

USDA NIFA

Contributing Organizations

- University of Vermont

Directors

- Fitzroy Beckford - Research & Extension Signed
- Jane Kolodinskyy - Research Signed

Overview

The Vermont Agricultural Experiment Station (AES) and UVM Extension (EXT), housed within the College of Agriculture and Life Sciences (CALs), integrate higher education, research, and outreach to meet the changing needs of Vermont citizens, communities, and organizations. Together, we work to protect and enhance a quality of life characterized by a healthy natural environment, vibrant economy, strong sense of community, resilient youth, and a deeply ingrained connection to agriculture.

Through multidisciplinary work and the integration of education, research and outreach, our efforts address the following critical issues in our state:

- Sustainability of Vermont agriculture, food, and forests
- Resilience of families and individuals
- Development of communities
- Stewardship of the natural environment
- Foundational and exploratory research in agriculture
- Nutrition, food safety and food security
- Animal health and production

In late 2020, CALs launched a Strategic Planning process to guide our efforts toward the following goals: 1) build on our reputation for exceptional research and scholarship to maximize local to international impact; 2) develop and support a dynamic community of students and alumni who make a difference in the world; and 3) create a culture of belonging that affirms the experiences and identities of diverse faculty, students, staff, and community partners.

Our Vermont Agricultural Experiment Station is home to faculty in the departments of Animal and Veterinary Sciences, Community Development and Applied Economics, Nutrition and Food Sciences, Plant Biology, and Plant and Soil Sciences. In FY21, 42 AES faculty conducted 28 Hatch and 14 Hatch Multistate projects addressing the critical issues of our state (as named above).

More than 150 UVM Extension specialists and professionals are located throughout the state. Among Extension's facilities are 11 field offices, a state Director's Office, one research farm, and an agricultural engineering lab. These people and resources provide solutions to contemporary challenges by integrating higher education, research and

outreach which helps Vermonters in all 14 Vermont counties make sound decisions about their families, communities, businesses, and the natural environment. Notably, user access to these farms, offices, and training facilities only happens because they are leased from private real estate providers and landowners.

In FY21, UVM Extension offered 300 significant educational events (educational programming of six or more hours), serving 3,175 non-traditional students. Thousands more learned by participating in webinars and workshops, through direct consultations or on-farm technical assistance, conferences and other educational events and publications. *Across the Fence*, Extension's signature farm, home, and community television show on WCAX-TV in Burlington, produces over 260 shows a year and reaches an estimated 15,000 households each day plus several thousand additional subscribers and followers via YouTube and Facebook.

Regardless of the spending demands placed on its resources, UVM Extension delivers high-level science-based, research driven programming and support in traditional and sustainable agriculture; 4-H youth development, family and farmworker outreach; horticulture; forestry business; water conservation and management; soil, nutrient and grazing management; food system education; and farmworker/migrant worker education.

The COVID-19 pandemic continued to impact our operations this year. While many research efforts were delayed and in-person activities limited, we recognize that the accomplishments of our faculty, staff, and partners were significant and valued.

Critical Issue: Animal Health and Production

The following ongoing AES research projects are addressing our critical issue of Animal Health and Production:

National Animal Genome Research Program, *ongoing research directed by Stephanie McKay, Ph.D.*

The goal of this project is to enhance annotation of epigenetic and epitranscriptomic elements in cattle and sheep genomes. Data generated from this project will be contributed towards the Functional Annotations of Animal Genomes (FAANG) project to enhance the bovine and ovine reference genomes. These tools and resources are utilized by academia, industry, and government researchers whose research enables enhanced livestock production and animal health.

Influence of diet on the rumen metaproteome, *ongoing research directed by Sabrina Greenwood, Ph.D.*

To improve sustainable productivity of dairy herds, we need to develop a better understanding of how the diet impacts rumen function. This project is aimed at characterizing how diet profile impacts the rumen metaproteome of dairy cows. Additionally, we aim to identify milk protein biomarkers that are indicative of rumen microbial protein profiles and rumen performance to create a non-invasive approach that can be used on-farm for herd assessment of rumen health. To date, we have completed proteomic analysis of the rumen metaproteome of lactating dairy cows fed different levels of starch and fiber. As we bring the experiments to full completion, we will continue to disseminate the research through presentations and written formats, which creates opportunity for broader impact and adoption.

Contributions to the Hatch Multistate project NE1748: Mastitis Resistance to Enhance Dairy Food Safety

- **Epidemiology and ecology of antimicrobial resistant Staphylococci on dairy farms**, *ongoing research directed by John Barlow, Ph.D.*

Bacteria in the *Staphylococcus* species group, including *Staphylococcus aureus*, are a major cause of mastitis leading to decreased productivity of dairy cattle, and are a group of pathogens of human public health concern. Antibiotic resistance is also an animal health and human health issue associated with this group of pathogens. There is limited information on the source of and spread of antibiotic resistant staphylococci on dairy farms. This project uses whole genome sequencing to explore the strain diversity and host specificity of antibiotic resistant staphylococci isolated from cattle and humans on dairy farms in Vermont that make farmstead cheeses.

- **Mastitis Resistance to Enhance Dairy Food Safety**, *ongoing Multistate research directed by Feng-Qi Zhao, Ph.D.*

Mastitis is inflammation of the mammary gland resulting from intramammary bacterial infection. It is the most widespread and costliest disease in the dairy industry in the US and imposes approximately \$2 billion of economic losses annually. The major cost of the losses is the reduced milk production in infected cows, but the underlying mechanisms remain to be elucidated. This study provides insight into the individual and combined effects of bacterial toxins and inflammatory cytokines on bovine mammary epithelial cell (MEC) survival and function. This will lead to the development of new interventions to reduce the damage of mastitis to the mammary gland and losses in milk production. Our findings provide candidates of biomarkers and targets to diagnose and treat mastitis in cows. The results have been published in a peer-reviewed scientific journal which is accessible to the public. The findings have also been presented in scientific meetings, including the ASAS Lactation Biology conference.

Critical Issue: Development of Communities

The following UVM Extension Programs made contributions toward our goal of "engaging with communities to support leadership development, capacity building and diverse voices in decision making" this year:

- Leadership Development
- Master Gardener
- Migrant Education
- Municipal Officer and Non-Profit Education
- PROSPER: Drug & Alcohol Prevention
- Tourism and Recreation
- Urban & Community Forestry

In total, these programs delivered 7,484 educational events (i.e., workshops, classes, consultations, presentations) that directly reached 13,283 participants. An additional 2,783 contacts engaged with the 58 publications produced by these educators.

Some program and project highlights from FY21 include:

- The black ash, an integral part of Vermont's environmental habitat, has deep cultural significance for the Abenaki and other indigenous people who use splints from these trees for basket making. The arrival of the emerald ash borer in the state has put all ash trees at risk, prompting the Vermont **Urban and Community Forestry** program and others to support efforts of local indigenous people to harvest black ash

for splints for baskets and to save seeds to preserve the genetic diversity of local trees for future replanting.

- This year, the **Migrant Education Program** (MEP) was able to successfully recruit 302 students. This number is particularly impressive given staff's limited ability to conduct identification and recruitment efforts due to COVID-19. Staff were able to recuperate reduced student numbers that occurred in the 2019/20 reporting year when we saw a decrease to 276 students due to the pandemic. The Identification and Recruitment Coordinator developed a COVID-19 recruitment plan to ensure staff were able to conduct recruitment efforts both effectively and safely. In addition, MEP hired a Recruitment Specialist during the summer months, the busiest time for identifying eligible students. Of 116 school aged children enrolled in MEP, 114 demonstrated school readiness, advancement and/or completion. MEP was able to provide especially strong support to the eight graduating seniors to ensure they successfully completed high school.

Critical Issue: Foundational and Exploratory Research in Agriculture

The following AES research projects concluded in FY21:

- **Improving Forage and Bioenergy Crops for Better Adaptation, Resilience, and Flexibility**, *research directed by Eric Bishop Von Wettberg, Ph.D.*
This research aims to improve the rotational value of pea as a legume cover crop due to its contributions to food security, resilience against climatic change and fluctuations, and to nutrient management. Legume cover crops have the ability to increase soil fertility and subsequent crop yields at lower costs and environmental risks than fertilizers. This project trailed over 20 cultivars of winter tolerant peas as legume cover crops in Vermont and are taking a few forward as potential double crops. Double cropping, although common in more tropical or southern areas, is novel in Northern New England, and may greatly improve vegetable farm finances and productivity. This and other results from the research have been shared with farmers via the "Across the Fence" television show, radio interviews, two field days, several conferences, and more. The scientific community has been reached via journal articles and scientific conferences.
- **Analysis of a novel endosomal trafficking pathway critical for growth and cell wall organization in plants**, *research directed by Mary Tierney, Ph.D.*
The ability of plants to control the selective degradation of proteins, the secretion of new plasma membrane and cell wall proteins, and the targeting of proteins to various compartments within a cell, is essential for plant growth and the interaction of plants with their environment. This project furthered understanding of the cellular mechanisms that modulate wall organization and growth in plants through endosomal trafficking. Results of this research have been presented at national and international meetings (Pan-American Plant Membrane Biology Workshop), the Midwest Plant Cell Dynamics meetings, and the Plant Biology Marvin Seminar Series. This work has also been published as a research paper in the Plant Journal and as a methods chapter in Methods in Molecular Biology.
- **Pathways and potential controls of pheretimoid earthworm invasions into Vermont sugar maple forests**, *research directed by Josef Gorres, Ph.D.*

Asian earthworms in the pheretimoid group, commonly known as jumping worms, are reported from sugar maple forest in Vermont with increasing frequency. As climate changes, expansion of their range into higher elevations is expected. These invasions have ecosystem-wide effects, threatening the sustainability of maple syrup production. One component of this research was to better understand the dispersal pathways of Vermont's pheretimoids invasion. It has become clear that their main dispersal pathways are horticultural activities and more recently composts and mulches. It can be assumed that a large number of nurseries and compost facilities are contaminated with these earthworms. The main ecological and economic effects are the loss of biodiversity and reduction of regeneration of tree species. In Vermont, the reduction of maple saplings is of concern to both the maple syrup producers and to tourism (foliage). Building a network of citizen scientists has been difficult because of Covid restrictions. However, there are now several initiatives across the northeast that have taken on this task. We promote the use of easy-to-access smart phone web applications such as iMapInvasives and iNaturalist to report the worms. Using these apps makes it possible to obtain data on the distribution of these worms. This research has been shared at more than 20 workshops and seminars in Vermont and regionally to academicians, garden clubs, and horticulture/landscape professionals. In addition, we published eight journal articles and received significant press coverage with at least 21 articles and radio interviews.

Critical Issue: Nutrition, Food Safety and Food Security

The following AES research projects concluded in FY21:

- **Creating the Conditions for Healthy Meal Preparation: Testing a Culinary Pedagogy in Different Circumstances**, *research directed by Amy Trubek, Ph.D.*

Home cooking has increasingly become the focus of public-health, nutrition, and policy intervention campaigns. But what is important to know and do? There is a need for a better understanding of cooking skills and knowledge to inform research on the connection between cooking and health. Our team defines Food Agency as one's ability to procure and prepare food within the contexts of one's social, physical, and economic environment. Addressing issues with present research on cooking, a comprehensive theory of Food Agency offers a nuanced understanding of daily food practices and provides guidance on how to teach cooking skills that are generalizable throughout varied life contexts. Our research has found that frequent cooking of all meals, more frequent scratch cooking, and less frequent cooking with packaged ingredients are all associated with greater food agency. We believe that this framework offers a promising approach to helping people be empowered to act, and improving everyday food lives. Communities of interest can learn more by visiting <https://site.uvm.edu/foodagency>.

- **Evaluation of crystals and their relationship to grittiness in soft washed rind cheeses: Survey of the U.S. marketplace**, *research directed by Paul Kindstedt, Ph.D.*

Soft washed rind cheeses are known for their formation of yellow-orange smears at the cheese surface. Our previous work demonstrated that cheese smears induce the nucleation and growth of brushite, calcite, ikaite and struvite crystals, which may be responsible for the textural defect known as grittiness. Currently, there are no known strategies to prevent grittiness defect in this cheese variety. Therefore, the specific objective of this project was to determine the relationship between grittiness and the types and sizes of crystals in soft washed rind cheeses. Through our research, it was

determined that a key to preventing grittiness is to limit crystal growth to less than 66 microns. Research also strongly suggests that grittiness may be controlled/prevented by controlling atmospheric levels of carbon dioxide and ammonia. Results of this research have been presented locally and internationally and published as two articles in the Journal of Dairy Science. Future work should seek to determine the effects of atmospheric levels of carbon dioxide and ammonia in the ripening room on crystal growth rates and grittiness intensity.

