2019 Annual Report of Accomplishments and Results

UTAH
Utah State University
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I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your Plan of Work. Use this space to provide updates to your state or institutions as needed.

1. Executive Summary (Optional)

This annual report highlights the 2019 accomplishments of the Utah Agricultural Experiment Station (UAES) and Utah State University Extension. The report is organized on the basis of the five planned programs outlined in our 2017 Plan of Work: (a) Global Food Security and Hunger, (b) Climate Change and Natural Resource Use, (c) Sustainable Energy, (d) Food Safety, and (e) Childhood Obesity, Nutrition, and Community Sustainability.

The **Utah Agricultural Experiment Station** supports diverse research programs in six of the eight colleges at Utah State University: the College of Agriculture and Applied Sciences, the Quinney College of Natural Resources, the College of Sciences, the College of Engineering, the Emma Eccles Jones College of Education and Human Services, and the College of Humanities and Social Sciences. In 2019, UAES supported scientists engaged in 159 individual research projects and participated in 47 Multistate projects.

Utah State University (USU) Extension has demonstrated significant progress towards meeting the persistent and emerging needs of residents of Utah. A statewide needs assessment was conducted in 2019 which highlighted priority areas and emerging needs for USU Extension. As a result, many programs were created, modified, and/or aligned to reflect the changing social, economic, and environmental conditions of the state. Further, several new programs were created and piloted as a response to clientele preferences for relevant information, and some were tailored to different audiences based on timely results of multiple county-level needs assessments. This report highlights some of the research impacts and Extension success stories of 2019. Major successes include the impact of the Rural Online Initiative, Utah Money Moms, the Celebrating Women Conference, the Central Utah Grazing Expo, and Utah Water Watch.

With respect to statewide performance of USU Extension, a clientele satisfaction survey was conducted in 2019 with residents who engaged with Extension over the past 12 months. With 2,075 respondents (n = 2,075), results indicated almost all clientele (94%) indicated they were satisfied with the accuracy of the information they received from USU Extension. Further, most clientele indicated they used the information (94%), it was

easy to understand (95%), it was up to date (89%), and it solved their problem (82%). Most respondents strongly agreed that USU Extension is an important organization in their county (78%), they trusted the information provided by USU Extension (86%), they can count on USU Extension for quality information (82%), and they were willing to recommend USU Extension to others (86%). Lastly, results indicated an overall satisfaction rate of 96% for USU Extension.

Program evaluation activities allowed USU Extension to monitor, revise, and measure the impact of programs offered throughout the state. This report provides evaluation results as evidence of statewide program impact. It demonstrates diversity in programs and audiences, and it shows the responsiveness of Extension to emerging needs throughout the state.

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your 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
1. The Merit Review Process	No updates, please refer to Plan of Work.
2. The Scientific Peer Review Process	No updates, please refer to Plan of Work.

III. Stakeholder Input

The NIFA reviewer will refer to your 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
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. Planned Program Table of Contents

V. Planned Program Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). See Section V of the Guidance for information on what to include in the qualitative outcomes or impact statements. Add additional rows to convey additional accomplishments. You may expand each row as needed.

No.	Title or Activity Description	Outcome/Impact Statement	Planned Program Name/No.
1.	***Research Impact:*** **Enhancing Rural Economic Development in the Intermountain West through Ag/Food Tourism Expansion**	K. Curtis has been studying opportunities for ag/food tourism in the Intermountain West. The local foods movement in the US has fueled the expansion of direct market outlets such as farmers' markets, farms stands, and community supported agriculture (CSA) programs. Growth is due to consumer concerns regarding food safety, health, the environmental impacts of conventional food production and transportation, as well as the desire to support local agriculture and preserve agricultural land. Direct marketing of local foods has been crucial in creating jobs, expanding market opportunities for agricultural producers, and spurring regional economic development. However, the growth in farmers' markets and CSA programs nationally has leveled off since 2010. Thus, small scale-agricultural producers look to diversify their operations in order to become more sustainable. Simultaneously, tourism providers struggle to find the regional distinctiveness necessary to differentiate themselves against other tourism destinations, and food tourism is gaining momentum as a vehicle to achieve distinctiveness. Hence, the expansion of ag and food tourism in rural areas is beneficial to the agriculture and tourism industries. Specifically, ag and food related tourism such as farm stays, farm shops, etc. provide a year-long revenue stream for farmers, as well as a diversification strategy. Additionally, they improve the destination activities available to tourists and enhance the destination image. This project sought to enhance economic development in rural areas of the Intermountain West by opening up new markets and diversifying outlets and product lines of small-scale agricultural and food producers through ag/food tourism development and expansion. As small-scale producers make up 90% of	Global Food Security and Hunger / #1

		all farms in the Intermountain West, they are an important audience as their long-term success is vital to the economic survival of their communities. The four primary goals of the project included: (1) investigate the tourism destination image of the Intermountain West, traveler motivation to visit, and the role food plays in both; (2) examine the production, distribution and marketing needs of agricultural producers and small food processors interested in entering the food tourism sector; (3) evaluate various models for incorporating ag/food tourism into the marketing portfolio of agricultural and food processing operations; and (4) disseminate study results and information to agricultural and food processing operations, tourism enterprises, and policy makers. The data for this project were collected through three primary efforts. First, an in-person survey of 700 Utah visitors was conducted to assess visitor interest in food and ag tourism related activities, views towards local and regional foods, and food related activities of preference. Additionally, this data was used to identify visitor types, and their product, activity, and promotional preferences. Second, in-person interviews were conducted with 40 farm shop owners in two western states and the UK. This data was used to assess best practices in ownership structures, sourcing and processing options, food safety and other labeling regulations, location considerations, funding mechanisms and educational opportunities, etc. The final set of data were collected through an online survey of 149 small-scale growers in five western states. This was done to assess current products, markets, interest in agritourism and food tourism expansion, as well as potential benefits and hurdles associated with new products and market expansion. Noteworthy results from the visitor survey include: (1) a lack of visitor "knowledge" regarding food/culinary tourism products and activities in Utah and surrounding states; (2) visitors who have a high interest in local foods and food experiences, also exhibit these preferences while traveling; and (3) two of the five primary visitor groups are very interested in food and agritourism	

		activities while traveling and thus provide a substantial market for food/agritourism expansion; (4) visitors to Utah are likely to return if they have good food experiences, recommend Utah to others, participate in outdoor activities or visit cultural areas, etc.; and (5) visitors who have a high interest in local foods and food experiences, also exhibit strong preferences for outdoor activities. As outdoor activities are the primary focus to Utah tourists, they present a great market for growers and local food producers. Results from the in-person farm shop owner survey include: (1) need for diversified operations, including multiple products and guest services; (2) need for assistance in terms of capital funding and educational opportunities; and (3) need for location near or on route to a major travel destination, such as national park or resort. Results from the grower survey include: (1) a clear interest in expanding current farm offerings of food and agritourism products and activities; and (2) a lack of knowledge on how to best do so and how to market their farm's activities along with current tourism activities. This project resulted in eight academic papers, three book chapters, one undergraduate textbook, three Extension fact sheets, and two full Extension workshop curricula. Additionally, academic presentations were made at 14 national and international conferences. Two grants were applied for and funded ($107,000 total funding) to disseminate results to target audience across the Intermountain West through workshops and curriculum materials. To dissemination project results ten one-day Extension workshops were held in five western states. Six-month follow-up evaluation results for the Extended Season Marketing workshops show that at least 20% of the participants had established a farm shop or stand of their own and had visited farms or food producers looking to source locally. Almost, two-thirds or 60% planned to implement a new product or service to sell in the extended season through a farm shop within 3 months. Approx. 80% had increased the number of products sold and 40% had increased their customer base and overall profitability.	

		One-year follow-up evaluations from the Food and Ag Tourism workshops show that 82% of participants had incorporated workshop materials into their job/operation, 50% stated that the value of the attending the workshop exceeded $500. Participant level of understanding/skills increased (from 25 to 75% on average), 44-56% completed or planned to complete six activities within one year. Finally, 12% of producer participants increased operational profits, 38% increased customer numbers, and 25% increased the number of employees working on their operation. In Utah, rural communities have benefited from expanded tourism. Seven of the top 10 countries with the highest number of jobs growth in tourism were rural, with tourism jobs expanding from 131,500 in 2014 to 147,800 in 2017. Tax revenue in Utah expanded from $172.2 to $216.2 million from 2014 to 2017, and visitor spending increased by $900 million during the same time period. Results from the grower, food processor, and tourism workshops show that the participants used the project materials to increase their overall profitability, as well as the number of products, markets, and employees.	
2.	***Extension Success Story:*** **Urban Farming**	S. Hansen conducted a needs assessment to understand the needs of urban farmers in the Wasatch Front. A horticultural program was developed based on the assessment. Hansen found that people who are starting small urban farms are generally new farmers and lack education and experience in horticulture and horticulture related practices. Therefore, work began to adapt programming such as a Master Urban Farmer Program for the Wasatch Front. Farm finance classes and community supported agriculture classes were taught at the Utah Urban Homestead Expo. Key concepts and topics addressed at the Urban and Small Farms Conference were tailored specifically to this audience. Talks and panel discussions were conducted with about 90 urban farmers on site selection, marketing, becoming a farmers' market vendor, and irrigation.	Global Food Security and Hunger / #1
3.	***Extension Success Story:*** **Public Agriculture**	Many Utah residents are generations removed from living or working on a farm which has resulted in a public with little or no understanding of food production systems. Residents and producers look to Extension for research-based information. C. Zesiger worked with youth and adults on food systems based on an assessment of audience needs. Zesiger found residents were most	Global Food Security and Hunger / #1

		interested in pasture management, Alfalfa production, weed management, and horticultural plant diagnostics. Zesiger provided workshops and individual consultations to approximately 400 residents and producers on these topics over the past year, and evaluation results indicated participants were highly likely to adopt the recommended horticultural practices and use the information to improve their operations.	
4.	***Research Impact:*** **Compost Carryover and Cover Crop Effects on Soil Quality, Profitability, and Cultivar Selection in Organic Dryland Wheat**	J. Creech and colleagues have been studying compost carryover and cover crop effects on organic dryland wheat. Dryland organic wheat production in UT, WA, and WY encompasses a large percentage of the organic wheat acreage in the U.S. However, declining wheat yields and poor quality caused by lack of soil fertility and growing weed pressure threaten the economic and environmental sustainability of these farms. The goal of this integrated research and Extension project was to foster the development of economically viable and environmentally sustainable farming systems to address the critical issues facing dryland organic wheat producers in the western U.S. The overarching objective of this project was to develop long-term on-farm research sites across UT, WY, and WA devoted to testing and showcasing organic dryland wheat management strategies for increased water use efficiency, weed management, soil quality, wheat yield and quality, and economic viability for dryland organic wheat growers. In total, 14 long-term trials were established during the performance period; 4 on university research farms and 10 in organic producers' fields. In addition, parallel greenhouse, laboratory, and short-term field experiments were conducted. At the historical site established in 1994 in Snowville, UT, significant compost carryover effect was still observable twenty-four years after a single application. The available soil phosphorus, P, (185%) and acid phosphates (67%) were significantly higher in plots that received compost compared with the control plots. Furthermore, the particulate organic carbon concentration in the topsoil was higher indicating the long-term effect of compost and increased wheat residue and root biomass on labile organic carbon, which drives microbial activity. Mineral associated carbon down to 90 cm was also	Global Food Security and Hunger / #1

