrupted by COVID-related problems in 2020 and early 2021, we were able to resume our research as originally intended in the latter part of 2021. We don't anticipate any changes or problems in continuing this work in 2022.

Dr. Messina died unexpectedly in February, 2022. Consequently, this will probably be the final report for this project.

Training and Professional Development -

Research in 2021 involved four undergraduates in our laboratory. Two obtained research credits under the Biol 5800 course, and presented research posters at the spring and fall Undergraduate Research Symposia for the Department of Biology. Two other students served as part-time technicians. Two of the undergraduates will be included as co-authors on a paper that will be submitted in 2022 and will include the results describe above in Objective 2. In addition, two graduate students working with Dr. Zach Gompert are now following up our original results on beetle adaptation to lentil.

Dissemination -

The research is mainly disseminated through peer-reviewed publications and poster presentations at national meetings. In 2021, we published our results on the two-years study that identified the genomic basis of cowpea resistance to seed beetles, as described in the Accomplishments section. The ongoing work described in Objective 2 in the Accomplishments section will be submitted in 2022, as will some of the results obtained by the two graduate students working with Dr. Gompert.

Plan of Work -

Our research efforts in 2022 will mainly involve completing, analyzing, and publishing the work described in Objective 2 in the Accomplishments section. This work will be used to ask whether 1) there are genetic trade-offs associated with colonizing an initially poor grain-legume host, and 2) whether rapid adaptation to a poor host leads to some degree of cross-adaptation to other grain legumes to which the beetle population and selection lines have never been exposed. A third set of experiments will examine the relative importance of the parental host on the success of larvae colonizing a novel legume host.

Publications

Refereed Journal Articles

Messina, F. J., Lish, A. M., & Gompert, Z. (2021, June 12). Disparate genetic variants associated with distinct components of cowpea resistance to the seed beetle *Callosobruchus maculatus*. *Theoretical and Applied Genetics*, *134*, 2749-2766.

Messina, F. J., Lish, A. M., Springer, A., & Gompert, Z. (2020, August). Colonization of marginal host plants by seed beetles (Coleoptera: Chrysomelidae): effects of geographic source and genetic admixture. *Environmental Entomology*, *49*, 938-946.

Messina, F. J., Lish, A. M., & Gompert, Z. (2019, September). Components of cowpea resistance to the seed beetle *Callosobruchus maculatus* (Coleoptera: Chrysomelidae: Bruchinae). *Journal of Economic Entomology*, *112*, 2418-2424.

Rego, A., Chaturvedi, S., Springer, A., Lish, A. M., Barton, C. L., Kapheim, K. M., Messina, F. J., & Gompert, Z. (2020, April). Combining experimental evolution and genomics to understand how seed beetles adapt to a marginal host plant. *Genes*, *11*, 400.

Rego, A., Messina, F. J., & Gompert, Z. (2019, June). Dynamics of genomic change during evolutionary rescue in the seed beetle *Callosobruchus maculatus*. *Molecular Ecology*, *28*, 2136-2154.

Springer, A., Messina, F. J., & Gompert, Z. (2020, November). Measuring the effect of environmental stress on inbreeding depression alone obscures the relative importance of inbreeding-stress interactions on overall fitness in *Callosobruchus maculatus*. *Evolutionary Applications*, *13*, 2597-2609.

Presentations

Springer, A. (Presenter & Author), Gompert, Z. (Author Only), Messina, F. J. (Author Only), Symposium, Annual Meeting of the Entomological Society of America, "Genomic basis of adaptation to a marginal host (lentil) by hybrid and non-hybrid populations of the cowpea seed beetle, *Callosobruchus maculatus*," Entomological Society of America, Denver, CO. (November 3, 2021)

[Switching Sex to Apomixis in Crops](#)

Project Director

John carman

Organization

Utah State University

Accession Number

1016300



Switching Sex to Apomixis in Crops

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

Through pharmacological studies, we demonstrated that apomeiosis, parthenogenesis and autonomous endosperm formation (the three elements of apomixis in angiosperms) are metabolically inducible at high frequencies in sexual *Arabidopsis thaliana*, sexual *Boechera stricta* and sexual cowpea. Through expression profiling experiments, we identified candidate genes that should accomplish the targeted metabolic modifications when engineered into crop plants. Engineering these candidate genes into crops so that apomixis is induced constitutes the major goal of the current proposal. we propose to:

1. Select and clone 8-10 candidate genes based on expression profiling and results of subsequent pharmacological studies (July,2020).
2. Acquire promoters that will express the candidate genes in ovule cells and tissues (Dec, 2020).
3. Combine selected promoters and candidate genes into transformation constructs (July 2021).
4. Engineer the designed cassettes into *A. thaliana* and evaluate their effects in terms of inducing apomeiosis, parthenogenesis and autonomous endosperm formation (July, 2022).
5. Engineer constructs that induce apomixis processes in *Arabidopsis* into maize and soybean and evaluate levels of apomixis expression (July 2023).

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.

Major activities completed. The 4857 gene ontology (GO) categories of 14,500 differentially expressed genes from an RNA Seq study involving pistil tissues from sexual and apomictic plants and apomictic plants induced by stress to reproduce sexually were individually assigned to 15 reproduction mode related categories: signaling, stress, catabolism, protein modification, transcription, translation, photosynthesis, transporters, bioenergetics, other metabolism, cytokinesis, mitosis specific, meiosis specific, gametophyte related, and other development. Chi square analyses of frequencies of occurrence within these new categories across species, reproductive modes and treatments were then performed. The results were used to identify metabolic pathways that differentiate sexual from apomictic development. This information was then used to refine our previous molecular models of sex apomixis switching in plants (in preparation). Using this information, we extended our previously published procedures for pharmacologically inducing high frequency apomeiosis (first step of apomixis, which produces genetically unreduced eggs) to two major agronomic crops, maize and soybean (in preparation).

Specific objectives met. Objectives 1-4: select and clone apomixis candidate genes, build constructs using appropriate promoters, transform constructs into *Arabidopsis*, and phenotype the transformants. We have now identified 20 candidate genes to be transgenically misregulated in *Arabidopsis* for altering redox homeostasis and have identified strategies for completing these four (of five) objectives during the coming year. Objective 5: genetically engineer maize with apomixis inducing constructs. In preparation for this objective, we pharmacologically induced high frequency apomeiosis (unreduced

embryo sac formation) in maize and soybean (in preparation) using modifications of our previously published procedures. We also collected immature maize cobs for RNASeq comparisons: treated cobs with ovules producing aposporous and diplosporous (apomeiotic) embryo sacs vs. control cobs with ovules producing meiosis generated reduced embryo sacs. An undergraduate student in my lab recently won an URCO (undergraduate research) grant to conduct the RNASeq portion of this work.

Significant results achieved, including major findings, developments, or conclusions (both positive and negative). High? frequency apomeiosis has been initiated in all sexual species tested so far: Brassicaceae family, *Boechera stricta*, *Boechera exilis*, and *Arabidopsis thaliana*; Fabaceae family, *Vigna unguiculata* (cowpea) and *Glycine max* (soybean); Asteraceae family, *Antennaria dioica*, Poaceae family, *Zea mays* (corn). Unreduced gametophytes formed from ameiotic female and male sporocytes, first division restitution dyads, and nucellar cells. These results are consistent with modes of reproduction and types of apomixis, in natural apomicts, being regulated metabolically.

Key impacts or other accomplishments realized. Developing hybrid crops whose seeds are clones of the mother hybrid (apomictic hybrids) will reduce by 80 % hybrid seed production costs for crops that are currently grown as hybrids, a savings of \$800 M per year for U.S. hybrid corn seed producers alone. Additionally, it will enable superior yielding hybrid seed production for crops currently grown as varieties, due to the prohibitively high cost of generating commercial quantities of superior yielding hybrid seed. This could generate an annual value added of over \$30 B annually for wheat and rice alone. We have reported pharmacological induction of unreduced egg formation (apomeiosis, first step in apomixis) in eight sexual species from four families of angiosperms, including maize, soybean and cowpea. The publication reporting on maize and soybean (in preparation) will also report the use of megasporocyte and gametophyte specific molecular markers to verify apomeiosis induction in the sexual model plant *Arabidopsis*.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

Problems requiring a redirection of our efforts have not been encountered.

Training and Professional Development -

Our research findings have largely been made and elucidated by undergraduate and graduate students. These students have participated in preparing and writing up their findings for publication and are included as authors on several papers. The project helped fund the presentation of our findings at the American Society of Agronomy meetings in Salt Lake City in November. One undergraduate student in my lab applied for and obtained an URCO undergraduate research grant to further elucidate the molecular biology of apomeiosis induction in maize. Much professional development, in terms of understanding and applying molecular biology, is occurring as a result of multiple informal one-on-one meetings and discussions among molecular biology trained professors in the PSC department.

Dissemination -

In addition to published abstracts and additional patent filings, descriptive materials regarding our recent publications and patent filings have been disseminated to potentially interested seed companies.

Plan of Work -

Our work for the coming year will focus on objective 3, combine selected promoters and candidate genes into transformation constructs, and 4, engineering the designed cassettes into *Arabidopsis* and evaluating their effects in terms of inducing apomeiosis, parthenogenesis and autonomous endosperm formation in this taxon.

Publications

Refereed Journal Articles

Albertini, E., Barcaccia, G., Carman, J. G., & Pupilli, F. (2019, March 11). Did apomixis evolve from sex or was it the other way around? *Journal of Experimental Botany*, *70*(11), 2951–2964.

Carman, J. G., Mateo de Arias, M., Gao, L., Zhao, X., Kowallis, B. M., Sherwood, D. A., Srivastava, M. K., Dwivedi, K. K., Price, B. J., Watts, L., & Windham, M. D. (2019, May 31). Apospory and diplospory in diploid *Boechera* (Brassicaceae) may facilitate speciation by recombination-driven apomixis-to-sex reversals. *Frontiers in Plant Science*, *10*(May 2019), 724.

Mandakova, T., Hlouskova, P., Windham, M. D., Mitchell-Olds, T., Ashby, K., Price, B., Carman, J. G., & Lysak, M. A. (2020, May 28). Chromosomal evolution and apomixis in the cruciferous tribe Boechereae. *Frontiers in Plant Science*, *11*(514).

Mandáková, T., Ashby, K., Price, B. J., Windham, M. D., Carman, J. G., & Lysak, M. A. (2019, December 10). Genome structure and apomixis in *Phoenicaulis* (Brassicaceae; Boechereae). *Journal of Systematics and Evolution*.

de Mateo Arias, M., Gao, L., Sherwood, D. A., Dwivedi, K. K., Price, B. J., Jamison, M., Kowallis, B. M., & Carman, J. G. (2020, December 02). Whether Gametophytes are Reduced or Unreduced in Angiosperms Might Be Determined Metabolically. *Genes*, *11*(12).

Other

Carman, J. G. (2021). Chemically induced apomictic embryo sac formation in sexual *Arabidopsis*, soybean and maize. American Society of Agronomy, Crop Science Society of America.

Carman, J. G., Price, B. J., Gao, L., Sherwood, D. A., & Mateo de Arias, M. (2020). Meiosis to Apomeiosis Switching Is Metabolically Inducible in Angiosperms. www.scherago.com: Plant and Animal Genome XXVIII Meetings.

Carman, J. G., & Lacey, J. (2019). Bioenergetic Activity is Correlated with Apomeiosis in *Sorghum* Ovules. GEO publications: NCBI Gene Expression Omnibus.

Carman, J. G., Gao, L., Sherwood, D. A., Mateo de Arias, M., & Price, B. J. (2019). Wanting to induce high frequency Antennaria-type diplospory, Taraxacum-type diplospory or Hieracium-type apospory in crops? It's your choice. International Plant and Animal Genome XXVII Conference, San Diego, CA.

Gao, L., Price, B. J., Sherwood, D. A., & Carman, J. G. (2019). Switching apomixis to sex in *Boechera*. Components of Apomixis Workshop, International Plant & Animal Genome XXVII Conference, San Diego, CA, January 12-16.

Maughan, M., & Carman, J. G. (2021). Cytological and molecular analyses of chemically induced apomeiosis in maize. American Society of Agronomy, Crop Science Society of America.

Price, B. J., & Carman, J. G. (2019). Inducing apomeiosis and disrupting meiotic reduction in gametes of sexual *Antennaria* (Asteraceae) and *Arabidopsis thaliana* (Brassicaceae). Plant Biology 2019. Annual Meeting of the American Society of Plant Biologists, San Jose, CA, Aug. 3-7.

Sherwood, D. A., Gao, L., Mateo de Arias, M., Price, B. J., & Carman, J. G. (2019). Pharmacologically induced apomixis in *Boechera*, *Arabidopsis* and *Vigna*: longstanding theories of apomixis origins and regulation are contradicted. Components of Apomixis Workshop, International Plant & Animal Genome XXVII Conference, San Diego, CA, January 12-16.

Presentations

Carman, J. G., Plant and Animal Genome Meetings, "Can Infrequent Chromosome Pairing and Segregation in Allodiploid Apomictic *Boechera* produce Genomically Unique Sexual Species?," San Diego. (January 11, 2018 - January 15, 2018)

Patents and PVP's

Carman, J. G. "Methods for transgenically inducing apomictic or sexual reproduction."

Carman, J. G. "CIP, Methods of inducing apomictic or sexual reproduction." (Application: April 2021).

Carman, J. G., Sherwood, D. A., Gao, L. "METHODS OF INDUCING APOMICTIC OR SEXUAL REPRODUCTION," 16/273,132. (Application: February 11, 2019).