Critical Issue: Quality of the Natural Environment

The following UVM Extension Programs made contributions toward our goal to "integrate business and conservation to improve the quality of the natural environment where Vermonters live, work, and play" this year:

- Forest Business
- Forest Stewardship
- Grazing & Livestock
- Maple
- Soil Health & Conservation
- Urban & Community Forestry
- Watershed Outreach & Education

In total, these programs delivered 1,184 educational events (i.e., workshops, classes, consultations, presentations) that directly reached 57,727 participants. An additional 21,310 contacts engaged with the 123 publications produced by these educators.

Some program and project highlights from FY21 include:

- Approximately 150 riparian forest restoration practitioners participated in **Watershed Forestry Partnership** (WFP) programs and received WFP materials, resulting in improved riparian forest restoration best practices, outreach to landowners, and collaboration between practitioners. WFP proudly launched its podcast "Restoration Roundup" this year, covering topics related to riparian forest restoration. All podcast episodes can be found at <https://www.uvm.edu/seagrant/watershed-forestry-partnership/restoration-roundup-podcast> and on most podcast streaming platforms.
- While irrigation is widely used on Northeast vegetable farms, few growers rely upon soil moisture sensors to schedule irrigation. Many farmers over-irrigate, causing nutrient leaching, or under-irrigate, leading to decreased yields and quality. Researchers with the **UVM Center for Sustainable Agriculture's Farming and Climate Change** program, in partnership with the University of Maine, conducted a survey of New England vegetable growers to ascertain how farmers make decisions about when and how much to irrigate. Better information about soil moisture conditions and soil moisture sensing technology, tailored to the scale and diversity of these farms, can greatly improve irrigation efficiency while protecting water quality and supply in an era of climate change.
- Invasive pests such as emerald ash borer (EAB) can change the nature and functioning of Vermont's forests and cost municipalities thousands of dollars to manage infested hazard trees. EAB is in Vermont, and although it cannot be eradicated, informed residents can slow the spread, giving municipalities and

property owners time to plan and spread out costs associated with management. In partnership with the USDA Forest Service, the **Vermont Urban and Community Forestry Program** (UCF) is designed to help communities plan, plant, and care for their community trees. For the 2021 EAB flight season (June - September) 50 UCF volunteers hung and monitored 112 purple prism traps for emerald ash borer in 61 municipalities across Vermont. We supported these volunteers by providing online training, helping them determine the best locations for the traps, preparing and distributing kits with all of the needed gear. Locations of the traps and results from monitoring were entered into a database shared with Vermont Agency of Agriculture, Food & Markets and the Vermont Department of Forests, Parks and Recreation.

The following AES research project concluded in FY21:

- **Evaluating Alternative Runoff Management Practices for Vermont Dairy Farm Production Areas**, *research directed by Stephanie Hurley, Ph.D.*

This funding supported two research projects on a relatively un-studied area of agricultural stormwater management. Water quality in the effluent of each system was improved compared to the influent runoff. Employing similar green infrastructure systems elsewhere in watersheds that have significant runoff from impervious surfaces in agricultural areas like roads and rooftops and silage bunkers, would help reduce nutrient loading and algae blooms in downstream waters. A master's thesis and two papers (one published on the silage system, the second in preparation related to the bioretention system) serve as examples of speaking to an academic audience about the efficacy of these systems; however, lessons have also been shared at academic conferences, on site tours (though limited by covid-19 in 2020 and 2021) with agriculture and engineering professionals, and in undergraduate courses. We are doing continued groundwater monitoring of sampling wells near the silage treatment area. We have used the bioretention findings to develop design recommendations for use in bioretention soil media, and leveraged the current research to pursue additional research targeting improvement of design guidance and soil media testing for the state of Vermont stormwater manual.

Critical Issue: Resilience of Families and Individuals

The following UVM Extension Programs made contributions toward our goal to "increase the resilience of families and individuals around health, education, and personal and family well-being" this year:

- 4-H
- COPE: Coping with Separation & Divorce
- Migrant Health
- Migrant Education
- PROSPER: Drug & Alcohol Prevention

Together these programs delivered 7,792 educational events (i.e., workshops, classes, consultations, presentations) and directly reached 12,861 participants, including 7,348 children and youth. 4-H volunteers continue to be a critical component of our program, and this year contributed 4,648 hours of service. At an hourly rate of \$24.60 in Vermont (lower than the national rate of \$28.54) the value of that volunteer time totals \$114,341.

Some program and project highlights from FY21 include:

- In partnership with the [Vermont Network](#), UVM Extension **4-H** educators trained 83 adults using the “Askable Adult” curriculum, equipping them to be more askable and supportive for children and youth in their lives. Of those who responded to a three-month follow-up survey, 72% used their learning to be more askable for youth in their life often or a lot. Bringing the Askable Adult training to adults in our communities aims to ensure that youth have supportive and affirming adults in their lives. This is always an important factor for youth resiliency but also particularly during this global pandemic when many young people are feeling isolated and anxious. Survey respondents also believe their learning is making an impact often or a lot (61%). As one participant reflected, "The training was a great reminder of how important simply being consistent is. I've really ramped up my efforts to ensure I am following through for the kids in my life".
- **4-H World Changers** has allowed us to reach and provide computer science opportunities to more youth. To date, our collaboration with Marion County Ohio 4-H has benefited more than 125 youth from Vermont, Ohio, and other states. We are building a new generation of coders who are excited and passionate about learning web design, game design, coding languages and more.
- In the past year, 562 individuals received health education and health access assistance from the **Migrant Health** program, including at least one of the following: health screening, mental health promotion, immunization education, COVID tests, COVID and/or flu vaccines, preventative, acute, or emergent health care services.
- The Vermont **4-H Teen and Leadership** program offers a wide variety of opportunities which enable teens to develop knowledge, skills, attitudes, and aspirations needed for success in the 21st century. In FY21, more than 1,800 young people engaged with almost 100 program offerings including: Teen Science Cafés, TRY for the Environment, Natural Resources Management Academy and more. Evaluation data show that 637 teens reported an increase in their STEAM related knowledge and/or skills because of their participation.

Critical Issue: Sustainability of Vermont Agriculture, Food and Forests

Please reference our AES final reports in REEport for accomplishments achieved in the following Hatch and Hatch Multistate projects:

- **Developing Multi-stakeholder Approaches to Dairy Personnel Health and Well-being**, *directed by Daniel Baker, Ph.D.*
- **Consumer Response to Mandatory Genetic Engineering of Foods: A Suite of Analyses**, *directed by Jane Kolodinsky, Ph.D.*
- **Modernizing Tapping Guidelines for Sustainable High Yield Maple Syrup Production**, *directed by Timothy Perkins, Ph.D.*
- **Supporting Agricultural Growth: Women Farmers' Social Networking & Social Media**, *directed by Sarah Heiss, Ph.D.*
- **Renewing an Agriculture of the Middle: Value Chain Design, Policy Approaches, Environmental and Social Impacts**, *directed by David Conner, Ph.D.*

The following UVM Extension Programs made contributions toward our goal to "improve the financial, environmental and social sustainability of Vermont's agriculture, food and forest sectors" this year:

- Agricultural Engineering
- Agritourism
- Crops
- Farm Business
- Food Safety for Processors
- Forest Business
- Forest Stewardship
- Grazing & Livestock
- Integrated Pest Management (IPM)
- Maple
- Master Gardener
- Soil Health & Conservation
- Tourism and Recreation

In total, these programs delivered 4,641 educational events (i.e., workshops, classes, consultations, presentations) that directly reached 34,110 participants. An additional 32,946 contacts engaged with the 247 publications produced by these educators.

Some program and project highlights from FY21 include:

- Although more than one third of all farmers and ranchers in the U.S. are women, these operators do not access available resources, including agricultural support programs, training, and other business tools, as effectively as their male counterparts. The national **Women in Agriculture Learning Network**, launched in October 2013 with leadership provided by the UVM Women's Agricultural Network (WAgN), is working to change that by providing information specific to this target group through its website, social media, e-newsletters, and other outreach efforts. To date, WAgN's outreach efforts have connected over 6,500 people with resources and information. Currently, the WAgN e-newsletter has 1,251 active subscribers with representation from all 50 states and Washington, D.C. Roughly 50% of subscribers are women who described themselves as either aspiring or beginning farmers.
- **Community Accreditation for Produce Safety (CAPS)** is a program of the Vermont Vegetable and Berry Growers Association, administered by UVM Extension, that helps diversified produce growers in Vermont reduce risk and meet market expectations around produce safety requirements. By the end of 2020, 140 farms completed produce safety plans and provided all documentation required to demonstrate implementation of their plans to earn accreditation. These farms reported having 2,865 acres of vegetable production, 417 acres of fruit production, and 1,822,000 square feet of greenhouse production. Using 2017 Census of Agriculture data, we estimate total annual sales of fruits and vegetables by these farms to be \$32 million.
- The **Northeast Center to Advance Food Safety (NECAFS)** had a productive year focused on continued support of existing programming and workgroup activities, conducting extensive center evaluation, expanding the Food Safety

Resource Clearinghouse to include a peer-review process of add-on content, and creating a significant body of original educational content pertaining to Food Safety Modernization Act (FSMA) Produce Safety Rule key legal questions. Since its inception, NECAFS has reached 55,371 participants in a wide range of programming. At the 2020 Annual Conference and Meeting, attendees overwhelmingly reported (93%) that they met someone new through NECAFS *and* the relationship created opportunities for collaboration on education, research and future funding. Evaluations also indicate that NECAFS participants are progressing along the collaboration continuum from information exchange (consulting) to decision-making based on interpersonal trust and shared language (coordinating).

- The **Vermont Vegetable and Berry Growers Association** listserv was evaluated in February 2021. Of the 150 respondents answering the question, 142 (95%) indicated that over the past 3 years they had gained information from the listserv that they used in their farm operation or work and that the information helped improve farm profitability (70%), pest management (81%), soil health and/or nutrient management (77%), equipment or infrastructure (78%), food safety practices (64%), and marketing (52%).
- Through Northeast Dairy Business Innovation Center funding, the **Grazing & Livestock** program was able to successfully develop a pilot program to provide technical assistance to dairy farmers seeking to transition to rotational grazing. The program has been running since May 2020 and serves five dairy farmers. One of those farmers estimated saving \$34,000 in stored feed costs during their first season grazing. Savings were also realized in animal healthcare-related expenses, particularly with hoof health. Based on this, the farm anticipates a return on initial infrastructure investment by the time of early grazing this coming season. This farmer's words speak volumes, "I'm very pleased with how this went. I should have done this ten years ago."
- The **Vegetable Nutrient Management** program of UVM Extension provided technical assistance on soil health to 122 farms with 1,152 acres in production in 2020. As a result, an estimated 18,000 lbs. of phosphorus application was avoided, and 644 acres of cover crops were planted. In collaboration with the UVM Agricultural Testing Lab, 774 soil test recommendations were provided for vegetables and berry fields, and 178 soil test recommendations for high tunnels were provided in collaboration with the University of Maine Soil Testing Lab.
- Research, outreach, and network development is needed to support agritourism in Vermont and around the world. As a follow up to the First World Congress on Agritourism organized by Eurac Research in Italy in 2018, UVM Extension's **Agritourism** Program will host the International Workshop on Agritourism (IWA) in Burlington August 30 – September 1, 2022 as a hybrid conference. Leading up to the Vermont conference, we hosted nine virtual agritourism gatherings (webinars) on a variety of topics between September 2020 and May 2021, engaging 1,704 participants from 66 countries.
- Evaluations collected from participants engaged in the programs of addressing this

critical issue show that **721 individuals and business owners** implemented recommended practice(s) designed to accomplish owner values and goals to improve/protect business sustainability. Some of these practices include completing a business or action plan, installing new infrastructure, adjusting feed rations, and improving food safety procedures.

Updates

Vermont Agricultural Experiment Station:

Hatch and Hatch Multistate projects give the Vermont Agricultural Experiment Station (AES) seed funding to enable faculty to pursue research and to apply for additional funding. A call for Hatch/Multistate proposals is issued in January and proposals are due the last week of April. A Hatch Committee is charged with reviewing the proposals and assessing how the research proposed relates to Vermont's critical issues. The committee is made up of the College's research faculty from each unit and scores proposals based on the following criteria: significance of work based on the critical issues, scientific and technical feasibility, past progress, and innovation. The committee weighs each project with the availability of funding and decides which proposals merit funding.

UVM Extension:

To make progress on our purpose to “cultivate healthy communities,” and provide organizational focus and direction, UVM Extension orients its work towards four Result Areas:

1. Improve the financial, environmental, and social sustainability of Vermont’s agriculture, food and forest sectors
2. Increase the resilience of families and individuals around health, education, and personal and family well-being
3. Engage with communities to support leadership development, capacity building, and diverse voices in decision making
4. Integrate business and conservation to improve the quality of the natural environment where Vermonters live, work and play

UVM Extension plans programming and measures success annually through the lens of the Result Areas and has internal processes that increase transparency and participation in decision making. This results framework provides boundaries for decision making about future investments and effort while remaining flexible enough for Extension to adapt to unforeseen challenges and opportunities.