		significantly increased by compost application indicating important persistent soil carbon accumulation deep in the soil profile. Perhaps most impressive, wheat yield in 2018 from a one-time compost application in 1994 was twice as high as the control. In the 14 new long-term plots established in 2015 and 2016 across three states, compost amendment had positive effect on soil health indices. Compost significantly increased soil dehydrogenase activity, and acid and alkaline phosphatase enzyme activity. Readily mineralizable carbon, microbial biomass, and microbial efficiency were significantly higher in amended plots. Microbial biomass was highest in the 50 Mg ha-1 plots at all sites. Cover crop effects on soil properties were not noticeable at any site. This suggests that compost has greater potential to increase soil carbon and phosphorus cycling than cover crops in dryland wheat-fallow systems in the West. Compost amendment increased the soil organic carbon (SOC) content in the labile fraction in surface soils at all sites. At the 10-30 cm and 30-60 cm depths, the SOC content in the fractions were significantly increased. Cover crops had no measurable effect on SOC in our low rainfall systems. Compost application generally improved the soil P fractions in all states, but the results varied by site. Extractable micronutrients (zinc, iron and manganese) were generally higher in response to compost amendment. There was no significant cover crop effect on soil fertility. Root architecture was different as a result of compost application. The seminal wheat roots grown in compost amended soil were denser and extended 15 cm deeper into the soil than the seminal wheat roots of the control plants. A thick mat of nodal roots was present in the wheat grown in the composted plots; the nodal roots were absent in the wheat grown in the control plots. In addition, although the soil in the composted plots was drier than in the control plots, it was more friable. The beginning of granular soil structure was observed clinging to the nodal roots of the wheat in the compost treated plots. The results indicate that compost addition increased soil aggregate inorganic and organic P at both sites. The P distribution between the soil aggregates was	

		altered at most locations. The small macroaggregates generally had the highest inorganic phosphorus concentration. Compost-C promoted formation of macro-aggregates, organic P protection and increased long-term labile P availability. Macroaggregates play a key role in the long-term availability of P 24 years after compost application. In dryland agriculture, soil moisture is the primary driver and limiting factor of the cropping system. In the fallow years, compost did not generally alter soil moisture, but sometimes caused it to improve. Conversely, cover crops during the fallow year usually caused soil water content to decline, particularly at depths from 0-60 cm. Wheat yields in compost amended soils increased from 30 - 200% compared to the control over the two wheat-fallow cycles during the performance period. The compost rate response was mostly linear, with higher compost rates resulting in higher yield. Compost rate also increased grain protein. Preceding wheat with cover crops reduced yield up to 50%, with reductions greatest in dry years. Wheat cultivar trials (36 entry) were conducted in certified organic and conventional production systems over two growing seasons in Utah. Generally, the top producing cultivars under conventional production are the top cultivars under organic production. There were, however, some notable exceptions. A recent release from Idaho, “UI Silver”, and the Wyoming cultivar “Yellowstone”, both ranked in the top three entries in the organic trials but near the bottom in conventional trials. These results suggest that some wheat varieties may be more suited to organic production and emphasizes the need for continued evaluation of new wheat cultivars to characterize performance in organic systems. In the economic component of the project, surveys of wheat quality characteristics required for the baking industry and of western US consumers were completed to better understand the needs of organic wheat users. A	

		needs assessment of wheat growers in the study area (US West) was conducted to understand factors that influence producer adoption decisions and we developed a survey of both current and potential organic wheat producers to gage perceived obstacles to adoption. A separate study was completed to characterize the relationship between the organic and conventional wheat markets in the US. Now that the last of the data for the performance period has been received, we are in the process of estimating production functions that relate yield to input levels and estimating multi-year cost and return calculations based on that data. Progress towards the successful completion of this project has resulted in the development of new management recommendations for organic dryland wheat growers. A one-time application of compost can greatly improve wheat yields today and for many years to come (up to 24 years as of this writing). In a region, such as the West, that has experienced a long history of soil degradation, compost can increase resiliency in the dryland organic wheat system through improvements in soil fertility and health, while increasing soil carbon and soil moisture storage. This study is the first phase of a long-term effort to catalog how the benefits of these management practices can persist into the future. The application of compost on a large scale can help close a system-wide gap in nutrient cycling processes in wheat-fallow systems. If long-term benefits from a single application persist, compost may be a pragmatic way to stimulate the soil and provide long lasting crop benefits on large-acreage dryland organic wheat farms in the West.	
5.	***Extension Success Story:*** **Utah Agronomic Crops**	J. Creech delivered workshops to producers on educational topics such as general agronomic practices for Utah's major crops (seeding rates, row spacing, planting dates, etc.), reducing nitrogen fertilizer inputs in corn and pasture, no-till (direct seeding a new crop into last-year's stubble without the aid of tillage) in irrigated cropping systems, soil fertility issues in dryland organic wheat, testing new crop genetics, seed treatments, fertilizers, and other products entering the market, and alternative crop rotation options (teff grass, soybean, and quinoa). About 310 growers attended the biannual Utah Hay and Forage Symposium, an event co-sponsored by USU Extension and the Utah Farm	Global Food Security and Hunger / #1

		Bureau Federation. As program committee chair, Creech evaluation activities indicated attendees demonstrated significant gains in knowledge at the Symposium, and nearly all participants believed the new knowledge was relevant to critical issues they faced on the farm. Most farmers indicated the knowledge will improve their profitability. This suggests that producers see the value of this ongoing educational program and view it as an integral part of their profitability and success.	
6.	***Extension Success Story:*** **Crop Production**	Cash receipts from crop enterprises in Uintah and Daggett Counties are approximately $20 million. Alfalfa and other hay are most important to the economics of these counties. B. Kitchen provided a range of Extension activities such as workshops, field days, and demonstrations to approximately 460 producers in 2019. Producers received timely research-based education to improve profitability. Major outcomes indicated that farmers saved $31.97 per acre on average by soil testing and not purchasing surplus nutrients for a total savings of $49,653. By not applying an average of 51 pounds of unneeded nutrients per acre, 39 tons of unnecessary nutrients were kept out of the environment. Results for tests of garden soils showed that 71% were high in phosphorus, 41% were high in potassium and 35% were high in salt. The percentage of gardens with excessive phosphorus, potassium or salt is trending down.	Global Food Security and Hunger / #1
7.	***Research Impact:*** **Legume-Finished Beef: Achieving Current Production with Greater Environmental, Economic and Social Sustainability**	NIFA funded scientists at Utah State University led by J. Villalba have developed a transformative beef production system that uses nitrogen-fixing “non-traditional” tannin-containing legumes to support an 18-month birth-to-slaughter system for beef production. Activities and key impacts for the project are summarized below. Objective #1 was to explore environmental impacts of tannin-containing hays during winter feeding of beef mother cows and heifers. Beef cows (5 animals/hay species) and heifers (3 animals/hay species) were fed cicer milkvetch, meadow brome, or tannin-containing birdsfoot trefoil hays (Experiment 1), or alfalfa, tannin-containing sainfoin or tannin-containing small burnet (Experiment 2). The concentration of condensed tannins in tannin-containing hays was greater in sainfoin (3.0±0.35%) than in birdsfoot trefoil	Global Food Security and Hunger / #1

		(0.75±0.06%). Small burnet did not contain condensed tannins but the concentration of hydrolysable tannins was 5%. These tannin concentrations were lower than values typically observed in fresh forages of the same species. However, results from this study show that these hays maintained their bioactive properties. Methane emissions from cows and heifers were lower for small burnet than for any other treatment, although digestibility was reduced for animals consuming this hay. Heifers fed meadow brome (a grass) produced the greatest values of methane emissions. Additionally, cows and heifers fed tannin-containing hays showed lower urine and blood urea nitrogen (N) concentrations than animals fed non-tannin containing hays, suggesting a shift in nitrogen excretion from urine to feces. This shift is significant as it reduces N losses to the environment because fecal N is less volatile than urinary N. The shift in N excretion from urine to feces was attributed to the presence of condensed tannins (CT) in the forages as CT bind to dietary protein, which increases the flow of amino acids to the small intestine. Animals consuming birdsfoot trefoil, cicer milkvetch, or sainfoin excreted the lowest percentage of the N that was consumed, reflected in greater values of nitrogen retention. In contrast, total daily retention of N revealed the lowest values for animals fed small burnet or grass hays. There are significant concerns regarding the potential global environmental costs associated with livestock production such as methane and nitrogen losses to the environment. The significance of the present project to US beef producers is that “non-traditional” bioactive tannin-containing hays have the potential to reduce methane and nitrogen emissions and in the process increase the efficiency of N utilization by livestock, thus leading to a win-win situation of reduced environmental impacts and increased animal productivity. Objective #2 was to evaluate consumer willingness-to-pay (WTP) of eco-friendly legume-finished beef in order to formulate a marketing strategy to attract environmentally conscious consumers. Benefit transfer (BT) was used to estimate WTP for legume-finished beef. The BT approach involves the use of similar valuation or WTP studies for beef in other regions at other times. One	

		shortcoming is that there is no WTP study for legume-finished beef although the BT approach is useful and cost effective. Thus, we collected an in-depth literature review of consumer preferences on grass-fed or grass-finished beef to estimate WTP for legume-finished beef and the probability density approximation (PDF) of WTP. All WTP values were converted to 2016 dollars using Consumer Price Index for Food at Home category. There are numerous studies focusing on consumers' preferences and WTP for differentiated beef products. Among them, ten studies were selected to evaluate the WTP for grass-fed beef. These studies either focused on a single beef product attribute or a combination of beef attributes such as grass-fed, eco-friendly, branding, locally raised, and natural or regionally produced. We found that (at least some) consumers preferred the grass-fed beef over conventional grain-fed beef and that they were willing to pay a price premium to purchase it. The PDF of WTP showed that on average, grass-fed beef would have at least a $2/pound (st.dev. = $0.9/pound) price premium if it is marketed as grass-fed beef with better taste. This is because consumers rated freshness, taste/flavor, and tenderness as extremely important when they purchase beef. Some studies also suggest that consumers are willing to pay a price premium to obtain locally raised beef. Six studies were identified, and, on average, consumers were willing to pay $1.86/pound (st.dev. = $0.58/pound) more to purchase locally raised beef. Locally grown or raised would be one of key marketing strategies to attract local consumers. In summary, marketing legume-finished beef is a challenging task because consumers perceptions of legume-finished beef and their WTP are not known. However, our summary of the literature provides useful insights, and a completed study demonstrated that consumers rate the tenderness and juiciness of birdsfoot-trefoil (legume)-finished ribeye steaks higher than these characteristics of grass-finished steaks, and equal to conventional grain-finished steaks. The balance of desirable omega-3 fatty acids to undesirable omega-6 fatty acids in steaks from birdsfoot trefoil-finished steaks, however, was the same as this value for grass-finished steaks. Consumers are willing to pay a	

