

FY 2020 Annual Report of Accomplishments and Results

UTAH

Utah State University

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your FY 2020 Plan of Work located in the Institutional Profile. Use this space to provide updates if needed.

1. Executive Summary (Optional)

USU Extension rapidly transitioned to online learning at the beginning of the COVID-19 pandemic. County-level needs were assessed to ensure faculty were prepared to deliver most programming to clientele across the state. USU Extension's response was published online as one of the first peer-reviewed articles focusing on Extension and the pandemic: <https://agdevresearch.org/index.php/aad/article/view/35>.

Section V contains a summary of successful Extension programming that adapted to virtual and/or mixed-mode delivery during COVID-19.

The Utah Agricultural Experiment Station (UAES) determined early in the COVID-19 pandemic that, since agriculture is an essential critical infrastructure sector, UAES farm operations and farm-based research were essential activities. Because food production, farm operations, and long-term or time sensitive agricultural research are activities that cannot be put on hold during a State or National emergency and then resumed at a later time, these activities were allowed to continue uninterrupted. As a result of this determination, many UAES research projects were able to continue in 2020. Nevertheless, the pandemic did interrupt some research projects and slowed progress on other projects.

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates ONLY
1. The <u>Merit Review Process</u>	No updates, please refer to Plan of Work.
2. The <u>Scientific Peer Review Process</u>	No updates, please refer to Plan of Work.

III. Stakeholder Input

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates ONLY
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	No updates, please refer to Plan of Work.
2. Methods to identify individuals and groups and brief explanation.	No updates, please refer to Plan of Work.
3. Methods for collecting stakeholder input and brief explanation.	No updates, please refer to Plan of Work.
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	No updates, please refer to Plan of Work.

IV. Critical Issues Table of Contents

No.	Critical Issues in order of appearance in Table V. Activities and Accomplishments
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
7.	Community Resilience

V. Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). In your outcome or impact statement, please include the following elements (in any order): 1) the issue and its significance (e.g. who cares and why); 2) a brief description of key activities undertaken to achieve the goals and objectives; 3) changes in knowledge, behavior, or condition resulting from the project or program’s activities; 4) who benefited and how. Please weave supporting data into the narrative.

No.	Project or Program Title	Outcome/Impact Statement	Critical Issue Name or No.
1.	<i>Extension Success Story:</i> Smart Irrigation Sensors	With concerns around inefficient agricultural water use during times of increased droughts in dry states, there is an urgent need for producers to have access to data for irrigation optimization. Such data is necessary for reducing agricultural water use by informing changes to farm irrigation management systems. However, irrigation sensors that provide accurate data for optimization are costly, and producers in Utah lack access to affordable sensors. In response, C. Zesiger and a team developed prototypes for affordable wireless irrigation sensors. Zesiger is working with producers to test these sensors. The team acquired funding to pilot the prototypes and introduce the technology to producers. While in its early stages of development, the team is using a participatory approach to technology development by working with producers. Producers provide ongoing feedback through experiential-based educational workshops and	Global Food Security and Hunger

		on-site testing to increase the compatibility of irrigation sensors for irrigation optimization data. The goal of this project is to reduce agricultural water use and decrease cost of inputs for Utah producers.	
2.	Extension Success Story: A Demonstration Farm for Virtual Education and Food Pantry Donations	A needs assessment was conducted in 2018 to assess the core education needs farmers across Utah’s Wasatch Front. The assessment revealed an ongoing reduction in farming acreage, leading to an increase in small and micro-scale urban farms. However, new producers operating these urban farms generally lack education and experience in horticulture. In response, S. Hansen and team hosted a panel at the Urban Small Farms Conference for micro-scale farmers growing on less than 2 acres. A total of 80 people attended the panel meeting. The team gathered needs assessment data from the panel to identify their education needs and set programming priorities. Following, Hansen and team acquired internal funding to create a demonstration area for small scale urban farming. There were two main goals of the demonstration farm; (a) to serve as a USU Extension experiential teaching site for urban farmers, (b) to produce fresh produce for local food pantries. Evaluation results indicated approximately 2,200 lbs. of food was harvested from the demonstration site in 2020. Hansen and team partnered with the Bountiful Community Food Pantry to donate all produce to food-insecure populations in Davis County. In addition, many educational events were hosted at the site in 2020. Due to COVID-19, all events were broadcast over social media to demonstrate key concepts, principles, and skills to urban farmers in Utah. With the increase in urban farms in Utah, the demonstration site continues to serve as an educational venue for urban farmers. Hansen and team seek to improve food security by supporting small-scale farming.	Global Food Security and Hunger
3.	Extension Success Story: AgrAbility of Utah	AgrAbility of Utah is part of a national program designed to help farmers, ranchers and their family members remain in agriculture when facing limitations due to aging, disease, injury, illness, or other disability. R. Miller and team reported that AgrAbility of Utah is currently assisting a total of 72 clients and their families. Through on-site farm and home assessments, AgrAbility of Utah develops individualized plans that help producers and their families facing a disability. These plans often involve working with	Global Food Security and Hunger

		<p>other agencies/organizations (e.g., Vocational Rehabilitation) to help them obtain funding for assistive technology. Many AgrAbility of Utah clients receive assistance from Vocational Rehabilitation (VR). Miller reported over \$200,000 was obtained through Vocational Rehabilitation for assistive technology and modifications for clients. To date, AgrAbility of Utah has helped approximately 300 agriculturalists and their family members remain in agriculture. Outreach activities include educating producers and agricultural professionals on the role of AgrAbility and the options that exist to help producers, and their families, who are facing a disability remain in agriculture. As a result, more farmers and ranchers are receiving the assistance that they need to remain in agriculture. This project actively contributes to the longevity and success of existing farms in Utah.</p>	
<p>4.</p>	<p><i>Extension Success Story:</i> Farmers’ Market for Seniors: Neighbors Feeding Neighbors</p>	<p>COVID-19 has adversely impacted Utah seniors in many ways including food access, social isolation, loneliness, depression, and fear of death. While senior centers in Utah provide a setting that enables social interaction, these facilities also offer free meals to anyone over the age of 60. Due to COVID-19, many seniors face severely limited access to lunches by senior centers (Salt Lake Tribune, 2020). In response, K. Wagner and team led free farmers’ markets in 2020 to safely supply seniors with fresh produce and positive interaction via outdoor produce markets. The primary audience of this program was needy and food-insecure seniors. With assistance from SLC Aging and Adult Services, senior centers were selected based on the level of risk for food insecurity. In 2020, 2,500 seniors picked-up fresh produce during 40 free farmers’ markets held outside 7 senior centers. Nearly 10,000 pounds of garden produce was disseminated to food insecure seniors, with an estimated farmers’ market value of \$23,000. Seniors collected hot lunches via drive-through services, and we were able to coordinate outdoor produce markets at the same time. The farmers’ markets enabled volunteers to contribute to an impactful program during the pandemic. Many volunteers opted to ‘grow-a-row for a senior’ in backyard gardens and donate the produce for volunteer service time. Wagner reported the “Neighbors feeding neighbors” approach can be effective to disseminate fresh produce when</p>	<p>Global Food Security and Hunger</p>

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		traditional food distribution channels are stressed during high demand and/or uncertain times. Furthermore, seniors are an important target population, and Extension programs centered on healthy food and positive interaction can improve the lives of these individuals.	
5.	Extension Success Story: Farm and Ranch Succession Program	Approximately 80% of all owner-operated land was owned by individuals who were 55 years or older (Bigelow et al., 2016). This staggering statistic, coupled with the reported average age of producers in Utah being 58.7 years old, explains why Utah farm and ranch producers have listed succession planning as one of the most important programmatic needs from USU Extension. However, many producers reported they were unfamiliar with the succession process. In response to this gap, J. Dallin and team developed and modified educational tools and workshops for producers on succession planning. Post-evaluation results indicated 87% of participants strongly agreed that they know the value of developing a vision for their farm and ranch legacy, 90% strongly agreed that developing the next generation farmers/ranchers is extremely important, and 73% strongly agreed that they know what information is needed to meet with a professional. Further, 100% of participants stated that they intend to start a conversation with their family about succession planning, 86% plan to form a vision for the future of the family farm/ranch, 79% intend to gather information/documents that are needed for succession, and 90% of participants intend to use the workbook provided to begin their succession plan. In response to COVID-19, this program has been modified for virtual delivery to ensure accessibility and participants' safety during the pandemic. The Farm and Ranch Succession Program is gaining momentum and currently being planned for replication across Utah. The need for farm and ranch succession is evident, and J. Dallin of USU Extension is making a deliberate effort to expand relevant education and resources to producers.	Global Food Security and Hunger
6.	Extension Success Story: Efficient Landscape and Gardening Practices	There are over 10,000 homes in Sanpete county of Utah. On average, each home accounts for approximately 0.25 acre of irrigated landscape. This translates to roughly 2500 acres of irrigated lawns and gardens in Sanpete County, all managed by private homeowners. As a desert state, improper water use is a critical concern to Utah residents and government.	Global Food Security and Hunger

		<p>Inefficient landscape irrigation practices threaten the water supply. However, recent clientele assessments indicate many homeowners lack education on proper irrigation management and gardening practices. Major issues include inefficient irrigation systems, groundwater runoff, and improper fertilizer applications. In response, M. Palmer developed a comprehensive program to provide education to homeowners of Sanpete county on best landscape and gardening practices. In 2020, Palmer delivered seven educational workshops to a total of 141 residents on topics related to landscape and garden management issues. These workshops focused on the underlying need for water conservation and proper fertilizer use. Palmer reported that all workshops were rated as excellent by all 141 participants in Sanpete county. With increased droughts and weather uncertainty, there is an ongoing need to protect water resources, especially in dry states like Utah.</p>	
<p>7.</p>	<p><i>Extension Success Story: Producers’ Virtual Field Days</i></p>	<p>Using results of agronomic needs assessment in Utah, J. Creech designed a series of educational series to address unique challenges affecting producers. Many activities were traditionally delivered in a face-to-face format to producers. However, COVID-19 affected Extension’s ability to provide face-to-face education to clientele. With competitive funding of approximately \$500,000 in 2020, Creech shifted focus on expanding USU Extension’s digital footprint for online education through platforms such as Facebook, Instagram, Twitter, and YouTube. Funds were also used to implement the USU Crops website (https://extension.usu.edu/crops/). As a result, Creech delivered 24 presentations to producers through in-state crop schools, conferences, and workshops in 2020. Creech also co-organized a major two-day virtual field day event to replace shorter field day events that could not be held due to social distancing concerns. Creech reported the “mega” virtual field data attracted 243 participants. In addition, 35% of participants were new to USU field days. While traditional workshops were cancelled due to COVID-19, USU Extension faculty rapidly shifted focus to online education to ensure clientele had access to relevant programming.</p>	<p>Global Food Security and Hunger</p>

<p>8.</p>	<p>Extension Success Story: Crop Schools</p>	<p>Data from the Utah Department of Agriculture showed about 15 million pounds of safflower, valued at \$7 million dollars, was harvested in Utah in 2018. M. Pace and team leads the USU safflower research program. In 2019, the team completed safflower research on nitrogen fertilizer application rates and presented their findings in 2020 at several Utah and Idaho oilseed events. The team uses the research to develop educational programs for safflower producers in Utah. However, due to COVID, many educational activities were conducted in a virtual setting in 2020. Using their own research, Pace and team produced an educational video for the virtual field day series and delivered presentations regional meetings. In addition, Pace and team facilitated the Box Elder County Crop School for 97 producers. Each participant received a Continuing Education Unit credit towards renewing their pesticide applicators license in Utah or Idaho. During the crop school, participants learned about producing quality alfalfa hay, seedbed preparation and seeding rates, and the market outlook for 2020. As a significant addition to the crop school in 2020, Pace and team partnered with the Bear River Health Department to facilitate an educational activity on stress management to producers from a licensed therapist. Evaluation results indicated producers believed the information received from the crop school was very useful (4.87 out of 5) and they planned to use what they learned to improve their operations.</p>	<p>Global Food Security and Hunger</p>
<p>9.</p>	<p>Extension Success Story: Residential Gardening</p>	<p>While gardening and landscaping is considered a hobby, it is an important source of food in Duchesne county of Utah. An estimated 80% of the 3500 households in the county harvest fresh produce from their own gardens. Therefore, the home garden provides a major portion of vegetables consumed by a family. As a result, households in Duchesne county rely on USU Extension Service for gardening and horticulture information. T. Cooper conducts a series of educational activities with families that focuses on all aspects of home gardening. Major topics request by these families relate to general best gardening practices, landscape management, insects and diseases, and pesticide use, and water-related stress problems. In 2020, Cooper partnered with the Conservation District to expand education to families on topics related to the selection of trees,</p>	<p>Global Food Security and Hunger</p>

		<p>growing zones, fruiting, and drought tolerance. In addition, Cooper partnered with the local Farmers’ Market and provided individualized educational advice to vendors to diagnose pest and disease problems. Cooper effectively created a working relationship between Farmers’ Market vendors and USU Extension. As part of the horticulture program, Cooper partnered with a local High School to plant \$1,000,000 worth of turf and provided support on irrigation and pest management. Cooper leads an effective horticultural program in Duchesne county that reaches families, farmers, and public schools through continued partnerships. Such programs enable food security at a local level.</p>	
<p>10.</p>	<p>Research Impact: Functional Genomics and Ecology of Nitrogen Mineralization and Nitrification</p>	<p>Jeanette Norton has been studying the functional genomics and ecology of nitrogen mineralization and nitrification. Two genomes of ammonia oxidizing bacteria (AOB) were completed, annotated and published. <i>Nitrosospira briensis</i> C-128 was isolated from acidic agricultural soil in 1971 and maintained in the PI’s laboratory since 1995. <i>N. briensis</i> and <i>N. multiformis</i> (Norton et al 2008) are important comparative genomes for soil. <i>Nitrosomonas cryotolerans</i> ATCC 49181 is a marine cryotolerant AOB isolated from arctic waters. Eventually the JGI performed long-range sequencing enabling complete genomes for these reference bacteria. Comparative analysis of <i>Nitrosomonas</i> was completed with special attention to group 6A that is adapted to low ammonia. Targeted amplicon sequencing was accomplished for AOB, ammonia oxidizing archaea (AOA), and nitrite oxidizing bacteria (NOB) using marker genes. Enrichment cultures from Utah agricultural soils initiated in 2016 are under further investigation.</p> <p>Understanding the response of nitrifiers to N fertilization is essential to improve strategies for mitigating impacts of nitrate production in agriculture. In many agricultural systems, large amounts of fertilizer N are lost from the root zone through leaching and denitrification. Preventing these losses through improved management of nitrification may increase N use efficiency. N fertilization remains a crucial practice for crop production that exerts a significant influence on nitrifying communities.</p>	<p>Global Food Security and Hunger</p>