The Director’s Cabinet is an administrative leadership committee that supports human resource, financial, operations and programmatic decision making. The Cabinet is organized to support decisions in the context of aligning Extension’s work with the Result Areas, funding strategy and overall organizational strategy. In addition, Extension faculty and program staff participate in Result Area teams that meet regularly and provide overarching guidance on programmatic direction in support of alignment with the Result Areas.

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

To gain insight from industry leaders, elected officials, students and Vermonters, the Dean

of the College of Agriculture and Life Sciences (CALs) appoints an advisory board which meets twice a year to provide feedback and advice. In addition, they review the College Strategic Plan and provide information on future trends of agriculture and life sciences. They are an invaluable source of counsel to the Dean and usually serve a three year term.

Many UVM Extension (EXT) programs have advisory committees of one form or another that provide a sounding board and input on current issues and help prioritize programmatic direction. This input helps in all aspects of programming, including delivery method, outreach, and content. Most events ask participants if the programming met their needs and expectations. Post-event evaluations, including six-month follow-up check-ins about behavior change, are standard practice for EXT programs. This also provides an opportunity to gather further input informing future program effort.

Partnerships with communities, public and private organizations, and businesses are important to reaching and serving clients with appropriate programming. These relationships remain a critical part of identifying needs and gaps for programming.

Methods to identify individuals and groups and brief explanation

The CALs Dean and Associate Dean of Research/Director of AES look at a wide range of expertise and appoint individuals in the advisory board who have experience in dairy farming, state legislation, research, finance and marketing, to name a few.

UVM Extension faculty and staff identify logical external partners who work closely with their programs or generally within the scope of the Result Areas. Program participants are engaged in developing future programs through on-site data collection feedback tools.

In a small state, relationships are critical in accessing key individuals with knowledge of current relevant issues for Vermonters. For example, ongoing and regular participation in the Vermont Agricultural Water Quality Partnership (VAWQP) helps us identify and gain access to key individuals. Stakeholders currently include leaders from USDA Natural Resources Conservation Service, Vermont Agency of Agriculture, Food, and Markets, Vermont Association of Conservation Districts, USDA Rural Development, USDA Farm Service Agency, representatives from all three Congressional offices, and other organizations as available or interested.

Methods for collecting stakeholder input and brief explanation

Individuals on the CALs Advisory Board meet twice a year and provide information on future trends of agriculture and life sciences. In addition, AES uses the following methods:

- Meeting with traditional stakeholder groups
- Survey of traditional stakeholder groups
- Meeting with traditional stakeholder individuals
- Survey of traditional stakeholder individuals
- Meeting with invited selected individuals from the general public
- Survey of selected individuals from the general public

UVM Extension program personnel engage partners and stakeholders at multiple stages in the design and delivery of their programs. Stakeholder activities include:

- facilitating ongoing stakeholder groups (e.g. farmer watershed coalitions)
- program-level advisory groups

- inviting stakeholders to programmatic meetings
- conducting surveys and evaluations at and after programming events
- collaborative relationships with individuals at partner organizations

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

The CALS Board of Advisors provides expertise and experience to the Dean, College leadership, and faculty to enhance the mission and goals of the college. The objectives of the Board are to:

- Identify trends, issues, and new developments in areas significant to the College,
- Cultivate relationships and to serve as ambassadors of the College to prospective students, employers of graduates,
- alumni, policymakers, and others,
- Engage the College with state, regional, national, and international organizations, and agencies.

UVM Extension uses stakeholder input to develop and refine research and education programs that serve the needs of each program participants. This may result in the pursuit of new research topics, changes to the content of educational programs, or changes to how information is delivered to participants.

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

Variable environmental conditions can facilitate chemical modifications to DNA or RNA base pairs that can alter phenotypes. These modifications are termed, epigenetic or epitranscriptomic, for DNA and RNA respectively. The goal of this project is to enhance annotation of epigenetic and epitranscriptomic elements in cattle and sheep genomes.

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

Data generation via next generation sequencing is necessary to enable detection of epigenetic and epitranscriptomic modifications. To that end, we have generated sequence data to detect multiple epigenetic modifications in the DNA of cattle, sheep, and bison. These data are currently being analyzed to determine similarities and differences of epigenetic modifications between animals and tissues. We are currently generating sequence data to detect RNA mediated epigenetic modifications.

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

Multiple graduate students are currently working on analyzing the data generated for this project and are writing scientific manuscripts of their findings. Additionally, these students have gained professional development skills through poster and oral presentations of their research at national meetings.

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

Data generated from this project will be contributed towards the Functional

Annotations of Animal Genomes (FAANG) project to enhance the bovine and ovine reference genomes. These tools and resources are utilized by academia, industry, and government researchers whose research enables enhanced livestock production and animal health.

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

Data and results from this this project were disseminated via three oral presentations, one peer reviewed publication and two poster presentations.

Oral Presentations:

McKay S. 2020. Livestock Epigenomics. Purdue University.

McKay S. 2020. An Investigation of DNA Methylation and Hydroxymethylation in the Limbic System of the Bovine Brain. Michigan State University.

McKay, S. 2021. Examining the Extent of Environmental Contributions towards DNA methylation and phenotypic variation. Domestic Animal DOHaD and Epigenetics meeting, Quebec City, Quebec, Canada.

Peer Reviewed Publications:

Davenport, KM, AT Massa, S Bhattarai, SD McKay, MR Mousel, MK Herndon, SN White, N Cockett, TPL Smith and BM Murdoch. 2021, Characterizing Genetic Regulatory Elements in Ovine Tissues. *Frontiers in Genetics*. 12: 566 <https://doi.org/10.1093/af/vfab056>

Poster Presentations:

Bhattarai, S., K. Davenport, BM Murdoch, and S. McKay. 2021. Studying DNA Methylation in the Sheep Liver, Spleen and Cerebellum. University of Vermont Student Research Conference, Burlington, Vermont

Stassen, E., B. Murdoch, R. Funston, R. Weaver and S. McKay. 2021. Identification of 5-Hydroxymethylcytosine Markers in the Cattle Brain. University of Vermont Student Research Conference, Burlington, Vermont

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

The goal of this research is to help develop food systems that can restore ecosystems damaged by short-sighted farming practices, provide a sufficiently high quality of life (QoL) and sufficient income to attract the next generation of farmers, and feed all people a healthy diet, all while transitioning away from a dependence on non-renewable resources. On the production side, the project focuses on small-scale agroecological food systems that improve the well-being of the farmers, their communities, and the ecosystems upon which they depend. On the distribution and consumption side, the project focuses on economic mechanisms that efficiently allocate food to those with the greatest physiological and social needs, rather than those with the greatest ability to pay.

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

This project was stitched together to help fund research being conducted by three different grad students all taking different paths to achieve the goals discussed above.

With the average age of US farmers steadily increasing and few younger farmers entering the field, many next-generation farmers are likely to come from immigrant communities. We worked closely with two non-government organizations focused on sustainable agriculture: New Farms for New Americans in Burlington, VT, and The Farley Center for Peace, Justice and Sustainability in Verona, WI. We interviewed 28 immigrant and refugee farmers in Vermont and Wisconsin to better understand the quality-of-life (QoL) experiences of a population that generally has high levels of precarity and systemic stress. We are communicating our results directly to our partners to help them improve their programs and the quality of life of next-generation farmers. We will also be communicating results to other NGOs, policy makers and future researchers through publications and public presentations.

The challenges of recruiting the next generation of farmers is only one of many faced by agriculture. Despite its small share of GDP, agriculture is the most important economic sector. At the same time, conventional agriculture poses enormous threats to global ecosystems and the life-sustaining services they generate and is the economic sector most dependent upon those services. Furthermore, carefully designed regenerative agriculture may offer one of the most cost-efficient approaches to restoring ecosystem services. It is no longer enough for agriculture to focus on food production alone: we must develop agriculture systems that produce both food and ecosystem services and policies that provide the proper incentives.

To this end, and working with the same groups of farmers in Vermont and Wisconsin, as well as with teams of researchers at the UVM Agroecology Livelihoods Collaborative, the UVM ARS, and the Gund Institute for the Environment, we are developing a social-ecological-economic (SEE) sustainability analysis toolkit. This will be available for farmers and Extensionists to administer independently and for free, with the goals of increasing small and medium scale farms' sustainability and resiliency. The application of the toolkit will also help inform local communities and policy makers of the ecosystem service benefits that these farms are generating for the wider public – ultimately bolstering community support for farms that provide a host of public goods and services and informing policies that can incentivize the provision of these public goods.

Another element of this project was the analysis of alternative ecological farming strategies characterized by diversity and adaptation to local circumstance. We outlined a framework for understanding multiple dimensions of food systems movements, argued for its importance in understanding ecologically based alternatives and applied it to the history of the organic farming concept. While initially defined as a different way of looking at farming systems, organic farming has increasingly become identified with a set of farming practices, largely defined by the set of techniques that are prohibited. This innovation has made organic farming legible to bureaucracies and facilitated its promotion through differentiated markets and public subsidies, while also eroding democratic and popular control of the

concept. Many other alternative agriculture concepts have not coalesced around specific criteria for dividing farms who fit within that concept and those which do not. This stymies efforts to directly promote these approaches through bureaucracies but protects the aspects of these strategies built around democracy, participation, and traditional and tacit knowledge. Alternative agriculture movements face a tension between the usefulness and simplicity of rigorous and replicable categories, and their politics of ecology and participation. This research can help improve existing certification processes while also understanding their limitations.

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

The farmers with New Farms and the Farley Center will be the most immediate beneficiaries of the research on QoL of new farmers from immigrant communities. Both NGOs are also interested in using these results to improve their programs with direct benefits to participants. The NGOs will also benefit from the sustainability analysis toolkit, the results of which can be used in grant applications to justify public and donor support for these programs. We will also apply these results to the design of policies that incentivize the joint production of food and ecosystem services, such as payment for ecosystem services, co-investment in stewardship, and similar subsidies.

Our research also calls attention to a serious problem with the certification of alternative ecological farming strategies. Ecological farming by definition provides ecological benefits, many of which are public goods. The current certification system asks farmers to bear the costs of certification in exchange for higher prices born by consumers. In short, the private sector is being asked to pay for public goods. We hope this research will contribute to efforts to gain public funding for certification which will reduce its cost to farmers and help facilitate the transition to regenerative agriculture.

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

It is hard to overstate the broader public benefits of designing resilient and regenerative agriculture systems. Both agriculture and ecosystem services are essential to human survival and increasingly threatened by climate change and ecological degradation. Modern agro-industry is chemical intensive, contributing to ground water and surface water pollution, the catastrophic collapse of insect populations around the world with unknown consequences, worsening dead-zones around the world cause by nutrient and chemical runoff, and humanity's exceeding planetary boundaries for biodiversity loss, climate change, nitrogen and phosphorous emissions, and novel entities (e.g. chemicals). Modern agro-industry is also highly mechanized, reducing the demand for farm labor and hence employment opportunities in rural communities, driving a rural-urban exodus and diminishing quality of life for the remaining farmers. While no single project can change the agro-industrial paradigm, we believe this project contributes to the growing awareness of the need for regenerative agriculture and can help inform the policies required to achieve it.

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

This project was originally meant to fund the research of two additional PhD students in another department where the PI has a joint-appointment, but we learned afterward that the money had to be spent on students in my department. One of the additional PhD students was nonetheless able to complete his dissertation in 2021, while the other is on track to finish this year.

Over the past year we disseminated project results in the following venues:

Both in Session on Decommodification and Democratization of Essential Resources

Taylor, Josiah (2021). Universal access to farmland and quality of life support systems for farmers from diverse demographics. Presented at the International Online Joint Conference of the international degrowth research networks, the International Society for Ecological Economics, and the European Society for Ecological Economics: Building Alternative Livelihoods in Times of Ecological and Political Crisis. Hosted by University of Manchester, UK, July 5-8, 2021

Bliss, Sam (2021). Non-market food for degrowth. Presented at the International Online Joint Conference of the international degrowth research networks, the International Society for Ecological Economics, and the European Society for Ecological Economics: Building Alternative Livelihoods in Times of Ecological and Political Crisis. Hosted by University of Manchester, UK, July 5-8, 2021

Dartmouth College field course on agroecological transitions (Oct., 2021)

University of Vermont undergraduate class on Participatory Action Research (Nov 8/2021)

The research also contributed to the following related publications, some of which received support from other funding sources as well:

Dube, Benjamin Timothy, "Embracing Uncertainty, Ambiguity, And Complexity In Agriculture, Science, And Policy" (2022). *Graduate College Dissertations and Theses*. 1502. <https://scholarworks.uvm.edu/graddis/1502>

Neher, D. A., J. M. Harris, C. E. Horner, M. J. Scarborough, A. R. Badireddy, J. W. Faulkner, A. C. White, H. Darby, J. C. Farley and E. J. Bishop-von Wettberg (2022). "Resilient Soils for Resilient Farms: An Integrative Approach to Assess, Promote and Value Soil Health for Small- and Medium-Size Farms." *Phytobiomes Journal*.