		price premium to obtain locally grown, grass-fed, eco-friendly, and animal welfare certified beef. Consumers rate freshness, taste/flavor, and tenderness as extremely important when they purchase beef. Thus, legume-finished beef should be marketed as locally raised, econ-friendly, equally as healthy as grass-finished but tasting like grain-finished beef.	
8.	***Research Impact:*** **Toxicological Evaluation of Metals and Plants as They Apply to Livestock**	J. Hall has been studying toxic plants and metals on that are present on rangelands in Utah. Activities and key impacts for the project's 5 objectives are summarized below. Objective #1 was to identify potentially toxic plants for which needed data on toxicity is lacking. Several potential plant poisoning cases were investigated but well characterized poisonous plants or non-poisonous plant causes of mortality were found to be the causative factors for most of them. Potential cases of Kochia poisoning in a herd of cattle were investigated but the hepatotoxic disease syndrome could not be consistently replicated with dosing of the contaminated hay material. A different plant the hay was shown to consistently cause hepatotoxic effects; these findings will be published after further characterization. Objective #2 was to determine the female reproductive toxicity and effects of plant derived excessive dietary selenium in an ovine model and estimate the risks posed to human and animal health. High selenium containing plant material was harvested, dried, and ground for the preparation of feeds for the dosing of breeding ewes. Ewes were dosed for three time periods (starting 30 days prior to breeding; starting at breeding; and starting 30 days post-breeding) to evaluate the time component of the reproductive toxicity of 25 ppm plant derived selenium. There was a definite time critical component to the toxic effect of selenium on reproductive success in ewes. Only the ewes that were started on the selenium during the pre-breeding period experienced a high incidence of failed fetal survival. Sample analyses will be completed in the near future. Objective #3 was to determine the male reproductive toxicity and effects of	Global Food Security and Hunger / #1

		plant derived excessive dietary selenium and estimate the risks posed to human and animal health. High selenium containing plant material was harvested, dried, ground, analyzed, and incorporated into feed pellets at 0.25 (control), 7.5 ppm, 15 ppm, and 25 ppm for the dosing yearling rams. Yearling rams had semen evaluations performed pre-study and were then divided into treatment groups. These rams received the study diets for 8 weeks. At the 4- and 8-week semen evaluation, a majority of the rams on the 15 ppm and 25 ppm selenium diets had poor semen quality, with low percentage motility and high percentage abnormal sperm. These abnormalities were more severe at the 8-week time period with poor motility and high degrees of sperm abnormalities (looped tails, tail-less heads, and proximal droplets). There was a dose dependent effect, with lesser severity of effect at 15 ppm than 25 ppm. Lesser numerical effects were observed at 7.5 ppm, which will likely not be statistically significant. Tissue selenium evaluation has been completed, but histopathology is still being performed for animals of this project. Objective #4 was to identify the relative risks of different chemical forms of pyrrolyzadine alkaloids in an avian model. To assess the relative toxicity of structurally diverse Dehydropyrrolizidine alkaloids (DHPAs), male California White chicks were dosed orally with 0.01, 0.04, 0.13, or 0.26 mmol of seven different DHPAs and three DHPA N-oxides kg-1 bodyweight for 7 days. DHPAs were grouped in relation to their toxicity based on clinical, serum biochemical, and histopathological evaluations as well as tissue adduct accumulation rates. Using the same testing model, a reduced extract from comfrey, a commonly used DHPA containing herb, was compared to its two major constituent DHPAs, intermedine and lycopsamine. Based on the same parameters, the comfrey extract was more toxic than pure lycopsamine or intermedine, indicating either an interactive effect or an effect of other compounds within the extract. Objective #5 was to identify the occurrence and effects of excessive dietary copper and selenium on dairy cattle. It has been found that over 60% of dairy cow liver samples analyzed for copper and selenium have excessive concentrations. Attempts were made with multiple herd owners to obtain	

		cooperation in follow-up evaluation of the animals in terms of liver pathology evaluation and/or when dietary changes were made, but to date herd owners have not been responsive to more thorough evaluation or longer-term follow-up. Tissue samples and serum samples were obtained from a group of feeder Holsteins with extremely high liver copper. Tissue analyses, serum biochemistries, and response to vaccinations were started for some of the animals, but the animal owner decided to sell the animals prior to secondary sample collection.	
9.	***Extension Success Story:*** **Beef Reproduction**	K. Nay conducted a focus group with ranchers and found they were interested in workshops on many issues surrounding beef reproduction including basic animal care, calf health, new drugs, new diseases, shipping fever and stress issues with shipping beef, markets and marketing options, best farming practices, record keeping, and quick books. With other Extension faculty, Nay conducted workshops to address these topics. Evaluation results indicated significant knowledge gain among participants. Further, all participants indicated that their profitability would increase given the new knowledge acquired through the workshops. Nay and colleagues also created and disseminated information regarding beef production at county fairs and farm days to over 200 attendees.	Global Food Security and Hunger / #1
10.	***Extension Success Story:*** **Central Utah Grazing Expo**	C. Chapman worked with Extension faculty to plan the Central Utah Grazing Expo. More than 120 livestock producers, students, government agency personnel, and affiliated industry reps attended the first Central Utah Grazing Expo held in Ephraim and Salina. The three-day event was patterned after the highly successful AZ/UT Range Livestock Workshops. Producers gained knowledge on the economics of livestock production, managing grazing during and after drought, range monitoring, Forest Service and BLM monitoring for management decisions, role of the GIP program, Utah Watershed Restoration Initiative, NRCS range programs, best practices for protecting herd from calf scours, vaccine selection and storage, and options for controlling annual grasses. The evaluation results indicated producers demonstrated significant knowledge gain in these areas. During the year, Chapman and Extension faculty also hosted the Utah Beef Cattle Field day, Utah Beef Improvement Association Performance Bull Test and Sale, and the AZ/UT Range Livestock Workshops.	Global Food Security and Hunger / #1

11.	***Extension Success Story:*** **Dairy Extension Veterinary Program**	D. Wilson leads a major extension veterinary program for surveillance for important diseases of dairy cattle in Utah. Wilson Extension activities reaches audiences including veterinarians, milk buying company and feed company personnel, as well as producers and allied dairy industry. These participants learned about casein hydrolysate intramammary infusion as a dry cow treatment, mycoplasma mastitis and arthritis, official trichomoniasis testing using pools of preputial wash samples, and causes of death in dairy and beef cattle by age group. Wilson's Extension presentations and workshops led to an increase in producer, veterinarian, and allied dairy industry awareness of the high-test agreement and usefulness of each of conventional culture, MALDI-TOF and 16S rRNA for mastitis pathogen detection.	Global Food Security and Hunger / #1
12.	***Extension Success Story:*** **Emerging Issues Facing Livestock and Dairy Producers**	New Extension faculty, J. Hadfield, is working to implement an Extension program that addresses emerging issues facing livestock and dairy producers. The goal of this program is to provide relevant and timely education for producers in Cache County. Having conducted a needs assessment in 2019, Hadfield is designing educational content applicable to dairy and livestock producer's specific operations. The end goal being to improve the life and well-being of local agriculture industry and its producers. For example, Hadfield delivered fencing school to producers to make them aware of fencing laws as well as proper technique in fencing. Evaluation results indicated participants intend on updated their fencing practices based on fencing laws.	Global Food Security and Hunger / #1
13.	***Research Impact:*** **W3171: Germ Cell and Embryo Development and Manipulation for the Improvement of Livestock**	As part of the W3171 Multistate project, T. Bunch, S. Isom and I. Polejaeva studied the effects of electrical stimulation and silver ions on transcriptome dynamics. The applications of electrical stimulation and silver ions have been evaluated in laboratory experiments and clinical studies for more than two decades. The effects of the technique on infection prevention and wound healing are well established. However, little is known about the role of electrical stimulation and/or silver ions on change in cellular transcriptome dynamics, and no studies have been conducted to investigate the potential of electrical stimulation and silver ions in cell reprogramming. In this study, transcriptomic changes in porcine fibroblast cells in response to electrical stimulation and concomitant silver ions were investigated. Cells presented distinct morphological changes after treatment, which was mainly due to	Global Food Security and Hunger / #1

		exposure to silver ions rather than the electrical current. RT-qPCR data showed that electrical stimulation and silver ions had no influence on the expression of pluripotency genes. The results of RNA-sequencing identified a set of genes that were differentially expressed after cells were exposed to electrically generated silver ions for 21 hours. The functions and pathways related to these genes were highly related to cellular metabolism. This increase of respiratory complex I subunits might be a response to changes in cell metabolism induced by 2 mg/L silver ion, where the content of NAD+ and ATP increased but reactive oxygen species did not. The outcome of cell metabolic changes was supported by information on biochemical composition assessed by Raman spectroscopy, which also further proved that silver ion at this level is nontoxic to fibroblast cells. Liquid STEM imaging found that silver ion (Ag+) was reduced to the metallic form (Ag0) in fibroblast cells, which probably shares the same mechanism as silver nanoparticles biosynthesis in bacteria. The physiological changes induced by silver ions at a sub-toxic level might lead to alterations in cell function or cellular activity such as early cell reprogramming and cell differentiation. The findings of this work unfortunately did not suggest a reprogramming effect of silver ions on fibroblast cells, nor did they suggest that treated cells would serve as more efficient karyoplast donors for somatic cell nuclear transfer. But the studies did provide a better understanding of the biological effects of silver ions on cells, which can benefit the applications of silver in medical treatments and promote the development of silver products.	
14.	***Research Impact:*** **Development of a Translational Large Animal Orthopedic Model**	J. Mason has developed a sheep model for studying treatments for osteoarthritis (OA). The objectives of this project were to: (1) develop an improved, non-surgical large animal osteoarthritis model by induction of a transient orthopedic insult using a Botulinum toxin (Botox) model, and (2) to investigate gene therapy and stem cell therapies for the treatment of joint disease in an induced large animal model of OA. The most immediate impact of this work will be on: (1) biotech companies interested in pursuing this work for use in humans, and (2) for therapy in dogs and horses, particularly performance animals who suffer from high incidences of OA. Undergraduate, graduate and veterinary students, orthopedic specialists and the general public also benefitted from our work.	Global Food Security and Hunger / #1

		This study included the development of a novel oblique angle treadmill forced exercise procedure to exacerbate the progression of clinically detectable OA. Initial experiments included a classic cranial cruciate ligament desmotomy (CCLD) model of OA in female sheep. Results from these initial studies using the novel forced exercise regime and the CCLD procedure produced clinically detectable OA, which normally takes a year or more to develop, in 3-4 months. Because of this success and knowledge from other work involving the influence of ovarian function of development of OA (Mason et al., 2015) and the high costs associated with the proposed Botox approach, gene therapy was tested in CCLD and in OVX sheep. Both CCLD and OVX sheep were injected with saline or a therapeutic Timp-3 rAAV transgene virus and subjected to forced exercise. After 16 weeks of forced exercise, both models displayed evidence of OA progression and positive effects of the Timp-3 gene therapy were seen in both models as well. Timp-3 gene therapy reduced the incidence of osteophytosis, the most common marker of OA. Differences in serum and urinary glycosaminoglycan were also detected between gene therapy-treated groups and controls. This research demonstrated that the Timp-3 transgene positively influence traumatic OA progression in CCLD sheep and that the therapeutic Timp-3 transgene could positively influence non-traumatic, menopausal OA. These results were made possible by the application of the novel oblique angle forced exercise procedures. Substitution of an OVX model for the Botox model has still provided a non-traumatic OA model with the additional benefit of being a menopausal model. This will allow the future use of reproductive manipulation to dissect the causative factors in menopausal OA.	
15.	***Extension Success Story:*** **New Technologies in Sheep Production**	Box Elder County is the second largest sheep producing county in the state. J. Dallin conducted a needs assessment to understand the educational topics most relevant to sheep producers. Based on the results, Dallin delivered training workshops to 77 producers on new technologies in sheep production. Also, Dallin created online learning modules for producers, and this online content attracted about 2700 views in 2019.	Global Food Security and Hunger / #1