		<p>The organisms responsible for nitrification were found to be distinct under contrasting management. The activity of AOB dominated in systems receiving ammonium fertilizers, while activity by ammonia oxidizing archaea (AOA) was relatively increased in soils receiving composts and manures. Importantly, AOB and AOA responded differently to shifts in ammonium availability and temperature. In soils from both Utah and Georgia, AOB respond to fertilizers with changes in community structure and increases in their abundance and activity. AOB dominated nitrification in soils immediately following fertilization events (within three weeks). It was also found that abundance of organisms' marker genes does not necessarily predict activity. Multiple controlling factors including substrate availability, organism abundance, kinetic response to substrate and environmental parameters of temperature and moisture will need to be assessed for prediction. For ammonia oxidation, it was found that the AOB and AOA exhibited remarkably different kinetics and temperature responses. In Utah soils, AOB had higher maximum rates per cell, and lower optimum temperatures while AOA exhibited lower half-saturation constants suggesting higher affinities at the low range of substrate. These kinetic traits are responsible for differential responses to ammonium or urea fertilizers versus organic amendments. Nitrifier community shifts occurred over multiple years of repeated applications. In Georgia soils impacted by poultry manure, it was observed that AOB are functionally more important than AOA under elevated Zn and Cu concentrations and that management practices should focus on AOB. The community of NOB (<i>Nitrospira</i>) was also changed by N fertilization. Overall, AOB responded more extensively to readily available substrate by increasing their activity and eventually their abundance. However, during the crop growing season AOA may dominate nitrification activity after fertilizer depletion or when mineralization from organic sources controls substrate availability. It was also observed that organic amendments including steer manure, steer manure compost and poultry litter may have contrasting effects on nitrifiers due to ammonium availability and mineralization potentials. This new knowledge of ammonia and nitrite oxidizing community responses</p>	
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		<p>may be important for prediction and modeling of nitrification rates in agroecosystems under changing fertilization and climatic conditions.</p> <p>Soil extracellular enzymes play a significant role in N mineralization in agricultural soils. However, few studies have documented the linkage between enzyme activity and the microbial community that performs the function. In Dr. Norton’s studies, the application of high-throughput sequencing, real-time PCR and metagenomics shed light on how the abundance and diversity of microorganisms involved in N mineralization respond to N management. She examined enzyme activities and their encoding genes for urease, chitinase, protease and glucosaminidase. In Utah soils, N mineralization functions were explored in replicated field plots with contrasting N sources and in an organic management system over four years. Soils were collected from silage corn plots with four contrasting N treatments: control (no additional N), ammonium sulfate (AS100 & 200 kg.N./ha), and compost (200 kg.N./ha). Amplicon sequencing was used to assess bacterial community (16S rRNA genes), bacterial ureolytic community and bacterial chitinolytic community. Enzymes and their marker genes examined included protease, chitinase, urease, and arginase. Compost significantly increased diversity of bacteria even after one application, while ammonium fertilizers had no influence on bacterial communities over four seasons. Bacterial ureolytic and chitinolytic communities were significantly changed by N fertilization. Compost treatment strongly elevated enzyme activities after four-years of repeated application. Novel N mineralization genes were recovered from soil metagenomes based on a gene-targeted assembly. Organic farming systems receive amendments to maintain soil fertility and supply nutrients for plant growth. Dr. Norton’s team investigated the effect of organic amendments and their interaction with cover crops on soil enzyme activities, N transformation rates and functional gene abundances in an organic production system. Organic N amendment had a stronger effect than cover crop type on soil function and functional gene abundances. Soil enzyme activities were increased by both compost and manure. The</p>	
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		<p>activity of AOB and AOA were increased by organic N fertilizers, and their activities were higher in manure than in compost treated soils. Nitrification potential, nitrite oxidation potential, and denitrification potential were higher in manure treated than in control and compost treated soils, indicating application of manure had a higher N loss potential than compost. The abundance of functional genes was less important than soil chemical and microbiological properties to explain the variation in corresponding enzyme activity. Understanding how the structure and function of soil microbial communities involved with N mineralization change in response to fertilization may suggest suitable practices that improve ecosystem services while reducing negative environmental consequences.</p>	
<p>11.</p>	<p>Research Impact: Optimizing inputs for forages and field crops in Utah</p>	<p>Joseph Creech has been working on optimizing inputs for forages and field crops. The first objective for this project was to characterize the effect of cover crops and compost carryover on wheat yield and quality. The field research experiments were conducted on a university farm at Blue Creek, UT and on three grower farms in Snowville, UT. Data was collected on cover crop, weed growth, and wheat yield and yield components. Wheat yields at Snowville averaged 1525 kg ha⁻¹ across the trials from 2015-2020, and increased 2- to 4-fold in plots treated with a one-time compost application of 50 Mg ha⁻¹, compared to the untreated control. Cover crops decreased wheat yield dramatically. Little to no wheat yield difference was noted at Blue Creek. Measurement of wheat quality in the laboratory is ongoing. 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.</p> <p>A second objective was to evaluate strategies for integrating legumes into existing grass pastures in Utah. Field research experiments are ongoing at</p>	<p>Global Food Security and Hunger</p>

		<p>USU research farms in Lewiston, Millville, and Panguitch, UT. Two graduate students collected data on legume frequency, forage mass, and cattle weight gain. On a separate project, another graduate student collected data on phenological growth stage (Zadok’s scale), plant height, tiller count, and forage mass to test grass-legume mixture compatibility. Laboratory work was completed to test forage nutritive value through NIRS and validated by wet chemistry. Progress towards the successful completion of this objective will lead to the development of new management recommendations for agricultural producers to improve forage yield and nutritive value of irrigated and dryland pastures in Utah.</p>	
<p>12.</p>	<p>Research Impact: Identification and Management of Vegetable Viruses in Utah</p>	<p>Over the past five years Claudia Nischwitz found, two new viruses in vegetables. Tobacco streak virus in yellow zucchini and Potato virus S in potato. In addition, her research group identified tomatillos as a new host for Tomato spotted wilt virus (TSWV) in the state, and gourds and pumpkin as new hosts for Beet curly top virus. During this five-year project surveys showed that TSWV spread across the state. Another significant finding was that non-susceptible border crops were effective in reducing Watermelon mosaic virus in summer squash in small-scale field trials at the Kaysville research farm. Unfortunately, no funding could be obtained to extend the trial on a larger scale. At Dr. Nischwitz’s request, commercial growers tested several varieties of TSWV resistant tomato varieties in Northern and Southern Utah. The tomato varieties did well in the Utah climate. However, several growers didn’t like the flavor and texture of the varieties and will continue to look for other varieties to be tested. The testing of seed from tomatoes, peppers, eggplants and tomatillos for Tobacco mosaic virus/Tomato mosaic virus (TMV/ToMV) yielded surprising results. A lot of varieties, especially heirlooms of tomatoes and tomatillos had positive seed ranging from 5-100% of seed in a packet. In addition, seed were found to be contaminated with two related Tobamoviruses that had not been observed in the field in Utah. A total of 89 tomato, pepper, eggplant and tomatillos varieties from eight different seed companies were tested. Grow-out tests of tomatoes varieties with 100% infected seed showed a transmission rate of 4-94%.</p>	<p>Global Food Security and Hunger</p>

<p>13.</p>	<p>Research Impact: Soil Productivity Management Issues in Utah and the Western US</p>	<p>Grant Cardon’s research project focused on two main areas of study, namely, soil fertility and soil salinity management. Accomplishments in the soil fertility emphasis is best exemplified in the evaluation of the N needs of rotational crops following alfalfa. As a legume, alfalfa works in a symbiotic process with soil bacteria to fix atmospheric N into plant and animal assimilable forms. The process leads to N enrichment of the root zone of alfalfa above the need of the crop. The residual N is available over time and depth, to subsequent rotational crops such as silage corn, small grains, etc. Research completed under this project resulted in the revision of alfalfa N credits tailored to specific rotational crops, rather than the one-size-fits-all approach of the past. Specifically, it was found, and extensively validated in numerous locations in Utah, that there is no need for additional N in the first year of rotational corn silage production following alfalfa, and little to no need even in the second year of production. For small grains (wheat, barley, oats and rye) the result is quite different and depends on whether the crop is grown for forage or grain. These results indicate the critical need for on-going, regular revisitation of past recommendations as production-affecting factors (e.g., new crop varieties, soil conditions, climatic conditions, fertilizer technologies and delivery techniques, etc.) change.</p> <p>Accomplishments in the area of soil salinity management focused on improved calibration and application of remote methods of salinity measurement and spatial visualization. One of the outcomes of improved calibration techniques between remotely sensed EMI data and soil conductivity, is that other factors besides salinity affecting the EMI reading can also be determined. Soil properties such as organic matter content, water content, and clay content in particular, contribute to soil bulk conductivity. Thus, EMI data can also be used to map spatial differences in other soil properties that may affect crop growth, forming the basis for creating differential management zones that can improve the efficiency of cultural input (e.g., fertilizer, irrigation, pesticide use, etc.) application and improved spatial crop productivity</p>	<p>Global Food Security and Hunger</p>
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<p>14.</p>	<p>Research Impact: Integrated pest management for soil pests in forage</p>	<p>Ricardo Ramirez has been studying integrated pest management. Seasonal data was collected to determine the activity of clover root curculio (CRC) life stages in Utah. Using a combination of vacuum and sweep sampling for adults it was determined that spring populations were low until July when there was an increase from 0.74 adults per sample to >10 adults per sample from early August through November. Two distinct adult peaks occurred from mid-July to late-August in 2015, and from early August to early October in 2016. The separate peaks within these time periods appeared to result from summer aestivating adults that escaped being captured during sampling. Soil core sampling revealed that larval numbers in spring (early April) remain low (calculated 1.08 larvae per sample) until late May when larval numbers reached their peak (calculated 6.42 larvae per sample). Late spring into early summer, larval numbers declined the remainder of the growing season. The number of CRC eggs increase in the fall into the winter (calculated 4.18 eggs per sample in September to 13.09 eggs per sample in December). Therefore, CRC appears to primarily overwinter in the egg stage, a result of adult activity increasing from summer into the fall and most oviposition occurring in the fall. These findings assisted in validating CRC life history in Utah and in determining management timing of potentially susceptible life stages.</p> <p>To categorize and assess natural enemies, a series of soil core samples and pitfall traps were used. The primary predaceous arthropods collected were harvestmen, wolf spiders, sheet-weaver spiders, and predatory ground beetles and each predator overlapped peak CRC adult abundance. The most abundant predator was Pterostichus spp. recorded at 7.62 predators per trap for one 24-hr period during peak CRC. In addition, a survey of alfalfa field soil found that 9% of sentinel waxworms were infected with entomopathogenic nematodes (EPNs). Moreover, 4.7% infection of CRC larvae and pupae found in soil were infected with the fungus Beauveria bassiana. Considering seasonal timing of CRC larvae, applications of Bacillus thuringiensis spp. galleriae, the EPN Steinernema riobrave, B. bassiana, and a systemic insecticide, flupyradifurone, were tested for</p>	<p>Global Food Security and Hunger</p>
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		<p>efficacy against resident CRC larvae across two alfalfa field seasons (2018-2019). Treatments were applied before larval peak or during larval peak. Biological and systemic insecticides did not reduce resident CRC populations or affect larval development compared to untreated controls. Root damage was also similar across control and insecticide treatments. Further, application timing did not improve insecticide efficacy. Given the diverse insecticide types evaluated, differing mechanisms may exist for their lack of success against CRC. It is also important to note the difficulties in evaluating CRC suppression, in part, because of the variation in resident populations and their cryptic nature.</p> <p>A field biofumigation trial was completed and consisted of three mustard biofumigant varieties (Andante yellow, Caliente 199 blend, Centennial brown) along with a biomass control (oats), and a fallow control without plant biomass. Considering CRC activity, rapid bolting of summer planted mustard, and the negative agronomic effects of late alfalfa seeding on stand establishment before winter dormancy, a 30- and 60-day post cover crop incorporation were determined to be detrimental treatments. Therefore, biofumigant planting was established in the early spring and plants were subsequently incorporated into the soil. While the green weights of the different cover crops grown were significantly different ($P=0.01$), dry weights showed no difference ($P>0.10$). This was due to an overall low moisture content of the oats and relatively high moisture content of one of the mustard varieties (Caliente 199); however, the dry biomass measure of organic matter incorporated into the soil was consistent. Alfalfa was planted 2-weeks after biofumigant plant biomass was incorporated. Alfalfa germination and subsequent alfalfa yield was similar among treatments ($P>0.10$) suggesting the 2-week timing was sufficient to avoid detrimental effects on alfalfa.</p> <p>Crop biofumigation treatments were evaluated on CRC adults in the field and greenhouse. Quantifying the effects of biofumigation showed that the soil incorporation of mustard cover crops did not affect CRC feeding</p>	
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		<p>damage ($P > 0.10$). In a parallel greenhouse study, the overall direct effect of biofumigant treatments on CRC mortality was not significant ($P > 0.10$). A greenhouse trial indicated that alfalfa damage was decreased in treatments with biofumigants compared to non-biofumigant and oat treatments ($P = 0.002$; $P = 0.0003$, respectively). However, the overall response of CRC to biofumigants was variable. In field and greenhouse trials, biofumigant effects on CRC oviposition and feeding behavior did not appear to alter their behavior as most trials found no significant differences among soil amendments and control treatments.</p> <p>Results from these studies were a component of a funded USDA-NIFA grant proposal focused on CRC management, a publication in the Journal of Integrated Pest Management, and an extension fact sheet on CRC. Additionally, data from this project are a component of two pending USDA grant proposals.</p>	
<p>15.</p>	<p>Research Impact: Tannin-containing legumes in pasturelands and their ecological services</p>	<p>Juan Villalba and his NIFA funded colleagues at Utah State University have developed a transformative legume-based beef production system which leads to substantial ecosystem service improvements that benefit rural America.</p> <p>During the finishing phase, heifers grazed increasingly diverse combinations of tanniferous (birdsfoot trefoil-BFT, sainfoin-SF) and non-tanniferous legumes (alfalfa-ALF) presented in strips. Grazing tanniferous legumes led to lower concentrations of blood urea N, urinary N and greater fecal N concentrations than grazing alfalfa. Two-way choices between BFT and SF led to the greatest decline in urinary N concentration, showing that different types of condensed tannins (CT) in different legumes resulted in associative effects that enhanced N economy, reducing N excretion. Heifers grazing the 3 legumes partitioned 20% less N into urine and retained 43% more N than the average of heifers grazing monocultures. Enteric methane (CH_4) emissions were not affected by treatment, but heifers grazing the 3 legumes showed the greatest body weight gains (explained through maximal digestibility of the forages</p>	<p>Global Food Security and Hunger</p>

		<p>selected), implying reductions in the number of days to slaughter, and thus reduced CH₄ emissions.</p> <p>In another study, cows grazing BFT showed greater weight gains than cows grazing a non-tanniferous legume (cicer milkvetch-CMV) or grass (meadow brome-MB), but similar to cows fed a feedlot ration. Methane emissions were lower in cows grazing BFT than in cows consuming the ration. Legumes were exceedingly high in non-fibrous carbohydrate concentrations (ranging between 39 and 50% of dry matter) relative to grass (21 and 24%), which enhances performance and reduces N losses.</p> <p>Life Cycle Assessment. Seven different finishing scenarios were created to simulate typical soil types, forage yields and climatic conditions in northern Utah using Holos software, with inputs from grazing studies. Legumes decreased total greenhouse gas (GHG) emissions relative to grass forages. When comparing BFT, MB, and CMV, MB had the greatest total GHG emissions due to N fertilizer use coupled with lower feed quality. The use of both tanniferous and non-tanniferous legumes lowered enteric CH₄ production, N fertilizer use via N fixation, and overall GHG emissions while increasing feed quality. Thus, current Holos simulations distinguish differences in farm-level emissions from legume vs grass forage systems, but not from CT vs non-CT containing legume pastures.</p> <p>Soil Studies. Field experiments included BFT, SF and ALF (Exp. 1), and BFT, CMV and MB (Exp. 2) treatments. Tanniferous forages did inhibit N mineralization, and soils under SF had significantly lower ammonium concentrations and potential aerobic N mineralization rates than BFT and ALF (Exp. 1). Potential aerobic N mineralization rates were positively correlated with forage CT concentrations, suggesting that CT complexed with soil organic N. Similar results were observed in Exp. 2, where potential aerobic N mineralization rates were significantly lower under the CT-containing BFT treatment than under CMV. Tannins did not appear to</p>	
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		<p>have any effects on C cycling and any differences appeared to be a result of variations in soil N availability.</p> <p>A soil and feces incubation study determined the effect of CT-containing (BFT, SF) and non-CT (ALF, CMV, MB, small burnet-SB) feces on pasture soil carbon and nitrogen cycling processes. Feces from cattle fed these forages were each added to a uniform pasture soil on a C-equivalent basis and incubated for 84 days alongside a soil control and irrigation on days 0, 21, 42, and 84. Results supported field results, with evidence for CT complexation or microbial inhibition, although substrate C:N ratio was still the primary driver of soil N and C cycling dynamics. Nitrogen immobilization rates were the highest in CT-containing treatments, followed by ALF, CMV and SB. Tannins also delayed subsequent nitrate formation, with no differences in total nitrous oxide production among treatments. The effect of saponins in the ALF treatment was similar to CT effect on N cycling but of a smaller magnitude. Total C mineralization did not differ among fecal treatments, suggesting that CT mainly impacted nutrient cycling through organic N complexation.</p> <p>Another study was performed to determine the effect of purified CT (from BFT and SF) and saponins (from ALF) on pasture soil N and C cycling processes. Tannins from each species were added to a uniform pasture soil at both a low (3 mg/g soil) and high (15 mg/g soil) dose, while saponins were added at 3 mg/g soil. A soil control did not receive any treatment. Results suggested that both CT and saponins can increase soil N retention without a distinguishable impact on C cycling. Tannins were able to reduce soluble N yields in a dose-dependent manner, suggesting complexation with organic N. BFT tannins appeared to decrease nitrification in a dose-dependent manner. Neither the CT or saponin treatments had an effect on total nitrous oxide production. Total CO₂ production increased with high doses of CT, likely due to C added as CT. These results support both the preceding lab and field studies, confirming that forage CT are able to</p>	
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		<p>increase soil N retention through complexation with organic N to reduce soluble and mineral losses.</p> <p>Economic Benefits. A review of the literature was conducted on existing carbon prices and the social cost of carbon to assess the distributional properties of these variables. Estimates were categorized according to (1) an emissions trading system, (2) current carbon tax rates, and (3) social cost of carbon. The overall median estimate of the value of reduced GHG emissions associated with the adoption of the proposed alternative pasture system was \$45 per-metric ton (mt), with a mean of \$23/mt. The median carbon tax was \$22/mt, while the median carbon market price was \$15/mt. The subsample of marginal damage estimates reported in the academic literature suggested a median value of \$50/mt of reduced GHG emissions. Together, these results indicate wide variability both within and across estimate types. The median values of reduced CH₄ and NO emissions were estimated to be \$1,200/mt and \$15,000/mt, respectively, reflecting the potency of CH₄ and NO emissions in terms of their GHG equivalence. Thus, estimates of reduced GHG emissions suggest ample scope for sensitivity analysis whenever the value of these reductions are incorporated as sources of revenue in enterprise budgets designed for the alternative pasture system.</p> <p>To estimate the profitability of adopting the proposed new system, the value of legume-finished beef was evaluated via estimated willingness-to-pay (WTP) using a benefit transfer approach. It was found that consumers are willing to pay a price premium to obtain locally-grown, grass-fed, eco-friendly, and animal-welfare-certified beef. Consumers rated freshness, taste/ flavor, and tenderness as extremely important when they purchase beef. The literature suggests that legume-finished beef can be marketed as locally-raised, eco-friendly, healthier than grass-fed and tasting like grain-fed beef. Mean estimate of the associated price premium households are WTP for grass-fed beef (over conventional beef) was \$2/lb. Mean estimates of associated price premiums for locally-raised and eco-friendly</p>		
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		<p>beef were \$1.86/lb and \$0.74/lb to \$1.18/lb, respectively. The mean price-premium estimate for improved animal welfare was \$0.84/lb. Thus, consumers are WTP price premiums based on the ecosystem services provided by the proposed production system.</p> <p>In summary, a diversity of forage legumes with different chemistries (e.g., nutrients, condensed tannins) support the tradition of regional livestock production in rural America with potential for improved profitability, they enhance animal productivity and soil health with concomitant reductions in environmental impacts, all services that lead to a more sustainable pasture-based beef production system.</p>	
<p>16.</p>	<p>Research Impact: Factors determining individual variation in reproductive development among wild bees</p>	<p>Karen Kapheim has been studying reproductive development in wild bees. Her research group has found that the reproductive role of Juvenile hormone is not as consistent in <i>Megalopta genalis</i> as it is for <i>Nomia melanderi</i>. This is consistent with current understanding of the role of Juvenile hormone in highly social, but distantly related bees like honey bees. Knowledge was advanced by discovering that one of the strongest effects of Juvenile hormone in halictid bees is on the size of the Dufour’s gland, which has several functions related to reproduction. RNA sequences were generated to further investigate this in future lines of research.</p> <p>It was also found that changes in spring incubation conditions coupled with seasonal timing may change the way <i>Megachile rotundata</i> females provision their offspring. This may have consequences for pollination, because larval provision size influences diapause outcome. A subsequent investigation is looking at how changes in spring incubation influence the molecular products that females add to their oocytes.</p> <p>Another study investigated the role of nutrient stores, reproductive status, and response to an immune challenge in several bee species. In <i>Megalopta genalis</i>, it was found that social caste and nutritional status do not influence response to an immune challenge. In <i>Nomia melanderi</i>, it was found that immune challenge does not lead to a reduction in survival or</p>	<p>Global Food Security and Hunger</p>