Brasileiro-Assing, A. C., J. Kades, P. A. de Almeida Sinisgalli, J. Farley and A. Schmitt-Filho (2022). "Performance Analysis of Dairy Farms Transitioning to Environmentally Friendly Grazing Practices: The Case Study of Santa Catarina, Brazil." *Land* 11(2).

Simioni, G. F., A. L. Schmitt Filho, F. Joner, J. Farley, A. C. Fantini and A. P. T. Moreira (2022). "Response of birds to high biodiversity silvopastoral systems: Integrating food production and biodiversity conservation through applied nucleation in southern Brazil." *Agriculture, Ecosystems & Environment* 324: 107709.

Farley, J. and K. Kish (2021). "Ecological economics: The next 30 years." *Ecological Economics* 190: 107211.

Amazonas, I. T., et al. (2021). "A participatory modeling experience with young

farmers: assessing the sustainability of family farmers in Brazil." *Research, Society and Development* 10(1): e50610111928.

Castelo Branco Brasileiro-Assing, A., M. Wironen, A. Adams, J. Farley, P. A. De Almeida Sinisgalli and A. Schmitt-Filho (2021). "Sustainable intensification of livestock as a means to achieve forest conservation and food production in the Brazilian Southern Atlantic forest." *Agroecology and Sustainable Food Systems* 45(6): 817-842.

Several other articles are currently in preparation, including:

Taylor, J., Farley, J., Bliss, S., Egler, M., and Poudle, S. (Fall 2022). Creating resiliency and enhancing regional sustainability through integrated analysis of ecological, social, and economic factors on small and medium scale farms in the United States. *The Journal of Agriculture, Food Systems, and Community Development*.

Taylor, J., Farley, J. (Fall 2022). Assessing and improving quality of life supports for farmers from refugee and immigrant backgrounds in the United States. *The Journal of Agriculture, Food Systems, and Community Development*.

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

Public libraries, essential to the proper functioning of a democracy, are working hard to serve patrons and their communities during the pandemic. In recent months, this has included efforts to open or partially open library spaces for employees and patrons. Maintaining air quality is a challenge, limiting the space available for use by staff, and often entirely eliminating the ability to accommodate patrons. Recommended air purification equipment is not necessarily expensive, but library budgets are modest and were not created with a pandemic in mind.

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

A grant from the UVM Office of Engagement was used to buy air filtration and purification equipment so that selected libraries could operate more fully. Following recommended science, the equipment enables library spaces to be safer, fortifying other accepted practices in managing the spread of COVID-19. The Vermont Department of Libraries published ventilation guidance and resources from which library directors made their equipment selections. The grant provided \$22,989 toward the purchase and delivery of 54 portable air filtration and purification units for enclosed library spaces, and three mechanical modifications for ventilation and/or HVAC systems. In addition, the Office of Engagement awarded \$1,000 for publicity items, including printing and postage of these materials for delivery to all benefiting libraries.

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

The overall goal was to provide greater patron and community access due to higher assurances of safe air to breathe in Vermont public libraries. Librarians were very appreciative of the equipment and modifications and provided positive feedback about how the grant enabled them to create safer spaces for both employees and patrons and relieved the financial burden of purchasing the equipment themselves

on limited library budgets. "The UVM grant allowed for the purchase of air purifiers for our building that would have been out of our reach financially," the library director at the Putney Public Library in southeastern Vermont explained. "In addition to social distancing and other safety measures, our staff is able to work together in the same room, and we know that we will be providing a higher level of safety when we welcome the public back into our building." The library director of the Alburgh Public Library in northern Vermont shared that "With the winter season upon us, we had no way to properly circulate the air in the library. This grant enabled us to buy four HEPA air purifier units to improve air quality and circulation both upstairs and downstairs allowing for a safer workplace for our employees and patrons!" Other librarians commented on how safer spaces for both employees and visitors will allow greater patronage as not only can they open their libraries to the public again but that everyone can remain inside the building for longer periods of time.

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

The value of public libraries is indisputable. They are more than just a place to borrow books, access free educational resources, or use a computer. Libraries are a gathering place, a community hub, which are free, accessible, and safe for every member of the community. Patronage surged throughout the pandemic, challenging libraries to find innovative solutions to serve their communities. Funding for air filtration and purification equipment meant a safer work environment, allowing libraries to continue to meet the needs of their patrons while operating within COVID-19 guidelines.

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

Black ash (*Fraxinus nigra*) has no resistance to, or tolerance for, the emerald ash borer (EAB), an invasive pest that has been reported in several counties in Vermont. As a result, unless action is taken to conserve this species, this important riparian and wetland tree may soon disappear from the Vermont landscape. In addition to its ecological role in mitigating floods and providing wildlife habitat, black ash has very important cultural significance for the Abenaki and other Eastern Woodlands indigenous people. The Abenaki and other Northeast tribes have expressed interest in finding ways to harvest these trees and stockpile splints for basket making. In addition, they hope to save seeds to preserve some of the genetic diversity of local stock for future replanting.

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

In response to this interest, the Vermont Urban & Community Forestry program has partnered with a basket maker from the Nulhegan Band of the Coosuk Abenaki Nation; faculty and graduate students from University of Maine's School of Forest Resources; the Akwesasne Task Force on the Environment Black Ash Project coordinator; and staff from the Vermont Land Trust; the Vermont Department of Forests, Parks and Recreation; and the U.S. Forest Service, Northeastern Area State and Private Forestry, to offer an informational webinar in May 2021. Presentations focused on the cultural importance of black ash, current research, and efforts to inventory stands and save seeds. Future workshops are planned to educate the public about this species and the Abenakis' relationship to black ash and basket making.

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

To date, 50 people have viewed the recorded webinar with 19 responding to a post-webinar evaluation survey. The majority of respondents said that they plan to share the information with others. One individual commented, "Yes, I definitely have some thoughts to take back to my community. Perhaps we should identify any healthy, seed-producing, black ash in our town and consider investing in systemic pesticide treatment. Also, I will make sure that we use/donate any black ash we harvest in a preemptive cut wisely," a reference to municipalities that are cutting ash preemptively before EAB infestations devastate local ash trees. As a result of the connections made and information shared during the webinar, a group of concerned citizens, organizations, and agencies are collaborating to support efforts of local indigenous people to harvest black ash for pounding splints for basket making. Joining the Abenaki basket maker in this endeavor are representatives from the Vermont Urban & Community Forestry program; the Vermont Department of Forests, Parks and Recreation; the Vermont Land Trust; and the Montgomery Center for the Arts.

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

Black ash is an important component of wetland forests throughout Vermont and the northern United States. Decline and eventual extinction of this species due to a destructive insect pest, will have wide-reaching impact, including increased flooding and loss of habitat and a food source for many wildlife species that depend on forested wetlands. In communities with large ash tree plantings, loss may reduce the tree canopy, which provides shade, reduces rainfall runoff, and offers aesthetic benefits. Although not commercially important, black ash is valuable culturally to the Abenaki and other indigenous people who over the centuries have harvested this wood for basket making and other uses. Should the black ash disappear from Vermont forests, the cultural traditions associated with this species will be lost as well.

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

Vermont's tree wardens play a critical role in maintaining the health of public green spaces in our communities. They are on the front line of a host of environmental issues, managing the impacts of the invasive emerald ash borer, the decline of aging urban trees, regional climate changes, effects of natural disasters and other environmental stressors, and weaknesses in past municipal planning initiatives. In 2020, the Vermont Tree Warden Statutes, first adopted in 1904, were amended and updated to reflect the changing nature of the official duties and responsibilities of today's tree wardens. These changes resulted in an opportunity to better connect tree wardens across Vermont for education, collaboration, and networking.

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

The Vermont Urban & Community Forestry Program responded by establishing the Vermont Tree Warden School to provide direct educational assistance and elevate the role of the tree warden. This new course offering was designed to help both veteran and newly appointed state tree wardens and community decision-makers learn how to manage their public tree resources more effectively. It focused on such topics as understanding the role and responsibilities of the tree warden, identifying

trees as a public resource, and strategies for connecting with local stakeholders. Information was presented through video presentations, resources, and activities. Four live discussions focused on statutes changes, outreach, and tree risk management, among other topics.

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

While many tree wardens are trained arborists, foresters, or natural resources professionals, others are municipal employees in public works departments, parks departments, or highway road crews, all with varying levels of expertise and experience. The Vermont Tree Warden School helped fulfill a critical need for these appointed positions by increasing awareness of the legal changes of the newly amended statutes, sharing resources to help participants further develop their tree care technical skills, and providing a much-welcomed opportunity for networking. Forty tree wardens participated in this inaugural self-paced course offered in spring 2021. Feedback was positive with several participants commenting that they felt that the training was well-organized and thorough. A tree warden from a northwestern Vermont town noted, "The course work is extensive, and the presentations are great. I think novices as well as seasoned tree wardens will really benefit from the course. Another amazing service from the Vermont Urban & Community Forestry Program!" Many echoed the sentiments of a fellow participant who summed it up by saying, "I hope that you are able to offer Tree Warden School annually (or biannually). Online format is very convenient and accessible. Networking and education are invaluable for any public volunteer position."

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

Tree wardens have a unique legal responsibility to protect and celebrate a natural resource within their community. They consult with residents and their local highway department on specific tree issues and handle environmental issues that can impact individual tree health and the overall health of an ecosystem by managing invasive pests, assessing potential hazards related to dead or diseased trees, and making decisions to ensure the health of trees along public roadways and in municipal spaces--all for the benefit of the residents and visitors.

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

This project addresses genetic/epigenetic mechanisms that have shaped temperature-regulated flowering time evolution in the temperate Pooidae grasses. Goals include describing variation in the length of vernalization (above freezing cold) required to saturate flowering competency in *Melica* grasses, and defining the cause of this variation at the level of phylogeny, native climate, and underlying genes.

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

During the reporting period, my lab has treated 9 populations of *Melica ciliata* and a single representative population from 19 additional *Melica* species with different lengths of vernalization, and monitored number of days to flowering. We now have a good sense of the vernalization response and vernalization saturation time for 5 populations, and are continuing to monitor non-flowering individuals in the greenhouse. Georeference and climate data have been downloaded for all taxa and stems tissue has been collected from two *M. ciliata* populations for transcriptome

analyses. We have also sequenced chloroplast markers to define the phylogenetic relationships among species and are growing-up additional tissues for 24 *M. ciliata* accessions to examine the expression of the vernalization response genes *VRN1* and *VRN3*. Together, these data will allow us to determine if low temperature-mediated flowering variation can be explained by phylogeny, native climate, and variation at known vernalization response gene

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

Data generated from this project will increase the scientific community's knowledge on the drivers of flowering time variation. Since flowering time affects both vegetative and grain yield, this will be important for predicting the response of temperate perennial grasses to climate change. The discovery of genes involved in this variation will also be useful to agronomists interested in marker-assisted breeding.

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

Results of the project will add to our knowledge of how to improve crop yield in a changing climate. This is important in the context of a growing population that will require more food sources and alternatives to fossil fuels (e.g. biofuels). The focus on *Melica*, which is closely related to several potential biofuel and food crops will also provide insight into perennial grass flowering, a growth habit that is more sustainable than the annual habit of most grain crops.

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

Training and professional development opportunities: This project has so far trained one PhD and two undergraduate students.

Dissemination of results: Work from this project and a related project* have been published in peer-reviewed journals, and have been advertised across the UVM campus through the College of Agriculture and Life Sciences blog.

*Preston, J. C., Wooliver, R., Driscoll, H., Coughlin, A., and Sheth, S. N. (2022) Spatial variation in high temperature-regulated gene expression predicts variation of plasticity with climate change in the scarlet monkeyflower. *Molecular Ecology*. 31: 1254-1268.

*Preston, J. C., and Fjellheim, S. (2022) Update on the evolution of temperature regulated flowering. *Flowering time runs hot and cold*. *Plant Physiology*. *Accepted*.

Plans for the next reporting period: For the next reporting period we plan to finish collecting flowering time data on all *Melica* populations, use quantitative PCR to amplify *VRN1* and *VRN3* from *M. ciliata* populations, and to finish generating sequence data for chloroplast markers. Flowering time behavior will then be analyzed as a response variable, with genetic distance and minimum temperature of the coldest month as explanatory variables. We will also make cDNA libraries for the RNA of two *M. ciliata* populations with divergent flowering behaviors across treatments and carry out RNAseq, sequence assembly, and differential gene

expression analyses. This will comprise chapter 1 of a PhD thesis.