Other Products

Models - Molecular model for sex (meiosis/syngamy) apomixis (apomeiosis/parthenogenesis) switching in plants based on differentially expressed genes from microarray and RNA Seq analyses of sexual and apomictic plants and apomictic plants induced by stress to reproduce sexually

Audio or Video - Invited opening lecture (video, to also be published in the MDPI journal *Plants*) by John Carman (Utah State University, Logan, USA) titled "General Aspects on Plant Reproduction Evolution: Vegetative Propagation, Sexuality, Apomixis" for an International Online Postgraduate Course, Functional Genomics of Plant Reproduction, organized by Silvina Pessino (National University of Rosario, IICAR, CONICET-UNR, Argentina), Emidio Albertini (University of Perugia, Italy), Ueli Grossniklaus (Zurich University, Switzerland), Mathew Tucker (University of Adelaide, Australia), Gianni Barcaccia (University of Padova, Italy), Stewart Gillmor (UGA, Langebio, México)

Databases NCBI Gene Expression Omnibus (GEO) Accession number GSE156684 (Nov. 30, 2020): Expression profiling of immature ovule and pistil samples of sexual and apomictic *Boechea* (Brassicaceae). Sexual reproduction (meiosis and syngamy) is the major form of reproduction in diploid *Boechea* species, but most species hybrids reproduce by apomixis (unreduced gametophyte formation followed by parthenogenesis of the unreduced egg). In this study, we used *Arabidopsis* microarrays to detail global programs of gene expression underlying sexual and apomictic modes of reproduction. For apomictic *B. x formosa*, *B. lignifera* and *B. microphylla*, ovules were microexcised from ovaries at the megaspore mother cell, meiosis, early gametophyte and late gametophyte stages. For sexual *B. stricta*, pistils were excised at the meiosis and early gametophyte stages. RNA was extracted from ovules or pistils, amplified and hybridized to Affymetrix ATH1 microarrays.

Models - A model describing molecular processes regulating the switch between sexual and asexual (apomictic) seed formation was further developed based on previous gene expression profiling research in our lab that involved monocots and eudicots.

[Exploring the role of mitochondria in postmortem meat tenderization](#)

Project Director

Sulaiman Matarneh

Organization

Utah State University

Accession Number

1015331



Exploring the role of mitochondria in postmortem meat tenderization

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

Objective

The overall objective of this project is to define precisely the role mitochondria play in meat tenderization during meat aging and to identify new biomarkers associated with variations in meat tenderness.

Specific Aim #1: Determine mitochondrial role in postmortem calcium regulation and its effect on proteolysis.

Specific Aim #2: Identify the contribution of mitochondria to postmortem apoptosis and its significance to meat tenderness.

Specific Aim #3: Examine differences in the proteomic profile between red-oxidative and white glycolytic muscle.

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.

We have completed and published the in situ study of aim 2. Results obtained from this study indicated that mitochondrial dysfunction through ultrasonication improves postmortem proteolysis through activating caspase-3, the major effector protease of the apoptotic pathway. This, in turn, had a positive effect on beef tenderness. We have also completed the in vitro study under aim 1, and currently collecting the last bit of data needed to complete the in vitro study of aim 2. Data from these two in vitro studies confirm our in situ data of aim 1 and 2 that mitochondria play a major role in the development of meat tenderness during aging. The in vitro data of aim 1 and 2 will be included in the same manuscript, which will be submitted for publication this summer. As for aim 3, tandem mass tag-based proteomic analysis was conducted to evaluate variation in protein abundance between three bovine muscles varying in mitochondrial content. We are currently, performing bioinformatics and statistical analyses on the emerging data. We anticipate that we will submit a manuscript detailing this research by the end of 2022.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None.

Training and Professional Development -

I presented research from my laboratory at our departmental meeting and at a USDA multistate meeting. My three graduate students participated in a national conference presenting their research. Additionally, two of my undergraduate students presented their findings at the USU undergraduate research symposium. During the 2021 year, I trained 7 undergraduate students and three graduate students.

Dissemination -

We published one article from this project in a peer-reviewed journal. Additionally, my students and I presented information related to this project at national conferences.

Plan of Work -

Metabolomic data analysis (aim 3), prepare the manuscripts for publication, and final report.

[Chemical Diversity in Rangelands and Pasturelands: A Sustainable Tool to Enhance Livestock Production and Ecological Health while Minimizing Environmental Impacts](#)

Project Director

Juan Villalba

Organization

Utah State University

Accession Number

1012833

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

The long-term goals of the proposed project are to (i) create an innovative grazing strategy to restore degraded rangelands invaded by medusahead and (ii) assess the ecosystem service improvements of an alternative US beef production system in which livestock are fed and finished on tannin-containing legumes. In order to accomplish these goals, the supporting objectives are:

Objective 1. Investigate a grazing program that provides the appropriate nutrients to enhance utilization of medusahead by cattle.

Objective 2. Use grazing cattle as a tool to help establish perennial grasses and forage kochia, thus creating a positive feedback cycle of grazing-restoration that expands the abundance of nutritious forages across time and space.

Objective 3. Explore the influence of increasingly diverse combinations of tannin-containing legumes on forage intake and production by sheep.

Objective 4. Determine the antiparasitic effects of condensed tannins and how sheep prioritize selection of nutrients and condensed tannins.

Objective 5. Determine in cattle for the finishing phase, intake, animal performance, enteric methane and nitrogen emissions for the tannin-containing legume system compared with “conventional” grass and legume pastures.

Objective 6. Carry out a study on the winter feeding of beef mother cows on legume hay to complete a year-round system on tannin-containing legumes.

Objective 7. Initiate the adaptation of an established cow-calf life cycle assessment to compare environmental impacts of a conventional US beef system or grass-based production system with a tannin-containing legume-based system.

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.

Objectives 1 and 2.

Medusahead is an invasive weed which threatens biodiversity, value of land and livestock operations in rangelands. Utah State University researchers used a combination of treatments that include grazing and herbicide applications as novel tools to control this weed. In Experiment 1 they evaluated whether the chemical constituents within the herbicide Roundup RT 3[®] could improve the forage value of the grass and contribute to its control in medusahead-invaded landscapes. Four replicated pastures received five treatments: 1) Roundup RT 3[®] (RT3), 2) glyphosate in its potassium salt (GS), 3) glyphosate only (G) (all applied at 788 g ae · ha⁻¹), 4) the inert ingredients only (adjuvant; ADJ; 285.0 ml · ha⁻¹, and 5) no chemical application (CTRL). Eight steers were randomly paired and assigned to graze the medusahead-infested pastures for 10 h daily during 5 consecutive days. Plant biomass, bite counts, and nutritional composition of medusahead (MH), *Ventenata dubia* (Ve), other annual grasses (AG), perennial grasses (PG), annual forbs (AF), and perennial forbs (PF) were assessed. Application of chemicals containing glyphosate (RT3, GS, G), prevented large increases in MH biomass, relative to pre-chemical application values (chemical efficacy; P = 0.048). Furthermore, grazing cattle displayed greater utilization of the glyphosate-containing treatments, reducing relative biomass by 50 to 80%, respectively, relative to pre-grazing values (grazing efficacy; P = 0.044). However, bites on MH did not differ among treatments (P = 0.242), but they increased over the duration of the study (P = 0.012). No differences among treatments were observed for crude protein or silica content in MH (P > 0.05), although fiber content in MH, Ve, AG and AF were lower for the glyphosate-containing treatments than for ADJ or CTRL. In summary, the integrated approach of glyphosate application and cattle grazing reduces medusahead abundance, despite only small nutritional changes, providing an efficient and sustainable method of medusahead control. In Experiment 2 they determined the *in vitro* apparent digestibility and gas production kinetics of medusahead treated with different glyphosate rates (788 g ae·ha⁻¹(High), 394 g ae·ha⁻¹ (Low), and 0 g ae·ha⁻¹ (Control; CTRL), and at different plant particle sizes (1, 20, 30, and 40 mm). Medusahead was treated with glyphosate during the late vegetative to early reproductive stage at two locations, Utah (UT) and Washington (WA). *In vitro* gas production from fermentable substrates were measured over 120 h of incubation, and gas production kinetics were adjusted using a single phasic model with three parameters (A, B, C). Apparent digestibility (dDM, dOM) and silica content of the substrates were also determined. Across herbicide rates, medusahead silica concentrations were CTRL > Low > High, and silica was greater for the UT location (P < 0.05), whereas apparent digestibility, rates of fermentable gas production, and fermentation efficiency were greater for the WA location (P < 0.05). The smallest plant particle size, promoted the greatest apparent digestibility, and rates of fermentation (P < 0.05), whereas the High and Low herbicide rates led to greater apparent digestibility, rates of fermentation and fermentation efficiencies (P < 0.05). These results suggest that the lowest particle size and herbicide treatments improved the digestion of medusahead, explaining in

part the greater palatability of the grass. Increased particle sizes also impinged an inhibitory effect on medusahead digestibility, which may also explain the typically low and variable medusahead intakes by livestock. Increasing the digestibility of medusahead through herbicide application shows promise as a control tool for managing the weed within the plant community.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None

Training and Professional Development -

This project trained a technician, Elaina Cromer during 2021, and a PhD student, Marina Terra Braga, from Universidade Federale Rio Grande doSul, Brazil. Due to covid19 she postponed her travel to USU, but experimental protocols and plans were developed during 2021.

Graduate students and visiting scholars are being trained in the scientific method, proposal preparation, scientific writing, field data collection and laboratory analyses, near-peer mentoring and opportunities to improve project/personnel management and leadership skills.

Dissemination -

All the venues described below disseminate information about results related to my UAES project:

Website: <http://extension.usu.edu/behave/>.

BEHAVE blog. <http://blog.usu.edu/behave/>

Smart Foodscapes | USU

In addition to electronic venues, results during the reporting period are being disseminated by:

Peer-Reviewed Publications (Total: 13 [4 invited synthesis papers] during 2021) with Graduate co-Authors and Co-PIs in the scientific journals: 1-Journal of Animal Science (3), 2-Small Ruminant Research, 3- Proceedings of the XXIV International Grassland Congress / XI International Rangeland Congress, 4- Western North American Naturalist, 5-Italian Journal of Animal Science, 6-Plant Science and Management, 7- Journal of the Science of Food and Agriculture, 8-Agronomy, 9-Animal Frontiers, 10-Frontiers in Sustainable Food Systems.

Lecture: Animal welfare in grazing systems. Virtual Workshop for the “MS in Animal Welfare 2021-2022,” Autonomous University of Barcelona, Spain, November 3, 2021.

Invited Presentations

Villalba, J.J. 2021. Learning and Diet Selection in Herbivores: From the Central Idea to Landscape Management. USU Forestry Chapter. Intermountain SAF Virtual Conference. Climate Change, Management, and Policies. April 23, 2021.

Villalba, J.J. 2021. Extensive Livestock Production in the XXI Century. Interpretation and project implications. Final presentation of the funded project. Punta Arenas, Chile. Virtual meeting. June 24, 2021.

Villalba, J.J. 2021. Ingestive behavior in sheep in relation to body weight gains. 3rd International Conferences FESC-UNAM on Ovine Production. Autonomous University of Mexico (UNAM), Cuautitlán, Mexico. Virtual meeting, May 26, 2021.

DiLorenzo, N., Dubeux Jr, J. C. B., Garcia, L., Guevara, R. D., Lagrange, S., MacAdam, J., and Villalba J. J. 2021. Legumes as a Strategy for Reducing Greenhouse Gas Emissions of Forage-livestock Systems. The Joint XXIV International Grassland and XI International Rangeland Congress. Virtual meeting. 25-29 October, 2021.

Villalba, J.J. 2021. Designing Diverse Agricultural Pastures for Improving Ruminant Production Systems. International Workshop: Grazing in Future Multiscapes: From thoughts to landscapes, creating health from the ground up. Lincoln University. Centre of Excellence. Designing Future Productive Landscapes. Virtual meetings. June-July, 2021.

Contributed Presentations by Students and Visiting Scientists under my supervision:

Villalba, J.J., Mac Adam, J.W., and Guevara, R. 2021. Enteric methane and nitrogen emissions in cattle consuming tanniferous and non-tanniferous legumes, grass or a ration. The American Society of Animal Science (ASAS) and the Canadian Society of Animal Science (CSAS) Joint Annual Meeting. Louisville, KY. July 14-17, 2021.

Clemensen, A.K., Villalba, J.J., Lee, S.T., and Provenza, F.D. 2021. Do plant secondary metabolite-containing forages influence soil processes in forage cropping systems? Tri-Society Virtual Conference July 5-9, 2021.

Plan of Work -

Last year of the project. Write new project for the period 2022-2027.

Publications

Book Chapters

MacAdam, J. W., & Villalba, J. (2017). Beneficial effects of temperate forage legumes that contain condensed tannins. pp. 31-43 In C. Matthew (ed) Forage Plant Ecophysiology, MDPI, Basel, Switzerland

Books

Villalba, J. *Self-Medication in Herbivores*. Springer

Other Products

Other

Lagrange, S., Beauchemin, K. A., MacAdam, J. W., & Villalba, J. (2017). Effects of grazing diverse combinations of sainfoin, birdsfoot trefoil and alfalfa on beef cow performance and environmental impacts. *Journal of Animal Science*, 95:143-144.

Leggett, K., McCann, R. B., MacAdam, J. W., & Villalba, J. (2018). Rocky Mountain Trefoil Beef. (sustainability/2018/01pr ed.). Utah State University.

Stewart, E., MacAdam, J. W., & Villalba, J. (2018). Alternative Legume Species Can Reduce the Environmental Impacts of Cattle. (AG/Forage/2018-02pr ed.). Utah State University.

Stewart, E. K., Villalba, J., & Rood, K. (2018). Environmental and Animal Benefits when Beef Cattle Consume Condensed and Hydrolysable Tannins. (AG/Forage/2018-01pr ed.). Utah State University.

Stewart, E. K., Beauchemin, K. A., MacAdam, J. W., & Villalba, J. (2017). Environmental impacts from cattle consuming tannin-containing hays. *Journal of Animal Science*, 95:133-134.

Stewart, E., Thacker, E., Garcia, M., & Villalba, J. (2017). Understanding the Contributions of Beef Cattle to Greenhouse Gas Emissions. (AG/Beef/2017-03pr ed.). Utah State University.

Protocolse Protocol developed for assessing vegetation responses after re-vegetation efforts at the scablands of eastern Washington.

Protocol developed for assessing foraging behavior in cattle grazing strips of glyphosate-treated medusahead at different phenological stages.

Protocol for assessing fermentation kinetics of forages using the in vitro gas production technique.

Protocolse Protocol developed for feeding antioxidants in sheep.

Protocol developed for assessing foraging behavior in cattle grazing diverse legumes.