		<p>investment in reproduction. Another experiment was conducted to characterize the response to immune challenge as a function of reproductive status, nutritional stores, and social organization. While analysis is still underway, the combination of these experiments will provide a clear picture of how social and solitary bees allocate limited energy toward reproduction or survival under immune stress. This will be important for predicting how bees respond to pressures from a changing environment.</p> <p>It was also found that the microbiome of <i>Nomia melanderi</i> changes throughout its life cycle. Feeding status is a major determinant of microbiome composition, whereas the microbiome of small feeding larvae is very similar to that of pollen provisions, the microbiome of older larvae that are no longer feeding is significantly different in overall composition and diversity. The microbiome of small feeding larvae and pollen provisions is highly uniform, suggesting there may be a functional role for bacteria in preventing food spoilage or digestion. Experimental evidence revealed that the hindgut microbiome in adult females is largely shaped by the external environment. This is particularly true for lactic acid bacteria, which are likely acquired from flowers. These results will serve as the foundation for future research on metagenomics function and development of probiotics for these native pollinators.</p> <p>This project has contributed to a change in knowledge regarding how the reproductive effects of Juvenile hormone are influenced by social biology in bees. Furthermore, it has resulted in a change in knowledge regarding the role of overwintering conditions on nutrient stores and reproductive investment in the solitary bee, <i>Megachile rotundata</i>. In addition, it has resulted in a change in knowledge with regard to how reproductive hormones and nutrient levels interact with the immune system to influence reproductive development and longevity in <i>Megalopta genalis</i> and <i>Nomia melanderi</i>. It has also contributed to a change in knowledge with regard to how microRNAs regulate nutrient stores in <i>Bombus</i></p>	
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		<p>impatiens. Finally, it has resulted in a change in knowledge with regard to the microbial associates of solitary bees and how these bacteria are acquired and change throughout the lifespan.</p>	
<p>17.</p>	<p>Research Impact: Production and Economic Factors Associated with Automatic Milking and Feeding systems (Robotic) Dairies Under Western U.S. Conditions</p>	<p>Allen Young and Dillon Feuz have been studying how automated milking systems influence milk production and the economics of dairy production. A feeding study was conducted to investigate the effects of including novel alfalfa products: ProLEAF MAX™ (PLM), an alfalfa leaf pellet; and ProFiber Plus™ (PFP), alfalfa stems, in the ration of lactating dairy cows on DMI, milk yield, milk components, body weight, rumination, and somatic cell count. Holstein cows were housed in a freestall barn and milked in a free-flow Automatic Milking System (AMS; Lely Astronaut 4). All cows were fed each treatment for 21-day periods, then switched to the next treatment utilizing a crossover experimental design. The five different treatment groups were: control (CON, typical ration that included alfalfa hay; n = 65 ± 0.5); low-quality alfalfa hay (LQ+PLM, a ration that replaced alfalfa hay with low-quality alfalfa hay and PLM; n = 62 ± 0.6); PLM+PFP (a ration that replaced alfalfa hay with PLM and PFP; n = 66 ± 1.1); PLM (a ration that replaced alfalfa hay with PLM; n = 69 ± 0.6); and PFP (a ration that replaced alfalfa hay with PFP; n = 70 ± 0.5). Cows were group fed a mixed ration balanced for 90 lb milk, 3.9% milkfat and 3.3% milk protein. Milk yield, milk fat, milk protein, body weight, rumination, and SCC were recorded daily for each cow. Pen-level DMI was also recorded daily. When fed the PFP treatment ration, cows had decreased (P < 0.01) DMI compared to the other treatment rations. Milk yield per DMI was increased (P < 0.01) when cows were fed the PLM treatment ration compared to the CON, LQ+PLM, and PLM+PFP treatment rations. Milk yield and adjusted milk yield were increased (P < 0.01) when cows received the PLM treatment ration compared to the other treatment rations. The PFP and PLM+PFP treatment rations had higher milk fat and adjusted milk fat when compared to the other treatments (P < 0.01). Analysis of milk protein yield (kg) and percent showed that cows fed the PFP treatment resulted in lower milk protein and adjusted milk protein than all of the other treatment rations. Average BW was increased (P < 0.01) when cows</p>	<p>Global Food Security and Hunger</p>

		<p>were fed the LQ+PLM treatment ration when compared to feeding the PLM and PFP treatment rations. Average rumination minutes per day were increased ($P < 0.01$) when cows were fed the PFP treatment ration when compared to the PLM treatment ration. No differences ($P > 0.05$) were observed in SCC between the different treatment rations. These data indicate that inclusion of fractionated alfalfa products in the ration of lactating dairy cows has the potential to increase milk yield and milk components and, therefore, may increase profitability.</p> <p>Many dairies in the Intermountain area have converted to AMS with a variety of different types of facilities constructed to house the robots. There are questions related to what type of barn should be constructed to maximize profitability. To help answer these questions budgeting models that looked at some of the key variables affecting profitability of AMS were developed. Three different levels of capital investment in facilities were considered in addition to the capital cost of the AMS. A partial budgeting framework was used to calculate the net financial impact, which is the sum of the positive financial impacts less the sum of the negative financial impacts and includes depreciation and interest costs associated with the AMS system and the barn to house the system. This framework was modified from the partial budget of Bentley et al. (2018). The change to total cash flow under three facility investment scenarios was determined. All three AMS scenarios assumed a 144-cow dairy (milking 120 cows) requiring two robotic milking units. Each AMS was purchased for \$190,000 with a useful life of 15 years, a salvage value of \$40,000, and an estimated annual repair cost of \$7,000. Ten-year averages (2009-2018) were used for milk price, feed price, and interest rate. The interest rate used was the FED prime rate and 2 percent and 3 percent markups were added to the prime rate for the AMS equipment and facility loans, respectively. The ten-year average of the prime rate was 3.5%, so the interest rate was 5.5% on the robots (7-year loan) while for the barn construction, the interest rate was assumed to be 6.5% (15-year loan). The original budgets kept the repair</p>	
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		<p>costs of the robots at a static value, but due to questions/concerns from local bankers, variability was added in the budget for this parameter.</p> <p><i>Scenario 1</i> represented a minimal retrofit to existing facilities with cost of the facility retrofitting at \$70,000. <i>Scenario 2</i> involved the construction of a new open-sided barn at a cost of \$470,000. For <i>scenario 3</i> a new fully enclosed barn was constructed at a cost of \$920,000. The initial capital outlay obviously changes across the three scenarios, but perhaps less intuitive, milk productivity, feed efficiency, and labor savings also vary across the scenarios. Using the assumptions, the static net annual financial impact as well as the total change to cash flow under the three investment scenarios were calculated. Scenario three had the largest positive increase in net financial impact and cash flow was least negatively impacted. Furthermore, changes to cash flow can be neutralized by increasing the AMS loan payout period from seven to 11 years for Scenario 1, 10 years for Scenario 2, and 9 years for Scenario 3. With these payout periods the change to cash flow is near zero for all three scenarios.</p> <p>Palisade’s @Risk program was used to model the uncertainty of milk price, change in milk production due to the robot, cost of the robot, repair cost of the robot, and changes in total mixed ration (TMR) costs. It would appear that the fully enclosed barn had the potential for the greatest net annual income and would be the most desirable investment strategy. However, scenario 3 has the greatest risk of all scenarios (variability, range, and % of values < \$0). In short, scenario 3 requires the largest financial investment, but has the potential of the greatest gains – depending on your level of risk aversion. Some producers may be unwilling or unable to make this large of an investment. All three scenarios are likely viable for individual producers with different risk tolerances and financial positions. The results of the analysis indicate that all three scenarios would be expected to have a positive annual financial impact. However, this positive financial impact must be considered together with the projected total annual change in cash flow. Before any producer makes the switch to</p>	
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		<p>AMS, consideration must be given as to whether the farm has the ability to absorb the projected negative impact to cash flow until the loans can be paid down. Restructuring the loan payout period can alleviate some or all of the negative change to cash flow depending upon the payout period.</p>	
<p>18.</p>	<p>Extension Success Story: Water-efficient Architectural Designs</p>	<p>With looming consequences of climate change, water quantity and water quality continue to be major concerns to Utah’s citizens and leaders. It is a one of the primary limiting factors for sustainable growth in a state projected to double in population over the next few decades. The current vernacular for Utah landscapes is patterned after an English style landscape that is not sustainable in the west. Currently, over 60% of municipal water is used to irrigate landscapes. This represents a significant opportunity for water savings if a change in vernacular can be illustrated and accepted as both aesthetically pleasing and functional. J. Powell and team is working with state leaders and citizens to conduct ecological water research and educational outreach. Powell and team developed program resources that address two interrelated sides of the water resource issue: (a) water conservation, and (b) storm water management. Powell acts as an ambassador for USU Extension efforts in water resources management by conducting statewide presentations on water-efficient architectural designs. These presentations taught water-wise landscape design principles and provided continuing education credits to a total of 85 landscape design and construction professionals. Powell and team are currently working to create educational programs on conservation landscape design and implementation for a variety of target audiences. For example, they are developing an online course that provides a user-friendly guide to a water wise landscape design process. Additionally, Powell is developing a new curriculum targeted to contractors, engineers, landscape architects, and project managers on storm water prevention plan development and implementation. In 2020, Powell and team developed eight projects related to water-wise designs and storm water management. These initiatives illustrate the role of USU Extension in improving current systems to protect water resources. The effect of climate change on water supply continues to be a critical issue in Utah.</p>	<p>Climate Change and Management of Natural Resources</p>