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

Bovine fatty liver disease (FLD) is a disease that occurs in nearly 50% of all dairy cattle to some degree around the time of calving. Fatty liver disease in dairy cattle is associated with a number of costly co-morbidities. In this grant we proposed to identify underlying biochemical mechanisms of development of fatty liver disease in dairy cattle. With that project we continued to develop an *in vitro* model of fatty liver disease and collected hepatic tissue from animals with and without fatty liver disease.

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

We studied the basic biology of the dairy cow near the time of calving and found that a significantly greater incidence of fatty liver disease (FLD) occurred than we anticipated. As such, our findings indicate that FLD and the associated co-morbidities, such as ketosis, could be a highly attractive target for prevention of economical losses to the dairy farmer.

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

Several publications have been generated from this work with more expected. Our target audience will hopefully benefit from the understanding that bovine fatty liver disease is potentially much more economically costly than originally estimated.

Submitted

1. **Testroet**, E. D., J. M. de Avila, S. Clark D. C. Beitz, and M. Du. 2021. The effect of palmitate and TNF α on abattoir-derived Holstein cow liver primary cell culture. In preparation to be re-submitted to *J. Dairy Sci.*

In Preparation

1. S. Choudhary, M. LaCasse, R. K. Choudhary, M. Rincon, D. C. Beitz, and E. D. Testroet. 2021. *In vivo* and *in vitro* expression of mitochondrial complex 1 inhibitor in bovine liver. In preparation to be submitted to *J. Dairy Sci.*

Published Abstracts

1. LaCasse, M., S. Choudhary, R. Choudhary, J. de Avila, D. C. Beitz, M. Du, and **E. D. Testroet**. A nonperfusion-based method of hepatic cell isolation and development of fatty liver disease model for dairy cattle. Poster. To be presented at the 2020 Experimental Biology Annual Meeting, San Diego, CA.

S. Choudhary, R. Choudhary, LaCasse, M., J. de Avila, D. C. Beitz, M. Du, M. Rincon and **E. D. Testroet**. Expression of mitochondrial complex 1 inhibitor in bovine tissue, primary hepatic cells, and detection of its' transcript in conditioned media mimicking

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

The broader public will benefit from the results of this project through, ultimately,

seeing improvements in animal health that translate to improved animal efficiency, welfare, and decreased cost for dairy products.

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

Summary of progress.

Many of our research plans were delayed significantly by the COVID-19 pandemic.

It is our hypothesis that dysregulation of PDE4b results in hepatic lipidosis and that ultimately modulation of PDE4b activity can lead to prevention of hepatic lipidosis in the periparturient cow. Currently we are in the process of finalizing an *in vitro* model of bovine hepatic lipidosis (manuscript in final revision to be submitted upon validation of hepatic cell function and gluconeogenic behavior in response to glucagon stimulation). We have isolated and cultured primary bovine hepatocytes and have completed functional validation (i.e., lipid accumulation, urea production, albumin production, LDH leakage, and cytotoxicity markers) but are completing the above further validation at the request of the associate editor.

We have performed liver and adipose biopsies on 24 cattle that were meant to either experience hepatic lipidosis or not based on dietary treatment during the dry period. We had expected to examine key signaling pathways related to protein kinase A (PKA), AMP-activated protein kinase (AMPK), and phosphodiesterase 4b (PDE4B). We have analyzed key gene and protein expression data collected from these 24 cows and are in the process of interpreting these data (to be submitted for publication and form the M.S. thesis of Ms. Michelle LaCasse – defense scheduled for 12/2021).

Unexpectedly, during our on-farm experiment, all cattle, regardless of treatment, developed fatty liver disease as characterized by percentage lipid in liver tissue on a wet weight basis. We have contacted authors of recently published manuscripts that have utilized similar methodologies and found that they have observed similar results (induction of fatty liver disease regardless of dietary treatment in the dry period). We are undergoing efforts to perform a limited meta-analysis of these data from combined studies. Our hypothesis is that genetic selection has altered the physiology of the “modern” dairy cow such that previously established experimental protocols to induce fatty liver disease are no longer effective (and in fact nearly all dairy cattle develop fatty liver disease in the periparturient period).

In addition, we have received funding to characterize the bovine hepatic lipidosis model as a model for human NAFLD and NASH, and to examine use of a novel siRNA as a preventative for development of hepatic lipidosis in the transition period of dairy cattle. We have made little progress on this objective because of pandemic-related delays, but currently have RNA collected from cattle with fatty liver disease from our on-farm experiment, primary cells grown and induced to develop fatty liver disease *in vitro*, and we will be submitting these samples for RNA-seq and bioinformatic analyses and comparison to published sequencing data of humans with NAFLD and NASH.

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

Milk and dairy products are a unique source of bioactive branched-chain fatty acids as they are principally derived from rumen microorganisms. Because little is known about the biosynthesis of branched-chain fatty acids in bacteria and protozoa in the rumen environment, this project is designed to assess the interconversion of various branched-chain fatty acid substrates, branched-chain amino acids, to branched-chain fatty acids by rumen bacteria and protozoa.

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

In the past year, we conducted three in-vitro dose-response studies using different dietary substrates (leucine, isoleucine, and valine) to gain a better understanding of how rumen microbes synthesize branched-chain fatty acids. We isolated bacterial and protozoal cell fractions from rumen fluid contents and measured the branched-chain fatty acid content and composition of their lipid membranes. Two studies have been completed and our data provide direct evidence that rumen bacteria and protozoa use dietary leucine and isoleucine as a precursor for the synthesis of branched-chain fatty acids. The data analysis of the third study, testing valine as a dietary substrate, is currently under way and will be completed this summer.

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

The results from this work are being disseminated to the scientific community. Two abstracts have been submitted and accepted to be presented (oral presentation) at the 2022 American Dairy Science Association (ADSA) annual meeting. Undergraduate and graduate students will be presenting their research to the University of Vermont community at the annual student research conference. In addition, one manuscript has been submitted to a scientific journal for peer review. This project expands the scientific knowledgebase on rumen microbes producing branched-chain fatty acids, a distinct and understudied group of bioactive fatty acids. The research findings will provide the framework for the development of innovative feeding strategies designed to enhance the content of BCFA in milk/dairy products.

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

The broader public has not yet benefited from our project's activities as outreach has been limited due the ongoing pandemic. We will continue to disseminate our research findings to the scientific community but specifically aim to reach stakeholders, such as farmers, agricultural professionals, and educators.

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

Training and professional development opportunities: This project has trained two Master's students and three undergraduate students.

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

Many college students struggle to cook frequently which has implications for their

diet quality and health. Students' ability to plan, procure, and prepare food (food agency) may be an important target for shifting the college student diet away from instant and inexpensive staples like packaged ramen.

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

The randomized intervention study included two sequential cooking interventions (1) six weeks of cooking classes based in food agency pedagogy held once per week, and (2) six weeks of weekly home delivered meal kits (3 meals per kit) to improve food agency, diet quality, and at home cooking frequency of college students. Based on availability and subsequent randomization, participants were assigned to one of four conditions that included active cooking classes, meal kit provision, or no intervention. Participants who took part in the cooking intervention had significant improvement in food agency immediately following the intervention period. Participants who did not participate in cooking classes and only received meal kits experienced significant, though less pronounced improvement, in food agency scores following the meal kit provision. Neither intervention improved diet quality or routinely improved cooking frequency.

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

College students in the study participated in cooking classes, some received meal kits, and some improved their food agency. We learned that cooking classes are one way to improve food agency for college students.

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

We learned that cooking classes are one way to improve food agency for college students. Young adulthood is a pivotal time for developing cooking skills and agency, participating in cooking classes but not necessarily meal kit provision helped improve food agency.

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

The results of the study were published in *Nutrients*. Citation: **Pope, L.**, Alpaugh, M., Trubek, A., Skelly, J., Harvey, J. (2021). Beyond Ramen: Investigating methods to improve food agency among college students. *Nutrients*. 13: 1674. <https://doi.org/10.3390/nu13051674>.

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

Nutritional stability – a food system's capacity to provide sufficient nutrients despite disturbance – is an important, yet challenging to measure outcome of diversified agriculture. Understanding how the diversity of crop production in a place influences the availability and supply of nutrients is an important food and nutritional security question, especially as the world grapples with changing environment, trade, markets and disruptions such as war or famine. This project explores how the diversity of crops produced in a given place relates to the nutrients

available to the people in a place, including these relationships over time, as well as their relationship to climate change and actual dietary intake.

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

This project has three core goals, for which progress has been made in this reporting period on two. The objectives include:

Objective 1: Assess the importance of individual crops to nutrient availability and stability.

Objective 2: Link climate change sensitivity of individual crops to nutrient network to assess potential impact of climate change on nutrient availability and stability

Objective 3: Develop case studies in specific countries to examine the relationship of crop diversity and nutritional stability to the diversity of diets using nutritional intake data

Through continued data analysis, joining together of datasets, and visualizations and online tools, we have continued to explore the role of individual crops for nutrient availability and stability globally, as well as examined the relationship of crop diversity to nutrition outcomes in the U.S., and begun efforts to do so internationally.

The work has resulted in two publications:

Nicholson, C.C., Emery, B.F. & Niles, M.T. Global relationships between crop diversity and nutritional stability. *Nat Commun* **12**, 5310 (2021). <https://doi.org/10.1038/s41467-021-25615-2>.

Rodríguez-Cruz, L.A., Álvarez-Berrios, N., Niles, M.T. 2022 *Environ. Res. Lett.* in press <https://doi.org/10.1088/1748-9326/ac6000>

In addition, we are piloting and developing a beta version of our online crop-nutrient networks: <https://nutrinet.shinyapps.io/nutrinet/>

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

The intended audience for our work includes academics, as well as policymakers and decision makers. Our publication was published open access to facilitate broader dissemination to these audiences. As well, this publication was discussed through social media and blogs, demonstrating its broader impact. Finally, we have been working to build a public facing dashboard, that allows people to explore the data from 180 countries over time on crop production and nutritional outcomes. This will enable a user interface that includes maps and figures, as well as network diagrams that enable interactive "play" and data exploration, especially for policymakers and practitioners outside of academia. In addition, the work from Puerto Rico, where we explored how on-farm crop diversity related to food security outcomes among farmers after a climate disaster, was translated into Spanish, and publicly shared. As well, a Spanish and English policy brief were developed to be publicly disseminated with policymakers and Extension in Puerto Rico.

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

We have prioritized the development of a public facing dashboard, that allows people to explore the data from 180 countries over time on crop production and nutritional outcomes. This will enable a user interface that includes maps and figures, as well as network diagrams that enable interactive "play" and data exploration, especially for policymakers and practitioners outside of academia. The joining of datasets together, as this project has enabled, and visualizing them in a connected way is especially important to explain and visualize relationships that are hard to grasp. For example, showing the nutrients that are found in a single serving of a particular crop can expand nutrition education and understanding, but also showing how a countries' food production has changed over time, and is influenced by imports and exports, also provides important insight into market and trade policy. For our work in Puerto Rico, our work, including the translation of our work into Spanish, is helping to inform policy discussion and decisions related to disaster preparedness, nutrition and agriculture following climate disasters.

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

One challenge we are facing is the lack of existing datasets that can provide climate sensitivity of crops, which we could incorporate into our models. While there is some work happening in this area, it is primarily with major crops, and in limited geographic contexts, which limits our global approach with hundreds of crops. We will continue to try to make progress on this effort, but may have to limit our climate assessment to single crops or locations with better quality existing data.

We did hire a new undergraduate student, and provided professional mentorship and development opportunities for this student to learn new programming skills and web development platforms. This student has developed our online platform and visualizations.

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

Invasive plants are a major threat to ecological communities in Vermont and elsewhere. However, introduced species may not start out that way but may evolve to become invasive post-introduction. Hybridization between two closely related species can result in a third species that is more invasive than either of the original two species. Our goal is to understand the role that hybridization plays in contributing to the invasive success of *Centaurea moncktonii*, an invasive species in Vermont that forms from two less invasive species (*Centaurea jacea* and *Centaurea nigra*).

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

The main goal of this project was to determine if there has been evolution post-introduction in either invasive hybrid species or the two parental species. A second goal is to determine how the traits expressed by the hybrid differ from the trait expressed by the parental species through common garden studies and identify how

this shift in plant functional traits has increased the invasiveness of the hybrid species relative to the original parental species. A third goal is to be able to identify the different species through specific morphological traits that will allow someone to determine if they have the invasive hybrid on their property.

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

In our study, we were able to identify specific morphological traits that will allow for a determination of whether the invasive hybrids are present in the plant community. Because we verified each species' identity with genetic markers, we can correlate the genetic identity of each species with specific morphological traits. Therefore, our research provides a way for farmers, state agencies and non-profits like the Nature Conservancy to determine if the invasive hybrid is on their property and take steps to remove it.