Protocol for determining cortisol in hair in order to assess stress in grazing cattle

Employing Forage Legumes to Improve the Sustainability of Ruminant Production

Project Director

Jennifer MacAdam

Organization

Utah State University

Accession Number

1012899



Employing Forage Legumes to Improve the Sustainability of Ruminant Production

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

The goal of this project is to explore the composition and influence of irrigated perennial legumes, with and without tannins, on ruminant production, and impacts on the environment compared with ruminant production on irrigated grass or in feedlots.

This will be addressed under three objectives:

1. Determine the effect of perennial legume fiber-carbohydrate-tannin-protein dynamics on ruminant productivity, compared with ruminants on grasses.
2. Determine the long-term impact of nitrogen-fixing perennial legume pastures on soil carbon and nitrogen dynamics, compared with nitrogen-fertilized grass pastures.
3. Determine the effect of perennial legume tannin-ruminant-soil nitrogen cycling on soil organic matter and carbon sequestration.

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.

Data from five years of grazing research at the Lewiston pasture farm was analyzed by the research station statistician and a paper was submitted to the journal *Agronomy* as part of a special issue that Juan Villalba and I co-edited. The paper has been reviewed and the reviews have been responded to. The results are consistent among the three classes of cattle used in the study (mother cows, calves and 2-year-old heifers) and show that dry matter intake was significantly greater on legume pastures than on grass pastures. Enteric methane emissions as a function of intake were significantly less for legume pastures than for grass pastures, and were similar to the enteric methane emissions of total mixed ration-fed cattle. A nitrogen balance calculated for the study demonstrates that, while nitrogen intake is much greater for legume pastures than on grass pastures or on total mixed ration diets, nitrogen retention is also much greater. We believe this is due to the greatly elevated non-fiber concentration of the two legumes used in the study, birdsfoot trefoil and cicer milkvetch.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

No significant problems were encountered and no changes were needed.

Training and Professional Development -

While no graduate students were associated with this project in 2021, two undergraduate students earned BIOL 5800 credits for associated research, and one carried out an URCO-funded project.

Dissemination -

The PI has participated in field days and has presented data from this project at two multistate committee meetings, NCCC-31 and WERA-1014, in 2021. The PI also volunteered a paper at the Crop Science of America meeting in 2021.

Plan of Work -

A new project proposal has been submitted for the coming year, so further work on this project through June of 2022 will include early-season harvest of ongoing studies.

Refereed Journal Articles

Chail, A., Legako, J., Pitcher, L. R., Ward, R. E., Martini, S., & MacAdam, J. W. (2017). Consumer sensory evaluation and chemical composition of beef gluteus medius and triceps brachii steaks from cattle finished on forage or concentrate diets. *Journal of Animal Science*, *95*, 1553–1564.

Christensen, R. G., Eun, J.-S., Yang, S. Y., Min, B. R., & MacAdam, J. W. (2017). In vitro effects of birdsfoot trefoil (*Lotus corniculatus* L.) pasture on ruminal fermentation, microbial population, and methane production. *Professional Animal Scientist*, *33*, 451–460. 1196,

DiLorenzo, N., Dubeux, J., Garcia, L., Guevara, R., Lagrange, S., MacAdam, J. W., & Villalba, J. (2021). Legumes as a strategy for reducing greenhouse gas emissions of forage-livestock systems. *Proceedings of the International Grassland Congress*.

Ghelichkhan, M., Eun, J.-S., Christensen, R.G., Stott, R. D., & MacAdam, J. W. (2018). Urine volume and nitrogen excretion are altered by feeding birdsfoot trefoil compared to alfalfa in lactating dairy cows. *Journal of Animal Science*. *96*: 3992-4001.

Lagrange, S., MacAdam, J. W., Stegelmeier, B., & Villalba, J. (2021). Grazing diverse combinations of tanniferous and non-tanniferous legumes: Implications for foraging behavior, performance and hair cortisol in beef cattle. *To appear in Journal of Animal Science*, *99*(11), skab291..

Lagrange, S., MacAdam, J. W., & Villalba, J. (2021, November). The use of temperate tannin containing forage legumes to improve sustainability in forage-livestock production. *Agronomy*, *11*(November), 2264.

Lagrange, S., Beauchemin, K. A., MacAdam, J. W., & Villalba, J. (2020, December 01). Grazing diverse combinations of tanniferous and non-tanniferous legumes: Implications for beef cattle performance and environmental impact. *Science of the Total Environment*, *746*, 140788.

Legako, J.F., Cramer, T., Yardley, K., Murphy, T.J., Gardner, T., Chail, A., Pitcher, L.R., & MacAdam, J. W. (2018). Retail stability of three beef muscles from grass-, legume- and feedlot-finished cattle. *Journal of Animal Science*. *96*: 2238-2248.

Leggett, K., McCann, R. B., Brunson, M. W., Miller, B. A., & MacAdam, J. W. (2021, February 25). “From a chef’s perspective or what I can sell on the menu?” Exploring culinary professionals’ attitudes toward specialty beef production and barriers to adoption. *Agroecology and Sustainable Food Systems*.

Li, D., Shu, G., Wang, H., Xu, Y., Adni, J., Zhang, Y., MacAdam, J. W., Villalba, J., Dai, X., & Chen, L. (2021). In vitro fermentation performance of alfalfa (*Medicago sativa* L.) mixed with different proportions of paper mulberry (*Broussonetia papyrifera*) leaves (PML) or condensed tannins extracted from PML. *Italian Journal of Animal Science*..

Lira, R., MacAdam, J. W., Sales, F., & Villalba, J. (2020, November 01). Supplementation strategies to enhance intake of romerillo (*Chiliodactylum diffusum*) by sheep in southern Patagonia. *Small Ruminant Research*, *192*.

Lira, R., MacAdam, J. W., Sales, F., & Villalba, J. (2020, October 01). Supplemental levels of protein and energy influence ingestion of Romerillo (*Chiliotrichum diffusum*) by sheep in southern Patagonia. *Small Ruminant Research*, 191.

MacAdam, J. W., Pitcher, L., Bolleta, A., Guevara, R., Beauchemin, K., Dai, X., & Villalba, J. (2022). Increased intake and reduced nitrogen and methane emissions of beef cattle on legume vs. grass irrigated pastures in the Mountain West USA. *Agronomy*, 12, 304.

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

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

Stettler, J. M., Johnson, D. A., Bushman, B. Shaun, Connors, K. J., Jones, T. A., MacAdam, J. W., & Hole, D. J. (2017, July 08). Utah Lotus: North American legume for possible use in rangeland revegetation in the southern Great Basin and Colorado Plateau. *Rangeland Ecology and Management* 70: 691-699, 70(6), 691-699.

Stewart, E. K., Beauchemin, K. A., Dai, X., MacAdam, J. W., Christensen, R., & Villalba, J. (2019, August 01). Effect of tannin-containing hays on enteric methane emissions and nitrogen partitioning in beef cattle. *Journal of Animal Science*, 97(8), 3286–3299.

Villalba, J., MacAdam, J. W., & Ates, S. (2021). Non-Fiber Carbohydrates in Forages and their Influence on Beef Production Systems. *Frontiers in Sustainable Food Systems*, 5, 71..

Villalba, J., Beauchemin, K. A., Gregorini, P., & MacAdam, J. W. (2019, June 05). Pasture chemoscapes and their ecological services. *Translational Animal Science*, 3(2), 829–841.

Wilson, R.L., Bionaz, M., MacAdam, J. W., Beauchemin, K.A., Naumann, H.D., & Ates, S. (2020). Milk production, nitrogen utilization, and methane emission of dairy cows grazing grass, forb, and legume-based pastures. *Journal of Animal Science* 98 (7) 13 pp..

Zhang, Y., MacAdam, J. W., Villalba, J., & Dai, X. (2021, January 15). In vitro digestibility of mountain-grown irrigated perennial legume, grass and forb forages is influenced by elevated non-fibrous carbohydrates and plant secondary compounds. *Journal of the Science of Food and Agriculture*, 101(1), 334-340.

Zhang, Y., MacAdam, J. W., Villalba, J., & Dai, X. (2020). Nutritive value and plant secondary compounds influence forage in vitro digestibility. *Journal of the Science of Food and Agriculture* 101:334-340.

Presentations

MacAdam, J. W., "Effect of Oven- Vs. Freeze-Drying on the Condensed Tannin Concentrations of Sainfoin and Birdsfoot Trefoil," Crop Science Society of America. (November 2021 - 2021)

Volenc, J.J. (Presenter & Author), MacAdam, J. W. (Author Only), Crop Science Society of America, "C. Jerry Nelson: A Career with global impact." (2019)

MacAdam, J. W. (Presenter & Author), Crop Science Society of America, "The elevated carbohydrate concentrations of high altitude-grown perennial legume forages," San Antonio, Texas. (2019)

Bolletta, A. I. (Author Only), Villalba, J. (Presenter & Author), Dai, X. (Author Only), MacAdam, J. W. (Author Only), 2018 American Society of Animal Science - Canadian Society of Animal Science Annual Meeting, "In vitro digestibility and fermentation kinetics of six irrigated forage hays in the US Intermountain West," American Society of Animal Science (ASAS) - Canadian Society of Animal Science (CSAS), Vancouver, Canada. (July 8, 2018 - July 12, 2018)

Lagrange, S. (Author Only), Guevara Ballesteros, R. D. (Author Only), Beauchemin, K. (Author Only), MacAdam, J. W. (Author Only), Villalba, J. (Presenter & Author), 2018 American Society of Animal Science - Canadian Society of Animal Science Annual Meeting, "Methane emissions by cattle grazing tannin-containing legumes," American Society of Animal Science (ASAS) - Canadian Society of Animal Science (CSAS), Vancouver, Canada. (July 8, 2018 - July 12, 2018)

MacAdam, J. W., North America Alfalfa Improvement Conference, "Forage Legumes for Meat and Milk Production," Logan, Utah. (June 4, 2018 - June 6, 2018)

Slebodnik, K. (Presenter & Author), Norton, J. M. (Author Only), MacAdam, J. W. (Author Only), Reeve, J. (Author Only), Spring Runoff Conference, "Effects of tannins on nitrogen cycling in pasture soils," USU, Logan, Utah. (March 27, 2018)

Improving the efficiency of gene editing in livestock

Project Director

Irina Polejaeva

Organization

Utah State University

Accession Number

1012999



Improving the efficiency of gene editing in livestock

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

The long-term goal of the proposed project is to employ the phenomenon of CRISPR/Cas9 genome editing to improve the efficiency of knock-in for the production of genetically engineered livestock for agriculture and biomedical research. The specific objectives are to: 1) Optimize efficiency of Knock-Ins using CRISPR/Cas9 and chemicals (NHEJ inhibitor and HDR enhancer), 2) Assess effectiveness of Cas9 nickase for KIs in sheep and goat fetal fibroblasts, 3) Develop a safe-harbor ROSA26 KI method, 4) Evaluate efficiency of a novel NHEJ-based method for KIs, and 5) Generate and characterize genetically modified goats and sheep using CRISPR/Cas9 mediated KIs.

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.

This project is focusing on utilizing new approaches to improve efficiency of gene editing in livestock. Three different studies were performed during this year.

Introduction of Sickle Cell Disease (SCD) Mutation in sheep genome. SCD is the most common inherited hemoglobinopathy, with more than 2 million people in the US alone carrying the sickle gene. Roughly 100,000 of these people are homozygous and suffer from SCD. SCD is caused by a single 'A to T' nucleotide replacement at the sixth codon of the β -globin (*HBB*) gene, which results in the substitution of valine for glutamate in the β -globin protein at that position. This causes the resultant tetrameric hemoglobin molecule to be unstable and the red cells carrying this aberrant protein to "sickle", decreasing the ability of these cells to carry oxygen.

In domestic sheep, fetal *HBB* (*fHBB*) and adult *HBB* (*aHBB*) genes contain many homologous sequences including the site of SCD causing mutation. Thus, based on the sequence results for exon 1 of *fHBB* and *aHBB* genes, we designed a target sequence (converted into gRNA) using the Benchling software (gRNA: 5'- CAUGCUGACUGCUGAGGAGA-3') that potentially would target both genes simultaneously. Single-stranded oligodeoxy-nucleotides (ssODN) homologous to the *aHBB* gene carrying the SCD mutation (ssODN_1), and ssODN with homologous arms to the *fHBB* gene containing a silent mutation (ssODN_2) were also designed to contain 50 nt of homologous arm each and synthesized by IDT. The ssODN_1 was designed to replace the 'A to T' nucleotide at the sixth codon of the *aHBB* gene. The ssODN_2 was designed to carry a silent mutation in the eighth codon to protect the *fHBB* gene from being disrupted by the action of CRISPR/Cas9, thus, preventing random mutations in the site.

Generation of SCD sheep fetal fibroblast cells using CRISPR/Cas9. Nucleofection was performed using an Amaxa Nucleofector System (Program EH-100, Lonza). Prior to the transfection, 3 μ l of 100 μ M gRNA was incubated with 2 μ l of 5 μ g/ μ l Cas9 protein for 10 min at room temperature to form a ribonucleoprotein (RNP) complex. The RNP was then incubated with 2ml of 200 μ M of each ssODN for 5 min and transfected into 2.8x10⁶ SFFs in a 100 μ l Nucleovette system. Two days post-transfection, cells were harvested for genomic DNA isolation using a Dneasy Blood & Tissue Kit (Qiagen). The sequences flanking targeted genomic loci of the fetal and adult *HBB* genes were PCR amplified and submitted for sequencing. Single cell colonies were derived by limited dilution and were also subjected to PCR-RFLP testing. Using process of elimination, we first identified the colonies that presented only wildtype (WT) and/or knock-in (KI) (the silent mutation) in the *fHBB* gene. RFLP assay result in PCR product from *fHBB* locus, using BbvCI restriction enzyme, indicated that 22 out of 30 colonies contain at least one allele carrying the WT genotype for *fHBB* gene. RFLP assay using HindIII – for identification of KI – indicated that nine colonies contain the genotype: WT/WT or WT/Knockout (KO); whereas another nine colonies were possibly KI/KI. These 22 colonies were then PCR amplified for *aHBB* gene and submitted for Sanger sequencing. The sequencing results from both *fHBB* and *aHBB* genes indicated that two colonies (9%) contained SCD biallelic mutations and KI mutations, respectively. Additionally, we have three colonies with genotypic SCD/KO for *aHBB*, and KI/WT or KI/KO for *fHBB* gene, which should exhibit the SCD phenotype in the adult gene and prevent abnormality in fetal protein. The colonies were cryopreserved for cloning in the following breeding seasons.