<p>19.</p>	<p><i>Extension Success Story:</i> Aspen Regeneration and Recruitment</p>	<p>Given increased occurrences of wildfires in the western states over the past decade, there is an urgent need for effective forest and rangeland management protocols. Aspen has conventionally been thought of as "fire dependent," meaning that it requires forest fires to thrive. The quick-sprouting root system of an aspen clone rapidly regenerates after all types of disturbance, including burning. Stable aspen is much less conducive to wildfire or prescribed burning; rejuvenation in these forests is dependent on more continuous, low-level, tree mortality and regeneration. C. Chapman and team leads USU Extension efforts in Aspen regeneration, recruitment, and ungulate use of aspen communities as it relates to human-wildlife interactions. To date, Chapman's partnership with the Monroe Mountain Working Group, the US Forest Service (FS), and Utah Forestry, Fire and State Lands (FFSL) led to the treatment of more than 2,000 acres of mixed conifer/Aspen forest using prescriptive fire in 2020. Additional acreage was also treated through mechanical thinning on other portions of the mountain. These efforts demonstrate the role of USU Extension in rangeland management through partnerships with state-level organizations. Outcomes of such partnerships are reflected in the vast amount of rangeland managed through controlled fires and mechanical treatments annually.</p>	<p>Climate Change and Management of Natural Resources</p>
<p>20.</p>	<p><i>Extension Success Story:</i> Turfgrass Integrated Pest Management</p>	<p>Turfgrass comprises the majority of amenity landscapes in Utah. As a result, ineffective turfgrasses management poses a threat to water resources and nutrients in the state. As a faculty of the Center for Water Efficient Landscaping (CWEL) at USU, K. Kopp conducts major educational programming to different stakeholder and clientele groups on turfgrass management educational programming. The overall aim of Kopp's programs is to improve the management of turfgrasses in Utah to conserve water resources and protect water nutrients. Kopp delivered five formal presentations on various aspects of landscape water conservation in 2020 to statewide audiences, including Master Gardeners, green industry members, and water industry members. Kopp also serves on USU Extension Integrated Pest Management team to create educational material on Turfgrass Integrated Pest Management (IPM). This new online</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>publication was launched in 2020 and was distributed to a listserv of 8896 subscribers across the state of Utah and nationally. With 124 unique publications related to water conservation and turfgrass management, Kopp’s educational reach is reflected by a total of 12,759 publication downloads in 372 institutions across 85 countries across. Kopp’s work with county Extension agents, members of the green and water industries, and the public is essential to overcoming the water conservation challenges in Utah and the Intermountain West.</p>	
<p>21.</p>	<p><i>Extension Success Story:</i> Utah Water Watch</p>	<p>Water quality was ranked as the top critical issue in Utah based on a 2019 statewide needs assessment conducted by USU Extension. While the importance of water science, management, and conservation on climate change is well-documented, other state-level assessments indicated many Utah educators are not confident in their knowledge of water quality science. H. Braithwaite and team conducts water science education for educators and volunteers. For educators, Braithwaite and team provides experiential learning opportunities such as field trips and workshops to improve educators’ knowledge of watershed science and water quality monitoring techniques. Using a train-the-training approach, participants (i.e., educators) return to their classrooms to engage their students using hands-on learning about local watersheds. For volunteers, Braithwaite and team leads the Utah Water Watch (UWW) program to provide water quality education to volunteers and the general public. UWW also trains volunteers to collect data and monitor Utah watersheds as a method of increasing awareness of the importance of water quality and demonstrating the urgent need for stewardship of Utah’s aquatic resources. In 2020, the team attracted 34 new UWW volunteers, and conducted water education for 776 participants. With a total of 121 volunteers, 204 water sites are now continuously monitored throughout the state. Water quality data collected by volunteers were entered into UWW’s online database and shared with monitoring partners to enable informed decision making at a county and state level on abiotic and biotic changes to water resources. UWW’s monitoring activities add to the understanding of the natural variability in aquatic systems and the</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>relationship between parameters in these systems. This information allows identification of risks to water resources. For example, data collected by volunteers in 2020 was used to alert the Utah Division of Water Quality about harmful algal blooms in the Jordan River and Panguitch Lake.</p>	
<p>22.</p>	<p>Research Impact: Climate Change Perspectives for Utah: Citizen Attitudes and Food Security</p>	<p>One of the goals for David Coppock’s project was to determine factors influencing attitudes of Utahns towards climate change, renewable energy, air pollution, and other environmental issues. Data collection in support of this goal included: (1) Completion of 26 key informant interviews in 2016; (2) completion of a state-wide survey of 1,300 Utah residents in 2017; and (3) completion of another state-wide survey of 1,600 Utah residents in 2019. This study led to several key findings. First, a clear majority of Utahns feel that air quality has become worse, and it poses threats to well-being. Most concerns about poor air quality occur in Weber and Salt Lake counties. Industry and automobiles are seen as the major sources of air pollution. Respondents address poor air quality via home energy conservation and changes in driving behavior. Second, surveys and interviews of Utahns confirmed that national public opinion patterns concerning climate change and renewable energy prevail in Utah. Namely, while there is a split between conservatives and liberals concerning the validity of climate change science, support of renewable energy is broadly supported by all. If renewable energy issues are framed without mention of climate change, more progress on public policy initiatives supporting renewable energy is likely. Third, a survey-based analysis of predictors of citizen concern about environmental issues found that the most important defining factor is political affiliation (liberal or conservative), followed by economic class, respondent age, whether a respondent expects to be impacted by policy, and level of trust in government or business. The mix of factors varies with respect to the environmental issue under debate. These findings can help stakeholders better understand what most influences citizens to support or oppose various environmental initiatives. In this survey an experimental format was used to assess how labile the attitudes are among Utah residents concerning human-caused global warming. As has been found among other groups across the USA, Utah</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>residents are ill-informed about the extent that the scientific community supports the idea of human-caused global warming. Utahns also typically underestimate the extent that human-caused global warming is believed by others across the country. However, once Utahns are made aware of the strong scientific consensus concerning human-caused climate change, their previous opinions discounting the phenomena can be readily changed. Policy makers should have interest in these results because they illustrate that climate-change education can alter public opinion.</p>	
<p>23.</p>	<p>Research Impact: Evaluation and improvement of turfgrasses for adaptation in the Western US</p>	<p>Paul Johnson has conducted a number of evaluations of several turfgrass species in cooperation with the National Turfgrass Evaluation Program. Those species include Kentucky bluegrass (<i>Poa pratensis</i>), perennial ryegrass (<i>Lolium perenne</i>), tall fescue (<i>Lolium arundinacea</i>), bentgrasses (<i>Agrostis</i> spp.), and other species for adaptation and tolerance to Intermountain West conditions. Special attention was given to traits for drought tolerance, long-term persistence, insect resistance, and snow mold resistance. These traits are necessary for sustainable management. Each trial evaluated between 20 and 110 varieties of each species. Evaluations worth special note are discussed here.</p> <p>(1) Lateral spread and rhizome growth of tall fescue. No differences were observed among varieties in the trial. Although some tall fescue varieties are marketed as having strong rhizome systems to spread and repair, data showed little to no difference among varieties for numbers of rhizomes produced and the ability to spread.</p> <p>(2) Two bentgrass evaluation trials were conducted, one irrigated at 60% of evapotranspiration (ET) and one at 80% ET. Typical management practices are nearer to or above the 80% level. Those plots irrigated at 60% of ET produced visual quality similar to that at 80% in most of the years. This constitutes an irrigation savings of up to 20% compared to typical recommendations. However, we noted that the plots at the lower irrigation level grew slower and were much slower to recover after aerification and other disruptive management practices. While we did not</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>have traffic applied to this trial, we expect the lower irrigation levels, while saving water, will reduce the traffic tolerance and recoverability of bentgrasses when grown under putting green conditions</p> <p>(3) Tall fescue entries were irrigated at 50% of ET and produced satisfactory quality. This represents an irrigation savings of 20-25% compared to typical recommendations. This is under conditions with infrequent traffic.</p> <p>(4) A cool-season low-input trial was established which included many diverse species and varieties including wheatgrasses, clover, yarrow, as well as more typical turfgrasses such as Kentucky bluegrass, tall fescue, hard fescue, creeping red fescue, and perennial ryegrass. Once established, the study continued with no irrigation and no fertilization. The only management practice applied was mowing at 3.5 inches as needed. This has been a very interesting trial. During the first year without irrigation, all plots eventually went dormant as expected. Nearly all the entries recovered well after the first year’s drought conditions but the accumulation of stress on the plants in successive years became evident. Most of the Kentucky bluegrass and fine fescue declined in coverage to less than 20% and in some case 0% coverage by 2020. Weeds, especially prickly lettuce (<i>Lactuca serriola</i>) became very prevalent in those plots. The plots that had significant coverage of grasses, and few weeds, were the wheatgrasses: crested (<i>Agropyron cristatum</i>), thickspike (<i>Elymus lanceolatus</i>), and intermediate (<i>Thinopyrum intermedium</i>), yarrow (<i>Achillea millefolium</i>), and to a lesser extent, tall fescue (<i>Lolium arundinaceum</i>). While tall fescue maintained good plot coverage in 2020, it was reduced in coverage compared to 2018. Yarrow has continued to maintain green cover much longer than other plots into the summer. Wheatgrasses were dormant but fully recovered in fall. Clover did not appear to survive well in these conditions</p>	
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		turfgrass quality traits of other lines. Dr. Bushman has also pursued gene sequencing of selected lines of bluegrass.	
24.	<p>Research Impact: Abiotic and Biotic Drivers of Utah Rangeland Plant Distribution and Recruitment</p>	<p>Eugene Schupp recently completed a project that addressed Utah rangeland plant distribution and recruitment. This project was organized around three objectives.</p> <p>Objective 1 was to investigate the soil and vegetation characteristics associated with <i>S. wetlandicus</i> distribution and experimentally determine the potential for re-establishing <i>S. wetlandicus</i> on reclaimed well pads. Results from vegetation and soils data strongly suggested that the threatened <i>S. wetlandicus</i> is not associated with any particular plant community or indicator species; there were no differences in the vegetative communities between occupied and unoccupied undisturbed rangelands. However, reclaimed well pads have vegetation communities that are vastly different from vegetation in occupied habitat. As part of this study, a successful protocol for germinating <i>S. wetlandicus</i> seeds was developed and refined. Results suggest that <i>S. wetlandicus</i> is not a habitat specialist, suggesting that its populations perhaps can be augmented by establishment in presently unoccupied areas to mitigate for damage to existing populations during energy development. In addition, we have Development of a successful germination protocol will facilitate production of seedlings for transplantation, presumably on a large scale; germination and initial establishment are the bottlenecks. Evidence suggests that reclamation of well pads, and likely roads and pipelines as well, has been inadequate to create suitable habitat. Together these results are critical for developing management plans to balance energy development and species conservation across 460,009 acres (186,159 hectares) of the Uintah Basin, the region of Utah with the greatest energy reserves.</p> <p>Objective 2 was to experimentally and observationally investigate key biotic and abiotic drivers of patterns of <i>P. fasciculata</i> recruitment to</p>	Climate Change and Management of Natural Resources

		<p>develop a foundation for future studies that will go into greater detail. Genetic analyses demonstrated that shrub clumps arise both through vegetative spread and through multiple recruitment events. Censuses revealed that fruiting is irregular and that many years no fruit are produced at the population level. Results of 2019 fruiting surveys were as follows: Plot DER1 (1619 m elevation), 0/50 plants with fruits; Plot DER2 (1630 m), 0/50 with fruits; Plot DER3 (1726 m), 5/50 with fruits; and Plot DER4 (1763 m), 17/50 with fruits, indicating spatial variation in fruit production when it does occur. Preliminary results help us begin to more thoroughly understand shrub recruitment throughout the semi-arid rangelands of the Intermountain West. Initial insight into drivers of plant reproduction in this desert environment were gained. Results of fruiting surveys suggest climatic influence of fruiting, with fruit production increasing with elevation and less harsh conditions. The value of this information will grow with time and additional censuses. These ongoing results will help inform sustainable management of these desert rangelands that are used for both cattle and sheep grazing.</p> <p>Objective 3 was to monitor the spatial and temporal pattern of tree seedling recruitment and tree mortality in four woodland plots spanning a 350 m elevational gradient in the Grand Staircase-Escalante National Monument (GSENM). No recruitment of new individuals occurred during the life of this project. Similarly, no saplings or adults died. Although there has been periodic seedling recruitment in the plots during the first 10 years of the overall project, there has been no successful recruitment to the populations in the 15 years of this overall study. Ongoing work is critical for developing the basic scientific foundations to improve management decisions affecting these woodland ecosystems, which cover about 17,000,000 acres of woodlands in the western US including large parts of Utah. Because woodland management is contentious, with some groups arguing for removal of most trees and others advocating preservation of all, reliable information on natural recruitment and</p>	
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		<p>mortality across a range of climatic conditions is critical. Because of the slow dynamics of these woodlands reliable data require long-term studies.</p> <p>In summary, all parts of this project have contributed to a Change in Knowledge that is critical for wise land management. Although an understanding of the ecological processes addressed in this project and changes in management paradigms develop relatively slowly, knowledge that is being generated contribute to a Change in Actions and, ultimately, to a Change in Condition of the land and of the rural and urban communities deriving diverse values from healthy rangelands. This project has also contributed to a Change in Condition by adding to our basic ecological understanding of plant recruitment in semiarid environments.</p>	
<p>25.</p>	<p>Research Impact: Disturbance, invasion and restoration in forests and rangelands: a social-ecological systems perspective</p>	<p>Mark Brunson’s project included seven studies on how public and private forest and rangeland owners make stewardship decisions, with emphasis on decisions about non-native species invasions, wildfire hazard mitigation, and restoration of degraded landscapes. Objective 1 focused on rancher perceptions of ecosystem services. Interviews and a survey of >450 public land grazing permittees indicated that ranchers consider a wide range of ecosystem services when making decisions. While a provisioning service, forage for livestock, is of course a primary consideration, a large majority of ranchers also consider cultural services such as preserving community heritage and providing open space, and supporting services such as water quality. Objective 2 focused on the role of uncertainty in restoration decision-making and ways to reduce such uncertainty, state and federal land managers were interviewed as well as private- and NGO-sector practitioners on a variety of topics including drought adaptation, pre-emptive approaches for increasing resistance for non-native species invasion, and use of local native seed in restoration projects. This research identified a number of barriers to adaptive or pre-emptive management, only a few of which are related to environmental conditions. Much more frequently it seems that proactive and adaptive management is hampered by rigid agency regulations that discourage adaptation, fear of interest-group opposition, lack of funding or</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>manpower, and lack of trust in predictive models or non-practitioners' expertise. Objective 3, focused on two types of restoration decision and implementation framework: use of weather-predictive models for proactive restoration; and collaborative, multi-organizational, landscape-scale planning and implementation for restoration and invasive species control. There was skepticism about weather-centric restoration, especially since it involves synthesis of computer models, but strong interest in collaborative landscape-scale restoration. Barriers to the latter include lack of time and resources, variable interest in participation by government entities, as well as inadequate skillsets for resolving conflicts. A weather-centric restoration tool was developed and deployed online for use by land managers, and efforts continue to refine the tool and improve its use in decision making.</p>	
<p>26.</p>	<p>Research Impact: The energetics of stress: Physiological responses to stressors in a changing landscape</p>	<p>Susannah French and her research team are studying the physiological responses of lizards to stressors in a changing landscape. Because of COVID they were unable to collect any new data. Consequently, they focused on analyzing results from previous years' work. Their project has three goals. The first goal is to understand the effects of different types of stress on energy allocation decisions. From analysis of previously collected data they found that food supplementation of wild populations of rock iguanas led to altered energy metabolites, elevated oxidative stress, changes in reproduction and shifts in the microbiome. This has important implications for changing landscapes and different natural and novel sources of stress on the physiology of animals. Similar findings are also emerging in spiny tailed iguanas, whereby oxidative stress and energy metabolites vary across populations and in response to reproduction. The second goal is to explore how energy status influences physiological and energetic responses to stressors. To address this goal, the team is analyzing previously collected microbiome samples to test for vertical transfer. As part of this objective the PI and graduate students have validated for the first-time immunological assays for use in egg yolk. These procedures can be applied to assess immune activity across a variety of oviparous model systems. The third goal for the project is to test how variable ambient and body temperatures affect</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>energy-stress interactions. Analysis of previously collected data suggests that thermoregulatory behavioral responses vary depending on the type and magnitude of immune challenges. These results are echoed in the performance measures of the animals. This is significant in that it suggests that animals are differentially adjusting their energetic strategy partly through behavioral thermoregulation depending on the challenge at hand. The PI was recently awarded an NSF RAPID grant to expand this work.</p>	
<p>27.</p>	<p>Research Impact: Leveraging the NADP network to fill critical dust deposition data and knowledge gaps</p>	<p>Janice Brahney is studying dust deposition. Eleven dry deposition sites have been established and are fully operational across the western USA with contiguous data. An additional four sites have intermittent data and new long-term sites are being sourced and set up. To date, 336 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. Non-destructive analyses include: mass deposition rates, plastic content and composition, pH, metal chemistry (including total P) using XRF. Destructive analyses include: organic carbon and nitrogen, mass and abundance, extractable phosphorus fractions, grain size analyses, leachable nitrate and ammonium, microbial composition, bioassays. To date, mass deposition rates, plastic content and composition, pH, XRF, organic carbon and nitrogen isotope analyses have been completed. Extraction techniques for phosphorus fractions have been tested to determine the minimum amount of sample required to obtain quantifiable results. Four lakes have been identified for bioassay studies that span broad alkalinity and nutrient limitation statuses. These are Castle Lake, CA; Tony Grove Lake, UT; No-name lake (Uintas), UT; Molas Lake, CO. With respect to source attribution, air mass back trajectory data is being generated and students are learning techniques for aerosol optical depth evaluation. Dust microbial analyses began in the Fall of 2020. DNA extraction procedures are being tested to determine minimum dust sample requirements. BacLight viability and flow cytometry methods have</p>	<p>Climate Change and Management of Natural Resources</p>

		<p>been finalized to determine the number of viable organisms within each sample.</p> <p>Results to date have identified a seasonality in both total mass deposition rates as well as dust composition. As hypothesized, dust deposition rates increase through the spring at most sites but reach their peak during the summer months. This pattern is repeated at all 11 current field sites. This 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. 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, $d^{13}C$ values migrate towards more depleted isotopic values more consistent with atmospheric methane and perhaps other yet unidentified sources. Nitrogen isotopes also show seasonal signals reflecting shifting atmospheric aerosol sources. Dust pH is markedly lower and more acidic in winter months and trends towards more alkaline values in the mid-summer. Of particular relevance to this study are the distinct seasonal changes in phosphorus concentrations, 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. An additional interesting and somewhat unexpected result is the positive association of organic matter content with elevation, 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. Phosphorus fractionation methods have been tested on several samples from sites in eastern Utah. The data suggest that for this location, approximately half of the winter deposition is bioavailable. Summer bioavailability has not yet been assessed; however, winter values can be used for a first-order approximation. Here</p>	
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		<p>the bioavailable fraction is defined 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 $10.13 \text{ g m}^{-2} \text{ year}^{-1}$ and a bioavailable P concentration of 1.09 mg g^{-1} of dust, we arrive at a bioavailable P deposition rate of $11 \text{ mg P m}^{-2} \text{ year}^{-1}$. This is potentially an underestimate given the higher P concentrations observed through the summer. Nevertheless, for a lake that is 0.5 km^2 in area with an epilimnion depth between 5 and 10 m, direct dust deposition to the lake surface could account for a $1.1\text{-}2.2 \text{ ug P L}^{-1}$ increase in water column nutrients. This approximation does not account for catchment focusing; 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 indicate that dust could be a significant driver of ecosystem change. In the future these calculations will be tested in bioassay experiments.</p> <p>Establishing the first high-resolution long-term dust sampling study is not only allowing Dr. Brahney to address pressing questions related to nutrient transport and the implications for freshwater ecosystems but is also leading to unforeseen insights and novel outcomes. An unanticipated finding of the project was the identification of microplastics within dust samples. This outcome is tangential to the main goals of the project. Nevertheless, Dr. Brahney elected to process this data first since analyses are non-destructive and the implications of the finding timely and significant. The sample design of the dust-nutrient project meant to target sources of dust and deposition to remote locations of the US, was also ideal for answering these questions as they relate to microplastics. It was possible to do more than just quantify short term plastic mass loading rates to remote locations as other studies have done. Importantly, the study design including the high temporal resolution and distinction of wet and dry deposition, allowed Dr. Brahney and her collaborators to identify seasonal signals and identify key sources. Proximal sources of wet deposition included cities, soils, and roads while dry deposition was</p>	
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		associated with distal sources and broad climate patterns, such as the location of the jet stream. The results of these analyses were recently published in <i>Science</i> .	
28.	Extension Success Story: Create Better Health Utah: Adult Education	Utahns experience hunger, poverty, unemployment, and other hardships that contribute to an increased risk of obesity and chronic diseases. Over 14% of Utah households are food insecure, and 12.7% are living in poverty (FRAC, 2014). In addition to economic challenges, low-income individuals are also at higher risk of chronic diseases and poor health outcomes such as obesity, diabetes, and high blood pressure. USU Extension focuses on a comprehensive approach reaching all target audiences across 29 counties through various educational methods. Led by H. LeBlanc, Create Better Health (CBH) Utah (formerly known as SNAP-Ed) is a major Extension program that offers group nutrition education classes to adults and youth, and implements policy, systems, and environment strategies to improve healthy food access for target audiences. CBH also uses social marketing campaigns and social media platforms to disseminate information related to improving diet and physical activity of those most at risk for food insecurity. Shifting to virtual education in 2020, short-term evaluation results of CBH indicated significant improvements in participants' ability to eat healthy food on a budget, early adoption of MyPlate recommendations for healthy recipes, and increases in daily physical activity. In addition, medium-term evaluation outcomes were increased use of MyPlate to make food choices, increased use of nutrition fact labels to make food choices, increased daily fruit and vegetable intake, and increased physical activity. CBH continues to be an important Extension program that focuses on improving the nutrition of food insecure household across Utah.	Nutrition and Health
29.	Extension Success Story: Health and Wellness Education	USU Extension Health and Wellness team lead programs related to many aspects of mental health (e.g., depression, suicide, anxiety) and physical health (e.g., exercise, diet, sleep, hygiene). Nutrition is a common factor that affects both mental and physical health. Washington county in Utah has a 24% obesity rate among adults. Further, the Robert Wood Johnson County Health Rankings indicated 14% of Washington county residents are food insecurity. In response, A. Schmutz and the Health and Wellness team	Nutrition and Health