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

Invasive species are among the greatest threats to the world's biodiversity. Vermont is not immune to this threat. By studying two closely related species that hybridize to form a more invasive third species, we are beginning to understand how changes at the genetic level create morphological changes that lead to greater invasive ability and ultimately to greater spread. Because introduced species can undergo evolutionary change post-introduction, our study is documenting the potential detrimental effects of continually introducing new genetic variants or varieties into landscapes, even when the landscape already contains non-invasive relatives.

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

Publications resulting from this work

Palacio-Lopez, K. and J. Molofsky 2021. Phenotypic shifts following admixture in recombinant offspring of *Arabidopsis thaliana*. *Evolutionary Ecology*
DOI: [10.1007/s10682-021-10118-9](https://doi.org/10.1007/s10682-021-10118-9)

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

Climate change is disrupting precipitation patterns and leading to increased droughty periods during the growing season. As a result, vegetable farmers in the Northeast are increasingly recognizing the need for irrigation, and for more efficient irrigation. While soil moisture sensors are commonly used in other regions and sectors, these systems often are not optimized for Northeast growers, so few rely upon this technology to schedule irrigation. Many farmers are interested in understanding if networked soil moisture sensors with continuous measurements are worth the investment. That is, will the increased irrigation efficiency brought by this technology pay back in terms of yield or quality of produce?

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

Researchers with the UVM Center for Sustainable Agriculture's Farming and Climate Change Program, in partnership with the University of Maine, conducted a survey of New England vegetable growers to ascertain how farmers make decisions about when and how much to irrigate. Using the survey results, they successfully applied for a Northeast Sustainable Agriculture Research and Education Novel Approaches grant. The funded project entails research for two full growing seasons to measure water usage, yield, quality, and nitrogen leachate in cucumbers, tomatoes, and peppers as a function of various approaches to irrigation scheduling.

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

Although the project is still in its second year, valuable information was gained from the first year of study, as well as complementary work on other working vegetable farms in Vermont. No significant yield difference was observed as a result of the usage of the soil moisture sensing technology. This result has been shared through multiple farmer presentations and conversations with agricultural service providers, which has helped avoid costly investments in troublesome technology. At the same time, knowledge and awareness of the importance of efficient water usage has spread throughout the farming community. Awareness of other, less expensive and simpler technologies also has been raised. Farmers and service providers who have chosen these options have presumably used water more efficiently, resulting in improved yields and profits.

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

While irrigation is widely used on Northeast vegetable farms, few growers rely upon soil moisture sensors to schedule irrigation. Many farmers over-irrigate, causing nutrient leaching, or under-irrigate, leading to decreased yields and quality. Better information about soil moisture conditions and soil moisture sensing technology, tailored to the scale and diversity of these farms, can greatly improve irrigation efficiency while protecting water quality and supply in an era of climate change.

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

Invasive pests such as the emerald ash borer (EAB) can change the nature and functioning of Vermont's forests and cost municipalities thousands of dollars to manage infested hazard trees. EAB is in Vermont, and although it cannot be eradicated, informed residents can slow the spread, giving municipalities and property owners time to plan and spread out costs associated with management.

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

The Vermont Urban & Community Forestry Program (VT UCF) partnered with the Vermont Department of Forests, Parks and Recreation; the Vermont Agency of Agriculture, Food and Markets; and the Vermont Land Trust on EAB Awareness Week, held May 15-22, 2021, sending out press releases and social media posts to raise awareness. In addition, VT UCF provided support and gave away EAB Awareness Week Toolkits to the first nine towns that submitted requests plus supplied an additional two towns that held events with other outreach materials. Volunteers in the Forest Pest First Detector program and members of Conservation Commissions in each of the 11 municipalities created publicity and outreach and education events in their communities. These included articles and press releases,

guided ash tree walks, presentations, ash tree tagging events, community displays, and event booths.

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

As a result, residents are learning about EAB and management options from other residents of their communities. As an example, a Forest Pest First Detector, who is also a town tree warden and forest owner, used materials and support from the VT UCF program to put together an invasive pest awareness booth at his town's Memorial Day Celebration, the largest and best attended town-wide event every year. Using his knowledge of the community, this individual picked the right event to host a display booth, was able to recruit a Conservation Committee member to help staff it, and placed the booth in a high-traffic location next to the fire department's BBQ booth. As a result, approximately 60 town residents received information about the threat of this invasive pest and management options for different types of property (yard, forest, and municipal) through one-on-one conversations and educational literature, including wallet-size EAB identification cards. An often-heard comment was, "I didn't know that." These outreach and education efforts by community volunteers have greatly expanded the state's outreach capacity for disseminating EAB information.

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

In recent years, EAB has become a significant threat to urban and community forests in Vermont and many other states as it kills both stressed and healthy ash trees that not only beautify neighborhoods, but provide shade to cool streets and homes. Loss of these trees has a staggering economic impact on communities that need to spend thousands of dollars to manage or remove infested trees and replace with other species. Increasing public awareness will encourage people to take action to help the places where they live, work, and play to better manage this invasive pest through information sharing as well as monitoring and reporting of trees suspected to be infested.

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

According to the "Beyond the Gap: How America Can Address the Widening Opportunity Gap Facing Young People" white paper released by the National 4-H Council, "PYD programs provide a place for youth to experience psychological and physical safety, to belong and matter, to develop supportive peer relationships, and to experience positive social norms and boundaries (Eccles & Gootman, 2002) – all important ingredients for alleviating youth stress and building resilient mindsets and skills." This white paper also states that "the widening opportunity gap in America is affected by four key elements – race, ethnicity, ZIP code and socio-economic status" and that "COVID-19 has exacerbated the inequities our young people face in terms of their mental health, their access to education and their employability – particularly amongst those who were already experiencing trauma, systemic social inequity and other disadvantages prior to the pandemic." In facilitating the Vermont Network's Askable Adult training, two UVM Extension 4-H educators (Lauren and Allison) aimed to expand the number of adults trained in providing safe, trusting, and affirming relationships with youth in their lives to help build protective factors and increase youth resiliency in Vermont communities.

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

technical summary.

At the onset of the pandemic, Lauren and Allison attended the Askable Adult training and were inspired to take up the training as facilitators. They have since facilitated five sessions of the Askable Adult training. Each training is a total of three hours and covers topics such as:

- Building Trusting & Affirming Relationships
- Commit to Consistent Connections
- Commit to Caring Communication
- Be a Curious Co-Pilot

Askable Adult is a conversation based training. Participants listen to interviews of youth-mentor pairs and then are given reflection questions discussed in several formats: small group, large group, and breakout pairs. The training was developed out of and looks at data collected from a 2017 survey by the Vermont Network of 584 youth ages 10-24. The survey "identified an array of concerns that cause them stress in their everyday lives—including drug and alcohol use; poverty; sexism and harassment; body shaming and bullying; and homophobia and transphobia. When asked what would help, young people said that the number one solution would be having more supportive and “askable” adults in their lives."

(source: <https://vtnetwork.org/wp-content/uploads/2020/03/Askable-Adult-Lesson-Plan-Facilitator-Guide.pdf>) We can also assume with the onset of the global pandemic that both new and old stressors have been accentuated for youth in our communities. Equipping adults with the skills to be more askable can help support youth particularly during this time and help address this added stress for youth.

Through the training, we reached 83 adults spanning across Vermont and other states including New Hampshire and Massachusetts. Participants included educators, parents, Afterschool professionals, foster parents, youth sports coaches, members of religious organizations, and other youth serving organizations.

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

At the end of each session an evaluation was administered. The VT Network also followed up with respondents in a three month survey. In the initial program survey, 31 participants responded that they had practiced communication and listening skills to improve caring communication with youth. When asked what participants learned that they will bring back to their relationships with children and youth, eight specifically listed the WAIT tool (why am I talking?) that helps adults remember to practice listening when talking to youth. Many other participants listed listening, patience, and cultivating a sense of curiosity in their relationships with youth.

In the three month follow up survey, 18 participants responded. It is important to note that we do not have a way of knowing if these participants were in our UVM Extension led sessions or if they were led by other facilitators. Ten respondents said that they has used what they learned in the Askable Adult training often with three saying that they use it a lot and three participants who have used their knowledge sometimes. As a result of the training 15 participants had identified and worked on building a skill to become more askable and 14 had actively learned about a topic relevant to youth as prompted by the training.

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

Bringing the Askable Adult training to adults in our communities aims to ensure that youth have supportive and affirming adults in their lives. This is always an important factor for youth resiliency but also particularly now when many youth are feeling isolated and anxious due to the global pandemic. As one participant reflected, "The training was a great reminder of how important simply being consistent is. I've really ramped up my efforts to ensure I am following through for the kids in my life". Another participant reflected on how they have adapted their virtual programs with youth: "I used what I learned in the training to structure a virtual youth program for more sharing out and space for youth to lead the conversation. I also tried to be consistent in affirming and not judging what youth shared in that space. I also am working to bring Askable Adult to other adults." Lauren and Allison look forward to continuing to bring this content to different segments of the community that might find the tools offered in the Askable Adult training helpful to supporting youth in their community.

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

Latino farmworkers leave loved ones and familiar sights, sounds, and tastes behind when they take an often-arduous path across the United States border. They come to Vermont to support their immediate and often extended families in meeting daily living expenses while at the same time hoping to provide a stable economic future for themselves. Once in Vermont, they work long, hard days while facing significant geographic, cultural, and linguistic isolation. Their lived experiences and the expectations of their ability to provide for their families can create or contribute to stress and anxiety. Despite increasing awareness, conversations, and media coverage about mental health promotion and self-care across the United States, these concepts and practices are not familiar to many workers.

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

Bridges to Health (BTH) is a grant funded health access and outreach program that works with migrant farmworkers across every county in Vermont to create more equal health opportunities. For the past three years, BTH staff have incorporated conversations about personal health and wellbeing into their visits to farmworker households by utilizing comics based on stories told by workers, wellbeing wheels, and engaging in one on one and group conversations. Last year, BTH hired a Personal Health and Wellbeing Coordinator to offer more one on one sessions exploring strategies – like yoga, meditation, and drawing – to address non-clinical stress and anxiety. This expanded capacity enabled the BTH team to help over 60 farmworkers learn new skills designed to mediate mental health stressors.

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

Through the following stories are of individual results, they are a strong representation of the value of this work:

Story 1: Dario* is a migrant farmworker who lives in a remote town in northeastern Vermont. Until recently, he worked seven days a week and over 12 hours a day. He now works six days a week on the overnight shift of 12 hours. He describes his workday as "hard and long without breaks." He said that living isolated with no-one nearby to visit and working all the time meant that he often would go from work to the house and back to work without connecting with anyone off the farm. He often

felt “stressed, isolated, and bored.”

Dario had never heard of yoga and meditation until he met Meghan (BTH’s Personal Health and Wellbeing Coordinator). Meghan explained that both practices could help both his body and mind. He met in person a few times when the weather was nice last year and then did some sessions virtually. He says that yoga “helped his body relax after the stress and exhaustion of daily work.” The meditation helps him “concentrate his mind and let go of the things that are bothering him.” Dario doesn’t have a lot of time in his day and prefers to do sessions with someone else. However, he says he has practiced enough that he knows many of the movements and can practice independently or using videos that Meghan has shared for both yoga and meditation. Dario says he feels “happier and lighter” after doing both yoga and meditation and that both have helped with his sleep – something that was a challenge for him previously.

Story 2: Last fall, an outreach nurse offering a health screening and COVID education with a migrant farmworker, identified high blood pressure as a significant concern. She referred the worker to the Personal Health and Wellbeing Coordinator who introduced him to yoga. A follow up visit with the nurse found that his blood pressure had decreased, and he reported feeling much better.

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

Vermont farms are increasingly dependent on the immigrant farmworker population. The economic success of these farms relies on having a healthy, productive, and contented workforce; a goal reached in part by supporting improved culturally and linguistically appropriate health care access, health education, and the promotion of healthy living choices, including mental health and self-care.

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

Our project addresses the evolution of insecticide resistance in the Colorado potato beetle, a globally invasive agricultural pest. Insecticide resistant threatens the productivity of US agriculture. Since temperature rises due to climate change are projected to increase in population expansions in insect pests, our project also addresses the interactive effects of insecticide exposure and heat stress on insect performance as well as genomic responses. By examining these responses among insecticide resistant and susceptible Colorado potato beetle strains, our aim is to provide information to help develop effective pest management tools to combat the evolution of insecticide resistance

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

We have made substantial progress in accomplishing our project goals. In the past year, we conducted all of the cross-tolerance experiments using two sets of resistant and susceptible beetle strains. We collected the phenotypic data from these experiments and analyzed for statistical differences. For the genomics part of our study, both gene expression and epigenetic sequencing projects were completed last summer, and we are currently analyzing those data sets using a high computing server. The analysis will be completed by the end of this summer.