16.	***Extension Success Story:*** **Refugee Goat Production Project**	There are approximately 40,000 refugees living in the Salt Lake Valley. Most of them struggle to find employment and faces many problems such as language barriers and lack of education. Based on religious beliefs and geographical norms, many refugees favor goat meat. C. Chapman's Refugee Goat Production Project helps develop leadership capacity within the Somali Bantu, Somali Bajuni, and Burundian refugee communities living on the Wasatch Front. This program teaches refugees how to effectively manage a goat herd through proper husbandry techniques. Over eight years, Chapman has developed a rapport with the leaders of the three refugee communities. This has allowed them to have confidence in Extension's ability to help them meet their goals. The next step of the project is a Goat Management Certificate program for refugees.	Global Food Security and Hunger / #1
17.	***Research Impact:*** **Sperm Chromatin Composition and the Fertility of Domestic Animals**	The rationale for R. Meyer's project is that the reproductive fitness of stallions is essential for their use in the horse industry. This project is focused on early recognition of poor semen quality in breeder stallions with the goal of developing simple diagnostic tools for semen quality analysis. The aims of this proposal were to: (1) identify protein markers indicative of poor sperm quality, (2) develop screening assays for the detection of candidate proteins in semen samples, and (3) determine the predictive value of marker proteins indicative of low sperm quality. Aim #1 was to identify protein markers indicative of poor sperm quality. Proper sperm development includes the replacement of histones for protamines in postmeiotic germ cells, so that excessively retained histones in sperm were hypothesized to be a marker of poor sperm chromatin quality and hence a predictive sign of poor stallion fertility. While this is true for humans and mice, experimental data to support this hypothesis in the horse were found to be missing from the knowledge base. A graduate student therefore characterized the nucleoprotein exchange dynamics in the stallion and we published this work, along with the finding that horses express the testis-specific histone TH2B. Several other antibodies recognizing different proteins in horses were identified in the lab in years 1 and 2 of the grant, but also two for the testis-specific histone TH2B, which do not recognize canonical, i.e. somatic histones.	Global Food Security and Hunger / #1

		Based on outcomes of these investigations, the TH2B protein was subsequently selected as the lead potential indicator protein of sperm chromatin quality. Aim #2 was to develop screening assays for the detection of candidate proteins in semen samples. Two graduate students working on this project also identified a second antibody for TH2B, which should allow for establishment of an enzyme-linked immunosorbent assay (ELISA) method for the detection of poor chromatin quality. Such poor chromatin quality would also be detectable by quantitative chromomycin A3 (CMA3) staining of sperm, but the method is not suitable for quick or high-throughput analysis of sperm in the field. CMA3 staining of sperm was established to provide a method for validation of the ELISA assay. Ultimately, immunoblotting of sperm proteins was chosen to identify poor and good quality semen samples. Aim #3 was to determine the predictive value of marker proteins indicative of low sperm quality. In combination with TH2B immunoblotting of sperm proteins, CMA3 staining was used to screen 32 semen samples from stallions used in a commercial setting. These samples were provided by P. Loomis, the founder and CEO of Select Breeders Service, Inc. (www.selectbreeders.com). The graduate student working on the project used data from her own analyses, but also sperm number, and concentration and motility data obtained from Select Breeders, as well as FCCR (First Cycle Conception Rate) and ESPR (End of Season Pregnancy Rate) of each stallion to gauge how well these data correlated with data generated using CMA3 assays and immunoblotting for TH2B retention in sperm. Statistical analysis of the correlations between the tests in the laboratory and the actual fertility data proved to be difficult and remained mostly inconclusive. The reasons are: (1) the stallions we analyzed all have similarly good fertility, and it was not possible to obtain semen from a poor breeder, (2) the number of mares covered by the stallions ranged from 2 to 281 (average 37) per stallion, making power analyses and stallion ranking difficult, and (3) the semen samples were collected at different time points of the year, which increases variability of semen sample quality due to stallion seasonality and an associated variability of semen quality. As additional	

		samples are collected over time by USU veterinarians and residual semen samples are frozen and archived the statistical analysis will be revisited. Despite the fact that the envisaged quick analysis test kit has not yet been developed to completion, the project has overall been tremendously productive with respect to new knowledge produced. This study was the first to report the timing of TH2B, protamine 1 (Prm1), TP1, and H2AZ expression in the equine testis and to determine the nature of developmental landmarks in stallion spermatogenesis and of corresponding epigenetic marks. The new insights from the stallion also added new perspectives relevant to mice, human and other mammalian species, which prompted publication of a chapter in the new edition of the book "Transgenerational Epigenetics" (Elsevier). Moreover, the study shed new light on histone H4 acetylation events and their importance for chromatin maturation in spermatogenesis, which supports the hypothesis that nutritional deficiencies contribute to poor sperm chromatin quality. The extent and timing of histone acetylation depends on the balanced activities of histone acetyltransferases (HATs) that use acetyl-Coenzyme A (acetyl-CoA) as a substrate, and histone deacetylases, which are NAD-dependent. NAD-deficiency is widespread in mammals (nothing is known about the stallion in that regard), but difficult to model in the animal. In collaboration with a colleague at USU, a transgenic mouse was generated that finally permit studying low NAD metabolism in vivo. The new mouse strain, which will also be useful for continuation of this project, was published last year in Cell Reports. Low NAD and concomitant high acetyl-CoA levels in this mouse should theoretically drive excessive histone acetylation in the animal, and preliminary data look very promising, where sperm are CMA3 positive and have excessively retained histones in sperm. The mouse model will be used to identify new markers of sperm chromatin quality that may then be investigated in the stallion. Relevant to aim #2, a single-lens microscope that fits an iPhone ("Phone Scope") was developed using 3D printing and a small glass bead as the lens. The Phone Scope is similar to a Hamilton-Thorne CEROS II computer-assisted sperm analysis (CASA) system, which is considered the gold standard for semen motility analysis. However, the Phone Scope can be used to quantify	

		sperm motility in the field. Development of this microscope is ongoing, as the quality of the lenses still needs improvement.	
18.	***Research Impact:*** **Mechanism of Neurological Respiratory Failure Caused by Viral Encephalitides**	J. Morrey has been studying the mechanism by which West Nile Virus (WNV) causes neurologic respiratory failure. His team showed that respiratory distress and failure caused by WNV occurred from lesions in the cervical spinal cord motor neurons and not primarily in the brainstem. They have also demonstrated that synaptic retraction of terminals from motor neurons is associated with Zika virus (ZIKV)-induced paralysis in mice and that re-association of synapses is associated with recovery from paralysis. Their Brazilian collaborator, Dr. A. Oliveira, analyzed the ultrastructure of synapses of spinal cord samples by electron microscopy. The retraction of synapses from motor neurons (synaptic retraction) of paralyzed mice was statistically increased compared to control non-paralyzed mice. Conversely, mice that had recovered from paralysis were also statistically recovering from synaptic retraction. In another study, electromyographic assays were improved to measure the F-wave, which is an electrochemical circuit ascending from the point of electrode stimulation at the ankle, ascending to the spinal cord, through motor neurons, and back through peripheral nerves to the foot. F-wave electromyography was able to detect motor neuron deficits in ZIKV-, WNV-, and poliovirus-infected mice using the percentage of detectable f-waves in 50 repeated stimulations (% F-wave persistence). The F-wave assay was able to putatively detect proximal peripheral neuropathy using F-wave latency. The F-wave latency is the time required to complete the F-wave circuit. If neuropathy is present, F-wave latency will be increased. Through a series of experiments measuring distal nerve conduction velocity and proximal F-wave latency, it was observed that ZIKV infection in mice possibly causes neuropathy of the nerve rootlets coming from the lumbar spinal cord, whereas F-wave latency was not altered with WNV and poliovirus infections. Confirmatory histopathology will be required to confirm these findings.	Global Food Security and Hunger / #1

19.	***Research Impact:*** **Assessing Changing Precipitation Effects on Dryland Agriculture Production**	A. Kulmatiski is studying the effects of increased precipitation intensity on northern Utah's rangelands and dryland agriculture. At the dryland agriculture site (Clarkston, UT) soil moisture increased with experimentally increased precipitation intensity, but this did not affect wheat moisture, biomass or seed production. The lack of wheat response to increased precipitation intensity was surprising because a very large range of precipitation intensities was applied. Results suggest that winter wheat is highly resistant to variations in precipitation intensity and thus an excellent choice for mitigating the effects of anticipated increases in precipitation variability. Alternatively, wheat or crop varieties that can better respond to increased precipitation intensity may be more productive. A lack of winter wheat biomass and seed production response to increased precipitation intensity was corroborated by multiple repeated physiological measurements (NDVI, PRI, leaf temperature and root production). One potential explanation for the lack of winter wheat response to increased precipitation intensity and consequent increase in soil moisture is that weed moisture increased. It appears that weeds may have been able to out-compete winter wheat for increased soil moisture. Higher crop densities, more variable winter wheat phenotypes or more intense weed management may allow greater winter wheat production under increased precipitation intensity. Results demonstrated that increased precipitation intensity is likely to increase soil moisture availability. Increased soil moisture availability can be expected to increase plant productivity; however, this may not translate to increased crop production. First, precipitation events are expected to become both larger and fewer resulting in larger inter-precipitation periods (i.e., dry spells between rain events). These dry spells in some locations may decrease germination or early-season growth. Second, larger precipitation events are more likely to increase overland flow, particularly on steeper slopes. Overland flow will decrease infiltration, soil moisture and erosion. This experiment was performed on gentle (~5% slopes) and there was little evidence of overland flow. At the rangeland site, increased precipitation intensity also increased soil	Climate Change and Natural Resource Use / #2

		moisture availability. This resulted in increased shrub growth, but no change in grass or forb growth. These results are important because we are not aware of other studies that have tested the effects of precipitation intensity in a system that receives large amounts of snow. Also, results show that shrubs can respond quickly to these changes. These results, therefore, suggest that increasing precipitation intensity may help explain shrub encroachment seen in many high elevation and high latitude sites around the world. Taken together, results suggest that increased precipitation intensity is likely to increase soil moisture availability and plant productivity in northern Utah. There are, however, several important caveats to this finding. First, as the atmosphere warms, evapotranspiration will increase and some of this soil moisture will be lost. Second, not all plants will benefit from increased soil moisture. In a dryland winter wheat system, weeds benefited more than crops. In a rangeland system, shrubs benefited more than forage plants. Third, greater variability in precipitation timing may harm some plant species that rely on more consistent shallow soil moisture (i.e., shallow rooted species). Finally, greater precipitation intensity is likely to increase overland flow and erosion on steep slopes.	
20.	***Research Impact:*** **Decadal Scale Patterns in Climate and Connections to Water Use by Plants**	L. Hipps studied the evapotranspiration (ET) of both irrigated crops and urban turfgrass. The studies included: state-of-the-art measurements of ET with eddy covariance and energy balance approaches; connections of ET to variations in weather and climate, complexities of measurements and models of ET for vineyards; and the ability of remote sensing models to simulate the actual measured values. The related externally funded projects that were integrated with this one included: a NASA study of evapotranspiration (ET), and use of remote sensing-based models in vineyards; and a Bureau of Reclamation (BOR) project to measure the ET of irrigated lands at four sites in the Upper Colorado River Basin, in order to validate various ET models; and a US Golf Association funded project to study ET of turfgrass and use of remote sensing models. These different locations, vegetation types and projects all shared the goals of quantifying the water use by ET, documenting the mechanisms that control the size of ET, and validating some emerging ET models to simulate its variations in	Climate Change and Natural Resource Use / #2