		offers a series of educational workshops to youth and adults on improving mental and physical health. Short-term evaluation results indicated most participants planned to eat the recommended quantity of fruits and vegetables, drink less sugary drinks, consume the recommended amount of water, stay physically active, and prepare healthy foods or snacks with their families. USU Extension focus on health and wellness is evident through the variety of educational program offered to residents across the state. The long-term goal of these programs is to improve the mental and physical health of residents.	
30.	<i>Extension Success Story:</i> Create Better Health Utah: Youth Education	Create Better Health (CBH) conducts youth and adult programming aimed at improving the diets of low-income families. Many food insecure households struggle to meet recommended nutritional intake guidelines on a limited budget. Poverty, hunger, obesity, and chronic diseases are represented in every demographic group in Utah; however, there are several groups that experience these at disproportionately higher rates including children, Hispanics, and single female-headed households. K. Riggs of CBH conducts a variety of nutrition education programs aimed at youth. In 2020, Riggs delivered educational activities to over 501 Youth. Short-term evaluation results from these activities indicated almost all parents/guardians of youth reported an increase in their child’s knowledge about the importance of consuming fruits and vegetables and increase in their child’s knowledge of whole grains. Medium-term evaluation showed an increase in youth participants’ intake of fruit, vegetables, and whole grains. Further, most parents reported their children were more physically active after completing the CBH activities. These results point to the critical role of CBH in improving the diets of food insecure youth.	Nutrition and Health
31.	<i>Extension Success Story:</i> Utahns Against Hunger	A diet high in fruit and vegetables is associated with a lower risk of obesity, heart disease, and some cancers. Because fruits and vegetables are low in calories, high in fiber, high in vitamins and minerals, and high in phytochemicals, substituting fruits and vegetables for high calorie foods should increase the overall nutrient density of the diet while decreasing the energy density. In the U.S., the average person does not meet recommendations for fruit and vegetable consumption, and this is	Nutrition and Health

		<p>especially true for low-income and food insecure individuals. C. Durward of USU Extension co-wrote a grant, Utahns Against Hunger, in collaboration with the Utah Department of Workforce Services, the Utah Department of Health and Salt Lake City Corp. Through the grant, the community partners implemented a Utah Double-up Food Bucks (DUFB) program that provided a match of up to \$10 for SNAP customers to purchase additional produce at farmers markets. In 2020, DUFB served 2,124 new Double Up users and 1,091 returning users. A total of \$103,969.00 in Double Up incentives were redeemed for local produce. Durward reported a total of 5325 transactions averaging \$19.50 on produce per transaction. Double Up Food Bucks increases low-income shoppers' purchasing power for fruits and vegetables while supporting Utah growers.</p>	
<p>32.</p>	<p>Research Impact: Improving Animal Models for Nutrition and Chronic Disease Studies</p>	<p>Korry Hintze has been developing better animal models for studying the role of nutrition in chronic diseases. His studies have resulted in a number of major findings: (1) The whole food, total Western diet (TWD) induces a greater degree of obesity and metabolic syndrome in mice compared to an identical diet made from purified ingredients. (2) Pigs fed a Western diet, based on American intakes, became obese, diabetic, and have a microbiome that is similar to obese humans. This has resulted in a change of knowledge in terms of the physiological relevance of animal models. (3) Mice fed a diet formulated with a complex food matrix have a microbiome that is unique from mice fed purified diets. However, the food matrix did not alter response to inflammation driven colorectal cancer. This has resulted in a change of knowledge in terms of the physiological relevance of animal models. (4) Mice inoculated with bacteria from obese human donors consumed more calories compared to mice inoculated with bacteria from lean human donors but only when fed the TWD. (5) Both vancomycin treatment and the TWD had significant main effects for increasing tumor burden and aberrant colon pathology. These results have changed our knowledge about interactions between diet, the microbiome, feeding behavior, and colon cancer. (6) It was also demonstrated that the mouse microbiome is more heavily influenced by diet compared to human donor. In a separate study, it was demonstrated that certain bacterial taxa, notably Bifidobacteria, are associated with lower tumor burden and that antibiotic use coupled with a poor diet increases colon cancer risk. These findings have resulted in a change of knowledge regarding diet, the microbiome, feeding behavior, and colon cancer.</p>	<p>Nutrition and Health</p>

<p>33.</p>	<p>Research Impact: Manufacture of cheese using highly concentrated micellar casein concentrate made using microfiltration and vacuum evaporation and recombined with cream</p>	<p>Donald McMahon has developed a model cheese making system using a rotating system and centrifugation. Moisture loss was compared to moisture loss from curd that occurs during the traditional method for manufacture of cheddar cheese. When making cheese from nonconcentrated milk the moisture content is about 87.5%. When using recombined microfiltered concentrated milk (RCM) the moisture content is lower as the solids content is increased. For RCM containing 3.5% casein, 7% casein, and 10.5% casein, the moisture contents were 87.9%, 77.5%, and 67.9%, respectively. Even though the 3.5% casein RCM contained about 35% more casein than normal milk, the moisture contents are similar because the whey proteins have been mostly removed and some of the lactose as well via the microfiltration and diafiltration.</p> <p>In making cheddar cheese, by the time the whey is drained (about 1 h 45 min after adding rennet) the moisture level in the curd has dropped to about 62%. During cheddaring which may take an additional 3 h, whey continues to be expelled and the moisture content of the curd drops to about 43%. Then after salting and pressing the cheese will be about 38%. When using the model process, the process time had been reduced to 2 h and the average moisture was 48.5%, 47.9%, 44.6% curd made from RCM containing 3.5%, 7%, and 10.5% casein, respectively. While the model system had differences between RCM with different casein levels, the model was not able to achieve the moisture level of cheddar cheese but rather a moisture level comparable to part way through the cheddaring process. When using the model system, curds from RCM expelled moisture faster than in regular cheesemaking but the moisture loss did not continue.</p> <p>As expected, the yield of curd from RCM increased with concentration level from 14.4% with 3.5% RCM to 36.2% and 55.0% for RCM having 7.0% and 10.5% casein, respectively. When these yields were considered on the fat and protein content of the RCM and the relative concentration factor compared to the 3.5% RCM, there were more fat and protein retained as</p>	<p>Nutrition and Health</p>
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		<p>the concentration level increased. It increased from 7.4% for the lowest level of percent casein in RCM to 8.8% and 9.5% at the higher concentrations. This can be explained by less fat and protein being lost into the whey because of less whey expulsion needing to occur during cheesemaking because it had been removed during filtration before cheesemaking.</p>	
<p>34.</p>	<p>Research Impact: A Cross-Sectoral Framework for Developing and Evaluating Farm to School Programming</p>	<p>Kelsey Hall has been evaluating farm to school programming. The theoretical framework for this research project was the theory of planned behavior, which is effective at predicting individuals’ intention to implement a behavior based on several factors: attitude toward the behavior, subjective norms for the behavior, and perceived behavioral controls (PBC). As Utah farm to school (FTS) establishes opportunities to increase participation statewide, understanding the factors that influence principals, food service directors, and farmers to participate in FTS programming is necessary. This research followed a multilevel, mixed methods, sequential design. Qualitative interview data with K-12 principals were collected at one level of the analysis, and quantitative survey data from farmers and food service directors were collected at other levels of analysis. Data from different levels were merged during interpretation. The interview guide and survey development process included a literature review, feedback from expert panels, and approval from the IRB.</p> <p>Determine K-12 principals’ perceptions of and experience with FTS activities. Purposive sampling identified principals who served 1 year as an administrator at a Utah high school, junior high, elementary school, or charter school. The final sample was 4 principals whose schools participated in FTS and 3 principals whose schools didn’t participate. Qualitative data were collected using 30-minute semi-structured telephone interviews. Six principals had positive attitudes about FTS even while 2 principals didn’t know what FTS encompasses due to their lack of experience. Much of the positive attitude was directed more at farming and its importance. Principals’ positive attitude seemed directed toward students making connections about where their food comes from. Five</p>	<p>Nutrition and Health</p>

		<p>principals mentioned that parents would support FTS, while 4 principals admitted their schools need the support of their teachers to implement FTS. However, 2 principals mentioned teachers might resist if they need to teach additional curriculum or use their own money for curriculum and materials. Principal 1 mentioned the support of the school board, school district, and parents. Principal 5 said parents are a subjective norm that influences FTS adoption. Only 2 principals mentioned needing local farmers. Principal 2 suggested farmers could be involved in the environmental science and botany classes. Support from agricultural organizations (Wasatch Community Garden, Thanksgiving Point, and Utah Ag in the Classroom) influenced FTS involvement at 2 schools. Three principals cited the lack of information about FTS activities as a reason for why they weren't confident about their schools' ability to implement FTS. Budgetary restrictions, time constraints, and personnel for oversight would restrict FTS program involvement. Two principals described how their school garden complemented classroom instruction or provided fruit in the cafeteria; however, 1 principal didn't know gardening is an FTS activity. Principal 7's school provided opportunities to learn about agriculture: pre-school visits a farm, 2nd grade visits a pumpkin patch, and 3rd grade attend farm day.</p> <p>Determine foodservice directors' perceptions of, challenges with, and experience with FTS activities. Foodservice directors indicated the biggest barrier for FTS was the lack of year-round products, followed by higher prices, difficulty in coordinating local with regular procurement, information about product availability, lack of variety, local producers aren't bidding, doesn't meet quality requirements, unreliable delivery, hard to find growers, kitchen equipment can't process/prepare local food, unavailable precut/processed items, hard to place orders, and vendors lack GAP/other food safety requirements. Twenty-eight school districts participated in FTS activities, including field trips to farms or orchards, promotion of local foods at school, cafeteria food coaches, taste testing/demos of local foods, farmer visits, media coverage of local foods</p>	
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		<p>used in schools, and gardening. The majority offered fruit, followed by vegetables, fluid milk, other dairy, baked goods, meat/poultry, herbs, grains/flour, and eggs. Twenty-seven school districts offered activities to K-5 children, while 22 school districts offered activities to children in 6-8 grades. The smaller number of school districts (n=16) offering FTS activities to high school students was interesting since Utah FFA has 85 chapters that offer curriculum relevant to FTS, and some agricultural education programs grow produce in greenhouses or gardens that could be sold to their school districts.</p> <p>Determine farmers' perceptions of, challenges with, and experience with FTS activities. The population was farmers who belonged to the Utah Farm Bureau (N=5,470). Following the Tailored Design Method, farmers were contacted 3 times to achieve a higher response rate with the online survey. A total of 143 surveys were complete. Attitude toward FTS programming was measured with 8 items using a 7-point bipolar attitudinal scale. Farmers reported a slightly positive overall mean of 5.79 (n=143, SD=1.16) for their attitude toward FTS programming. Five of the 8 dichotomous pairs had a mode of 7, the most positive response possible: good, positive, beneficial, useful, & valuable. Seventy-three farmers were neutral about school officials wanting them to be involved in FTS. Farmers were neutral that family, other farmers, policymakers, & agricultural professionals (Extension educators, agriculture teachers) wanted them to be involved in FTS. Twenty-one farmers participated in FTS programming. Fifteen farmers visited a classroom, and 13 hosted a guided farm tour. Farmers were willing to provide food products for classroom activities, school taste tests or lunches in the future if they knew about the event, who to contact, and what was needed. One hundred farmers had not participated in FTS programming. Most farmers were not Good Agricultural Practices certified (n=86) and didn't have a HACCP Plan (n=85). A few school districts buy from farmers who have GAP certification and a HACCP Plan. This finding is significant as other studies have found farmers involved in FTS had engaged in annual inspections. Cost concerns for these</p>	
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		<p>inspections may be a barrier for interested Utah farmers. Those who didn't participate had not heard about FTS programming (n=33) and didn't think it was offered in their area (n=9).</p> <p>In conclusion, principals and foodservice directors recognize the benefits of FTS for their teachers and students and have a positive attitude. Farmers exhibited positive attitudes although, like 3 principals, the majority had not participated in FTS. More principals said their teachers and parents would support FTS, yet few principals mentioned farmers as a subjective norm. High school agriculture teachers, Extension agents, and Ag in the Classroom staff are the missing link for schools. They offer gardening experience, supplies, and curriculum so that principals and their teachers are not as overwhelmed with implementing FTS. Utah K-12 schools will purchase these products from local farmers: meat/poultry, grains/flour, vegetables, eggs, fruits, and dairy. But 33 farmers didn't have information about selling to schools. Challenges for foodservice directors were the lack of connection to local farmers, seasonality, cost, and quantity. Three principals and 8 foodservice directors stated reasons their PBC was less: lack of information, seasonality, budget, curriculum requirements, and needed resources. It is worth considering that farmers can make the decision to participate in FTS; however, the principal, teachers, and/or food service director are all involved in making the final decision within a school.</p>	
35.	<p>Research Impact: Biliverdin and mesobiliverdin cytoprotection of retinal pigmented epithelial cells against oxidative stress</p>	<p>Jon Takemoto has demonstrated cytoprotection by mesobiliverdin of human retinal pigmented epithelial cells (ARPE-19 and polarized embryonic stem cell (ESC)-derived) against oxidative stress and damage. His group shown that one cellular mechanism of mesobiliverdin cytoprotection against oxidative stress is to suppress cell cycle progression to cell senescence. The suppressive mechanism was shown to occur via cell cycle stage 1 regulatory protein kinase inhibitors p21 and p16 and by induction of heme oxygenase 1 which is a universal regulator of anti-inflammatory cell responses. These findings with human retinal pigmented epithelial cells indicate the potential of mesobiliverdin to be a therapeutic</p>	Nutrition and Health

		<p>against age-related dry macular degeneration (the leading cause of blindness).</p> <p>To facilitate the project research, the production of pure mesobiliverdin from microalgae feedstock was accomplished and green and scalable methods for production in gram amounts were achieved. Mesobiliverdin has also been shown to be effective against other inflammatory conditions including: intestinal bowel diseases, cardiovascular diseases and osteoporosis. Recently emerging observations show a similar pattern of inhibition of hyper-inflammatory cytokine expression – most notably IL-6 – in experimental models for all of these inflammatory disease conditions.</p>	
<p>36.</p>	<p>Research Impact: The Origins and Consequences of Sociodemographic Disparities in Obesity</p>	<p>Eric Reither has been studying sociodemographic disparities in obesity. His project has three objectives: (1) monitoring sociodemographic disparities in obesity prevalence and related comorbidities, with a special emphasis given to understudied populations—including those in rural areas and the Intermountain West, (2) examining behavioral and biological origins of obesity disparities, and (3) tracing the health consequences of obesity disparities. In collaboration with several colleagues, he studied how changes in obesity-related comorbidities such as diabetes and heart disease have contributed to racial/ethnic disparities in life expectancy in Washington D.C. and (in a separate study) the four-corner states, including Utah. Through a series of decomposition life-table analyses of restricted-use mortality data from the National Center for Health Statistics, his team found that racial/ethnic disparities in obesity-related causes of mortality and changes in these conditions have contributed to large gaps in longevity between groups. He has also dedicated substantial effort to an NIH-funded study of longitudinal associations between sleep characteristics and obesity in the Wisconsin Sleep Cohort Study (WSCS). Specific activities have included (1) working with a team of scientists at Stanford University, who recently completed bioassays of blood samples of WSCS participants, and (2) collaborating with scholars at the University of Wisconsin-Madison to conduct longitudinal data analyses using multilevel models to separate within- and between-person associations between</p>	<p>Nutrition and Health</p>