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

The results from our project will allow our target audience (growers, pest management scientists, evolutionary biologists) to better understand the impacts of stress on insect pest life-history traits, patterns in gene expression, and epigenetic modifications. Given that epigenetic modifications have been linked to stress tolerance in other organisms, our findings will contribute to this growing field in insect pests. This information may potentially help identify genetic targets for the development of genetically based pest management tools that can help reduce the rates of evolutionary change within economically important insect pests.

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

The activities of our project can potentially benefit the broader public through outreach events geared towards educating others about rapid evolution in insect pests and what it means for food security and pest management. Presenting our findings will allow us to not only discuss the importance understanding how insect pests adapt to multiple stressors but will also help create a dialogue around the urgency of finding more sustainable pest management solutions.

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

Bueno, E. M., C. McIlhenny, and Y. H. Chen. Submitted. Cross tolerance to stress in insect pests: Implications for pest management in a changing climate. *Pest Management Science*.

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

Healthy and well-adapted forest ecosystems are key components of sustainable environments, providing clean air and water, carbon sequestration, wildlife habitat, forest products, and recreational opportunities. As the climate changes, forest tree populations face the threat of potential maladaptation that may offset these critical ecosystem services. This project assess the climate adaptability and responses of a keystone forest tree species -- red spruce -- using a combination of genomics, field demographic surveys, and modeling for prediction.

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

In this activity, PI Keller and his research staff and collaborators traveled to Colebrook, NH, where red spruce has been established in a plantation trial dating back to the 1960s for the purpose of assessing growth responses of trees from different climate provenances. This plantation contains mature red spruce trees that have experienced over 6 decades of weather variability and changing growing seasons -- effects that are recorded by different indices of plant growth response. In fall 2020, we measured all surviving trees for their diameter at 1.3 m trunk height, and their total overall height using a laser range-finder inclinometer.

In addition, we sampled tree rings of red spruce to get detailed growth measurements for each annual growing season from the 1960's to present. For this, we sampled 2 cores each from >100 trees in the Colebrook plantation and

brought them back to UVM for processing. These tree rings are currently being processed by our collaborator at UVM's dendrochronology lab in collaboration with our colleague at the USDA Forest Service, Paul Schaberg, who is an expert in dendrochronology and climate associations in red spruce.

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

While this activity is largely reporting new sampling and has not produced results yet, the overall activity and the results it will produce are a great benefit to other researchers in forestry, environmental science, genetics, and climate change science who are interested in assessing how genetically differentiated source populations respond uniquely in their tree ring growth patterns to major shifts in climate, including earlier, warmer springs, prolonged summer drought, and unpredictable winters. We have been sharing our study's goals and experimental design with other researchers in the field and have engaged in open and collaborative discussions on this activity and our plans for relating the data to climate adaptability in red spruce and other forest trees.

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

The broader public benefits from policies and environmental stewardship decisions that are guided by the best scientific knowledge available. But, with the pace of climate change happening rapidly, and the long-lived nature of most trees, it is difficult to gather the kind of detailed growth data needed that span decades of climate variability and also integrate the genetic diversity of different source populations responding to this climate variability. Our activity provides the basis for just such an analysis, and will form the basis of a mechanistic understanding of how trees experience long-term climate effects that are integrated into their annual patterns of growth and seasonal dormancy. This will be a direct benefit to the managers of users of the U.S.'s forest ecosystems.

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

We are on-schedule with our sampling of overall growth indices, and ahead of schedule with the sampling of the tree rings.

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

Winegrapes are a growing sector of Vermont agriculture, with growth from essentially zero acres in the 1990s to approximately 175 acres (~70 hectares) in 2019 and potential economic value of \$6.5 million of wines grown in the state. Vineyards may be expected to attain positive cash flow after fifteen or more years from the time of planting, so selection of a cultivar poorly suited to the site or with suboptimal winemaking quality can substantially impact vineyard profitability. Long-term cultivar evaluations have been conducted at UVM since 2007, but newly-released or advanced evaluation selections may offer improved wine quality or horticultural characteristics that make them more suitable to Vermont vineyards and wineries. However, new cultivars must be evaluated under controlled conditions before recommending to industry to avoid costly mistakes that may cost up to \$250,000/ha in lost production.

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

In this new evaluation, five cultivars (Crimson Pearl, Petite Pearl, Verona, St Pepin, and MN 1285) were planted in a randomized, replicated trial, and four solid rows of Brianna, Louise Swenson, Marquette, and Marechal Foch were also planted to evaluate management practices on those cultivars. In 2018-2019, vines were managed without fungicide applications to evaluate natural susceptibility to disease. No cultivars were consistently disease-free, and all exhibited some degree of black rot and powdery mildew infection. Relative susceptibility to disease was not consistent across both years, but 'Brianna' had greater incidence of black rot and 'Louise Swenson' showed lower incidence of powdery mildew in both years. The relatively new cultivars 'Crimson Pearl' and 'Verona' exhibited comparatively moderate disease susceptibility overall.

Crop yield remains relatively low for some cultivars. Marechal Foch had the greatest mean yield in 2021 with 8.4 kg per two-vine panel (~3.5 tons/acre), whereas some less-vigorous cultivars, e.g., Crimson Pearl, Louise Swenson, and Brianna, had less than one tone per acre equivalent yield. Brianna has suffered from crown gall in previous years and was largely cut back to the ground in 2020 to manage that disease. Louise Swenson has been under-vigorous at this and other nearby sites in prior plantings, typically until the fourth or fifth year from planting when it catches up with other cultivars. In this planting, Crimson Pearl appears to have a similar tendency. However, the no-spray management in the first three years of growth likely reduced overall growth for this and other cultivars. Juice quality for winemaking was acceptable, with chaptalization, for all cultivars. Of particular note is that all cultivars except Marquette had juice titratable acidity below 1.01 g/100 ml.

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

In the 1990s, there was no grape or wine industry in Vermont, but continued refinement of cultivar breeding and selection for unique cold-climate regions have increased the quality of wines made and the economic impact of wineries in the region. By 2016, winegrapes were grown on 165 acres and wine was valued at over \$5 million annually. In a 2021 survey, growers indicated a reduction of plantings of legacy cultivars like 'Frontenac' and 'St Croix' and an increase in plantings of newer cultivars with potentially improved juice chemistry for wine making. Innovation in the Vermont industry was recognized in 2019 when the state was selected to host VitiNord 2022 (originally 2021, delayed due to COVID). This is the premier international cold climate grape and wine conference in the world which will attract substantial attentions to the industry from regional, national, and international stakeholders.

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

A stable and even growing grape and wine industry provides substantial economic and cultural benefits to rural and associated communities. Respondents to a 2012 grape and wine producer survey indicated average of 2.6 full-time employees per operation, exclusives of owners and managers, and mean annual sales over \$200,000 per operation. However, winery tourism and associated activities extends economic activity far beyond individual wineries or even collective wine sales. In a 2016 study of economic impact of Northern, cold-hardy wine and grapes, including data from Vermont, vineyard employment income was estimated to be 20% of total

gross grape revenue, or \$1 million estimated in Vermont annually. Tourism-related economic activity was estimated at an additional 69% of total sales, or about \$3.5 million annually in Vermont [1,2]. We estimate that total economic activity from wine and related activities in Vermont contributes over \$10 million to the economy.

1. Tuck, B.; Gartner, W. Economic Contribution: Vineyards and Wineries of the North. Available online: https://www.apec.umn.edu/sites/apec.umn.edu/files/winery_final_report-1.pdf (

2. Vermont Sustainable Jobs Fund. *Vermont Farm to Plate Strategic Plan Chapter 3.3 Food Production: Hard Cider, Spirits, and Wine* Montpelier, VT, 2013; http://www.vsjf.org/assets/files/Agriculture/Strat_Plan/Chapter%20Getting%20to%202020_Low%20Res.pdf.

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

Project outputs and supporting activity:

Hazelrigg, A. L., T. L. Bradshaw and G. S. Maia. 2021. "[Disease Susceptibility of Interspecific Cold-Hardy Grape Cultivars in Northeastern U.S.A.](#)" *Horticulturae* 7(8): 216. Special issue on Grape Responses to Abiotic and Biotic Stresses. DOI:10.3390/horticulturae7080216

Bradshaw, T. (lead author). 2021. Grapes and Wine. Vermont Sustainable Jobs Fund Farm to Plate 2.0 Product Brief. Issue briefs drafted by statute for presentation to Vermont legislature in 2019-2020 session.

<https://www.vtfarmtoplate.com/assets/resource/files/Vermont%20Food%20System%20Plan%20Product%20Brief%20Grapes.pdf>

Bradshaw, T. UVM Fruit Website, <http://www.uvm.edu/~fruit>. Outreach website for tree fruit and viticulture-related horticultural and IPM information for commercial growers. Affiliated blog archives 12 email postings made to grape producer listserv (275 subscribers) during reporting period.

Bradshaw, T.L.; Hazelrigg, A.; Berkett, L. Relative Disease Ratings for Wine Grape Varieties Grown in Vermont; UVMFRT003; UVM Extension: Burlington, VT, 2020; https://www.uvm.edu/~fruit/grapes/gr_ipm/UVMFRT003_2020RelativeGrapeDisease.pdf.

Fund Leveraging

Evaluating systems components for orchard and vineyard crops in Vermont. Vermont Agriculture Experiment Station Hatch Grants Program, Oct 2020 -Sep 2025. \$63,942. PI: T. Bradshaw

VitiNord 2022: A pivotal opportunity for education, collaboration, and innovation among Vermont grape and wine producers. USDA/Vermont Agency of Agriculture Specialty Crops Block Grants Program. PI: T. Bradshaw. October 2021 – March 2023. \$20,548.

Vermont IPM Extension Implementation Program: 2021-2024. USDA CPPM EIP. PD: A. Hazelrigg. Co-PIs: S. Bosworth, T. Bradshaw, H. Darby, M. Skinner. August 2021 - July 2024. \$499,574 total, \$91,677 for Fruit emphasis area.

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

Hemp acreage is quickly expanding in VT and beyond. At the conclusion of 2019, the Vermont Agency of Agriculture, Food and Markets had registered over 9,000 acres of hemp and issued just under 1,000 registrations to grow the crop. The rapid expansion is a result of the passage of the 2019 Farm Bill which grants hemp "crop status", therefore removing it from the Drug Enforcement Administration list. The amount of research-based disease and pest information available to growers is limited and the information available is often based on areas with different climate conditions and disease/pest pressures. Many hemp growers are new to farming and are struggling with disease and pest identification and management. Researchers are unclear as to the scope of the problems and the severity. In addition, farmers lack basic research based information on fertility management and variety selection that will maximize yields and quality.

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

The goal of this project is to do a statewide survey identifying disease and arthropod challenges and to assist farmers with developing best management strategies for growing high yield and quality hemp. There were 11 farms visited twice throughout the season to survey for disease and arthropod pests. Spider mites and thrips were the least common pests seen on the hemp leaves. Spider mites were scouted at only one location in New York, and thrips were scouted at one farm in New York and one in Vermont. European cornborers (ECB) were only scouted in Connecticut and Vermont, and flea beetles were only seen in Vermont. Aphids were the primary insect pests and were identified in every state, followed by leaf hoppers in Maine and Vermont. The warm and dry growing conditions throughout much of the season resulted in relatively low levels of foliar and root disease. *Sclerotinia* white mold was observed in Maine and Vermont, and powdery mildew was observed in Connecticut and Vermont. Leaf spots were seen in every state, and at every farm site except one farm in Addison, Vermont. Botrytis was also recorded in every state.

In 2021, we tested organic approved fungicides in replicated hemp plots to determine efficacy and cost, in addition to assessing genera of plant parasitic nematodes in the crop, a known pathogen of hemp. Of the fungicides tested, only a copper-based product (Kocide 3000) showed efficacy against common fungal diseases in hemp. All other organic fungicides did not reduce disease compared to the control. Additional products will be tested in 2022.

Research trials were also initiated to evaluate the impact of nitrogen fertility and variety selection on hemp yield and quality. Nitrogen rates ranging from 0 to 200 lbs per acre were added to replicated plots of hemp being grown for grain, fiber, and flower. Nitrogen rates between 100 and 125 provided optimum yields at the lowest nitrogen rate. Nitrogen rates will be studied again in 2022.

Varieties of hemp being grown for grain, fiber, and flower were evaluated in replicated trials conducted at Borderview Research Farm in Alburgh, Vermont. Varieties were secured from companies throughout the United States, Canada, and

Europe. Separate trials evaluated the impact of variety on hemp fiber yield (13 hemp varieties were evaluated); the yield potential of hemp grain varieties in the Northeast (22 grain and dual-purpose hemp varieties were planted); and assessed hemp flower for yield, quality and tolerance to pests (27 full season hemp varieties for evaluation).