		space and time. The importance of temperature via its effects on how far the air is from being saturated (saturation deficit) is well understood theoretically. The project used climate data in Utah to show that the size of this value in the summer has grown significantly over the last 30 years, consistent with projections of climate models. This strongly suggests that the demand for water for irrigation will continue to grow larger, assuming the water is available. We also found that periodic transport of warm air from more arid surroundings can have a significant effect on ET at times, making modeling more difficult. The ET measurements of turfgrass were among the very first using the credible and “gold standard” approach of eddy covariance. The results showed that the daily values were quite significant, and varied with weather conditions, so that the historical simple models based on “reference ET” are not reliable. In addition, a graduate thesis used a published remote sensing model for ET using satellite data, demonstrated reasonable agreement with the measurements. However, more data and comparisons planned for that portion of the study, are needed to draw more general conclusions. In addition, future work will study the integration of models of the vegetative physiological responses to drier air (stomatal conductance), with the Penman-Monteith equation for transpiration in the case of irrigated turfgrass. Validating such a model will allow the simulation of how water use would respond to warmer summers of the future. The ET of vineyards in California is shown to be a very complex biophysical process due to the large spatial variability of the vegetation cover and exposed soil in production vineyards. In addition, a graduate thesis found that during typical light wind conditions of that region, the ET was very intermittent. Large amounts of water were evaporated during very brief periods of each hour, while the remining time was rather quiet. The emerging remote sensing models for ET being validated, assume this is not the case, and that the process is regular in time. Results showed that these models performed rather well under	

		more steady conditions with larger winds, but much less accurately under the intermittent cases. The model developers are using these results in their future plans. Recently, we have directed attention to the microclimate within the vineyards, and how it responds to changes in the same processes that drive ET. Microclimate is a very critical, but often poorly quantified aspect of wine production and quality. The ET study for the BOR included four sites, one in each of the states of the upper Colorado River basin. The measurements provide hard numbers for the ET, that are being used to evaluate a range of models that predict ET. At present, a great deal of variation is seen in the ability of the models to reproduce the actual measurements. The studies are continuing. The combination of studies that have been woven into this project have demonstrated some key overall conclusions. First, accurate ET measurements using appropriate sensors and methodology conducted and analyzed by properly trained people is essential for any of the question being addressed. All estimates and models need reliable data to show that they are valid. Second, since the ET process is so complex, very simple approaches are not likely to be robust, and require a good deal of calibration with the measurements above. Finally, the remote-sensing based ET models have progressed to the point where they are serious candidates for operational estimates ET over space and time. However, much more validation is required over a range of surfaces. Other studies are already doing this work. A key will be to integrate the validation results with the model developers, to allow improvements to follow the findings.	
21.	***Extension Success Story:*** **Utah Water Watch Project**	Water quality protection and restoration are needed statewide. Effective education and data collection are critical components to understanding and restoring waterways. H. Braithwaite and the Utah Water Watch trained 109 volunteers, and these individuals proceeded to monitor water at 154 sites. Water quality data collected by volunteers are entered into an online database and shared with monitoring partners. Volunteers observe and measure changes in microbial parameters over time. As a result, they acquire a better	Climate Change and Natural Resource Use / #2

		understanding of the natural variability in aquatic systems, how different parameters are related, and how to identify situations where baseline values appear higher or lower than normal. Volunteers also help identify potential problems, such as harmful algal blooms, which they then report back to Utah Water Watch. For example, a volunteer found a harmful algal bloom in Newcastle Reservoir in September 2019. As a result, a Warning Advisory for anatoxin-a. Microcystin levels was issued in a timely manner.	
22.	***Extension Success Story:*** **Waterwise Landscape Design**	During 2019, J. Powell and colleagues worked with partners to develop waterwise landscape designs for six properties. The first property was a US Forest Service office and visitor contact station in downtown Moab, UT. The design was implemented in 2019, and the project is estimated to save over 400,000 gallons of water per year. Additionally, the project is designed to capture and infiltrate stormwater from the street during storm events. Thus, reducing irrigation demands from the plants and improving the hydrology of the greater watershed. The project demonstrates the functional and aesthetic benefits of a water-sensitive landscape. Further, Powell and C. Schaible provided design assistance to create a section demonstrating a model waterwise residential neighborhood.	Climate Change and Natural Resource Use / #2
23.	***Research Impact:*** **Managing Utah's Working Landscapes for Sustainable Provision of Multiple Ecosystem Functions and Services**	The goal of K. Hulvey's project was to collect ecological and social data that allows landowners, managers, and policy makers to develop management systems that lead to sustainable provision of ecosystem functions and services (ESF&S) in Utah's working landscapes. Activities and key impacts for each of the proposal's 6 objectives are summarized below. Objective #1 was to identify suites of ESF&S currently provided by UT rangelands. This study examined how three grazing systems (time-controlled rotation; continuous turnout; 4-pasture rotation) differ in supplying stakeholder valued ecosystem services (ES) including: clean water, healthy sage-grouse habitat, and forage recovery. Information produced is altering management in UT rangelands. In particular, the data are available to Agency partners for use in litigation that may occur with implementation of a new grazing system in the study area (The Three Creeks Project). Project data are also serving as a baseline that will allow Agency and ranching partners to	Climate Change and Natural Resource Use / #2

		determine if the new grazing system is meeting environmental goals. Collected water quality data has been used by the BLM to alter grazing on an allotment that is facing litigation and these data are available to Agency partners. Finally, project information was shared with ranchers and agency managers from NV, which led to relationship building and information exchange about the innovative grazing systems being developed in Rich County, UT. Objective #2 was to learn how landowners value and manage various ESF&S in UT landscapes. A social scientific study including regional rancher interviews and a survey sent to a broader Great Basin audience was designed. This study is one of the few peer reviewed studies on rancher perspectives of rangeland ES. This work has increased knowledge of how ranchers value ES, which in turn allows managers to create partnership programs that focus on managing ES in rangelands. The collected data was the basis of two grant proposals to further this work. Objective #3 was to determine how landscape linkages including ecological & social connectivity among ranches affect the production of ESF&S. This study Involved a review of surveys/interviews conducted for Objective #2, plus development of new methods to visualize and measure linkages. In addition, GPS collars were placed on cattle to examine their movement on rangelands. This information is being linked with NDVI data to learn how cattle movement across landscapes affects plant productivity (measured by NDVI). K. Hulvey's team will link this to ecosystem service production at the landscape scale. The collected cattle collar data is being complied to create 'hotspot' maps of cattle use in pastures at monthly intervals throughout the grazing season. These maps will help Agency managers understand where cattle spend time during the season and can highlight where to reduce disturbance during key times to improve ES provision. The collected data will also serve as a baseline, allowing Agency and ranching partners to determine if the new grazing system being implemented in Rich County is altering cattle distribution, and what this distribution's effect is on grassland productivity.	

		Objective #4 was to examine the ecological and social factors that contribute to resilient social-ecological working landscapes in terms of sustainable provision of suites of ESF&S. This study used data collected as part of Objective #1 to examine the resilience of rangeland streams to different grazing durations. The team also examined how grassland restoration of native forb species changes under predicted climate variation – particularly the timing and intensity of rain events. A greenhouse experiment focused on establishment of two native forbs used in rangeland restoration projects, across three soil types common in rangelands, under four different watering treatments that simulated changing climate. Native forbs provide a suite of ES in rangelands including pollination services, wildlife habitat, and invasion resistance to weeds. This study resulted in some of the only information on the topic of how restoration efforts might be affected by climate change in northern UT. A key impact from this work was the finding that grazing duration can alter resilience of streams to water quality fluctuations. This information will help support the planned grazing system change in Rich County by indicating that the new system can improve water quality. Objective #5 was to find opportunities for altering management to sustainably provide desired suites of ESF&S. This was accomplished by participating in: field tours and Resource Management Meetings, organized mixed agency meetings to share data, private meetings with agency managers to share results, and discussions with ranchers to explain the research. Through these meetings partnerships were established with managers and ranchers that have led to trust and the ability to contribute to innovative solutions for managing public grazing lands. Specific outcomes include: Development of rangeland monitoring protocols that complement data collected by other groups so that agencies have more data to use when making management decisions and managing litigation; direct changes in management on an allotment in Rich County that was under litigation; a better understanding of how a new grazing system implemented in Rich County is affecting environmental objectives; and linking ranchers in NV with collaborators in UT so they can share ideas on innovative land management approaches.	

		Objective #6 was to expand UT-based research to assess how rangeland management affects provision of ESF&S in other US regions and working landscapes around the world. First, data from a 10-year, re-forestation study in Australia that focused on how planting a diversity of tree species can restore multiple ES was analyzed. Second, a network with ranchers and agencies in NV was established to share current work in UT and create opportunities to expand this work. Key impacts include ongoing synthesis of the Australian restoration study, with peer reviewed papers in process, plus introducing key collaborators in NV and UT to develop future projects.	
24.	***Extension Success Story:*** **Facilitating the Relationships Between Cattle and Sheep Producers and Government Agencies**	Grazing and forage production on public and private land dominate agriculture activity. Over 15,000 head of cattle and sheep graze on local pastures. Because a large percentage of land is federally owned, long term success and sustainability depend on the relationships between the governing agencies and private producers. Extension continues to work to facilitate the relationship between county and state level public agencies and producers to ensure sustainable use and conservation of rangeland resources. J. Gale works with elected officials to influence federal land management decisions, provide local support to federal land managers, protect multiple land use, and maintain access to public lands. As a result, congressional members demonstrated an understanding of Utah's public land natural resource issues. Also, Gale included conservation organizations and other special interest groups in a collaborative process with elected officials for conservation and multiple land use. There have been proactive management on portions of national forests and BLM field offices administered lands as an outcome of collaborative projects.	Climate Change and Natural Resource Use / #2
25.	***Research Impact:*** **Determining How Increasing Precipitation Intensity Will Impact Rangelands in Utah**	K. Beard studied the impact of precipitation intensity on rangelands in Utah. Activities and key impacts for the project's 2 objectives are summarized below. Objective 1 was to test the effects of increased precipitation intensity on rangeland plants, soil and hydrologic processes. This experiment commenced in August 2014, with construction of 11, 8 m x 8 m shelter plots and collection of preliminary data. Increased precipitation intensity treatments caused greater shrub growth for sagebrush and deeper root growth in a shrub-steppe	Climate Change and Natural Resource Use / #2

		ecosystem. This research represents a significant change in knowledge because no previous studies show this result to this treatment in this ecosystem type. More specifically, the results provide rare evidence of the effects of increased precipitation intensity on woody plants in a system that receives large amounts of precipitation as snow. Results suggest that intact shrub-dominated systems can respond positively and quickly (< 2 year) to increased snow and rain intensity. Results also provide evidence for a potentially important mechanism of shrub encroachment in high elevations and latitudes. Objective 2 was to test the effects of reduced winter precipitation in the first year, and drought thereafter, on rangeland plants and soil. This objective meets the goals of the International Drought Experiment (IDE) Network of which our site is part. There were two experiments under this objective: a 1-yr snow removal experiment, and a 4-year drought experiment to test the effects of increased frost and drought stress on rangeland plants. In seasonally snow-covered regions reduced precipitation also reduces snow cover, which can increase soil frost depth, decrease minimum soil temperatures and increase soil freeze-thaw cycles. In addition to the effects of reduced precipitation on plants via drought, freezing damage to overwintering plants at or below the soil surface could further affect plant productivity and relative species abundances during the growing season. Both reduced rainfall (via rain-out shelters) and decreased snow cover (via snow removal) were examined at 13 sites globally as an add-on to IDE, a coordinated distributed experiment. Across all sites, there was a significant correlation between the snow removal effect on minimum soil temperature and the effect on subsequent plant biomass. Across sites, there was no significant correlation between the rain-out shelter effect on soil moisture and the effect on plant biomass. Overall, results reveal that reduced snowfall, when it decreases minimum soil temperatures, can explain a substantial component of the total effect of reduced precipitation on plant productivity.	
26.	***Extension Success Story:*** **Aspen Biodiversity**	Regeneration and recruitment of Quaking Aspen throughout the West is decreasing, resulting in loss of diverse Aspen populations throughout the West. This biotype exhibits the greatest amount of biodiversity compared to other	Climate Change and Natural Resource Use / #2