		<p>markers of restorative sleep, (i.e., rapid-eye movement (REM) and proportion of time spent in stage 3 (N3) “deep sleep”), sleep duration, and body habitus. Key findings from these analyses are: (1) sleep differentials (i.e., differences between weekday and weekend sleep duration) contribute to weight gain and obesity, and (2) within-person changes and between-person differences in REM and N3 sleep both contribute to weight gain during mid-to-late life. These findings will strengthen scientific evidence regarding sleep as a contributor to obesity in adulthood, as extant literature is plagued by contradictory findings stemming from data issues (e.g., small clinical studies or cross-sectional data) and less-rigorous research methods. In another study relating to the second project objective, Dr. Reither recently completed a study of individual- and neighborhood-levels factors that contribute to late bedtimes among a nationally-representative sample of kindergarteners (as noted, insufficient sleep is a purported contributor to weight gain and obesity, and therefore an important point of focus in this Experiment Station project). This study found large racial/ethnic disparities, with parents of Asian, Black, and Hispanic kindergarteners reporting significantly later bedtimes than non-Hispanic whites.</p>	
<p>37.</p>	<p>Research Impact: Gestational diabetes and risk of orofacial cleft birth defects and fetal programming of obesity and diabetes mellitus in offspring</p>	<p>Ronald Munger has been studying the role of gestational diabetes (GDM) as a risk factor for orofacial cleft birth defects (OFCs), obesity and diabetes mellitus in children. Dr. Munger and his collaborators have found associations of note between orofacial clefts and genes known to be associated with gestational diabetes (GDM) including ADIPOQ (adiponectin) which is exclusively expressed in adipose tissue and is an important adipokine involved in the control of insulin sensitivity and fat metabolism with direct anti-diabetic activity and LEP (leptin) an adipokine made by adipose cells and enterocytes primarily known for involvement in regulating energy balance and hunger but recently found to be made by the placenta and to have important functions in pregnancy and to be expressed in the fetus during development. Recent publications have provided further evidence of significant associations between impaired vitamin B12 status and gestational diabetes. A recently accepted</p>	<p>Nutrition and Health</p>

		<p>manuscript by Dr. Munger and his colleagues reports on biomarker assays of vitamin B12 status in samples from a case-control study in India which found associations between poor B12 status and risk of orofacial clefts. This study found that mothers of CL+P children in southern India were 6.5 times more likely to have poor vitamin B12 status, defined by multiple biomarkers, compared to control-mothers. This research group plans to conduct further studies in populations with diverse nutritional backgrounds to determine whether poor maternal vitamin B12 or folate levels or their interactions are causally related to CL+P, and whether poor vitamin B12 status interacts with GDM or GDM-related genes to increase the risk of orofacial clefts.</p> <p>OFCs occur at a higher rate in Utah than any other state and the reasons are unknown. Dr. Munger and colleagues previously found that obese mothers have an increased risk of all types of OFCs and that both pre-existing and gestational diabetes were associated with risk. They also found that mothers of OFC children have abnormal values for biomarkers that define metabolic syndrome, a precursor to gestational diabetes and later post-pregnancy diabetes, and that elevated levels of leptin, a signaling molecule produced both by fat tissue and by placenta tissues, may be important as an early biomarker of maternal metabolic abnormalities in early pregnancy, before the detection of overt GDM. The impact of this research has been extended by discovering evidence of associations between adipokine genes known to be associated with GDM (adiponectin and leptin) and the possibility that impaired vitamin B12 status may increase with risk of both GDM and OFCs, hence strengthening the evidence for a causal association between GDM and risk of OFCs. The growing epidemics of obesity and diabetes and the challenge of early detection and treatment of GDM underscore the public health importance of further research in this area. More attention is thus needed for pre-conceptional education and pregnancy planning for mothers-to-be that stresses nutrition education, the early detection and treatment of</p>	
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		<p>gestational diabetes, and measures to reduce the risk of gestational diabetes including the reduction of obesity.</p>	
<p>38.</p>	<p>Research Impact: Mitochondria modulation of postmortem proteolysis and tenderization</p>	<p>Sulaiman Matarneh and Kara Thornton-Kurth have been exploring the role of mitochondria in postmortem meat tenderization. For an <i>in vitro</i> study, they harvested 8 steers and collected samples from the longissimus lumborum muscle. Mitochondria were isolated and mitochondrial protein concentration was determined. Isolated mitochondria were incorporated into an <i>in vitro</i> model that mimics postmortem glycolysis. This experiment utilized a 3 × 2 factorial design including isolated mitochondria (0, 0.5, or 2.0 mg/ml) and calcium (0 or 100 μM). Preliminary results showed that mitochondria are able to buffer and reduce calcium levels, which reduces the activity of muscle proteases and protein degradation, in this case detrimental to meat tenderization.</p> <p>In addition, 8 different steers were harvest at the USU animal harvest facility for an <i>in situ</i> study. Within 2 h of exsanguination, the longissimus muscle was excised from one side of the carcass, while the other longissimus muscle was collected following a 24-hour aging period. Longissimus muscle samples were then fabricated and subjected to ultrasonication. Immediately after ultrasonication, one steak from each treatment was used (0 h aging) while the remaining steaks were vacuum package and stored at 4°C for 24 h, 168 h and 336 h. At each storage period, approximately 5 g of tissue sample was collected and used to assess mitochondrial respiration. The remaining portion of the steak was used for oxidative stress, proteolysis, and tenderness determination. Preliminary results indicated the ultrasonication of meat enhances tenderness through changed muscle structural properties.</p> <p>In a second <i>in situ</i> experiment, beef muscle samples (n = 8) were fabricated into twelve 2.5-cm thick steaks. Steak numbers 1, 3, 5, 7, 9, and 11 were injected with 100 μmol/g DS16570511, an inhibitor of mitochondrial calcium uptake, dissolved in saline solution, while steak</p>	<p>Nutrition and Health</p>

		<p>numbers 2, 4, 6, 8, 10, and 12 were injected with saline only (control). Steak numbers 1 to 4 were used immediately (0 h aging) while steak numbers 5 to 8 and 9 to 12 were vacuum packaged and aged at 4°C for 7 or 14 days, respectively. Results demonstrated that inhibition of mitochondrial calcium uptake elevated cytosolic calcium concentration at 24 h postmortem. DS1657051-injected steaks had greater calpain-1 autolysis and activity at 24 hours compared to control steaks. Further, tenderness, TPA, calpastatin degradation, and proteolysis were all enhanced in the treated steaks. Therefore, data showed that inhibition of mitochondrial calcium uptake can enhance postmortem proteolysis through an early activation of calpain-1.</p> <p>In another study, beef muscle samples (n = 8) were excised from one side of the carcass and immediately fabricated into ten 2.5 cm thick steaks. Steaks were packaged in polyethylene bags and randomly subjected to power ultrasonication (treatment) of 40 kHz and 12 W/cm² or no ultrasonication (control). Immediately after ultrasonication, one steak from each treatment was analyzed while the remaining steaks were vacuum packaged and stored at 4°C for 1, 2, 7, or 14 days. At each storage period, samples were removed from their packages and color was evaluated. Then approximately 5 g of tissue was collected and used for mitochondria isolation. Afterward, each steak was divided into two portions. One portion was cooked and used for Warner-Bratzler shear force analysis and the other portion was immediately snap frozen in liquid nitrogen and stored at -80 °C for further analysis. Results indicated that ultrasonication increased meat tenderness, cellular calcium concentration, calpain-1 autolysis, and proteolysis, but negatively influenced mitochondrial integrity and respiration. The same animals used for the <i>in situ</i> experiment were also used for an <i>in vitro</i> study. Briefly, muscle samples from all animals were collected within 20 min of exsanguination. Samples were used for mitochondria isolation or immediately snap frozen in liquid nitrogen and stored at -80°C to be used for the <i>in vitro</i> assay. Isolated mitochondria (0, 0.5, or 2.0 mg/ml) were incorporated into an <i>in</i></p>	
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		<p><i>in vitro</i> model simulating postmortem metabolism and aliquots were removed from the reactions at 0, 240, 1440, and 2880 min for determining μ-calpain autolysis and the extent of selected myofibrillar protein degradation. Results demonstrated that inclusion of mitochondria to the <i>in vitro</i> assay reduced calpain-1 autolysis and myofibrillar protein degradation, most likely through reducing free calcium levels. These findings confirm the investigators' published <i>in situ</i> results, in which mitochondria buffer cellular calcium and delay the activation of calpain-1.</p> <p>In the final experiment, beef longissimus muscle samples were collected at 20 min and 16 d postmortem. The 20 min samples were immediately snap frozen in liquid nitrogen and stored at -80°C, while the 16 d samples were used to determine Warner-Bratzler shear force (WBSF) values, a measurement of meat tenderness. Based on WBSF values, the samples were allocated into less tender (average WBSF = 5.3 kg; n = 8) or more tender (average WBSF = 2.3 kg; n = 8) categories. Mitochondrial and glycolytic enzymes activity and abundance and mitochondrial calcium uniporter abundance were compared between the two categories. Results demonstrated that mitochondrial enzymes activity and abundance were greater in less tender samples compared to more tender samples. On the other hand, glycolytic enzymes activity was greater in the more tender than less tender samples. Additionally, mitochondrial calcium uniporter abundance was greater in less tender than more tender category. While not a cause-and-effect relationship, these data indicate that mitochondrial content likely plays a role in development of beef tenderness.</p>	
39.	<p>Extension Success Story: Preserve the Harvest</p>	<p>Estimates from the Centers for Disease Control in 2016 estimate 1 in 6 people in the United States suffer a foodborne illness annually. Improperly home canned foods continue to be a leading cause of foodborne botulism in the United States. According to a 2019 needs assessment done by USU Extension, food safety ranks as one of the top four critical issues Utah residents want addressed by Extension. M. Jewkes and team identified a priority need to ensure food safety through education on best practices related to home preservation, canning, freezing, and dehydrating food.</p>	<p>Food Safety</p>

		<p>Home-based food safety education focuses primarily on using safe and scientifically tested procedures to prevent food spoilage or food-borne illnesses. Jewkes facilitated a virtual 8-session series entitled “Preserve the Harvest.” This program was very popular, with 645 live participants in attendance. To further support this series, M. Jewkes and team hosted a webinar and two live demonstrations on social media that attracted over 10,000 views. Evaluation results revealed participants experienced significant confidence to apply to food safety practices with respect to canning fruits, food preservation methods, and freeze-drying techniques. Further, pre-post tests indicated almost all participants experienced significant knowledge gain in all areas related to reducing foodborne illnesses risk at home. Most participants stated they intend to use food preservation resources provided by USU Extension to minimize their exposure to pathogens that cause foodborne illness. M. Jewkes and team reported that the online information available to the public is constantly updated, and if followed accurately, will prevent food-borne illnesses that otherwise pose a risk when proper food preservation techniques are not followed.</p>	
<p>40.</p>	<p><i>Extension Success Story:</i> Food Processing Education for Small Businesses</p>	<p>Information related to business management is widely available to entrepreneurs. However, while there are a growing number of small food businesses in Utah, there is little information available to owners on commercial food safety practices for small-scale enterprises. K. Allen and team identified the need for Extension education targeted to entrepreneurs on food safety issues related to state and federal regulations and best production techniques. Allen and team work directly with food entrepreneurs by assisting with product development, ingredient analysis, packaging, and equipment supplies. Allen has also partnered with Utah Department of Agriculture and Food to provide labeling assistance to Utah food business. With respect to tailored education, K. Allen organized a half-day event at the Small and Urban Farms Conference for food entrepreneurs and on-farm processors. Allen partnered with the Utah Farm Bureau Insurance and Utah Department of Agriculture and Food to address several major topic areas including food</p>	<p>Food Safety</p>

		<p>product liability, food establishment inspections, and the basics of business contracts for food businesses. In 2020, Allen met individually with 39 small food companies in Utah and provided hands-on assistance with issues related to shelf stability, processing modifications, food recalls, traceability, COVID-19 protocols for employees, required changes to nutrition facts labeling, and packaging. As a result of these interactions, Allen reported companies realized cost savings in production, and were able to prevent potentially unsafe product from entering commerce. These efforts are necessary to ensure a reduction in foodborne illnesses through a safe food supply chain.</p>	
<p>41.</p>	<p><i>Extension Success Story:</i> Virtual Master Food Preserver Classes</p>	<p>Food safety among venders, restaurants, and other food service entities is a top priority of the State Health Department. As an administrator of one of the few Food Safety Manager's Certification programs approved by the state, USU Extension's role is key in facilitating the certification of food handlers. Therefore, K. Riggs and team provides essential services to food businesses in Iron county related to registration, materials, and exam proctoring. The goal of this program is to increase the level of food safety in Iron County's food establishments and prevent food-borne illness. While certification programs target businesses, food preservation and storage continue to be commonly practiced in many Iron county residences. Therefore, Riggs and team also provide other services to residents; they test canning equipment, deliver educational programs, and provide educational resources related to home canning and food storage. In 2020, K. Riggs and team conducted gauge testing for dial-type pressure canner gauges to a total of 56 residents. However, due to COVID-19 and limited face-to-face programming, there was a decrease in overall gauge testing. Still, K. Riggs and team delivered a virtual 8-series Master Food Preserver Class in 2020 to over 100 participants. This virtual class was facilitated by several Extension educators to provide a highly interactive experience for residents. Educators utilized virtual tools such as online chat and Q&A to keep participants engaged over the duration of the program. The evaluation results indicated most participants experienced knowledge gain and confidence in all major areas of food preservation and safety. K. Riggs</p>	<p>Food Safety</p>

		<p>and team adapted their programming for virtual delivery to ensure food safety. As a priority issue, foodborne illnesses concerns were adequately addressed by Extension during COVID-19.</p>	
<p>42.</p>	<p>Research Impact: Impact of organic acids on the stress response and virulence of <i>Listeria monocytogenes</i></p>	<p>Charles Carpenter, Jeff Broadbent and colleagues examined the impact of habituation to lactic acid and acetic acid on expression of transcription factors and genes related to acid resistance, bile resistance and virulence in <i>L. monocytogenes</i> strains N1-227 and R2-499 by qRT-PCR. In addition, they examined <i>in vivo</i> virulence of those same strains of <i>L. monocytogenes</i> using the <i>Galleria mellonella</i> infection model. Organic acid habituation significantly induced expression of the acid and bile stress response genes in both strains, while expression of virulence genes was strain dependent. Habituation in organic acid increased virulence of both strains as evidenced by decreased LT50 (median lethal time) of <i>G. mellonella</i> larvae. In addition to the original objectives, the transcriptional profile of <i>L. monocytogenes</i> strains N1-227 and R2-499 in the presence or absence of organic acid was followed using RNA-seq. As compared to <i>L. monocytogenes</i> grown in standard media, more differentially expressed genes (DEGs) were identified when cells were habituated with organic acid compared to cells habituated with inorganic acid. RNA-seq data were strongly correlated with the gene expression values obtained for those genes shared in the parallel qRT-PCR analysis ($R^2 = 0.74$ for strain N1-227 and $R^2 = 0.79$ for strain R2-499). Other DEGs included genes involved in cell motility, membrane transport, carbohydrate and amino acid metabolism and quorum sensing. Interestingly, the DEGs involved in flagella-mediated cell motility pathways were exclusively down-regulated in both of the tested strains, and this is consistent with enhanced virulence as loss of flagella and their antigenic determinants are key to <i>L. mono</i> avoiding the host defense systems. The majority of the DEGs involved in amino sugar and nucleotide sugar metabolism were down-regulated under organic acid habituation for both strains, suggesting that changes in cell wall architecture is part of the <i>L. monocytogenes</i> response to organic acid exposure. Results from this study suggest that exposure to acetic or lactic acid can induce increased virulence in at least some <i>L. monocytogenes</i></p>	<p>Food Safety</p>

		<p>strains and provide a comprehensive view of the mechanisms used by L. monocytogenes to adapt to organic acid exposure, which may provide new leads for research and help to develop better strategies to prevent L. monocytogenes contamination in food.</p>	
<p>43.</p>	<p>Research Impact: Engineering for Food Safety and Quality</p>	<p>Silvana Martini and members of her laboratory have been studying the use of high intensity ultrasound to change the physical properties of fats. In one study with an interesterified shortening, a graduate student looked at the effects of processing conditions such as crystallization temperature and agitation on the effectiveness of sonication. Findings include the generation of a more elastic lipid crystalline network by using ultrasound. These effects were more significant when the sample was sonicated at higher temperatures and in the absence of agitation.</p> <p>A study, conducted by undergraduate students, looked at the effect of high intensity ultrasound on oil migration. Lipid samples with different content of saturation were crystallized with and without the use of ultrasound. In all cases sonication generated harder and more elastic crystalline networks characterized by small crystals that melt over a narrow range of temperatures. These changes in the crystalline network resulted in a significant reduction in oil migration.</p> <p>Another undergraduate student evaluated the effect of high intensity ultrasound on lipid crystallization and physical properties of an all-purpose shortening during storage for a period of six months. Results showed that sonication created harder and more elastic materials and that this effect was maintained during storage for 6 months, especially when samples were stored at 25°C rather than at 5°C.</p> <p>Finally, in a study conducted by a couple of postdoctoral scientists, the effect of ultrasound as affected by sonication and processing conditions was evaluated. The effect of ultrasound was evaluated in samples with various levels of saturated fatty acids and crystallized at different supercoolings. In addition, various sonication parameters such as power</p>	<p>Food Safety</p>