In summary, using ssODN along with CRISPR/Cas9 RNP in a single round of transfection, we generated double KI in two genes that share homologous sequence and successfully introduce biallelic SCD mutations in sheep fetal fibroblasts.

Optimization of Point-Mutation Introduction Using Three ssODN Sizes. Previous report by Dr. Liang et al. has shown that 30 to 40 nt homology arms were optimal for ssODN to induce precise point-mutation (2017). In 2016, Richardson et al., proposed a biophysical mechanism that would optimize the HDR using asymmetric ssODN containing 127 nt. We compared efficiency of three sizes of homologous arms (HA) (60, 100, and 127 nts) to introduce point-mutations. The oligos were designed to introduce a single nucleotide change in the exon 12 of the *CFTR* gene (GGA to AGA), a common site for mutation in human Cystic Fibrosis patients.

Using CRISPR/Cas9 RNP, we transfected three groups of sheep fetal fibroblasts (SFFs) with CRISPR/Cas9 along with 400 μ M of ssODNs using an electroporation method described above. Three days after transfections, the DNA was extracted and exon 12 was amplified by PCR. PCR-RFLP analysis indicated that the knock-in efficiency was around 16% \pm 2 for each of them, thus, demonstrating that no improvements were observed using longer HAs and a small 60 nt ssODN can be as effective as a longer 127 nt.

Effect of RS-1 & M3814 compounds on KI efficiency in iSCNT embryos. When CRISPR nucleases and gRNAs are used to introduce double-stranded breaks (DSBs) in a genome, the DSBs are repaired either by non-homologous end joining (NHEJ), which often results in insertions or deletions (indels), or by HDR, which allows precise nucleotide substitutions to be introduced if a donor oligonucleotide is provided. Since NHEJ is more common than HDR, the frequency with which precise genome editing can be achieved is low. The DNA-dependent protein kinase complexes (DNA-PKcs) play a central role in the DNA damage response by phosphorylating various DNA repair factors during NHEJ. Knockdown of DNA-PKcs or its inhibition by the small molecule inhibitors were found to reduce NHEJ repair and increase HDR 2- to 4-fold in HEK293T. M3814, a new generation of DNA-PKcs inhibitor, has been used in phase I/II clinical trials for treatment of various cancers. Another option to improve the efficiency of HDR mediated genome editing is to directly target molecules involved in HDR. The binding of helical RAD51 filaments to ssDNA is a crucial step in HDR. RS-1 enhances hRAD51 binding activity in excess of 2-fold and thus might improve HDR-based targeted mutagenesis.

We investigated the effects of RS-1 and/or M3814 on the enhancement of KI efficiency in interspecies SCNT (iSCNT) embryos. We utilized embryos generated by ovine-bovine iSCNT due to a limited access to sheep oocytes. These iSCNT embryos carried a *CFTR*/G542X mutation, which we attempted to correct by cytoplasmic injection of a Cas9/gRNA RNP together with ssODN. Cas9/gRNA and ssODN compound were injected into 1-cell stage embryos 4 h post-activation using a Piezo system. The injected embryos were cultured in 30 μ l of either in SOF medium (control) or SOF medium supplemented with M3814 and/or RS-1 compounds for 48 hours. Combined use of M3814 and RS-1 looks promising ($P=0.066$), as we were able to produce embryos with both heterozygous and homozygous corrections of a disease-causing CF mutation in 25% of treated embryos (4/16 (25%)). Additional data using combine treatment will be generated in 2022 that would likely lead to significant improvements in KI efficiency since even with a small set of preliminary data the P value is approaching significance.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

No major changes/problems to report.

Training and Professional Development -

Multiple poster and oral presentations (related to these project) were given during 2021 including: 3 poster presentations at the 47 annual conference of the International Embryo Technology Society (virtual meeting, January); an oral presentation at the W4171 multistate virtual project meeting (Jan 2021); an invited oral presentation at the Animal Science Spring Virtual

Seminar Series at the University of Connecticut (Mar 19), presentation at the annual Cystic Fibrosis foundation meeting (virtual, October) and an invited oral presentation at the 54th Society for the Study of Reproduction annual meeting in St Louis, MO (Dec 18).

Dissemination -

The results of this project were presented at several international and national meetings listed above. The data were also published. In 2021, two review papers were published: the first Perisse et al. "Improvements in Gene Editing Technology Boost Its Applications in Livestock" was published in January (Frontiers in Genetics) and the second Polejaeva "Generation of genetically engineered livestock using somatic cell nuclear transfer" was part of an anniversary issue on the 25th Anniversary of cloning by somatic cell nuclear transfer published by Reproduction. We also published a research paper (Perisse et al., "Sheep models of F508del and G542X cystic fibrosis mutations show cellular responses to human therapeutics" in Aug 2021 in FASEB BioAdvances).

Plan of Work -

In the remaining 6 months of the project, we will continue to assess the effects of RS-1 and M3814 on the enhancement of KI efficiency in interspecies SCNT (iSCNT) embryos.

Publications

Refereed Journal Articles

Fan, Z., Perisse, I. V., Cotton, C. U., Regouski, M., Meng, Q., Domb, C., Van Wettter, A., Wang, Z., Harris, A., White, K. L., & Polejaeva, I. (2018, October 04). A sheep model of cystic fibrosis generated by CRISPR/Cas9 disruption of the CFTR gene. *JCI insight*, 3(19).

Viotti Perisse, I., Fan, Z., Van Wettter, A., Liu, Y., Leir, S.-H., Keim, J., Regouski, M., Wilson, M. D., Cholewa, K. M., Mansbach, S. N., Kelley, T. J., Wang, Z., Harris, A., White, K. L., & Polejaeva, I. (2021, October). Sheep models of F508del and G542X cystic fibrosis mutations show cellular responses to human therapeutics. *FASEB BioAdvances*, 3(10), 841-854.

Yang, M., Perisse, I., Fan, Z., Regouski, M., Meyer-Ficca, M., & Polejaeva, I. (2018, May 17). Increased pregnancy losses following serial somatic cell nuclear transfer in goats. *Reproduction, Fertility and Development*(30), 1443-1453.

Presentations

Polejaeva, I., The 54th Society for the Study of Reproduction Annual Meeting, "Small Ruminant Models for Agricultural and Biomedical Applications.," Society for the Study of Reproduction, Sr Louis, MO, USA. (December 18, 2021)

Perisse, I. (Author Only), Fan, Z. (Author Only), Keim, J. (Author Only), Liu, Y. (Author Only), Regouski, M. (Author Only), Bunch, K. (Author Only), Wang, Z. (Author Only), White, K. L. (Author Only), Polejaeva, I. (Presenter & Author), the Multistate W4171 annual meeting, "Germ Cell and Embryo Development and Manipulation for the Improvement of Livestock," USDA/NIFA, Virtual. (January 25, 2021)

Polejaeva, I. (Guest Speaker), Invited Seminar, VTech, "CRISPRing Livestock Genome: Animal Models for Biomedical Research.," Blacksburg, VA. (April 5, 2019)

Perisse, I. V. (Presenter & Author), Fan, Z. (Author Only), Liu, Y. (Author Only), Regouski, M. (Author Only), Van Wettter, A. (Author Only), Wang, Z. (Author Only), Harris, A. (Author Only), White, K. L. (Author Only), Polejaeva, I. (Author Only), The 45th International Embryo Technology Society Annual Conference., "Towards the correction of meconium ileus with cystic fibrosis transmembrane conductance regulator (CFTR) intestinal expression in CFTR knockout sheep.." (January 22, 2019)

Other Products

Data and Research Material - Improved methods for KI in livestock using CRISPR/Cas 9 platform.

[Agriculture and Natural Resources: Agricultural Productivity](#)

Project Director

Lendel Narine



Agricultural Demonstration Farms

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

While many rural communities in Utah lack steady access to fresh produce, many farmers in these communities also have limited access to education on best agricultural practices. K. Curtis and team led the Beginning Farmer and Rancher program to develop educational opportunities for underserved audiences in agriculture, including women, Hispanics and Native Americans. The goals of this project were to facilitate the sustainability of farmers' operations, improve their quality of life, and strengthen their communities through local agriculture.

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 2021, Curtis and team established an incubator farm for Native American farmers in Bluff, Utah. The 3-acre site was developed with the City of Bluff and the St. Christopher's Mission. The site served nine (9) farmers in 2021, and the project team facilitated 17 workshops. In addition, the program team hosted workshops for youth interested in agriculture; 115 high school students attended webinars and visited a refugee agricultural farm in Salt Lake and Logan. While existing sites in Salt Lake and Logan are used for formal and non-formal agricultural education, the Bluff site is geared towards improving food security and improving local agricultural productivity in a rural area with vulnerable populations.

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

Post-evaluation results from the Bluff site in 2021 indicated 82% of the participants increased their knowledge of agricultural production practices. For existing farm sites in Salt Lake and Logan, post-evaluation with high school (FFA/4H) students ($N=115$) showed 100% increased their understanding of urban farming systems, and 15-20% plan to complete a n urban farm project. In addition, newly established farmers market and Community Supported Agriculture (CSA) proved to be a successful component of the program. Farmer participants at the two (2) Salt Lake locations saw increased sales and income. With the creation two (2) new farmers markets and a CSA program, Redwood community farmers had \$99,000 in sales across the project. Farmers in the Wheadon Farm Park had \$198,000 in sales across the project. Sales greatly expanded in year three (\$140,000) with the addition of a new corporate CSA programs. At the Logan site, farmers had approx. \$5,500 in sales across the two years.

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

Farmer participants of the newly established CSA and farmers markets supported approximately 220 family members with fresh produce, which resulted in approximately \$17,200 in grocery savings across the two years of the project. This project is a critical step towards improving residents' access to affordable and fresh produce, and farmers' ability to operate successful farms.



Community Farmers Markets

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

Although Utah ranks seventh among the nation's lowest poverty rate at 10%, the Department of Workforce Services reports that 84,442 households in Utah rely on Supplemental Nutrition Assistance Program (SNAP), with over 25 farmers markets and farm stands accepting this service. Poverty and food insecurity in Utah disproportionately affect American Indians, Alaska Natives, Hispanic, and African American populations. In addition, a staggering 50% of all single mothers with children under five years of age are living in poverty in Utah.

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 response, K. Hall of USU Extension, the Utah Department of Health (UDOH), and Regan Emmons worked with 10 farmers market managers to facilitate acceptance of SNAP at new farmers markets. As a result, four Community Supported Agriculture (CSA) programs accepted SNAP for the first time, and enrolled a total of 19 SNAP customers. Additionally, six (6) new farmers markets and one (1) new farm stand accepted SNAP. Three (3) new beginning farmers, which included one (1) socially disadvantaged farmer accepted SNAP for the first time in 2021.

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

With these additions, a total of 34 farmers markets, farm stands and CSAs accepted SNAP benefits during the 2021 season. In turn, approximately 7,925 individuals reported buying, selling, aggregating, producing, or distributing locally or regionally produced SNAP-eligible products. In 2021, 7,736 customers benefited from SNAP assistance from these markets.

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

Extension facilitated an increase in the number of farmers markets accepting SNAP benefits in 2021. As a result, low-income households benefit from the program through greater access to fresh produce in their neighborhoods. As the network of farmers markets and CSAs grows, we expect a decrease in the number of communities facing food insecurity.



Local Food Security

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

The 2020 Census showed an 18.4% increase in Utah population, with Davis County reporting an 18.3% population increase. Between 2009 and 2014, a 63% increase in residential construction occurred in Davis County, which directly contributed to loss of prime farmland. Small- and micro-scale farms, defined as less than 9 acres, account for 49% of the remaining farm ground in Davis County (USDA, 2012). Although parts of Davis County are economically vibrant, food insecurity remains a concern in some parts of the county. For example, a zip code within Davis County was identified as “particularly vulnerable” to food insecurity (Davis County Health Department, 2017).

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 2021, S. Hansen partnered with the Create Better Health team in Davis County to develop a community garden and deliver nutrition education to residents living in subsidized housing complex of a community considered food insecure. The purpose of the program was to teach basic gardening principles, improve access to fresh food, and facilitate healthy food choices with nutrition education. This program led to the establishment of two community garden groups in Clearfield, Utah. The community gardens were maintained by residents and produce were shared among participants. Participants of the gardens and nutritional classes were diverse (65% Hispanic and 15% Asian) and had very limited gardening experience.

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

Post-evaluation results of the community garden and nutrition education activities in Davis County indicated participants increased their understanding in what crops grow best in Davis County, improved skills such as planting a seed and knowing when to harvest fruits and vegetables, increased their consumption of fresh fruits and vegetables, and reported increase in enjoyment in gardening. One participant said, “I made salsa with the produce I grew and I was so proud when my neighbors tried it and loved it!” Another stated, “Coming to the garden has been a huge stress reliever for me.” “We ate so many vegetables!” In a subsidized housing complex where one garden was developed, a participant stated, “this has really brought our community together and I am happy to say, everyone has shown the utmost respect for the project. The kids are still very enthusiastic, and some of the other kids that didn’t participate [with initial planting] have gotten involved too. Another said, “the littering has gone down. It’s amazing what a garden project can do for a community.”

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

The newly established community gardens in Davis county represents a major step to ensuring access to affordable fresh produce for low-income individuals. It also leads to increased interests in agriculture among residents. Extension is working in several communities to develop more community gardens that will encourage youth and adults participation to strengthen local food systems.



Mental Health and Agriculture

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

In 2017, nearly 38,000 working-age people (16-64 years old) in the United States died from suicide. The agricultural industry was one of the top five major industry groups with higher suicide rates compared to the general study population; 36% of total suicides were in agriculture. While many farmers, ranchers, and their families face extreme stress and mental health issues, these individuals lack educational and supportive resources to address farm stress and mental health. There is a general lack of professionals and relevant curricula targeted to mental health among agricultural producers and their families (Summers et al., 2019).

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.