		biotypes in alpine and subalpine mountainous habitats. As a direct result of efforts by Extension and the Monroe Mountain Working Group, the US Forest Service (FS) together with Utah Forestry, Fire and State Lands (FFSL) have been able to treat 13,044 acres of mixed conifer/Aspen forest using prescriptive fire in 2019. Additional acreage was treated through mechanical thinning. This also reduces the risk of damage to private inholdings on the mountain. Over 25,000 acres have been treated since the December 2015 Record of Decision on the EIS was signed and implementation began.	
27.	***Extension Success Story:*** **Agricultural Sustainability**	D. Morgan assessed the needs of landowners, farmers, and producers, then developed educational resources to meet those needs. Morgan found there was a need for education on weed management, pasture management, reseeding, and sustainable land use practices. As a result, new programming and partnerships for agriculture sustainability were created to address land use issues. Morgan developed and delivered workshops on biochar and hazardous fuels removal, pesticide management, spraying and bees, and weed management. Evaluation results indicated participants showed a high level of interest and demonstrated knowledge gain in land use topics discussed in the workshop. Morgan also conducted pasture visits, soil testing demonstrations, and created a working group for Aspen tree regeneration.	Climate Change and Natural Resource Use / #2
28.	***Research Impact:*** **The Origins and Consequences of Sociodemographic Disparities in Obesity**	E. Reither and his team have been: (1) examining behavioral and biological origins of obesity disparities; and (2) tracing the health consequences of obesity disparities. Data analysis has revealed that within-person changes in sleep quality are significant predictors of weight change over the adult life course. This finding makes an important contribution to the literature in this area, which is currently beset by contradictory findings and less robust research methods (e.g., cross-sectional associations of between-person differences). Reither's team has also continued to study neighborhood contributors to poor sleep hygiene among young children, which – as just noted – has implications for the etiology of obesity. Adding to previous findings, recent analyses of data from the kindergarten cohort of an Early Childhood Longitudinal Study show that neighborhood conditions (e.g., social disorder) partly account for large racial/ethnic sleep disparities. With regard to the health consequences of obesity, the research team is examining how obesity and obesity-related	Childhood Obesity, Nutrition, and Community Sustainability / #4

		conditions (e.g., heart disease and diabetes) contribute to overall wellbeing, as well as racial/ethnic disparities in life expectancy. Although specific findings vary across study populations, in each case there was evidence that causes of death related to the U.S. obesity epidemic explain a sizable portion of racial/ethnic disparities in life expectancy.	
29.	***Extension Success Story:*** **Food, Fun, and Reading Classes**	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. USU Extension takes a comprehensive approach to reach target audiences through various extension methods and activities in all 29 counties. D. Christensen and colleagues taught Food, Fun, and Reading lessons to over 900 children throughout the state. Evaluation results showed 48% of parents reported that their child talked about healthy foods more frequently after participating in Food, Fun & Reading classes. Children were willing to try a wider variety of foods and were willing to adopt health eating behaviors months after completing the Food, Fun, and Reading class.	Childhood Obesity, Nutrition, and Community Sustainability / #4
30.	***Extension Success Story:*** **4-H Community Garden Program**	T. Killian and the TRY Team worked with 4-H youth to grow food and learn gardening principles. Killian and the team delivered hands-on experiential learning activities with youth over a six-week practical program. The program was designed provide youth with opportunities to manage a community garden and grow their own food. Post-evaluation indicated youth learned principles of gardening and the benefits of growing their own produce, as well as the health benefits of eating fresh fruits and vegetables. Youth involved expressed a high level of enjoyment of gardening and learning about healthy eating principles.	Childhood Obesity, Nutrition, and Community Sustainability / #4
31.	***Research Impact:*** **Impact of Background Diet on Efficacy of Bioactive Food Components for Prevention of Colon Cancer**	A. Benninghoff and colleagues have been studying the effects of bioactive food components on the development of colon cancer. Over the course of the project, the major goal was to determine whether supplementation with various functional foods or dietary bioactives would suppress colon tumorigenesis in a Western diet model of inflammation-associated colorectal cancer, including dietary supplementation with tart cherries or black raspberries (both rich in anthocyanins, though with differing chemical profiles) or beta-carotene; calcium and vitamin D; or methyl donor micronutrients (B6, B12, choline, etc.). Additionally, the research team performed histological	Childhood Obesity, Nutrition, and Community Sustainability / #4

		analysis of colon tissues and gene expression analyses to understand how the Western diet may enhance colon tumorigenesis. As work progressed, a new focus on the contribution of the gut microbiome became increasingly relevant for this disease model. The aim of the first experiment was to determine whether dietary supplementation with tart cherries prevents colon tumor development in mice consuming a Western diet compared to a prudent diet. The hypothesis was that dietary supplementation with freeze-dried whole tart cherries would suppress development of colon tumors in a model of inflammation-associated colorectal cancer. A 2x2 factorial design was employed, whereby mice were fed either AIN93G (optimized for rodent health) or the total western diet (TWD), each with and without Montmorency tart cherry powder added to the diet for a total anthocyanin content of 188 mg/kg diet. Mice were initiated with 10 mg/kg azoxymethane and provided 1% dextran sodium sulfate (DSS) in their drinking water for 4 weeks to promote colonic inflammation and tumorigenesis. Necropsy and tumor assessment were performed after 15 weeks of treatment. TWD consumption markedly enhanced colitis activity (40-fold increase) compared to mice fed AIN93G. Moreover, TWD-fed mice had significantly higher histopathology scores for inflammation and mucosal injury during the period of colitis and, importantly, during the recovery phase of this disease model. Colonic inflammation in TWD-fed mice persisted to the end of the study (day 105), whereas mucosal injury (save for sites of neoplasia) had resolved. Also, as expected based on prior studies, mice fed TWD had higher tumor multiplicity (near 6-fold increase) compared consumption of the AIN93G diet. The most important observation in this study was that supplementation with tart cherry powder caused a significant 40% reduction ($p<0.05$) in tumor incidence in mice fed AIN93G. However, tart cherries had no effect on tumor incidence in mice fed TWD. Also, tart cherry powder supplementation did not significantly affect histopathology scores for inflammation or mucosal injury nor tumor multiplicity or size as compared to AIN93G- or TWD-fed counterparts. Moreover, addition of the tart cherry supplement did not significantly affect colitis disease activity. These observations point to important interactions	

		between basal diets and dietary bioactive supplements and underscore the need for careful consideration of the role of basal diet in dietary chemoprevention studies in rodents. Black raspberries have demonstrated protective effects against colitis and/or colorectal cancer via their antioxidant and anti-inflammatory actions at the colon epithelium. Moreover, consumption of these foods can lead to changes in the composition of the gut microbiome. The goal of this study was to determine the impact of dietary supplementation with whole, freeze-dried raspberries on colitis and colon tumorigenesis in mice consuming a Western type diet. C57BL/6J male mice were fed a standard diet (AIN93G), the total Western diet (TWD), TWD+5% (w/w) black raspberry powder (BRB) or TWD+10% (w/w) BRB for 16 weeks. All mice were dosed with axozymethane and provided 1% dextran sodium sulfate (DSS) in drinking water for 10 days to promote colonic inflammation and tumorigenesis. Composition of the fecal microbiome was determined by standard 16S rRNAseq following two weeks of dietary treatment, during active colitis immediately following DSS treatment and again two weeks later during the recovery period. As expected, mice fed TWD alone had a markedly higher colitis disease activity index score as compared to mice provided the standard AIN93G diet. Also, consumption of the TWD markedly enhanced colon tumorigenesis compared to AIN93G controls. Supplementation of TWD with 10% BRB significantly reduced the symptoms of colitis compared to TWD alone. Moreover, by the period of recovery (14 days after DSS exposure), the disease activity index was significantly reduced in mice fed TWD supplemented with 5% or 10% BRB compared to TWD alone. Addition of 5% BRB significantly reduced tumor burden and 10% BRB reduced tumor multiplicity and burden, such that the cancer response was not different from the AIN93G-fed control mice. Consumption of BRB at diet-relevant concentrations ameliorated symptoms of colitis promoted by consumption of TWD, most notably during the period of recovery from DSS-induced gut injury, and suppressed tumorigenesis in this mouse model of CAC. Fecal microbiome profiles in mice fed diets supplemented with 5 or 10% BRB were distinct from those fed AIN93G or TWD diets, shown by significant differences in beta	

		diversity at each of the time points (unweighted unifrac distance, permanova p<0.01). During active colitis, alpha diversity was significantly reduced in mice fed TWD+10%BRB compared to TWD-fed positive controls (Chao1, p=0.04; Shannon, p=0.006). Also of interest, LEfSe analysis identified bacteria families Bifidobacteriacea, Streptococcaceae and Turicibacteraceae as discriminating taxa for mice fed TWD with BRB supplementation compared to those fed TWD. Consumption of BRB at diet-relevant concentrations altered the composition of the gut microbiome in favor of some known health-promoting bacteria, a change that may explain the suppression of colitis and colon tumorigenesis previously observed. In the final year of the project, the impacts of the Western diet on function of the colon epithelium were studied using a new transcript counting technology (NanoString) for quantiation of mRNA. Colon tissues were obtained from mice fed either AIN or TWD diets at three time points: 2 weeks of feeding prior to DSS treatment (Pre-DSS); immediately following a 10-day treatment with 1% DSS in drinking water to induce colitis (Colitis); and 14 days after cessation of DSS during the period of recovery (recovery). mRNA was isolated and subject to transcript counting using the NanoString PanCancer Immune Profiling panel for mouse, and data were analyzed using the Advanced nSolver software system. Exposure to the TWD induced expression of several genes of the interferon pathway after only two weeks of feeding prior to DSS treatment, suggesting that TWD may prime the colon tissues to be more responsive to injury – perhaps excessively so. That hypothesis was born out when assessing gene expression during colitis, with nearly 200 transcripts differentially expressed in TWD-fed mice compared to their AIN-fed counterparts, including genes associated with adaptive and innate immunity, interferon response, antigen processing, inflammation and MHC pathways. Of note, this dramatic over-activation of immune response persisted through recovery phase in TWD-fed mice, an observation that correlates very well with the persistent inflammatory response evident in other phenotypic observations, including colitis disease activity index and histopathological assessment of tissue inflammation and mucosal injury. These molecular targets are attractive for future work to	