		<p>level, frequency, and pulse duration were evaluated. In all cases sonication generated harder and more elastic crystalline networks characterized by small crystals that melt over a narrow range of temperatures. In addition, sonication was more effective at inducing crystallization when used at lower frequencies (20 kHz vs. 40 kHz), short durations (10 s vs. 15 s) and higher power levels. As the level of saturation decreases in the sample, higher power levels are needed to induce crystallization. Ultrasound was also used in a scraped surface heat exchanger, which is a more realistic representation of an industrial set-up for the processing of shortenings.</p>	
<p>44.</p>	<p>Research Impact: Effects of ultrasound on the viscosity of concentrated milks and biofilm formation on processing equipment</p>	<p>Marie Walsh has been studying the use of ultrasound in during pasteurization of milk. Previous results showed that thermosonication using practical residence times in a lab-scale continuous system reduced the viscosity of concentrated milk, may improve milk quality during its shelf life and reduce biofilm formation in dairy processing equipment since there is a reduction in microbial load. Her group has proceeded to conduct scale up studies to confirm the results obtained with lab scale thermosonicator. Thermosonication was integrated into a high-temperature short time pasteurization system which included a pre-heat plate heat exchanger (PHE) (set at 80°C), a PHE set at 75°C followed by a 15 s hold (pasteurization conditions), a flow through sonicator (11 s resident time, set at 73°) and a cooling PHE set at 0°C. To simulate continuous operation, milk was pumped at a flow rate of 1 L/min. Raw milk was warmed to 25-30°C for each run. Samples were thermosonicated at 60% amplitude and the temperature of the flow cell was maintained at 72°C using a circulating water bath set at 73°C. Additionally, this system had thermocouples before and after each PHE so that pasteurization conditions could be monitored. Control samples flowed through the system with the sonicator turned off. Raw whole milk was passed through this system and evaluated for microbial count and biofilm weight and microbial composition. The average microbial count was significantly lower for thermosonication samples as compared to control after treatment and during shelf life. Control samples showed signs of curdling at 4 weeks while the treatment samples showed no signs of curdling at 6 weeks. To</p>	<p>Food Safety</p>

		<p>investigate the effect of sonication on biofilm formation, Skim milk protein was added to pasteurized milk to obtain solids contents of 16, 29 and 39%. The same thermosonication system described above was used while recirculating the milk for 2 hours with no sonication (control) to allow for biofilm formation. For the treatment, the sonicator was turned on for 5 min, followed by no sonication for 10 min. Cold water was rinsed through the system to remove particulates and the plates were air dried in place. The plates were rinsed in alkaline cleaner for 30 min, then left to soak overnight. The plates were then removed from the PHE and air dried. The weight of the plates was recorded and then scraped for biofilm solids. The average percent reduction in plate weights with sonication was 41.8, 26.3 and 15.2 grams with milks containing 16, 29 and 39% solids. The biofilm material was placed in sterile tubes containing saline solution and vortexed for 5 min. These samples were analyzed for vegetative cells and spores. Vegetative cells were determined by direct plating of samples. The presence of spores was determined by heat shocking the samples, then plating. Both vegetative cells and spores were observed in the material on the PHE plates for control and sonication. Although the sonication plates contained vegetative cells and spores, there was significantly less biofilm material on the plates.</p>	
<p>45.</p>	<p><i>Extension Success Story:</i> Women’s Conference</p>	<p>According to the World Health Organization (WHO), mental health 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.). A 2017 study in Utah revealed 32% of women ages 18-34, 21% of women ages 35-49, and 18% of women ages 50-64 reported poor mental health for at least one week out of the previous month of taking the survey (UDOH, 2017). In response to issues related to poor mental health among women, E. Parkhurst and team held the annual 2020 Women’s Conference. This half-day event is usually conducted in a face-to-face format but was adapted for virtual delivery due to COVID-19. Designed as an event to promote wellness and balance in the lives of women across the Wasatch Front, the conference featured workshops presented by</p>	<p>Healthy, Financially Secure Families</p>

		professionals and specialists in Utah. Workshops included topics such as self-care, body image, mindfulness, and communication. Evaluation results indicated that 91% of participants felt their knowledge of overall health and wellness improved because of attending the conference. In addition, 97% of attendees reported they were likely or very likely to make a change because of the conference. Examples include a commitment to cultivate a new skill or hobby, eat healthier, improve self-reflection, and self-care. Results also showed participants’ perceived improvements on key mental health indicators such as managing stress, positive thinking, healthy relationships, and handling multiple commitments. The Women’s conference facilitated by Parkhurst and team directly addresses the issues of mental health and serves as a holistic approach to empowering women.	
46.	Extension Success Story: New Home Buyer Education	Weber county has one of the highest personal bankruptcy rate in Utah. It also has the highest per capita ratio of payday lenders of any other community in the state. As consumer debt across the country continues to rise, there is a persistent need for personal financial management education. USU Extension offers a wide range of personal finance education to different target audiences. For example, T. Hunsaker of Weber county offers a new home buyer course to residents. In 2020, Hunsaker facilitated the course six (6) times to residents. Evaluation results indicated a significant improvement in participants’ knowledge of the home buying process, mortgages, and closing costs. In addition, a post-evaluation indicated participants saved up to \$5000 on down payment costs as a result of participating in the course. Hunsaker also delivered general community finance classes to low-income audiences in a focus group format. Hunsaker used this delivery platform to provide low-income families with personalized financial management education. These efforts are critical to improving the financial wellbeing of residents.	Healthy, Financially Secure Families
47.	Extension Success Story: Date Your Mate	There are many pressures facing families, these include divorce, single parenthood, financial pressures, blended families, remarriage, balancing work and family, or other family strains. In response, M. Jewkes and N. Brower of USU Extension collaborated with the Utah Commission on Marriage to facilitate a one-time couple relationship conference. With 10	Healthy, Financially Secure Families

		<p>invited speakers, the conference attracted 226 participants in 2020. In addition, M. Jewkes and team facilitated a relationship education mini conference to complement the Date Your Mate relationship program. Evaluation results from the mini conference indicated positive changes in key indicators of healthy marriages, including willingness to invest in activities to that strengthen marriages and spend more time with spouses. Further, participants expressed increased ability to communicate with their partners, resolve conflicts, strengthen commitments, and improve intimacy. With respect to practices, most participants indicated they intend to make changes based on what they learned during the conference, including making personal goals together, working on finances together, implementing conflict resolution ideas, controlling anger, and improving communication and listening. The new relationship mini conference is a successful example demonstrating the role of USU Extension in strengthening families.</p>	
<p>48.</p>	<p><i>Extension Success Story:</i> Utah Money Moms</p>	<p>According to the Pew Research Center, there is a narrowing, but consistent, gender gap in pay with women earning only 85% of what men earn. In Utah, this statistic is even more staggering at 72%. Furthermore, women are more likely to leave the workforce mid-career and live longer than their male counterparts, thus requiring adequate financial resources for a longer period of time. As a result, there is a need for women to make smart financial decisions. In 2018, A. Christensen launched the Utah Money Moms program and created an online platform to share research-based, personal finance information (www.utahmoneymoms.com). To date, Utah Money Moms has 1003 followers on Facebook, 953 on Instagram, and 304 followers on Twitter with over 35,500 website hits. In 2020, a retrospective evaluation indicated program participants created a financial goal (86%), saved money for emergencies, retirement, or college/technical education (92%), paid down debt (88%), reviewed their credit report (73%), and improved money conversations with a spouse/partner (91%) using the information provided by Utah Money Moms. Some qualitative feedback from participants were, “I am much better informed. I am less stressed, and I feel more confident spending</p>	<p>Healthy, Financially Secure Families</p>

		<p>money. I know where every dollar is going”, “I feel that I have more resources available to me to help with financial decisions”, “I have talked to my husband about starting a 1% savings fund and we have started to use the Step-Down Principle when going out to eat”, “I love the constant reminder I get to focus on my money goals-from a legit source”, “It’s given me the extra boost I need to work on our finances! We’ve paid off \$11,000 in debt this year”, and “We talk more as a couple and the personal allowance we have implemented has really helped our marriage!”</p>	
49.	<p>Extension Success Story: PowerPay</p>	<p>Utah residents file for bankruptcy more often than citizens in other states. USU Extension is uniquely positioned to provide educational programs for low- and moderate-income families. For example, D. Miner and team facilitates the Volunteer Income Tax Assistance program (VITA). In 2020, Miner and team assisted 159 qualifying households with preparation of their 2019 tax returns. These households received \$216,540 in state and federal refunds. From programs specifically designed to support low-income families, participants received approximately \$83,312 from child tax credits. These households also saved an estimated \$21,780 in tax preparation fees. D. Miner also facilitates the online PowerPay tool to provide consumers with free debt elimination plan options (https://extension.usu.edu/powerpay/). Users are able to customize a plan based on their financial situation. Web analysis shows that more than 11,100 debt elimination plans were created during 2020. These free resources provided by USU Extension are essential to empowering Utahns to manage their personal finances.</p>	<p>Healthy, Financially Secure Families</p>
50.	<p>Research Impact: Safety and Health Research for Utah's Agricultural Workforce</p>	<p>The overall goal of Michel Pate’s project is to examine injury risk factors and the impact of training methods on injury prevention for special populations working in Utah’s agriculture industry.</p> <p>An informational presentation was developed and delivered to youth engaged in FFA and 4H. Participants were from the Pennsylvania and Utah. After the presentation, participants were recruited to register for the SaferFarm.org tool. Students practice the functions of the tool assessing one tractor, one PTO-powered machine, and one agricultural structure.</p>	<p>Healthy, Financially Secure Families</p>

		<p>Participants then completed a user experience survey. Preliminary results showed that a third of participants (47%) indicated “it’s okay” when asked if the resource was interesting to use. Only 28% of participants indicated they were able to add the names of tractors, machines, and structures very easily. A quarter of participants (16.4%) indicated that the prompts were very useful in helping them understand what to do. Almost half of participants (48.5%) indicated the features and components worked at an average speed. This tool addresses the need for relevant and real time risk assessment on farms among young, less experienced workers. Incentives to use the tool should be considered by management personnel. Connecting risk assessment/management with successful agricultural careers will provide practical methods for improving worksite safety.</p> <p>Eighty-seven useable surveys were returned by farm bureau members. Most respondents were male. An average of one tractor without a ROPS/Cab was operated on participants farms. Ten respondents did not operate a tractor and were removed from the data set. Respondents were asked to identify barriers that would be important to them when deciding not to retrofit a tractor. The highest rank barrier was the belief that they had enough experience to avoid a tractor overturn.</p> <p>There was a significant association discovered between students’ age category and passing a safety pre-test ($\chi^2(1) = 10.1, p = .001, \phi = .315$). There was no significant association between students’ age category and passing the safety post-test ($\chi^2(1) = 0.74, p = .390$). Upper-class students of mid-career teachers were significantly more likely to have a passing score on the post-test than under-class students ($\chi^2(1) = 3.914, p = .048, \phi = .388$).</p> <p>This research project has resulted in several key impacts and recommendations. Implementation of digital technologies and mobile devices offer potential to transform hazard risk assessment among agricultural workers. Recommendations include targeting less experience</p>	
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		<p>teachers with targeted professional development. Training programs should be designed to provide a coherent strategy targeting influential factors at the organizational and individual level. Preliminary findings suggest a need for educational campaigns to encourage the use of safer tractors. More work will need to be done to address barriers to retrofitting or replacing tractors. It will be important to establish relationship with these community partners to develop a tractor safety culture in Utah.</p>	
<p>51.</p>	<p><i>Extension Success Story:</i> Utah 4-H Career Readiness</p>	<p>According to the Utah State Board of Regents, “Utah’s workforce demands are rapidly changing, and today’s jobs require an increasing amount of postsecondary education and training.” (Utah State Board of Regents, 2016). More so, a 2020 statewide needs assessment of over 400 Utah parents identified career readiness skills as one of the top ten emerging issues affecting youth. Led by K. Romney, Utah 4-H Career readiness programming is a proactive approach to providing a pathway to college and career opportunities for students before they graduate from high school. Using intentional, research-based curriculum and results from the needs assessments, Romney developed a learning experience to teach youth about applying the skills they learned in 4-H toward successful careers. 4-H University is co-hosted with other USU departments to facilitate hands-on education and career exploration activities in areas of Animal Science, STEM, Family and Consumer Sciences, and Small Business Development. In 2020, 4-H University transitioned to a virtual platform to accommodate COVID-19 precautions. Following the event, K. Romney and team surveyed youth to measure cognitive and behavioral outcomes. Ninety-three percent of participants indicated they were interested in attending college after their experience at 4-H University. On a post-evaluation, most youth participants agreed that they will use this experience to make decisions about their future, learn a new skill, plan to attend postsecondary education, and are likely to attend the event again. 4-H is uniquely positioned to strengthening the pathway from youth’s interests to post-secondary education.</p>	<p>Youth Development</p>

<p>52.</p>	<p><i>Extension Success Story:</i> Youth Mentorship</p>	<p>The literature shows many youth struggle to “fit in”, and this might be the result of a lack caring adult(s) in their lives. Mentorship is one solution to help youth at risk through positive role modelling. In response, J. Bunnell leads the 4-H Mentoring program. To date, this youth mentorship program served over 700 youth in Utah. Each youth is matched with a mentor and invited to a series of events aimed to model positive behaviors. Mentoring events include Family Night Out, family camp, and a mentoring conference. Due to COVID-19, some events were cancelled, and others were shifted to a virtual format. Nevertheless, evaluation results indicated the mentorship program was successful in the virtual format; participants reported an increase in their ability to consider the consequences to their decision and set clear goals for their future. Further, most youth participants indicated that they learned at least one new skill with their mentor and were more confident about themselves. Youth mentorship contributes to positive youth development, and represents a major program area of Utah 4-H.</p>	<p>Youth Development</p>
<p>53.</p>	<p><i>Extension Success Story:</i> STEM Education for Underserved Youth</p>	<p>4-H programs act as an early intervention that facilitates a positive life path by providing safe spaces for youth development with respect to belonging, learning, and mastery of skills. In Weber county, N. Brower and team implemented a series of 4-H afterschool programs. Past evaluations indicate afterschool programs help youth thrive in multiple ways (e.g. increasing STEM, communication, and interpersonal leadership skills). Through a partnership with YMCA afterschool leaders in urban areas of Weber county, 4-H curriculum was implemented in 12 school sites. Supported by Utah 4-H, YMCA leaders were trained on the curriculum to deliver lessons to urban youth that would otherwise not have 4-H experiences. Many of these youth were minorities from low-income and high-risk situations. In addition, STEM programming was implemented to help youth increase their science abilities and better prepare them to enter the workforce. Brower noted many efforts have been made to increase science opportunities for youth in Weber communities through partnering with schools, community organizations and the local libraries. Evaluation results indicate that after attending workshops, most youth</p>	<p>Youth Development</p>

		<p>participants increased recognition of the importance of science in their future, had an increased desire to explore more about STEM education, and they felt more confident about teaching someone else about STEM. After attending, youth indicated they were inspired to learn about robotics, help others learn about science, and conduct STEM experiments at home. Through a unique partnerships with YMCA and urban schools, 4-H was able to reach diverse populations of youth in Utah.</p>	
54.	<p><i>Extension Success Story:</i> Create Better Health Education for Youth in Low-income Households</p>	<p>With a food insecurity in approximately 15% of households, Sanpete county has one of highest food insecurity rates in Utah. Nearly 4,250 individuals experience hunger on a regular basis. Therefore, food insecurity is a major concern among Sanpete County residents. Food insecure residents lack access to adequate, well-balanced meals due to insufficient economic resources. With high levels of poverty, more than 50% students in all eight elementary schools of Sanpete county are eligible for free or reduced lunches. In response, S. Cromwell delivered Create Better Health (CBH) afterschool lessons to youth of low-income households in Sanpete county. In 2020, approximately 3,387 youth participated in nutrition education activities focusing on MyPlate concepts and physical activity. Evaluation results indicated an increase in participants’ knowledge of nutrition and making healthy food choices. CBH programs targeting youth in food insecure households are essential to improving the health of future adults.</p>	Youth Development
55.	<p><i>Extension Success Story:</i> Camp THRIVE</p>	<p>While a large number of Utah youth are resilient in the face of adversity and challenges (National 4-H, 2020), some youth face mental health challenges that can lead to suicidal tendencies. Results of the 2019 Utah Youth Risk Behavior Survey of high school students show that 36.7% felt sad or hopeless, and 22.3% considered suicide (Center for Health Data and Informatics, 2019). Among Utah youth, 62% of students in grades 6, 8, 10, and 12 also reported experiencing moderate depressive symptoms. In response, Z. Garcia of Utah 4-H leads the annual Camp Thrive event. The camp is a learning experience for youth to assess their physical, emotional, social, and intellectual needs. A virtual version of Camp Thrive was developed and implemented due to the COVID-19 pandemic in 2020.</p>	Youth Development