T. Howard and a team of faculty at USU Extension developed a research-based outreach course to address stress and mental health in agriculture. The faculty team had expertise in mental health, as well as working with farmers and ranchers. Combining varied experiences, the team was able to develop a research-based educational course with a mix of teaching and application activities. This course was adapted to an online format during COVID-19. The one-hour course was designed based on feedback from a group of 26 agricultural producers who attended a pilot Mental Health First Aid training. The course, entitled “The Biggest Asset is You” helps farmers and ranchers recognize the need to take care of their mental health, and the mental health of their friends, neighbors, and family. The course was delivered as a part of the Pesticide Certification training for producers in the Urban and Small farms conference. The conference attracted participants of different genders and age groups across all 29 counties in Utah. While *The Biggest Asset is You* course targets rural populations, several participants did not reside in rural Utah. However, all participants were employed in the agricultural industry. In total, 388 individuals participated in the educational course during the conference.

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

A recent needs assessment informed *The Biggest Asset is You* evaluation protocol. Evaluation questions included issues related to farm and ranch mental health, knowledge in recognizing, identifying, and responding to mental health issues, and intentions to adopt best practices to improve mental health. Evaluation data were gathered from 186 participants. Using a pre-post design, results indicated participants had an increase in knowledge related to recognizing, identifying, and responding to mental health issues after completing the course. With respect to intentions, more than half the number of total participants (62%) stated they intended to adopt mental health best practices. The evaluation also gathered qualitative data from participants. Many participants discussed their own personal experiences with suicides. One participant said, “a friend was talking about.... going to take their life. I was on the phone with them, the line got disconnected and they were not answering my calls. I called the police and let them know.... he later thanked me for getting him help.”

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

As a new initiative, *The Biggest Asset is You* course at USU Extension led to an increase in producers' knowledge of mental health best practices. As the Howard and team continue to deliver the course to more participants, they expect a positive impact on mental health among rural agricultural families throughout Utah. The team also plan to increase efforts on creating a network of informed citizens who can appropriately address mental health in agriculture. Next steps include an expansion of evidence-based information and transition to an online course format. The USU Extension team has partnered with the USU Center for Persons with Disabilities (CPD) to provide a more in-depth, online-based instruction which includes how agricultural gatekeepers (agricultural faculty, farm credit and lending agents, rural congregation leaders, etc.) can recognize and respond to mental health warning signs. Additionally, the CPD will provide further expertise through a mental health practitioner to inform best practices to reduce stress among farmers and ranchers.



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

Each year during the fall and winter months, Utah State University (USU) Extension and the Utah Department of Agriculture and Food (UDAF) provide face-to-face Pesticide Safety Education and Applicator Training to commercial, non-commercial, and private pesticide license holders (referred to as applicators). Applicators may maintain their current license by attending UDAF approved educational seminars that provide continued education credits in (a) pesticide law, (b) pesticide safety, and (c) pesticide use. However, due to the COVID 19 pandemic, face-to-face meetings in Utah were canceled at the Governor of Utah's request, the Center for Disease Control and Prevention, and Utah State University (USU) in 2020. The cancelation of regularly scheduled workshops left those seeking CEUs license renewal with limited options.

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.

M. Weirda and the USU Pesticide Safety Education team spearheaded an effort to partner with UDAF to provide a series of CEU opportunities in November 2020. This partnership led to the facilitation of virtual pesticide trainings for applicators. Of the eight (8) pesticide CEU events, four (4) were intended for private applicators and four (4) were intended for commercial applicators. These were held in November 2020. The topics covered varied, allowing participants to attend multiple events as needed. Private applicator and commercial applicator event participants possessed commercial licenses, non-commercial licenses, and private licenses

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

Evaluation results for the virtual pesticide trainings indicate eight (8) virtual events were hosted offering three CEU credits (1 Pesticide Safety, 1 Pesticide Law, and 1 Pesticide Use). All sessions provided a total of 24 presentations which resulted in 2992 credit hours for Utah pest management professionals. Participants were invited to complete a survey after the events. The survey was used to evaluate participants' satisfaction with the events, changes in knowledge, and intended behaviors. Most survey responses indicated participants' knowledge on pesticide safety, law, and use improved after the sessions. Results of a pre-post self-assessment indicated participants experienced a statistically significant increase in their knowledge related to most topics covered during the private and commercial applicator events, including mental health self-awareness, state and federal laws, and sprayer calibration. For self-reported behavioral changes, most participants in the private and commercial applicator events indicated they would change their behavior by adopting the recommended pesticide application practices

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

Given the prolonged effect of COVID-19, virtual pesticide events are likely to continue in the foreseeable future. However, based on the evaluation results, transitioning to a Zoom platform did not impede CEU delivery to applicators. M. Weirda and team learned that an Events Coordinator position is essential to provide successful virtual CEU trainings. In addition, the team stated program reach, convenience, and the ultimate success of virtual pesticide trainings was equal to, or greater than past face-to-face events. The Pesticide Safety Education team plans on exploring options for alternative attention verification measures and ways to reduce time in virtual waiting rooms. The goal is to develop hybrid CEU events offering options for group gatherings while still allowing for remote participation by attendees and presenters. Given the success of USU PSEP virtual pesticides events, applicators in Utah can benefit from a wider range of learning opportunities to maintain their pesticide licenses.



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

Cooperative Extension has placed emphasis on urban agriculture in recent years due to the rapid growth of small-scale urban farms. While urban farms can contribute to local food security, research also shows it positively affects social and environmental outcomes within a community. However, traditional agricultural Extension programs are rarely geared towards addressing the information needs of urban farmers due to its focus on large production systems. In 2016, A. Walker Bravo

joined a Facebook group called “*Utah Backyard Homesteaders*.” The group consisted of people with shared interests in sustainable agriculture, urban green spaces, and urban farming. As an agricultural Extension agent in Salt Lake County, Walker Bravo noticed a clear pattern of misinformation shared on a Facebook group with over 20,000 members.

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.

Working with other Extension faculty, Walker Bravo identified a need to provide research-based information to a growing number of residents who did not identify as farmers, but were interested in urban and small-scale farming. In response, A. Walker Bravo and team launched the first Utah Urban Homestead Expo in 2017. The event maintained over 300 attendees for the first two years and then saw a significant increase to 1,111 participants in 2020 and 1,465 participants in 2021. The Utah Urban Homestead Expo facilitates workshops on urban farming topics, guest presentations, and networking opportunities between residents, community organizations, stakeholders, and university experts.

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

Results from the 2021 Urban Homestead Expo evaluations indicated 87% of participants (n = 1085) experienced an improvement in their knowledge of interest topics, and 99% of respondents indicated they intend on implementing some of the best practices learned and recommendations made by instructors and facilitators in the expo.

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

The Utah Urban Homestead Expo has grown in participation since its inception in 2017. As interests in urban agriculture increases, USU Extension is responding to the informational needs of residents by providing evidence-based education on relevant topics. In the long run, the program seeks to facilitate sustainable urban farming practices and support community food systems to promote local food security. Communities and residents will continue to benefit from the expo through opportunities to connect with experts at USU Extension.



Varroa Mites Management

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

In recent years, beekeepers have been experiencing an increase of 20-30% hive losses statewide according to the Utah Department of Agriculture and Food Apiary program. New beekeepers often experience challenges in keeping their hives healthy and overwintering them successfully.

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.

According to the Utah Department of Agriculture and Food Apiary program, Varroa mites and the diseases they carry represent the single biggest challenge facing honey bees in most areas of the world. In response, A. Walker Bravo implemented the Thriving Hive class series, developed the beekeeping.usu.edu website, developed the Thriving Hive Beekeeping Trailer, and established two (2) apiaries at Wheeler Historic Farm in Salt Lake City with a total of 12 beehives. Additionally, Walker Bravo developed and funded a “pollinator outdoor classroom” at Wheeler Farm.

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

There was a 61% increase in the use of Varroa mite monitoring methods by participants after completing the Thriving Hive classes. One participant stated, “I never would have been confident enough to start my own beehive without actually having worked with bees directly under the instruction of someone else. This class made that opportunity possible and so easily accessible!” Another participant stated, “I also learned a lot about different resources that would be available to me when I start my own hive as well as bee biology, which is education I wouldn't have gotten just learning on my own.” In the beginner class, one participant stated, “This class gave me the confidence I needed to take the plunge and get my first hive. It also introduced me to a community of experienced beekeepers who I feel comfortable taking questions and problems to, which has been a vital resource already.” Evaluation results show 100% of respondents from beginning beekeeping classes intended to use Varroa mite monitoring methods and treat for Varroa mites.

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

In Utah, the vast majority of hive deaths are due to Varroa mite infestations that have been poorly managed. Proper Varroa mite management should be the top priority for beekeepers large and small. It is imperative that beekeepers regularly monitor for this parasite and treat their colonies with an effective Varroacide when mite levels are too high. The Thriving Hive class series is essential to helping beekeepers control Varroa mite in Utah.

Critical Issue

Healthy, Financially Secure Families

Assessment of Money Scripts and Money Disorders Among Millennial College Students

Project Director

Lucy Delgadillo

Organization

Utah State University

Accession Number

1012904



ASSESSMENT OF MONEY SCRIPTS AND MONEY BEHAVIORS AMONG MILLENNIAL COLLEGE STUDENTS

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

1. Identify how prevalent money scripts and money biases are among millennial college students.
2. Investigate what demographic factors are associated with money scripts and money biases.
3. Identify what money scripts (if any) are associated with (or predict) money disorders.

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.

I accomplished (and exceeded) all my goals for 2021. My first goal was to do a presentation at a national conference. My second goal was to write another journal article. My third goal was to sponsor one dissertation and one master thesis on themes related to financial literacy in secondary school settings.

National Presentation:

On November 16, 2021, I did a presentation with my graduate student, Erica Abbott, to the 2021 Association of Financial Counseling and Planning Education National Symposium, titled, Why is Saving Money so Hard in Practice? The presentation was a success. We had 287 attendees (usually, the average is n=60).

Journal Article

My goal was to submit at least one journal article related to the findings of this study. I wrote three manuscripts. One was accepted for publication in the Journal of Financial Therapy; the other was accepted for publication in the Family and Consumer Sciences Journal. The last one is under revision in the Family and Consumer Sciences Research Journal.

Sponsor a thesis/dissertation

The last goal for 2021 was to sponsor a thesis on financial literacy in the secondary setting. My graduate student, Jennifer L. Gardner, successfully defended her thesis on November 16, 2021. The title of her thesis is, Evaluating Parental Involvement in Required High School Financial Literacy Education Courses Taught in Utah School Districts.

Due to family complications, my Ph.D student, Karsten Walker, decided to take a hiatus in the 2021-2022 school year.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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 -

None to report.

Training and Professional Development -

I did two training activities in 2021. The first was for the Family and Consumer Sciences Education Teachers Summer Conference (about 25 attendees). The second was for financial counselors and financial educators from the USU Student Money Management Center (July 2021) (8 attendees).

Training on Financial Literacy for Family and Consumer Sciences Education Teachers

In May, I did a presentation/training to explain how to include the affective components of money in the FCSE 1350 Financial Literacy Concurrent Enrollment Course. Utah State Board of Education sponsored the conference. Here is the link to the presentation,

<https://screencast-o-matic.com/watch/crhtbjVhICX>

Training on Financial Literacy for Financial Practitioners.

I did a 90-minute training to the financial counselors and educators of the USU Student Money Management Center <https://www.usu.edu/smmc/>. I explained what money scripts and money biases are and how we can help students/clients overcome their own biases. The training expanded the attendee's knowledge on four emotional biases (loss aversion, overconfidence, endowment, and status quo) and four cognitive biases (conservatism, hindsight, anchoring and adjustment, and mental accounting). The webinar trained practitioners on intentionally using financial biases to increase the impact and success of financial interventions.

Dissemination -

As part of the dissemination process, I had one presentation published in the conference proceedings and three articles related to this grant, one under revision and two accepted for publication.

Delgadillo, L. (Presenter & Author), Abbott, Erica (presenter). Why is Saving money so much harder in practice? Five tools to trick your clients into saving. 2021 AFCPE Conference Proceedings Virtual Format.

Delgadillo, L. (in press). Investigating Financial Biases that Can Increase Impact on Paying Bills and Saving. *Journal of Financial Therapy* (accepted November 2021). The study provides insights that biases are not always harmful, and at times, they can help individuals choose the best course of action or commit the least costly mistake.

Delgadillo, L. (in press). Using Wlodkowski's model to enhance motivation to learn financial education. *Journal of Family and Consumer Sciences* (accepted September 2021). This paper proposes the inclusion of affective financial knowledge and motivation in adult financial education programs. Many current financial education programs assume that financial knowledge--the cognitive and numerical domains of finances--automatically result in behavior change. Teaching affective knowledge embraces andragogic principles, which include understanding how adults are motivated to learn and behave. The proposed paradigm builds on Wlodkoswski's model of motivation. The paper concludes with ideas for teaching affective knowledge and fostering motivation in financial education programs.

Delgadillo, L. (under review). Problematic Money Behaviors that Negatively Affect Paying Bills on Time and Saving. *Family and Consumer Sciences Research Journal* (submitted November 2021). This study reports on the findings of money biases. The results show statistically significant associations between money scripts and financial management practices such as paying bills on time and saving regularly. The study provides practical implications for financial educators and practitioners and paves the way for various possibilities for future research.

Plan of Work -

Plan of work: What do you plan to do during the next reporting period to accomplish the goals?

For 2022,

Submit another project to continue researching and improving the financial lives of Utah citizens. Look for opportunities to bring extramural funding, starting by considering a seed money grant. Expand my national visibility as a researcher and expert in financial literacy issues.

Publications

Book Chapters

Conference Proceedings

Delgadillo, L., & Abbott, E. (2020). Effective Strategies to Identify and Mitigate Financial Biases. (pp. 29-30). AAFPCPE Conference Proceedings.

Presentations

Delgadillo, L., Association of Financial Counseling, Planning and Education, "Effective Strategies to Identify and Mitigate Emotional and Cognitive Biases," Virtual. (November 18, 2020)

Delgadillo, L. (Presenter & Author), Stokes, C. (Author Only), AFCPE Annual Conference, "Effective coaching models to structure financial coaching sessions," Portland, Oregon. (November 19, 2019 - November 21, 2019)

Stokes, C. (Presenter & Author), Delgadillo, L. (Author Only), AFCPE Annual Conference, "Group Coaching for Millennials," Portland, Oregon. (November 19, 2019 - November 21, 2019)

Williams, A. (Presenter & Author), Delgadillo, L. (Presenter & Author), FCS Summer Conference, "Money & Society," Utah State Board of Education, West Lake High School, Saratoga Springs, UT. (June 12, 2019)

Delgadillo, L., American Association of Family and Consumer Sciences, "Emotional aspects of Money," Atlanta, Georgia. (June 24, 2018 - June 27, 2018)

Other Products

Educational Aids or Curricula - training video and examples of affective assignments for high school teachers teaching a Financial Literacy concurrent enrollment class.