		determine how functional foods, namely black raspberries, may alter gene expression in the colon to suppress tumorigenesis. This work is now ongoing as part of a new USDA NIFA grant.	
32.	***Extension Success Story:*** **Create Better Health Utah (SNAP-Ed)**	Low-income adults and youth are more likely to have poor quality diet and less physically active. This contributes to an increased risk of chronic health conditions, including obesity, Type II diabetes, heart disease, and certain cancers. Improving the dietary and physical activity behaviors of individuals through improved knowledge, skills, and access may improve individuals' health trajectories, outcomes, and overall quality of life. C. Coombs and colleagues delivered educational workshops for low-income families throughout the state, and evaluation results indicated most participants adopted healthy eating patterns after the program. Adopted behaviors include using MyPlate recommendations to make food choices, engaging in physically activity for at least 30 minutes five times per week, managing food dollars to last the entire month, and consuming fruit and vegetables daily.	Childhood Obesity, Nutrition, and Community Sustainability / #4
33.	***Extension Success Story:*** **Food $ense SNAP-Ed**	Over 14% of Utah households are food insecure and 13% are living in poverty (FRAC, 2014). E. Parkhurst and colleagues delivered a variety of Extension activities such as individual and family workshops, and public health interventions to tackle food insecurity through nutritional education to low income families. About 34 direct education activities were provided for Davis county which reached approximately 673 individuals. While participants demonstrated significant knowledge gain after these activities, several system-level changes were reported in communities, including prioritization of farm-to-table and availability of fresh and local produce, expanded use of standardized, healthy recipes, increased offerings of fresh produce in food pantry, creation of new food bank, pantry and distribution site, and expanded opportunities for parents and students to access fruits and vegetables from community gardens.	Childhood Obesity, Nutrition, and Community Sustainability / #4
34.	***Research Impact:*** **Sustainable Families, Firms and Communities in Times of Change**	Y. Lee has conducted several studies on community sustainability. A study on the impact of business ownership motives and goals on business success between Mexican American and Korean American families focused on how these two groups may have different business ownership motives and goals that could influence their business success. The findings of this study indicate that Mexican immigrant family business owners reported higher levels of family	Childhood Obesity, Nutrition, and Community Sustainability / #4

		life satisfaction as compared to Korean family business owners while most of the business-ownership motives were quite similar. This study concluded that business motives, family tension, satisfaction with community support, and business owners' human capital and business characteristics were important predictors of being successful business owners among Mexican and Korean immigrant business owners. The findings from this study can inform researchers and practitioners (i.e., educators, family professionals, and consultants), as well as government policy makers, on the factors associated with being a successful immigrant business owner from the perspective of entry motivation, family life satisfaction, and business success. Based on this study, the more successful immigrant family business owners become, in both business and family dynamics, the larger their collective economic and social contribution to businesses, community, and society can be expected. A study on community capital and small firm success focused on the relationship between community capital and small firm success surrounding a natural disaster. The results indicate that the effects of both individual and aggregate community capital were statistically significant in predicting firm success after a natural disaster. Specifically, the individual community capital (familiarity of neighbors, friends, and emotional attachment to the community) was positively associated with the perceived business success among the owners. The findings suggest that as firm owners perceived their community was strong, they had higher levels of perceived business success. The results also show that business owners' racial background, sole business ownerships, and older businesses decreased the level of perceived firm success, whereas business size increased the levels of perceived success. The findings from this research can provide insights for business consultants, community or organizational leaders, and policy makers to recognize the association between community capital, community leadership, and community unity to business success in the coastal area. This study supports the importance of community strength and its impact on business success after a natural disaster. It is also important for business owners to be aware that "communities without businesses" or "businesses without communities" don't exist.	

		A study on business owner and community involvement focused on the impact of business owner involvement in the community and community involvement in the business and how this 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 suggests that business owners' involvement in the community helps to build social capital and Corporate Social Responsibility (CSR). Family business owners in this study stated that they were willing to help other businesses in their community. This project showed that the interactions and relationships between a community and its family businesses can be crucial in growing and sustaining a family business. The findings from this research will be of interest to business and entrepreneurship professionals.	
35.	***Extension Success Story:*** **Rural Online Initiative**	The Rural Online Initiative (ROI) of USU Extension is a capacity building program created to strengthen the economies of rural communities. The ROI provides Utah's rural workforce and businesses with education, training, and services for online opportunities in remote employment, freelance work, and e-commerce. Between October 2018 to November 2019, the course accounted for 571 graduates. The ROI program served 15 rural counties in Utah during this period. On average, a graduate who found remote work experienced a 13% average increase in their monthly salary. Further analysis showed about two-thirds of graduates who found remote work believed their salaries would likely increase by 52% during 2020. This suggests the state government, cities, and counties can expect an anticipated increase in tax revenue from remote workers in the next fiscal year. Since starting remote work, 30% drove to a workplace, commuting on average 15 miles per day. This represents a 75% total reduction in the number of miles driven per week across all participants who found remote work. This equates to savings of $1,225 per month across all participants who found remote work due to lower fuel expenses. The number	Childhood Obesity, Nutrition, and Community Sustainability / #4

		of miles driven per month before and after participants found remote work decreased to 9,960. This equates to a total reduction of 3.37 metric tons of carbon emissions per month which helps promote clean air quality as remote workers drive fewer miles.	
36.	***Extension Success Story:*** **Mental Health First Aid Training**	T. Killian delivered several Mental Health First Aid trainings to communities in Juab county, UT. Evaluation reports showed these trainings provided participants with the confidence and strength to be able to combat issues of mental health, and empowered residents to seek mental health services instead of ignoring their symptoms. Killian also facilitated multiple Rural Stress Meetings and created partnerships throughout the state to collaborate in efforts to impact rural stress and farmer suicide. Meetings included sharing information with state departments and other counties to create a statewide strategy to support famers and those who live in rural communities. The overall goal is to build partnerships and create tailored mental health tool kits for those who work with farmers and community members in rural areas to help combat stress and mental health issues.	Childhood Obesity, Nutrition, and Community Sustainability / #4
37.	***Research Impact:*** **Early Family Building Behaviors and Subsequent Socioeconomic Well-being**	S-J. Lim studied the relationship between early marriage and subsequent socioeconomic well-being. The project objectives included: (1) documenting the prevalence and characteristics of early family building behaviors, with a focus on Utah and the Intermountain West relative to the nation as a whole; (2) identifying the predictors of early family building behaviors, with a particular focus on the role of selection into early family building behaviors by comparing the experiences of two birth cohorts and contrasting Utah and the Intermountain West with other regions; (3) tracing the consequences of early family building behaviors on subsequent socioeconomic outcomes, with a particular focus on gender differentials and the moderating effects of local context (e.g., religiosity, rural residence, level of female education and employment, local labor market conditions); and (4) examining two linkages between early family formation and later socioeconomic well-being, i.e., human capital accumulation (e.g., educational attainment and labor market experience) and family instability (e.g., high fertility, divorce). Research activities produced interesting cohort and gender differences in the	Childhood Obesity, Nutrition, and Community Sustainability / #4

		predictors of early marriage: higher income facilitated men's early marriage among the earlier cohort (NLSY79) but employment status was a more important predictor (for men's early marriage) among the more recent cohort (NLSY97). It appeared that one's employment status has become an important criterion for men's marriageability over time. This result was consistent with theoretical debates and empirical evidence on labor market polarization into good jobs and bad jobs and the spread of precarious employment and on shifting economic foundations of marriage in the context of labor market uncertainty and inequality. In addition, women's economic resources (e.g., income, employment status) were not related to the time of (early) marriage among both the NLSY79 and NLSY97 cohorts. This finding was again consistent with research evidence that women's economic conditions appear to be less relevant for marriage behaviors relative to men's. Linkages between early family formation and later socioeconomic well-being were examined. Marriage was defined as "early" if a respondent's age at first marriage was younger than the median age at first marriage in a given year (identified by sex and birth cohort). Findings from regression analyses (OLS models) using data from the NLSY79 revealed that early marriage was negatively associated with later socioeconomic outcomes. More specifically, early marriage, for both men and women, led to lower individual and family income at age 45. In addition, the mechanisms linking early marriage to lower socioeconomic status differed by outcome of interest: for individual income, early marriage seemed to interfere with human capital accumulation (i.e., education and employment), which in turn negatively affected income at the individual level. However, for family income, the posited linkages (human capital accumulation and family instability) did not explain the negative association between early marriage and lower family income at later ages. These findings had important implications by showing the mechanisms between early family building behaviors and subsequent socioeconomic outcomes. More importantly, the finding that human capital accumulation, i.e., education and employment, helped explain the negative association between	

		early marriage and later socioeconomic outcomes, regardless of gender added important knowledge to the literature on family, gender, and stratification. The additional knowledge gained from these research findings may contribute to family research by identifying determinants and consequences of early family formation behaviors. The study findings also have important policy implications since early family behaviors have been linked to negative outcomes for adults and children.	
38.	***Extension Success Story:*** **Celebrating Women Conference**	Women tend to play a central and critical role in the overall health of a family (Pew, 2015). However, mental health concerns such as anxiety and depression often disproportionately affect women (UDOH, 2017). E. Parkhurst and colleagues hosted the Celebrating Women Conference in 2019. The conference addressed various aspects of wellness, including financial wellness, stress management, positivity, and cultivating balance, while providing opportunities for women to connect with one another. Approximately 110 women attended, and the event is anticipated to grow in 2020. Evaluation data showed 71% of attendees believed their knowledge of overall health and wellness improved, and 100% of attendees reported they were likely to make a positive change based on something they had learned. Examples include a commitment to cultivate a new skill or hobby, eat healthier, communicate clearer, and discuss financial health with their spouse. Women indicated knowledge gain in healthy ways to manage stress, caring for their body in positive ways, managing the demands of multiple commitments/roles, creating a positive outlook, fostering healthier relationships, and finding passions in their life.	Childhood Obesity, Nutrition, and Community Sustainability / #4
39.	***Extension Success Story:*** **Utah Money Moms**	Utah Money Moms provides educational courses to empower participants for financial wellbeing. Led by A. Christensen, quantitative evaluation results from Utah Money Moms indicated widespread positive behavior change among participants. Follow-up evaluation results indicated most participants created financial goals, saved money for emergencies, paid down debts, reviewed and monitored their credit reports, took steps to prevent identity theft, implemented a monthly budget, prioritized purchases, tracked monthly spending, and decreased their overall expenses. The qualitative feedback was quite positive, one participant said, “Utah Money Moms has broadened my	Childhood Obesity, Nutrition, and Community Sustainability / #4

		view of what financial security should include. For example, identity fraud protection is an important part of keeping myself and my family financially stable. Utah Money Moms has provided tips how to do so." Another said, "It's given me the extra boost I need to work on our finances! A daily reminder is nice to help work toward our goal of becoming debt free. We've paid off $11,000 in debt this year." Someone else said, "Seeing the different, small Financial decisions that can be made has encouraged me to be more conscious of daily decisions."	
40.	***Research Impact:*** **The Impact of Agricultural Education Programs on Student Achievement, Attitude, and Career Aspirations in the STEM Areas**	Results of T. Sorensen's research have provided benefits to stakeholders of agricultural education programs. Overall, this research helped answer some big questions about the impact of agricultural education programs on student attitude and career aspirations related to STEM. Through this work, high school agriculture teachers and teacher educators, school administrators, and university recruiters and advisors have become better prepared to guide students towards STEM careers. The findings are also helping guide school based agricultural education (SBAE) programming towards impacting students in career decision-making in STEM areas. This study answered questions related to: (1) HOW and WHAT aspects of SBAE influence students to pursue a career in agriculture or STEM; and (2) the impact SBAE has on students after they graduate in terms of STEM achievement, graduation, and income. Findings show that SBAE does indeed have strong influence on students' STEM-related career decision-making. The study helped stakeholders better understand how science, math, and core academics are currently integrated, and the impact of that integration on STEM achievement and post high school success. Results showed that SBAE programs can have a positive impact on STEM achievement and post high school success (e.g., salary). Finally, results indicate that integrating agriculture and natural resources topics into post-secondary science courses improves non-science college majors' attitudes towards science and STEM. Furthermore, this study found that underrepresented minority students enrolled in STEM programs (post-secondary) face unique challenges that can impede their progress towards completing their STEM related degree and pursuing a STEM-related	Childhood Obesity, Nutrition, and Community Sustainability / #4