		<p>Garcia noted providing youth with access to this program was considered important given mental health concerns. The camp was held over a five-day period, and interactive learning activities for youth focused on the I THRIVE model that is rooted in the Maslow’s Hierarchy of Needs. Youth learned about the connection between their needs and mental health and resilience. Two sessions of Camp Thrive were held in July and August of 2020. A total of 37 youth registered for the camp. Evaluation results showed a majority of youth learned the importance of aspiring to meet the needs listed in the I THRIVE Model. They also learned that by meeting these needs, they can experience positive mental health and improve their personal resilience. In addition, results showed 71% planned to use the I THRIVE Model to identify their strengths, and 82% planned to use the I THRIVE Model to identify ways to improve on their existing strengths. Lastly, 76% of youth said they planned to help others increase their sense of belonging. Prior to COVID-19, many youth development professionals did not offer virtual camps. However, Utah 4-H rapidly shifted to online learning during the pandemic and adopted innovated approaches to engage youth in online learning. Results indicate efforts to shift traditional programs to online have been successful for positive youth development.</p>	
<p>56.</p>	<p>Research Impact: Ensuring a Sufficient Supply of Well-Trained School-Based Agriculture Teachers</p>	<p>The overall goal for Tyson Sorensen’s project is to help ensure a sufficient and diverse supply of well-trained agricultural educators by evaluating the factors and programs related to retention, recruitment, and professional development needs of school-based agriculture teachers, including both traditionally and alternatively certified teachers. His first objective is to evaluate the impact of current in-service and preservice teacher retention programs and strategies (e.g., teacher induction programs) within school-based agricultural education.</p> <p>In his initial study he collected and analyzed data from the new teacher induction program in Utah. From that data, he learned that beginning Ag Teachers in Utah benefitted from having an agriculture teacher mentor and someone to talk to, but the inability to connect with their mentor was frequently a challenge. He also found that new teachers desired an open</p>	<p>Youth Development</p>

		<p>relationship with others for sharing resources. These findings have implications for a more comprehensive community of practice that will help them stay in the profession longer.</p> <p>In a second study, Dr. Sorensen examined the impact of COVID-19 on teacher's satisfaction and work-family conflict, important variables related to teacher turnover. This national study produced findings of great impact, which include: (a) COVID-19 caused a significant decline in the work domain activities; (b) Job satisfaction diminished during COVID-19; and (c) other resources beyond time-based resources were impacted. Follow-up studies will be conducted in 2021.</p> <p>A third study examined the roles and impacts of Future Farmers of America (FFA) Alumni volunteer stakeholders on school-based agricultural education (SBAE) programs. Findings suggest FFA Alumni volunteers most frequently help agriculture teachers with FFA activities and desire training and resources so they can better serve. This study also found that SBAE volunteers are mostly motivated because it helps them in their own career pursuits and interests.</p> <p>A fourth study looked at the impacts of an international professional development experience on mid-career SBAE teachers, specifically as it relates to resilience and retention in the profession. Findings suggest this type of experience can be rejuvenating for mid-career teachers and can help with teacher retention.</p> <p>A fifth study looked at volunteers in SBAE programs and the perceptions of teachers related to volunteers. Significant findings from this national study include: (a) While former students make up the majority of volunteers, parents of current students contribute the most hours to SBAE programs; (b) Volunteers are used most often on advisory committees and for CDE training; (c) School district policies such as background checks and paperwork were the biggest challenge to utilizing volunteers.</p>	
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<p>57.</p>	<p><i>Extension Success Story:</i> Salt Lake County Employee Enrichment Series</p>	<p>A community’s economic stability is dependent upon the skills of its workforce. Recent literature suggests employees with “soft” skills are more highly sought after by employers and are more likely to stay employed and advance within their organizations. Many organizations lack the capacity to offer professional development training to employees to enhance soft skills. A 2019 statewide needs assessment revealed workforce readiness and entrepreneurship was among the top ten critical issues for urban residents. In response, L. Schainker led the Salt Lake County Employee Enrichment Series (SLCo EES) to address the need for employees to build their intra- and interpersonal skills for improved organizational productivity. L. Schainker and the team at Salt Lake County worked with county government divisions to learn about the stress of employees due to high-risk working conditions and uncertainty regarding frequently changing guidelines and protocols associated with COVID-19. Therefore, the first component of the program targeted issues related to with stress, work-life balance, and coping with working through the pandemic. In 2020, L. Schainker and team delivered professional development training on 25 unique topics over 36 sessions to county employees, with a total of 1,357 participants. The SLCo EES has been offered in collaboration with the mayor’s communication office, which promotes the sessions via the weekly E-Connect newsletter that includes all available resources for county employees. Evaluation results indicated most participants agreed the presentations were interesting and engaging, they had a deeper understanding of the topics, the information will help them in their work life, the information will help them in their personal life, and they intend to use the learning experience to make positive changes to their life. The SLCo EES further demonstrates the rapid response of USU Extension to emerging issues during the pandemic. Workforce readiness is also a major program area of Utah 4-H.</p>	<p>Community Resilience</p>
<p>58.</p>	<p><i>Extension Success Story:</i> Rural Online Initiative (ROI)</p>	<p>The Rural Online Initiative (ROI) program began as an economic development strategy in 2018. It was a legislative response to increasing unemployment rates and rural-urban migration in rural Utah communities. The Utah Legislature viewed remote work as a viable solution to address</p>	<p>Community Resilience</p>

		<p>these challenges. As such, USU Extension was tasked with developing capacity building courses in remote work best practices. The Master Remote Work Professional (MRWP) certificate course was designed to prepare Utah’s rural workforce for online opportunities in remote employment. With the onset of COVID-19, the ROI program held a unique position to transition the affected workforce to remote work. The program’s objectives are to create and deliver an educational online course targeting remote work skills and assist participants with remote job placement through skills scholarships. Through remote work education, the month-long MRWP course can help rural and urban communities recover from economic hardships caused by COVID-19. Since October 2018, about 1,298 participants completed the MRWP certificate course. Evaluation results showed statistically significant increases in participants’ knowledge after completing the course. Although 63% of participants did not have remote work experience, most (92%) indicated it was important or very important to acquire remote work skills. This included participants who experienced job losses because of COVID-19 and were eager to obtain remote work skills. On average, participants had high overall mean scores across all remote work skills; 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. Ninety-seven percent of participants felt their value as a remote worker improved and 96% were empowered to seek remote work after course completion. Follow-up surveys reported 30% of active jobseekers found remote work. One participant said, “...due to restructuring, I was laid off from a previous position. After five long months of unemployment and COVID standstill, I have been able to obtain a new position as a Payroll Controller. Besides making nearly a 40% pay increase, there are opportunities for new responsibilities, along with benefits and retirement!” With respect to environmental impacts, reduced commute times equated to savings of \$997 per month across all participants who found remote work due to lower fuel expenses. This further resulted in a total reduction of 3.34</p>	
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		<p>metric tons of carbon emissions per month which helps promote clean air. The ROI program expanded significantly since its inception, now offering new and revised courses to meet changing community needs. With remote work opportunities, rural residents secure well-paying jobs without leaving their communities. This benefit of remote work is especially emphasized in a global pandemic.</p>	
<p>59.</p>	<p>Research Impact: Sustainable Families, Firms and Communities in Times of Change</p>	<p>In collaboration with other members of the NC1030 Multistate research group, Yoon Lee has been studying factors that make family-owned businesses resilient during times of change.</p> <p>One study focused on the impact of business owner involvement in the community and community involvement in the business and how this reciprocal relationship could translate to business success in small family-owned businesses. The findings suggest that the more a family business is involved in the community, the greater perceived success the business has achieved. In this study, when seeking a profit, business owners tended to be more involved in the community than owners not seeking a profit. Since the study sample focused on long-standing family businesses, it became clear that success is tied to the level of business owners' community involvement. This study supports that business owners' involvement in the community helps to build social capital and Corporate Social Responsibility (CSR). The findings of this study become relevant to small family-owned business during the COVID-19 pandemic, as many small businesses are relying on community support. As these business owners get out into their community to be involved, their community can support them through this difficult time. Particularly because family business owners in this study stated that they were willing to help other businesses in their community. In addition, the findings can inform policy and programs for small family-owned businesses and community development and involvement, as policy makers can seek to bring the family businesses closer to their communities. The findings of this research can be used by business and entrepreneurship professionals, as the interactions and relationships between a community and its family</p>	<p>Community Resilience</p>

		<p>businesses can be crucial in growing and sustaining a family-owned business. A manuscript describing this study titled <i>The Reciprocal Involvement of Family Business Owners and Communities in Business Success</i> was published in the journal <i>Sustainability</i>.</p> <p>A second study that looked at cash flow problems and resource intermingling examined how businesses recovered after the natural disaster of Hurricane Katrina. It also examined business and owner characteristics that affected business recovery and resilience. The study found that a large majority of the businesses post-Katrina had cash flow problems and were less likely to have success following the storm. Business and owner conditions pre-Katrina had an influence on business survival whereas owner characteristics affected business resilience. Intermingling household and business finances can have negative effects on a business, especially after a natural disaster. While financial intermingling is not advised for any business venture, this research specifically supports the impact of financial intermingling on small businesses after a natural disaster. During the COVID-19 pandemic, it could be likely that many small businesses turned to cash flow and resource intermingling to attempt to survive. It could be important to help businesses dealing with cash flow problems to properly recover after the COVID-19 pandemic. This research also makes a contribution to the literature by examining how the influences of cash flow problems and financial intermingling have different effects on short-term recovery and long-term sustainability after a natural disaster. If businesses are expected to be prepared and able to support their business during a period of recovery and resiliency without financial intermingling, they can be expected to be more successful and sustainable in the long run. This study was published in the <i>Journal of Family and Economic Issues</i> under the title <i>The Effect of Cash Flow Problems and Resource Intermingling on Small Business Recovery and Resilience after a Natural Disaster</i>.</p>	
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<p>60.</p>	<p>Research Impact: Assessing Individual and Community Wellbeing Across Landscape Gradients</p>	<p>To address the goal of understanding wellbeing across community contexts and landscapes, Courtney Flint partnered with 19 cities to assess wellbeing and other local perspectives using an online survey. A total of 4,354 completed surveys were recorded during this effort across 18 Utah cities (1 city did not have enough responses for analysis). Results indicate that overall personal wellbeing for Utahans averages about a 4 (on a scale where 1 is very poor and 5 is excellent). There is not much variation across cities (low in Tooele at 3.77, high in Draper at 4.24). Local Environmental Quality is a wellbeing category that falls in the quadrant of lower rating, but high importance, suggesting this is a potential action item for 9 cities. Other prominent categories in this status include mental health and physical health. There were significant demographic variations revealed, suggesting that wellbeing and attitudes vary within cities as well as across cities. Education, income, and religion (Latter-Day Saint vs other) were prominent differentiating variables across Utah cities. Community connectedness was found to be positively correlated with overall personal wellbeing, suggesting that cities may want to put energy into building relationships among their residents with the city. Natural landscape features were overwhelmingly viewed as having positive influences on wellbeing. Residential and commercial development as well as manufacturing and extractive industries were found to have more mixed influences on wellbeing with particular differences found between rural and urban cities. Especially along the rapidly growing Wasatch Front, residents largely reported that they feel population growth is too fast. There were more mixed perspectives on the rate of economic development. Reports were presented to city leaders and city councils. Reactions were positive, with numerous comments that the information would be useful for general planning processes and fiscal decision-making.</p>	<p>Community Resilience</p>
<p>61.</p>	<p>Research Impact: Understanding Land Use Changes and the Effects of Greenbelt Act Policy in the Breadbasket Area of UTAH</p>	<p>Man Li is investigating dominant land use changes along the Wasatch Front in Utah over the period 2006–2016. As part of this study, she is looking at the mechanism through which Greenbelt assessment affects agricultural land development. The objectives for this study are to: (1) Assess major land use changes that occurred along the Wasatch Front in</p>	<p>Community Resilience</p>

		<p>the last decade, and (2) Examine the effect of the Greenbelt Act on preserving agricultural land from urban development along the Wasatch Front.</p> <p>Her assessment of land use changes between 2006 and 2016 primarily relies on the National Land Cover Database (NLCD) to examine land use changes on a basis of five-year time windows. The NLCD identifies 15 land cover classes at a 30-meter spatial resolution. This project further grouped the 16 classes into 7 categories, including high-intensity urban area, low-intensity urban area, cropland/pasture, rangeland, forests, water area, and barren land. The reclassification is based on the local land use activities and the spatial land use pattern in the Wasatch Front (e.g., cattle are often grazed on grassland and shrubland in addition to pasture, and most woody wetlands and emergent herbaceous wetlands are adjacent to open water). The finding from the land use conversion matrices in the five counties over the period 2006–2011 and 2011–2016 can be summarized into several points. First, the Wasatch Front has witnessed rapid urban growth over the two periods, with an annual growth rate of 1.01% and 0.53%, respectively. From 2006 to 2016, the total built-up area increased by 32,031 acres. More than 90% of the increase is from agricultural land, including cropland/pasture and rangeland. Second, the total acreage of agricultural land had experienced a significant decline over the first five years; the area slightly increased over the second five years, due largely to the conversion of rangeland to cropland/pasture and the conversion of forestland and wetlands (i.e., water area) to rangeland. The Wasatch Front had 1.149 million acres of forestland in 2011. By 2016, the total forestland had declined to 1.135 million acres, a 1.22% reduction. Almost all reduction was caused by the conversion to rangeland. Third, in addition to forest degradation, the significant loss of water area primarily in Weber and Davis is a matter of concern. The total acreage of water area had declined by 65,090 acres in the decade. The degradation of water area to barren land is the major source of the loss (70%), followed by the conversion to rangeland (27%). By exploring the evolution of conversion of agricultural</p>	
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		<p>land to urban use by county, Man Li’s group found that while urban development was mainly concentrated in urban core (e.g., Salt Lake County) over 2006–2011, there was a trend of urban sprawl, characterized with low-density, strip, or scattered development, in the other four counties during 2011–2016.</p> <p>To empirically examine the Greenbelt Act effect of on agricultural land conservation, this research project started with a case study on Salt Lake County, home to the biggest metropolitan city—Salt Lake City—in Utah with high concentration of large and growing cities. This case study combines an array of comprehensive annual data from 2008 to 2018 for empirical analysis, including the property tax assessment data which identify actual parcel boundaries and the Greenbelt status, the annual Cropland Data Layer (CDL) at the 30-meter spatial resolution, and the MODIS-EVI data at the 250-meter spatial resolution. To empirically examine the effect of receiving Greenbelt assessment on protecting agricultural land from urban development, Dr. Li’s team fit the parcel-level panel data to the equation in which the outcome variable is the percentage points of agricultural land converted to urban use and Greenbelt status is the key variable of interests. Other covariates include the closest distance of a parcel from the boundary of urban core and the EVI-based agricultural productivity. Voluntary farmland preservation programs often face the endogeneity issue as there are unobserved effects in the decision of Greenbelt enrollment. A two-stage least squares (2SLS) regression approach was adopted, by instrumenting Greenbelt with a dummy variable indicating whether or not a parcel qualifies the land size and land use criteria, to address this potential endogeneity issue. Overall, the point estimates of most covariates are robust across various specifications and can test the three fundamental assumptions of the classic urban spatial model. The rate of agricultural conversion decreases with the distance from the closest boundary of urban core and with the EVI-based agricultural productivity. These estimates are statistically significant at the 5% level or better. In contrast to the robust estimates of</p>	
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		<p>the covariates, failure to control the unobserved, parcel-specific permanent determinants of agricultural development and the unobserved transitory factors common to all parcels would bias the sign of the Greenbelt estimate. More important, failure to address the endogeneity issue of Greenbelt would substantially underestimate the effect of Greenbelt on agricultural land conversion. Turning to the Greenbelt variable, after controlling for the individual parcel fixed effects and the zip code-by-year fixed effects, the conversion rate of a Greenbelt parcel is statistically higher than that of a non-Greenbelt parcel at the 1% level of significance, all else being equal. This positive effect is mainly from the Greenbelt parcels with non-primary agricultural use. This result suggests that the Greenbelt policy may not be as effective as designated and will potentially inform policy debate on whether or not the Act should be amended.</p>	
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