Data and Research Materiale Completion of Data Collection.

Data and Research Material - Data was successfully collected.

Educational Aids or Curricula - A new website was developed to help FCSE teach financial literacy in high school.

Data and Research Material

Evaluation Instruments

Individual and Family Resource Management

Project Director

Lendel Narine

Organization

Utah State University

Accession Number

7000398



Celebrating Women Conference

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

According to the World Health Organization (WHO), mental health is not avoidance of mental illness, but rather it is a state of overall wellness that includes the ability to manage stress and live in a productive manner (WHO, 2014). Mental health concerns such as anxiety and depression often disproportionately affect women (WHO, n.d.). In Utah, 32% of women ages 18-34, 21% of women ages 35-49, and 19% of women ages 50-64 reported poor mental health for at least one week out of the previous month, in comparison to 19%, 12%, and 10% of men in these age groups respectively (UDOH, 2017). Overall Wellness is affected by physical, environmental, social, emotional, and financial factors (SAMSHA, 2017). It is also affected by an individual's ability to problem-solve, manage stress, think positively, find personal balance, and form personal connection (Roscoe, 2009).

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.

Given the disproportionate effect of mental health among women, E. Parkhurst and team started the annual Celebrating Women Conference in September of 2019. The conference is designed to address various aspects of wellness; financial wellness, stress management, positivity, and cultivating balance. It also provides opportunities for women to connect with one another. Over 139 women attended the conference in 2021.

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

Post-evaluation results ($n = 139$) showed that 97% of participants felt their knowledge of overall health and wellness improved after attending the conference. In addition, 90% of attendees reported they were likely or very likely to make a make positive changes to improve their health and wellness because of the conference. Some positive changes include a commitment to cultivate a new skill or hobby, eat healthier, improve self-talk, or plans to prioritize self-care. After the conference, 90% stated they planned to find healthy ways to manage stress, 74% intended to care for themselves in positive ways, 55% learned new ways to manage the demands of multiple commitments and roles, 87% knew how to create a positive outlook, 58% found new ways to have healthier relationships, and 55% learned how to identify their passions in life. One participant stated, "All of the info presented was so valuable and informative! Very helpful and I love the free resources available to us! Thank you all so much!" Another said, "I have been wanting to figure out how to better network with other women and step into a space where there were more female voices."

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

The Celebrating Women Conference addressed various aspects of wellness: financial wellness, stress management, positivity, and cultivating balance. It also provided opportunities for women to connect with one another. The conference directly addresses persistent issues affecting women and facilitated a positive environment for shared experiences, learning, and empowerment. With yearly increases in participation, USU Extension expects the conference to directly impact the wellbeing of women across the state.



Home Affordability

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

Homeownership has been linked to improved financial wellbeing, lower rates of crime, and increased civic participation within communities. However, families ability to afford a home is dependent on income, credit rating, current monthly expenses, down payment, and interest rates. As a result, first-time homebuyers are particularly in need of financial and housing education to prepare them for home purchase. Homebuyer education is often sought after by consumers and/or encouraged by assistance agencies and lenders. Consumers may benefit from financial incentives or increased savings by completing a homebuyer education certificate and presenting it to lenders. Homebuyer education prepares buyers by teaching financial management strategies and practices that enable consumers to make better housing and financial decisions.

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 USU Extension Homebuyer Education courses are HUD-approved and USDA Rural Housing approved. Therefore, courses offered meet the research-based National Industry Standards for Homeownership Education and Counseling, and the HUD guidelines for Homebuyer Education. Traditionally offered in-person, While demand for online programming has increased over the last two decades, the COVID-19 pandemic exacerbated the demand for online learning. As a result, USU Extension Homebuyer Education courses are offered to virtually residents.

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

Following the Targeting Outcomes of Program model (Rockwell & Bennet, 2004), a pre-and-post survey and 3-month follow up survey measured knowledge gain, intention to implement, and implementation of personal finance best-practices. Three (3) months after completing the Homebuyer course offered by USU Extension, most participants reported that they implemented financial management strategies to improve personal finances, made informed decisions regarding personal

finances and purchasing a home, developed confidence and understanding the process home buying process, and maximized financial assistance with homebuyer assistance programs. Findings also show about 135 participants were able to secure funds from a grant or other financial assistance program to help with their home purchase. These grants ranged from \$5,000 to \$20,000 each. One participant said, “this course has given me information about home buying process that I had no prior information. Now I can confidently go forward with this process.” Another stated, “understanding the process of buying a home step-by-step has helped me visualize my own path and feel less anxious about embarking. I feel better prepared and more confident knowing all the different terms and pros/cons of the decisions to be made ahead.” Lastly, a participant noted, “I feel far more informed about the home buying process and I am very glad I took this course in preparation for purchasing a home next year.”

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

With persistent and significant increases in home prices since the start of COVID-19, homebuyer education remains a critical resource to helping residents secure a home. The Homebuyer courses at USU Extension has proved to improve buyers' knowledge, confidence, and ability to make major financial decisions regarding home ownership. These courses are essential to residents in the midst of a home affordability crisis as it contributes to the economic wellbeing of current and prospective homeowners.



Marital Relationships

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

The relationships we have with others are critical to our personal health, professional effectiveness, and quality of life. Schramm (2006) estimates that divorce costs taxpayers in Utah \$300 million every year. Unhealthy relationships can have a negative impact not only on individuals, children and families, but extend to the workplace and society. Research suggests that relationship education (RE) significantly impacts participant's communication skills, relationship quality and strengthens relationships

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.

N. Brower and team implemented the Utah Marriage Celebration, an educational date night for couples. The event was held virtually in February with the goal of helping couples gain knowledge and learn skills to strengthen their relationships. While usually and in-person event, it was hosted virtually due to COVID. This resulted in an increase in participants, national speakers and sensitive topics areas that was not usually addressed in the in-person version. A total of 764 individuals attended the event. There were six (6) live workshop sessions, a live keynote, and 17 pre-recorded sessions. All sessions were available on the USU Extension Relationship website: <https://extension.usu.edu/relationships/>

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

A follow-up survey completed two weeks after the event indicated most participants agreed that since attending the Marriage Celebration they were “committed to working more” on their marriage (97%), and were more “committed to investing more time together for their marriage” (95%). There were also similar findings for couples seeking to improve their own life to help strengthen their marriage, such as expressing more kindness to spouse/partner. When asked what changes they have seen in their relationship since the Utah Marriage Celebration event, participants said, “Increased connection, more positivity, better communication,” “renewed commitment to each other,” and “much better communication, more united in our family goals, and proactive about keeping our self-regulation batteries from going dead!

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

Events such as these are critical to supporting healthy relationships. Literature suggests that healthy relationship events can make a difference in relationships. Evaluation results from the Utah Marriage Celebration event suggest participants experienced a greater sense of stability and quality of relationships. This may lead to less relationship dissolution and cost savings to taxpayers.



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

The National Endowment for Financial Education (NEFE) showed that 84% of Americans were stressed about finances because of the COVID-19 pandemic. As a result, more people tapped into savings and investments, deferred bill/debt payments, and took on more credit card debt (NEFE, 2020). Consequently, an increasing number of people were left with inadequate incomes and savings (Federal Reserve, 2020). Total consumer debt continues to trend upwards, surpassing \$14 trillion in 2020. According to the Financial Industry Regulatory Authority (FINRA), only 34% of Americans are able to pass a basic financial literacy test. Collins and O'Rourke (2010) noted financial education leads to improved financial decision making and ultimately, an improvement in the financial well-being of individuals. Fox et al. (2005) further indicated financial literacy education provides individuals with the knowledge, aptitude, and skills to effectively manage their finances and become informed consumers of available financial services. Therefore, financial literacy education can promote improved personal financial behaviors such as writing or rewriting a budget, starting a filing system, ordering a credit report, paying bills on time, and balancing a checkbook (Osteen et al., 2007).

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

A. Christensen and team implemented the Empowering Financial Wellness program (EFW) in 2020. The program aims to provide personal financial management education to counties across Utah. EFW seeks to support and empower individuals and families to achieve economic stability. With program implementation in September of 2020, EFW provided online education to individuals via the PowerPay Money Master (PPMM) course and topic-specific online webinars. The PPMM is a research-based financial education course developed by Accredited Financial Counselors (AFC). The PPMM course is available online to all individuals through USU Extension and consists of seven (7) video-based learning modules on financial habits and attitudes, goal setting, budgeting, debt repayment, understanding credit, and saving. EFW is geared towards families and adults across Utah. However, the program team works with several organizations such as the DWS, Division of Child and Family Services, and Utah's Intergenerational Poverty Committees to deliver programming to low-income families and women. EFW is also initiating a collaboration with the Rural Online Initiative (ROI) to promote financial education programming to women. After Year 1 of EFW, 91 participants successfully completed the PPMM online course and approximately 264 participants completed at least one EFW webinar.

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

A three-phased evaluation process following the Targeting Outcomes of Programs (TOP) framework (Rockwell & Bennett, 2004) was implemented to evaluate short, medium, and long-term outcomes of EFW. For the PPMM course, a directional paired samples *t*-test indicated participants experienced a statistically significant increase in knowledge on personal financial management topics after completing all eight modules of the course ($t = 15.31, p < 0.001$). Similarly, for EFW webinars, 92% of participants ($n = 249$) stated they had a better understanding of personal finance management topics after completing a webinar. With respect to skills, over 90% of participants in the PPMM course indicated they were confident in their ability to create a SMART financial goal, keep track of their expenditures, and create a zero-based budget. On average, participants demonstrated strong intentions to implement a personal finance management plan ($M = 4.57$ out of 5, $SD = 0.41$). For EFW webinars, 92% of participants ($n = 230$) stated they intend on making positive changes to their personal finance management practices because of the webinar.

Two months after completing the PPMM course, participants ($n = 42$) reported adoption of best financial management practices; 100% of participants identified their money personalities, 83% created SMART money goals, 71% tracked their expenditures every month, 93% reported positive changes to their credit scores, and 88% established emergency savings. In addition, 71% of participants reported some decrease in their monthly debts, with about 42% stating their monthly debt decreased by 5-10%. Overall, approximately 83% of participants implemented a finance management plan by adopting the recommended practices two months after the PPMM course. A Spearman's rho bivariate correlation indicated there was a positive relationship between the total number of recommended financial management practices implemented and savings ($\rho = 0.41, p < 0.05$); an increase in the adoption of recommended practices led to an increase in savings for participants two months after the program.

Four months after completing the PPMM course, results show positive financial wellness among participants ($n = 20$); 95% of participants agreed they could handle a major unexpected expense, 90% agreed they can enjoy life because of the way they managed their money, and 65% agreed they had money left over at the end of the month. Overall, about 75% of participants

expressed improved financial wellness. With respect to financial shocks, more than half the number of respondents (55%) indicated they were completely confident in their ability to come up with \$2,000 if an unexpected event occurred in the next few months. This is supported by a 38% average increase in participants' savings rate since starting the program. Lastly, most participants (65%) rated their overall personal financial well-being as good, while 20% rated it as excellent four months after completing an EFW activity.

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

Evaluation results demonstrate favorable program outcomes; participants experienced significant increases in their knowledge of finance management topics and gained skills to implement a financial management plan immediately after completion of the program. Further, almost all participants adopted a finance management plan by implementing sound financial practices two months after the program. Four months after, participants reported an increase in savings, increase in their ability to handle unexpected financial burdens, and a general increase in their financial well-being. EFW has been successful in improving the economic well-being of families and individuals after the first year of operations. Moving forward, the program will seek to expand programming activities to new audiences through increased collaborations with economic development programs such as the Rural Online Initiative. To learn more about EFW, visit <https://extension.usu.edu/finance/empowering-financial-wellness/index>



Worksite Wellness

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

According to the CDC, chronic diseases and other illnesses (including mental health) contribute significantly to high healthcare costs and affects the quality of life of workers and their families. Productivity losses related to personal and family health problems cost U.S. employers more than \$225 billion every year. By implementing evidence-based workplace wellness programs, employers can control their healthcare costs while improving their employees' overall health.

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

In Davis County, Utah, E. Parkhurst implemented Working Minds, a suicide prevention 2-hour training for worksites. Deaths by suicide cost the United States approximately \$44 billion annually. Depression is estimated to cause 200 million lost workdays each year at a cost to employers of \$17 to \$44 billion. Working Minds is designed to provide organizations with the skills needed to proactively address the early warning signs of suicide in the workplace. As organizations realize they can help reduce heart disease by encouraging exercise, they can also reduce suicide by promoting mental health and encouraging early identification and intervention. The Working Minds training session aims to educate and equip businesses with tools to address mental health and suicide concerns within the workplace. E. Parkhurst and team implemented ten (10) virtual Working Minds sessions for supervisors and managers in Davis County. A total of 87 individuals completed the training in 2021.

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

Post-evaluation results indicated 88% of participants reported increased knowledge of suicide prevention after training, 92% reported increased confidence in talking to someone about getting help, 88% reported increased confidence in identifying suicide risks, 89% reported having new knowledge and skills from the training, and 89% agreed they will be able to apply what they learned from the training. When asked about what they liked most about the sessions, one participant said, "the focus it brings to the mental health and how important it is in not only in the workplace but in personal life."

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

Employee wellness is recognized as a priority for organizations as they seek to increase productivity and reduce costs associated with healthcare and insurance. The wellbeing of employees has significant implications for both professional and personal factors, making it an important aspect of individuals' overall quality of life. The worksite wellness program is an

innovative approach to improving workers' wellbeing, and as the program expands, more employees will have the opportunity to participate in onsite wellness activities across the state. The worksite wellness program contributes to economic productivity, employee health, and lower healthcare costs.