		career.	
41.	***Extension Success Story:*** **Latino Youth Leadership Development**	Latino youth represent 16% of children in Utah's K–12 system (Pew Research Center Hispanic Trends, 2014). Given these changing demographics and the need to prepare youth for the workforce, C. Wille strengthened educational resources and built local, state, and national relationships to engage Latino youth in leadership development, higher education, and college and career awareness. C. Wille partnered with the Latinos in Action (LIA) organization and hosted a Latino youth conference in 2019. About 270 Latino youth from across the state attended the three-day program. Evaluation results indicated more than half the number of participants perceived their knowledge on the eight core topics improved after the conference. Particularly, almost all participants (92%) indicated their knowledge on using different communication strategies as a leader improved after participating in LIA 2019. Further, most participants perceived their knowledge to put other members first when making team decisions (87%) and trust members to handle important team responsibilities (84%) improved after the conference. Overall, approximately 3 out of every four participants (74%) perceived their knowledge of all core topics covered improved after LIA 2019. In addition, a closer look at the results showed youth experienced relatively high and stable improvements in their knowledge of the core topic areas regardless of their demographic background. In other words, there were positive knowledge gain on all topic areas irrespective of a student's personal characteristics.	Childhood Obesity, Nutrition, and Community Sustainability / #4
42.	***Extension Success Story:*** **4-H STEM Program**	A 2019 statewide needs assessments showed the need for college and career readiness programming. Utah 4-H is in the initial stages of developing a program to meet the needs of 4-H youth. In prior years, there were no STEM 4-H programs or after school programs in North Summit or South Summit Schools. D. Morgan piloted a STEM program in the county in 2019. The youth program offered five camps and included learning experiences relating to a variety of topics in animal science and natural science. Evaluation results indicated all camps were attended in full capacity (14 to 24 youth per camp). Youth stated they were more interested in 4-H and STEM after participation in	Childhood Obesity, Nutrition, and Community Sustainability / #4

		the camps. Participants were excited to enroll in more STEM 4-H camp in the future and showed a high level of interest in learning more about nature, space, ecosystems, pets/small animals, and large animals.	
43.	***Research Impact:*** **Gestational Diabetes and Risk of Orofacial Cleft Birth Defects and Fetal Programming of Obesity and Diabetes Mellitus in Offspring**	R. Munger and colleagues have continued analyses of genetic data related to gestational diabetes (GDM) from the International Genetic Epidemiology study of Oral Clefts, a part of the Gene-Environment Association Studies Initiative (GENEVA) of the National Institutes of Health. This study is a multi-center, international study of samples from Europe, the U.S., China, Taiwan, Singapore, Korea, and the Philippines. The study design is based on trios of children with an isolated orofacial cleft and their mothers and fathers using genome-wide association (GWA) data. A recent meta-analysis has provided evidence of significant associations between impaired vitamin B12 status and gestational diabetes. While broadly interested the associations between orofacial cleft birth defects and genes known to be associated with gestational diabetes, recently the primary focus has been on leptin and adiponectin genes and potential interactions with impaired vitamin B12 status and other nutrients in folate-related one-carbon metabolism. Recently biomarker assays of vitamin B12 status in samples from a case-control study in India, found associations between poor B12 status and risk of orofacial clefts. Orofacial clefts (OFCs) occur at a higher rate in Utah than any other state and the reasons are unknown. Previously it was 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. It was 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 placental tissues, may be important as an early biomarker of maternal metabolic abnormalities in early pregnancy, before the detection of overt GDM. In the past year 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 increasing with risk of both GDM and OFCs, hence strengthening the	Childhood Obesity, Nutrition, and Community Sustainability / #4

		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 gestational diabetes, and measures to reduce the risk of gestational diabetes including the reduction of obesity.	
44.	***Extension Success Story:*** **Nutrition Education for Adults**	M. Jewkes and colleagues delivered nutrition education programs to adults in the Salt Lake area. Evaluation results indicated participants who attended the nutrition classes experienced an increase in knowledge and were more likely to adopt healthy eating behaviors. Follow-up evaluation indicated most participants had enough food to last through the month, ate more fruits and vegetables, better managed their food budgets, adjusted meals to reduce food waste, followed USDA food safety guidelines when preparing foods, used nutrition fact label to make food choices, and were physically active for at least 30 minutes five days a week.	Childhood Obesity, Nutrition, and Community Sustainability / #4
45.	***Extension Success Story:*** **Health and Wellbeing Program**	High obesity rates, rising health care costs, chronic diseases, and increasing stress levels negatively affect personal and family health and wellness. Through a large health and wellbeing program, C. Nelson delivered educational workshops to families to assist them in forming healthy habits and living an active lifestyle. Both youth and adults participated in the five-month program to help increase healthy behaviors and mental wellbeing. Health assessments were completed at the beginning and end of the program to monitor progress. Results showed participants improved their wellness in several areas. Participants report better nutritional intakes, higher physical activity, lower stress levels, increased water consumption, and weight loss.	Childhood Obesity, Nutrition, and Community Sustainability / #4
46.	***Research Impact:*** **Evaluation of Native Wild-growing Utah Berries as Potential Food Antioxidants**	K. Allen has been investigating the potential use of wild berries - Silver buffaloberries (Shepherdia argenta), River Hawthorne berries (Cragaegus douglasii var rivularis), and Skunkbush berries (Rhus trilobata) - as food antioxidants. Freeze dried, vacuum packaged berry powders were stored at 4°C for 2, 4 and 6 months then analyzed for antioxidant content. Indicators of two types of antioxidant potential, radical scavenging and metal binding, were examined at each time point. Radical scavenging potential measures included	Food Safety / #4

		pigment content (anthocyanins and carotenoids), oxygen radical absorbance capacity (ORAC), and ferric iron reducing antioxidant potential (FRAP). During storage, anthocyanins degraded significantly ($p < 0.05$) after 4-6 months of freezer storage but no change was seen in carotenoid content. No significant changes in ORAC or FRAP during freezer storage were observed. Overall, river hawthorn and silver buffaloberries were found to have the highest antioxidant content from the 2016 harvest, regardless of storage time ($p < 0.05$). Because of their high antioxidant content, river hawthorn and silver buffaloberries were selected for use in fresh ground meat studies. Samples of ground beef chuck or ground boneless and skinless chicken thigh were packaged with 0.5% or 1% (w/w) freeze-dried berry powder, then stored at 4°C and analyzed at days 1, 4, 7, 10 and 14. Both berries delayed the oxidation of lipid (rancidity development) and oxymyoglobin (loss of red color) in both chicken and beef ground patties. Buffalo berry increased yellowness of chicken patties, though neither berry significantly changed the instrumental color of ground beef patties. Buffalo berry at 1% preserved oxymyoglobin levels for 10 days in beef (6 days longer than other treatments or the control), and both berries maintained rancidity levels within acceptable levels during the 14 day storage period (< 1 mg malondialdehyde / kg of meat) as compared to the control which showed signs of rancidity by day 7. No differences in bacterial counts (spoilage) were seen between treated patties and untreated controls for either berry, indicating that while the berry powders did not prevent bacterial growth it also did not introduce additional bacteria into the meat. Overall, either berry could be used as an effective antioxidant in beef. While antioxidant activity was seen in poultry, the naturally light color of the meat may be unacceptably changed by the highly pigmented berry powders.	
47.	***Research Impact:*** **Improving the Microbial Quality of Milk by Combining a Novel Technology, Ultrasound, with Pasteurization**	S. Martini and M. Walsh have been studying a novel method for reducing microbial contamination in milk. Thermophilic bacteria and spores survive pasteurization and reduce milk and milk product quality. This research investigated the use of thermosonication (sonication combined with heat) as a processing treatment for milk to reduce the thermophilic spoilage microbial population allowing for an extended shelf live and improved quality without	Food Safety / #4

		affecting milk properties. The first objective was to evaluate the effect of thermosonication in batch and a continuous flow system on the survival of thermophilic and indigenous milk microflora. The second objective was to evaluate the effect of thermosonication in a continuous pilot scale flow system that simulated high-temperature short-time (HTST) pasteurization on the shelf life and sensory properties of milk. Thermosonication in a continuous system coupled with pasteurization conditions successfully improved the shelf life attributes of whole milk during storage as compared to pasteurization alone which could potentially increase the shelf of milk by 2 weeks. The average microbial count was lower for thermosonicated samples as compared to control throughout its shelf life. Shelf life of control and thermosonication samples was estimated to be 4 and 6 weeks, respectively. The pH of milk for both control and treatment were not significantly different immediately after processing, but decreased during the shelf life, with thermosonicated samples having significantly higher pH values as compared to control at respective weeks. The free fatty acids (FFA) content increased over shelf life with thermosonication samples having significantly lower FFA at the end of the shelf life. The first consumer panel showed significantly lower scores for overall appearance, smell, flavor, and overall liking of treatment samples but not for color. Panelists commented on thermosonication samples having an off flavor, which when further investigated in a focus group seemed to decline after 2-4 days. The second consumer panel performed on control and treatment samples on day 1 and day 4 after processing showed no significant difference between treatment samples on day 4 as compared to control samples on day 1 and 4.Therefore, application of thermosonication in a continuous system using practical residence times (10-15 s) coupled with pasteurization may improve the overall milk quality and potentially increase the shelf life of milk. Future studies should focus on investigating thermosonication conditions for industrial applications and changes in sensory attributes in scale up systems.	

48.	***Extension Success Story:*** **Food Safety and Preservation**	The CDC estimates 1 in 6 persons in the US suffer from a foodborne related illness annually. Improperly home-canned foods continue to be a leading cause of foodborne botulism in the US. According to a 2019 statewide needs assessment by USU Extension, food safety ranks as one of the top four critical issues by Utah residents. USU Extension Facebook Live's "All About Apricots" highlighted preservation methods for the apricot harvests of 2019. It had over 4,425 views with 509 engagements. Further, C. Merrill delivered workshops and demonstrations to local canning suppliers. Merrill also appeared on The Utah Public Radio for segments on food safety with turkey during the holidays. Segments were aired during All Things Considered and Morning Edition. C. Merrill canning and preservation food safety workshops reached over 400 individuals in 2019.	Food Safety / #4
49.	***Extension Success Story:*** **Food Safety Workshops**	According to the USDA food safety recommendations, bacteria, yeasts and molds can grow in home-canned foods if not preserved properly. In addition, low-acid foods are at risk for clostridium botulinum which can grow into the food-borne illness botulism. M. Jewkes provided food safety workshops and demonstrations to individuals and families. These activities focused on reducing food waste, food preservation, and canning. Evaluation results indicated participants experienced significant knowledge gain in all areas of the Master Food Preserver course, and most indicated a strong intent to adopt the recommended practices.	Food Safety / #4