Critical Issue

Nutrition and Health

Obesity, Wellbeing, and Longevity: Persistent Inequalities and Pathways to Change in Disadvantaged Populations

Project Director

Eric Reither

Organization

Utah State University

Accession Number

1026558



Obesity, Wellbeing, and Longevity: Persistent Inequalities and Pathways to Change in Disadvantaged Populations

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

The three main objectives of this UAES research project are: (1) to characterize the impact of obesity on wellness and longevity in disadvantaged populations — including racial/ethnic minorities and persons living in rural areas, Utah, and the Intermountain West; (2) to investigate upstream contributors to obesity incidence and prevalence, suboptimal wellbeing, and reduced longevity in these same disadvantaged populations; (3) to identify pathways to reduce the incidence and prevalence of obesity, improve wellbeing, and extend longevity in disadvantaged populations.

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.

Over the first reporting period for this UAES project, my research activities addressed all three project objectives, namely to (1) characterize the impact of obesity on wellness and longevity in disadvantaged populations, (2) investigate upstream contributors to obesity incidence and prevalence, suboptimal wellbeing, and reduced longevity, and (3) identify pathways to reduce the incidence and prevalence of obesity, improve wellbeing, and extend longevity. In a study addressing all three aims, I led a team of graduate students (Olusola Omisakin and Max Roberts) and USU faculty (Hyojun Park) to investigate how obesity contributes to reduced life expectancy among Native Americans in the four-corner states of Utah, New Mexico, Colorado, and Arizona. By using restricted-use mortality data from the National Center for Health Statistics (NCHS), we created and subsequently decomposed a series of period life tables among Native Americans and non-Hispanic whites. Our results indicated that diabetes and alcohol-related mortality were primary causes of life expectancy disparities between these groups, pointing to upstream contributors like nutrition and substance use as primary targets for future interventions and social policies. In another project addressing the first and third research aims, I collaborated with Dr. Patrick Krueger at the University of Colorado-Denver to summarize the literature on the determinants of obesity disparities and potential policy solutions. This cooperative effort resulted in a manuscript that comprehensively characterized the current state of knowledge regarding obesity and its health consequences in multiple disadvantaged populations. Finally, through an ongoing NIH-funded study of longitudinal associations between sleep characteristics and obesity in the Wisconsin Sleep Cohort Study (WSCS), I collaborated with scholars at USU and the University of Wisconsin-Madison to conduct a series of multilevel data analyses. We subsequently produced a manuscript of our findings, showing that differences between weekday and weekend sleep duration significantly contributed to weight gain and obesity. This research suggests that sleep differentials are an upstream contributor to obesity incidence, which addresses the second aim of this UAES project.

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

Dissemination of information from this project has resulted in a change in knowledge for our target audience.

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

Nothing to report.

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

Changes / Problems -

I do not anticipate any notable changes or problems to my UAES objectives between now and the project end date.

Training and Professional Development -

In 2021, my UAES project provided excellent research training and professional development opportunities for three graduate students in Sociology; Amin Etemadifar, Ph.D. student; Max Roberts, Ph.D. student; and Olusola Omisakin, Ph.D. student. All three students have contributed to my ongoing program of research focusing on obesity-related contributors to racial/ethnic disparities in life expectancy. In summer 2021, both Max Roberts and Amin Etemadifar successfully defended their dissertations and graduated from USU with Ph.D. degrees. With ongoing UAES support, Olusola Omisakin is making excellent progress toward degree completion and professional development. To illustrate, Mr. Omisakin was first author on our UAES-supported research project on reduced life expectancy among Native Americans, which he presented at the Population Association of America (winning an outstanding poster award) and subsequently published in a peer-reviewed journal.

Dissemination -

In the past year, I disseminated UAES-related research by presenting research and publishing manuscripts in peer-reviewed journals. As noted, Olusola Omisakin and our team (Hyojun Park, Max Roberts, and me) were granted a top-poster award by the Population Association of America for our research on Native American mortality disparities in the four-corner states. We subsequently published this manuscript in *PLOS-ONE*. In a project related to both UAES and NIH funding, Yin Liu (USU faculty) presented our collaborative research on sleep differentials and obesity at the Gerontological Society of America conference. Subsequently, we published this manuscript in *Sleep Health*. We also published another manuscript related to this NIH project in *SLEEP* earlier this year, which is notable as *SLEEP* is arguably the top sleep-research journal in the world. Earlier this year, I published a manuscript with former Ph.D. student (now faculty at BYU-Idaho) and other colleagues on COVID-19 vaccination disparities in the peer-reviewed journal *Vaccine*. Finally, our manuscript summarizing the literature on obesity disparities has been accepted by Springer for publication in the International Handbook on the Demography of Obesity.

Plan of Work -

Over the next year, I plan to complete NIH-funded research on sleep-obesity associations, which are related to my second and third UAES project objectives. In addition, I plan to work with current and former Ph.D. graduate students and colleagues in Sociology to (1) estimate the effects of obesity on life expectancy disparities by race-ethnicity, (2) complete ongoing research on “deaths of despair” in the U.S., (3) assess the feasibility of sleep-obesity research on racial minorities with WSCS data, and (4) begin research on how COVID-19 and obesity have jointly affected wellbeing in the U.S.

Public Nutrition and Health Education

Project Director

Lendel Narine

Organization

Utah State University

Accession Number

7001913



Access to Fresh Produce for Low-income Households

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

Findings from a recent statewide assessment show addressing hunger and supporting local food systems were critical issues in Utah (Narine, 2019). According to the United States Department of Agriculture (USDA), 10% of Utahns experienced food insecurity, meaning they did not have reliable access to the food they need to live a healthy and active life (Coleman-Jensen

et al., 2021). In addition, the Utah Department of Health (2021) reported that many Utahns with lower incomes were not eating sufficient servings of fruits and vegetables. The USDA emphasizes the importance of eating fruits and vegetables; the *MyPlate* model shows most meals should include nutrient-dense foods (USDA, 2021).

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.

Create Better Health, formerly known as Utah's SNAP-Ed program, created the *Buy Produce for Your Neighbor* healthy food drive initiative to address food insecurity and low consumption of fruits and vegetables. Create Better Health staff promoted fresh, local produce donations at farmers' markets by working with farmers, market vendors, managers, food pantry directors, USU Extension's Master Gardener program volunteers, and USU Extension county faculty. Donors dropped off extra produce they purchased at the farmers' market, providing additional support to local producers. Then, Create Better Health staff and partners delivered donations to local food pantries. The Buy Produce for Your Neighbor program began in the Summer of 2019 and was adapted to include donations from communities that do not have farmers markets. Two program variations include *Share Produce with Your Neighbor* and *Grow Produce for Your Neighbor*. Both adaptations utilize household gardeners and USU Master Gardeners who donate excess produce they grow. The primary target audience of the Buy Produce for Your Neighbor program is food pantry clients in Utah. The eligibility requirements for food pantries vary by location, but many clients are families and individuals with lower incomes who experience food insecurity. For example, the Cache Community Food Pantry describe their clients as single-parent households, people with disabilities, and people with limited incomes (Cache Food Pantry, 2021).

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

The reach of the *Buy Produce for Your Neighbor* program has expanded since it began, providing donations to one (1) food pantry in 2019, five (5) in 2020, and eleven (11) in 2021. The amount of donated food has also increased significantly over the past three years that the Create Better Health team has implemented the project. Approximately 381 lbs. of food were donated in 2019, while 6,206 lbs. were donated in 2021. This represents a 1500% increase in the amount of food donated to pantries over a three-year period. While the program has not conducted an outcome evaluation directly with food pantry clients to assess the changes in diets and nutritional intake due to the donations, it has received positive feedback from farmers' market produce donors, food pantry customers, and employees. A single mother of six children expressed gratitude for the program and its impact on her family after receiving fresh produce from her local food pantry, saying, "This is the only way my family can get fresh fruits and vegetables; we are so grateful for this program." Multiple food pantry employees report that the program is valuable to their pantry and clients. One director said she values working with USU Extension and Create Better Health. She noted the Buy Produce for Your Neighbor program is particularly beneficial due to the quality of donations.

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

Create Better Health has improved food access to lower income families in Utah through the Buy Produce for Your Neighbor program. This program has been particularly valuable during the COVID-19 pandemic; the Utah Food Bank president has reported a 300% increase in the demand for food assistance (Lee, 2020). In addition, food pantry clients have expressed a desire for more fresh food options (Utahns Against Hunger, 2021). The increase in donations of high-quality fresh produce addresses a critical need at food pantries by providing access to recommended servings of fruits and vegetables to low income families. Since donations are supported by local farmers, the Buy Produce for Your Neighbor program also helps local agriculture. The Buy Produce for Your Neighbor program will continue to expand in the future. Due to media news coverage during 2021 (e.g., Foster & Lane, 2021; Reese, 2021; The Place, 2021), many new farmers' markets have expressed interest in participating in the program. Additionally, expanding the program's partnership with the USU Master Gardeners program will likely lead to an increase in the program's reach, particularly in rural Utah, where there are fewer farmers markets.



Access to Fresh Produce in Rural Counties

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

Utah has seen a 300% increase in the need for food assistance since the onset of COVID-19 in March 2020 (Utahns Against Hunger [UAH], 2020). The spike in food insecurity led many Utahns to turn to emergency food sources (e.g., food pantries). Initially, food pantries reported not having enough food to support the demand for food assistance (UAH, 2020). While the need for food assistance increased, the agricultural market was experiencing significant losses due to global trade disturbances and economic shrinkages in the travel, hospitality, and restaurant sectors (Aday & Aday, 2020; Poudel et al.,

2020). Risk mitigation efforts, such as social distancing, limited movement across borders, and high rates of COVID-19 among employees also led to significant interruptions in the labor supply. These factors resulted in food processing shortages (Poudel et al., 2020).

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.

Supply chain disruptions left many Utah farmers and ranchers without a market for their products. Farmers and ranchers reported having to cull animals they could not process or sell due to supply chain issues (Marchant-Forde & Boyle, 2020). Nationwide, dairy farmers were dumping up to four million gallons of milk daily (Poudel et al., 2020). Meanwhile, the need for food assistance was growing due to the pandemic. Therefore, the Farmers Feeding Utah (FFU) Campaign was created by the Create Better Health team and USU Extension to connect food-insecure residents to farmers and ranchers for locally produced food. As an innovative approach, the FFU facilitated increased food assistance to Utahns while supporting local farmers and ranchers.

In response to the needs of both Utah farmers and families, USU Extension's Create Better Health (CBH/SNAP-Ed) program and the Hunger Solutions Institute partnered with the Utah Farm Bureau and Miracle of Agriculture Foundation to develop FFU. The goal of FFU is two-fold; (a) to provide Utah farmers and ranchers an outlet for their products, and (b) to provide nutritious food to families in need. FFU enables a food system change that connects families in need directly with locally produced fresh foods. To meet both goals, FFU relies on a combination of key individuals and corporate monetary and in-kind donations that are collected through social media campaigns and in-person solicitation. Donations are then used to purchase food directly from farmers to distribute to those in need. In addition, many Utah farmers and ranchers have donated or discounted food items for distribution at events. Purchased or donated foods are then distributed through pop-up food pantry events or given to local food pantries.

Special care was taken to ensure pop-up events and pantries received food that was culturally appropriate for their clients. For example, live sheep were distributed in the Navajo Nation. Additionally, pantries that serve refugee communities in Salt Lake county received commonly consumed items including goat meat, potatoes, and mushrooms. Recipients also received nutrition education on how to store and prepare the produce. The events were supported by volunteers from a multitude of partnering businesses, local organizations, and USU Extension's CBH faculty and staff, as well as local Extension county faculty.

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

Since inception in April 2020, FFU has provided twelve miracle distribution projects across ten counties in Utah and the Navajo Nation. Each event served an area at risk for food insecurity, which was defined as areas affected by economic challenges such as industry shutdowns and rising unemployment. Over the past year, FFU served over 23,000 Utah families directly through food distribution, with each family receiving approximately \$80 worth of locally grown Utah food. Food pantries ($n=31$) were provided with a variety of local fresh foods to stock their shelves. The retail value of food that has been distributed to families and pantries through FFU totaled over \$3.1 million dollars. FFU has also supported 32 Utah farmers and ranchers, including those that raise livestock, vegetables, fruits, and grain. Each distribution event offers products from at least one farmer or rancher local to the area.

In addition to providing food to families in need of assistance, the CBH program developed healthy recipes and other nutritional education materials and information that was distributed at each event. Based on survey results, the average household served by FFU consisted of five individuals. Accordingly, food received by participants at the events served a family of five for approximately two weeks. Respondents reported learning about the distributions through targeted mailings from CBH listservs, social media, and word of mouth from neighbors and friends. To date, FFU has been featured in over 100 news articles throughout the year. It was also recognized by the state of Utah in the concurrent resolution HCR019 which celebrated the work that Farmers Feeding Utah has accomplished during COVID-19.

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

While FFU was developed in response to the COVID-19 pandemic, there is an ongoing need for food system changes that can facilitate access to locally produced foods by food insecure individuals and families in Utah. FFU is dedicated to finding innovative and sustainable solutions towards a more equitable regional food system. We anticipate an expansion of FFU services. CBH plans to create farm-to-fork educational videos for events to further connect FFU food recipients to the local farmers and ranchers. This can lead to increased awareness and knowledge of the local food system among residents. CBH will conduct an outcome evaluation to understand the impact of FFU services on food recipients, farmers, and ranchers. Evaluation data will also be used to inform program improvement and expansion.



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

With increasing levels of obesity, chronic disease, and poor dietary habits, there is a need for non-formal nutrition education that addresses individual and family health and wellness. In Box Elder County, Utah, 65% of the population is overweight or obese, which may eventually lead to chronic diseases like diabetes and hypertension. However, Box Elder has a 7.5% poverty rate, with close to 3,400 families receiving SNAP benefits. There is also a 12.3% family food insecurity rate, and child food insecurity rate at 15.7%.

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.

Poor food choices and lifestyle behaviors are contributing to an increase in body weight and disease. A. Litchford created an educational series to inspire personal dietary change in participants through nutritional health classes, cooking classes, social media campaigns, Extension factsheets, and community events.

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

Post-evaluation results indicated 85% of participants were satisfied with the activities, while 90% reported an increase in confidence to make healthy behavior changes. Participants committed to making healthier food choices, cooking more meals at home, and participating in more physical activity.

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

The burden of chronic diseases on individuals and families is evident based on the ever-increasing healthcare costs. There is an undeniable need to promote healthy eating habits in an effort to reduce the effects of chronic diseases on society. Nutrition education will remain a critical part of Extension programming as more activities are designed to target long-lasting healthy eating behaviors. Public nutrition education can directly reduce healthcare costs, and improve individuals' health and quality of life.

Critical Issue

Youth Development

Utah 4-H: Positive Youth Development

Project Director

Lendel Narine

Organization

Utah State University

Accession Number

7001689



Career Exploration

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

Based on a statewide needs assessment in 2020, career readiness was ranked as a top 10 skill needed by Utah youth according to their parents. More specifically, interview skills were ranked as the number one need in the category of career readiness.

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

To meet the needs of Utah's youth, K. Romney created the 4-H Interviews with Pros series. This new program gives youth exposure to new careers, experience in an interview setting, and provides them with the opportunity to interview professionals from the fastest growing careers in Utah. Utah 4-H teens were recruited to interview professionals in careers related to 4-H project areas. The teens helped prepare questions for the interviews ahead of time, and the virtual interviews were broadcast live on social media. The interviews can be accessed here:

<https://extension.usu.edu/utah4h/programs/career-readiness/interviews-with-pros>

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

The Interviews with Pros series trained teen interviewers from 10 counties in Utah. Throughout 2021, youth interviewed nine professionals: an agricultural communication specialist, a food scientist, a physical therapist, a physician assistant, a registered nurse, a speech language pathologist, a software developer, a veterinarian, a small farm owner, and a welder. Overall, the series received 4,155 viewers from 28 states. On social media, 101 individuals have engaged with the interviews by asking more questions about the careers, sharing the interviews with their friends, and commenting on the posts during the interviews. Youth who interviewed professionals were able to practice formal interviews during the designated broadcasts and were able to speak casually in preparation for the meetings. During the preparation and debriefing of the recordings, many professionals offered the youth more personalized advice. Often youth and professionals were exchanging screen shares to discuss the nuances of their interests such as a 3D rendering of a building a student shared with a software developer in one meeting, and the application requirements for medical school from a physician assistant in another.

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

According to the Utah State Board of Regents, workforce demands are rapidly changing and today's jobs require an increasing amount of postsecondary education and training (Utah State Board of Regents, 2016). The Interviews with Pros series provide youth with the opportunity to interact directly with professionals in growing occupational fields. This experience allows youth to gain an early insight into emerging professions they can pursue through their educational journey. 4-H Career readiness programming is a proactive approach to providing a pathway to college and career opportunities for students.



Career Readiness

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

A statewide youth needs assessment ranked writing cover letters and résumés as top life skills needed by Utah's youth. Guided by a nationally recognized curriculum, the 4-H Portfolios program aims to help youth achieve developmental milestones as they become contributing, successful adults in their communities.

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

Each 4-H Portfolio consists of a cover letter and résumé written by youth in grades 3 – 12 to record developmental milestones and set goals for the future. However, an evaluation in 2018 showed the original 4-H Portfolio was an ineffective, inaccessible, and a difficult process for youth and volunteers. Statewide, only 24% of 4-H members were submitting a 4-H Portfolio in 2018, and all counties reported that these were submitted in modified formats to simplify the process. In response, K. Romney led a complete restructuring of the Utah 4-H Portfolio program. Romney and team sought to transition the 4-H Portfolio requirements and simplify the process to a standardized cover letter and résumé format. The revised 4-H Portfolio format spurred development of many new 4-H resources, including a 4-H Portfolio training template, guidebook, webpage, cover letter and résumé examples, and judging rubrics. Resources were provided statewide to 4-H members, volunteers, and professionals. During 4-H contests throughout the state, youth were asked to tailor their cover letters and résumés to different job applications and submit them electronically for review. Due to the ease and practicality of the new process, there was a dramatic increase in youth participation in the 4-H Portfolios program after the restructure.

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

Preliminary evaluation results after the restructuring of the 4-H Portfolio program indicated the new format led to increased accessibility, streamlined coordination, and real-world job application experience for youth. There was a transition from the original format as counties adopted the new simplified cover letter and résumé format. Most recent results showed 1,190 submissions at the county level (i.e., a 38% increase from the old format last used in 2018). After the revised 4-H Portfolio

became a standard application tool for state contests and leadership roles, there were over 600 submissions to state-level events; a whopping 2,122% increase since 2018. Internally, 94% of counties with an active 4-H Portfolios program are now using the new standardized format. With respect to youth outcomes, results show that youth benefited from the revised 4-H Portfolio; 89% of 4-H Portfolio participants reported learning to write a cover letter and résumé, and 87% of youth indicated they will use their 4-H experience to make decisions about their future. Youth also reported they intend to use the skills learned through creating 4-H portfolios for job applications (98%), scholarship applications (96%), leadership roles (81%), and college applications (93%).

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

The Utah 4-H Portfolios program serves as a self-evaluation tool for youth to measure their progress towards positive youth development. Youth participating in 4-H Portfolio develop skills that can positively impact their future. Through 4-H Portfolios, youth gain career readiness skills, group belonging, goal achievement, and community involvement. The 4-H Portfolio program gives youth the opportunity to write cover letters, explain their efforts throughout the 4-H year, and list their goals for the future. 4-H Portfolios are beneficial for youth and their communities; youth learn career readiness and life skills as they compile personalized documents, and adult community leaders get a glimpse into the future through the ambition and goals of young people. Research demonstrates a need for career readiness skills among Utah youth. Utah 4-H members are learning the skills necessary for finding employment, applying for postsecondary education, and setting personalized goals by creating their 4-H Portfolio. The 4-H Portfolios program is uniquely positioned to provide young people with a voice in their communities. Counties should support the 4-H Portfolio program; it serves as an essential component of youth development education. As a keystone activity in the youth career pathway, 4-H Portfolios facilitate a pipeline of youth excited to make a difference and contribute to society.



Social and Emotional Learning

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

Social and emotional learning (SEL) is the process through which youth acquire the knowledge, attitudes, and skills needed to recognize and manage their emotions, demonstrate caring and concern for others, establish positive relationships, make responsible decisions, and handle challenging situations constructively. Increasing protective factors among youth promotes well-being, helps 'buffer' the effect of risk exposure, and aids youth in navigating difficult circumstances.

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

To gather relevant and up-to-date data relating to SEL, S. Cromwell administered an IRB-approved Qualtrics survey to 45 parents who had youth in the 4-H Afterschool program. Thirty-six (36) parents completed the survey, resulting in an 80% response rate. Survey results showed 86% of parents placed high importance on the need for their children to learn life skills such as effective communication, positive problem-solving techniques, and conflict resolution strategies. Additionally, 82% indicated a need for social-emotional learning lessons in afterschool programs for their children. To understand youth's perspective, another IRB-approved survey was administered to 73 youth participating in the 4-H Afterschool program. Results indicated 38% of youth believed they could not control their anger when disagreeing with others. Research relating to the benefits of SEL, coupled with parent and youth data, indicated a need for SEL lessons and activities focusing on emotion regulation, particularly pertaining to anger control. S. Cromwell and afterschool team members implemented SEL lessons with elementary-aged afterschool students ($N=73$) at four schools in Sanpete County, Utah over a six-week period. Intentional, focused lessons were taught 1-2 times per week, included experiential learning techniques which allowed youth to practice new skills.

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

Participation in SEL lessons resulted in learning and behavior changes among youth participants. While initial data indicated 38% of participants were unable to control their anger, post-test results showed only 13.7% of youth reporting trouble controlling their anger after participating in emotion regulation lessons. In addition, post-evaluation results showed a 25% reduction in risk behaviors among youth participants. About 90% of afterschool educators ($n=12$) reported a decrease in impulsivity among youth and an increase in youth applying positive techniques for controlling their emotions, resulting in positive changes in daily school environments.

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

Providing youth with SEL lessons in safe, caring, and well-managed learning environments has been found to reduce risk behaviors, increase self-perception, and enhance academic attainment. Results indicated a positive change in youth social learning and emotional regulation after a short 6-week intervention with elementary-aged youth in Sanpete county. This program demonstrates the value of SEL for youth to curb risky behaviors. Therefore, evaluation findings from this intervention will be used to implement SEL lessons in other 4-H afterschool programs.



Youth Healthy Living

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

While Utah has comparatively low rates of alcohol and tobacco use, the state ranked seventh in the nation in 2015 for drug overdose deaths. The majority of overdose deaths were related to opioid misuse (Centers for Disease Control and Prevention [CDC], 2016). From 2010 to 2015, Utah experienced a 400% increase in deaths due to the misuse of prescription drugs (Violence and Injury Prevention Program, 2014).

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.

S. MacArthur and a team utilized the PROSPER delivery framework for a substance prevention program to youth. Intended outcomes of this program are to facilitate positive youth development skills, reduce youth at risk for substance misuse, and reduce opioid misuse among youth. The PROSPER framework and the 4-H Thriving Model served as the guiding approach for program implementation and delivery. The program includes a series of family- and school-based education activities that promote resiliency and developmental strengths for middle-school aged youth. Main activities of the program are delivery of the *Botvin LifeSkills* Training to middle school students, delivery of the *Strengthening Families program* to parents in the program, and guided enrollment of student participants to their respective local 4-H program. While COVID-19 impacted implementation, USU Extension has adapted virtual programming to rural youth and families. To date, the LifeSkills component of the program has been delivered to 7th graders in Wayne county ($n = 40$) and Emery county ($n = 41$).

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

An exit survey was used to evaluate the short-term outcomes of the youth substance abuse program. Evaluation results indicated after completing the LifeSkills training, 7th grade students demonstrated highly positive anti-drug ($M = 4.80$, $SD = 0.33$), anti-smoking ($M = 4.82$, $SD = 0.32$), and anti-drinking ($M = 4.78$, $SD = 0.37$) attitudes. Students also expressed strong drug refusal skills ($M = 4.00$, $SD = 1.67$). A correlational analysis showed strong positive correlations between all anti-drug sentiments, indicating an individual was likely to exhibit anti-drug, anti-smoking, and anti-drinking attitudes simultaneously after participation in the training. After completion, over 70% of youth participants strongly agreed they would not smoke a cigarette, drink alcohol, smoke marijuana, use cocaine or other drugs, use prescription drugs that were prescribed to others, and vape or smoke an e-cigarette. ANOVA analysis revealed anti-drug, anti-smoking, anti-drinking, and drug refusal skills were consistent across gender, race, age, and number of parents in the household. This suggests the program led to positive short-term outcomes for all youth participants regardless of their demographic background.

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

S. MacArthur and team implemented the PROSPER framework to provide a nationally recognized substance misuse prevention program in three rural counties in Utah. The program targeted 7th grade youth, and activities included prevention science through PROSPER and positive youth development guided by the 4-H Thriving model. Evaluation results showed youth participants exhibited strong anti-drug attitudes after the program. Positive outcomes were consistent across youth demographic characteristics, indicating all youth benefited from the program irrespective of their personal background. Positive youth development and strong drug-refusal attitudes are necessary to curbing the upward trajectory of substance misuse rates in rural counties. This program serves as an effective model for non-formal interventions targeting drug prevention among youth vulnerable to the opioid epidemic. Therefore, the program will be expanded to other counties to facilitate positive youth development.

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

E-cigarette usage has increased nationally among students, leading to the Surgeon General to declare e-cigarette usage a youth epidemic (U.S. Department of Health and Human Services [HHS], 2016). Southeast rural Utah has the highest rates of e-cigarette use among youth in the state (Utah Department of Human Services [DHS], 2019). According to the Prevention Needs Assessment Survey, 21% of students of grades 8, 10, and 12 in the Southeast Utah Health Department reported use of e-cigarettes in 2019 (Utah Department of Health [UDOH], 2020). While results indicated an increase in youth’s use of e-cigarettes as they progress to higher grade levels, there is also an increase in the usage of e-cigarette among youth in lower grades. In the Four Corners District (i.e., Carbon, Emery, & Grand), there was an increase in e-cigarette use among 6th graders from 0.4% to 4.2% over a four-year period (2015-2019; Bach-Harrison, 2020). The prevalence of e-cigarette threatens the progress made to decrease youth tobacco 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.

In response, C. Pay and Extension faculty from Carbon, Emery, and Grand county implemented an educational program in communities to combat initiation and use of e-cigarettes among youth. The name of the program was shortened to “Be Epic.” The program coordinators facilitated a 1.5-hour training for teachers of grades 5 to 12 and school staff. The training provided up-to-date information about vaping (e.g., identifying vape devices, common hiding places for these devices, and vape ingredients), health effects of e-cigarettes, and relevant statistics on the prevalence of youth vaping. Teachers were introduced to the CATCH My Breath curriculum, which is available at no cost for use in their classrooms. The teacher training component of Be Epic was delivered to nine schools across the three-county program area. Across all sites, 42 teachers attended the 1.5-hour training (n = 42). Seven (7) trainings were delivered virtually, and one (1) school requested in-person delivery.

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

Pre- and post-surveys were conducted to examine changes in teacher knowledge and confidence in delivering the CATCH My Breath lessons about vaping to students. Participating teachers most often taught at the elementary school-level (61.5%) and 34% taught more than one subject. Results of paired sample t-tests showed participants (n = 38) had statistically significant increases in their knowledge of the health risks associated with e-cigarettes and confidence to address e-cigarettes in the classroom with students. Specifically, there was a statistically significant increase in teachers’ knowledge of the basics of what e-cigarettes are and how they work, health risks associated with youth vaping, and common misconceptions that minimize the impacts of youth vaping. In addition, there was a statistically significant increase in teachers’ confidence to discuss tobacco and vaping specific information with students, incorporate information and discussions about tobacco and vaping into classes, discuss with students how to decline tobacco or vaping from peers, model healthy behaviors with students, and incorporate information about tobacco and vaping into class content.

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

The Be Epic program has received continuing support by the Southeastern Utah Health Department. Using evaluation results, the program team at USU Extension seeks to modify program components to improve program delivery. For example, Be Epic plans to broaden the teacher component by adding another session to reorient teachers to the curriculum. The program team also plans to provide quarterly in-service opportunities to teachers to improve implementation of the CATCH My Breath curriculum in the classroom. The first iteration of Be Epic was an effective educational intervention that other health districts can adopt to strengthen their youth vape prevention efforts.