Results from all trials were summarized and distributed to our target audiences (see publications and outreach channels referenced below). This adds to the body of research-based hemp information available and necessary to support this rapidly growing crop.

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

Project information and results were delivered to our target audience throughout the 2021 growing season. The target audience includes farmers and other stakeholders that assist farmers with growing hemp.

The 3rd Annual Hemp Conference was held virtually in February, 2021. There were 185 attendees from 8 states and 3 provinces. The conference provided information on pest and fertility management, variety selection, marketing, and a wide range of diverse hemp information. Research from the Hatch trials was highlighted. There were 16 live presentations and 13 on-demand presentations. Essentially there was nearly 25 hours of educational material offered through the conference.

In the spring of 2021, a series of webinars focused on hemp production was delivered to stakeholders during the summer. There were 2 webinars held from June through September. The goal was to provide timely information to growers related to production and regulation.

Growing High Quality Hemp Starts with Gretchen Schimelpfenig, Lauren Tonti, and Chris Callahan. (12-April, 21). 57 attendees & 225 views. https://www.youtube.com/watch?v=aih9_Dytzdg

Development of Triploid Seedless Hemp Varieties. (20-May, 21) 43 attendees & 215 views. https://www.youtube.com/watch?v=Ny1_ZUyEQOU

On August 10, 2021 a hemp field day was hosted at Borderview Farm. There were 65 attendees from 3 states. Farmers were able to tour hemp research trials including fertility, variety, and pest management trials. In addition, a scouting intensive was held to help farmers learn more about pest identification and pest management.

Of the farmers in attendance 75 indicated that they were able to better identify pests, understand fertility amendments, take and read a soil test, and pest management options.

The pandemic shifted much of our outreach remotely but we still were able to provide farmers with high quality education. We focused on various topics such as fertility management, taking soil samples, and reading a soil test over several educational events. Attendees were surveyed post event and the number of farmers indicating changes in knowledge were recorded.

We also were able to complete online reports to distribute to the farming community and other professionals (see list in comments section).

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

The general public are welcome to join the UVM outreach events and often members of the public do join to learn more about agriculture. Hemp is a crop that is often misunderstood and educational events can draw large crowds. In general, our outreach in-person, virtual, and online resources have helped the general public better understand the opportunities that exist for industrial hemp.

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

There were no major challenges during the 2021 growing season. Weather was exceptionally dry but did not seem to impact hemp growth and development. Dry weather did keep most pest pressure low. Outreach of the results to stakeholders was limited due to the ongoing pandemic but virtual events were held to share research information.

Online reports distributed to the farming community and other professionals:

Darby, H., Sullivan, L. and J. Bruce. 2021. Industrial Hemp Fiber Variety Trial. University of Vermont Extension Northwest Crops and Soils Program. St. Albans, VT. https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2021%20Research%20Rpts/2021_hemp_fiber_report.pdf (accessed 13 Jan 2022).

Darby, H., Sullivan, L. and J. Bruce. 2021. Industrial Grain Hemp Variety Trial. University of Vermont Extension Northwest Crops and Soils Program. St. Albans, VT. https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2021%20Research%20Rpts/2021_Grain_hemp_VT_report_final.pdf (accessed 24 Feb 2022).

Darby, H., Bruce, J., Davidson, C. and L. Sullivan. 2021. Hemp Flower Nitrogen Fertility Trial. University of Vermont Extension Northwest Crops and Soils Program. St. Albans, VT. https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2021%20Research%20Rpts/2021_Hemp_Nitrogen_Fertility_Final.pdf (accessed 14 Mar 2022).

Darby, H., Bruce, J., Sullivan, L. and S. Ziegler. 2021. Hemp Flower Variety Trial. University of Vermont Extension Northwest Crops and Soils Program. St. Albans, VT. https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2021%20Research%20Rpts/2021_UVM_Hemp_Flower_Variety_Trial_Final.pdf (accessed 14 Mar 2022).

Darby, H., Sullivan, L. and J. Bruce. 2021. Industrial Hemp Fertility Trial. University of Vermont Extension Northwest Crops and Soils Program. St. Albans, VT. https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2021%20Research%20Rpts/2021_Industrial_Hemp_Fertility_Report.pdf (accessed 14 Mar 2022).

Darby, H., Hazlerigg, A., Malone, R., Bruce, J., Wilcox-Warren, S. and S. Lewins. 2021. On-Farm New England Hemp Pest & Disease Scouting Report. University of Vermont Extension Northwest Crops and Soils Program. St. Albans, VT. https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2021%20Research%20Rpts/2021_On-Farm_Hemp_Scouting_Report.pdf

(accessed 14 Mar 2022).

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

Saffron is a high-value crop that could provide small US farmers with added revenues to sustain their agricultural operations. Hundreds of farmers nationwide are starting to grow saffron, selling their crop for \$20-75/gram. Damage from bulb mites and small mammals can reduce saffron revenues. Saffron is a fall-blooming crocus that could provide a valuable food source for pollinators, helping to sustain them over the winter.

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

The primary goal of this project is to assess biological control tactics to address saffron pest problems. We tested the effectiveness of a commercially available predatory mite, *Stratiolaelaps scimitus*, as a biological control tool. This first involved identification of the species of bulb mites that are associated with saffron corms, and learning how to rear them in the laboratory. We also conducted lab trials to determine what release rate was best to suppress pest problems. Through this research, we determined that the predatory mite species tested consumed the bulb mites quickly, and the 1:5 predator/prey ration was the most effective. We also found that combining predatory mites and an insect-killing fungus increased the effectiveness of bulb mite suppression.

We also conducted a survey of insects attracted to saffron flowers and found that over 90% were honeybees. We also learned that honeybees were more abundant on days with a few clouds than on sunny days.

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

We held multiple on-farm and online educational events reaching over 1,000 growers. These events included discussion of bulb mite and disease management in saffron fields. We also prepared factsheets for new growers, describing how to plant, harvest, dry and market saffron.

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

The general public benefits from our work to promote saffron production because saffron supports small family farms. These make up over 90% of farms in the US and are responsible for producing vegetables and other staple food crops. Developing saffron as a high-value crop will contribute to sustaining these farms, and discourage suburban sprawl and non-agricultural development on arable land.

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

Major changes:

We focused on field rather than high tunnel production because most growers in the

US are growing saffron in the field, not high tunnels. We have learned that saffron survives over the winter even in plant hardiness zones 4 and 5, allowing field production.

We focused our research on bulb mite management rather than small mammals because the latter posed a minimal problem in our field sites. In addition, placing deer netting over the saffron beds appeared to be sufficient in most cases to reduce this issue based on discussions with growers.

Opportunities for training and professional development provided:

Because saffron is still a new crop training of beginning growers is critical for supporting and expanding the industry. Therefore, we have invested considerable time holding educational events, both on farms and online to introduce new growers to the basic methods as well as provide advanced training for established growers.

Project plans in the future:

1. Continue outreach to growers, including hosting the 6th annual workshop on saffron in March 2022, managing and expanding the saffron listserv; updating the UVM Saffron Center website.
2. Continue research on assessment of biological control of bulb mites.

Peer-reviewed publications:

Ghalehgolabbehbahani, A., C.F. Sullivan, A. Davari, B.L. Parker, A. Razavi & M. Skinner. 2022. Biological control of *Rhizoglyphus robini* using the entomopathogenic fungus, *Metarhizium brunneum* and predatory mite, *Stratiolaelaps scimitus* under laboratory conditions. *Experimental and Applied Acarology*. In press.

Ghalehgolabbehbahani, A., M. Skinner, B.L. Parker, A. Razavi, P. Reese & A. Davari. 2020. A standardized method for rearing *Rhizoglyphus robini* (Astigmata: Acaridae). *J. Plant Dis. Protection*. doi.org/10.1007/s41348-020-00381-3

Presentations, Workshops and non-refereed Publications:

Skinner, M., B.L. Parker, Jonathan Chapple-Sokol & A. Ghalehgolabbehbahani. 2021. Saffron Corm Harvesting. UVM North American Center for Saffron Research & Development, Burlington, VT.

Ghalehgolabbehbahani, A., M. Skinner, B.L. Parker, & S. Schneebeli. 2021. Saffron Drying Methods. UVM North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., B.L. Parker & A. Ghalehgolabbehbahani. 2021. Where Can You Order Saffron Corms? UVM North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M, B.L. Parker & A. Ghalehgolabbehbahani. 2021. Harvesting Saffron Flowers. UVM North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., B.L. Parker & A. Ghalehgolabbehbahani. 2021. Saffron: A Golden

Opportunity. A New Crop to Support Small Family Farms. UVM North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., B.L. Parker & A. Ghalehgolabbehbahani. 2021. Saffron: A Golden Opportunity for Diversified Farmers. UVM North American Center for Saffron Research & Dev., Burlington, VT.

Skinner, M., B.L. Parker & A. Ghalehgolabbehbahani. 2021. Saffron Production for Home Gardeners: Planting Depth and Density for Saffron Corms. UVM North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., B.L. Parker & A. Ghalehgolabbehbahani. 2021. Saffron Cultivation: Descriptions of Planting Methods. UVM North American Center for Saffron Research & Devel., Burlington, VT.

Parker, B.L., M. Skinner, A. Razavi & A. Ghalehgolabbehbahani. 2021. How to Balance Your Saffron: UVM North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., A. Ghalehgolabbehbahani & J. Pylypiv. 2021. The Potential of Saffron for Small Farmers. Podcast #14. Wisconsin Extension System.
<https://soundcloud.com/cutting-edge-podcast/cutting-edge-episode-14-saffron>

Skinner, M., A. Ghalehgolabbehbahani, J. Pylypiv & P. Shorey. 2021. The Market Potential of Saffron for US Farmers. Podcast #15. Wisconsin Extension System.

Skinner, M., A. Ghalehgolabbehbahani, J. Pylypiv & P. Shorey. 2021. The Finer Points of Producing Saffron in the US. Podcast #16. Wisconsin Extension System.

Skinner, M., A. Ghalehgolabbehbahani & B.L. Parker. 2021. Saffron: From Start to Finish, Planting to Selling. 4th annual saffron workshop. North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., A. Ghalehgolabbehbahani & B.L. Parker. 2021. Saffron from the Beginning and Saffron Drying Research; on-farm demonstration, Hyde Park, VT Sept. North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., A. Ghalehgolabbehbahani & B.L. Parker. 2021. Saffron Winter Survival and the Next Step in Cultivation; on-farm demonstration, Wells River, VT May. North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., A. Ghalehgolabbehbahani & B.L. Parker. 2021. Saffron Corm Sampling, Plot Preparation and Disease and Mites; on-farm demonstration, Barre, VT July. North American Center for Saffron Research & Development, Burlington, VT.

Skinner, M., A. Ghalehgolabbehbahani & B.L. Parker. 2021. Corm Harvesting; online training August. North American Center for Saffron Research & Development, Burlington, VT.

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

The 2017 USDA Census of Agriculture reports that 36% of all farmers and ranchers are female, and 56% of all farms have at least one female decision-maker. The number of U.S. farms with a female principal operator nearly quadrupled over the

past four decades, from 5% in 1978 to about 29% in 2017. But women farmers and ranchers encounter many challenges. More than 80% of women-operated farms reported sales and government payments of less than \$50,000 according to the USDA-National Agricultural Statistics Service. Women operators do not apply for or utilize agricultural support programs as effectively as their male counterparts, and the businesses of many beginning farm and ranch women do not survive the first five years.

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

The national Women in Agriculture Learning Network, launched in October 2013 with leadership provided by the UVM Women's Agricultural Network (WAgN), is working to enhance opportunities for educators interested in improving, expanding, and starting outreach programs for beginning farm and ranch women. The overarching goal of the initiative is to help women farmers and ranchers across the U.S. meet their business and quality of life goals. One component is a national website (womeninag.extension.org) that provides informational resources and tools geared to topics of high relevance to women farm and ranch operators. The website also includes a national directory of U.S. women in agriculture programs and links to training, curriculum, and research reports to help educators and technical assistance providers develop effective programming.

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

Outreach efforts, conducted using a combination of e-newsletters and social media posts, have connected over 6,500 people with resources and information. Currently, the Women in Agriculture Learning Network e-newsletter has 1,251 active subscribers. All 50 states and Washington, D.C. are represented on the list. Of the total number of subscribers, 954 people provided information about their occupation. Of those, 368 indicated that they are agricultural educators and technical service providers working for Cooperative Extension Services, nonprofit organizations, land-grant universities, or other institutions of higher education. The balance of subscribers are a mix of farmers, ranchers, landowners, farm employees, and the general public. This list includes 476 women who described themselves as either aspiring or beginning farmers. According to Google Analytics data, since the beginning of 2019, the national website has had 6,586 unique U.S. visitors in 8,211 sessions. About 23% of users were return visitors. Roughly 64% of all visitors use desktop computers to access the site, while 32% use smart phones, and 4% use tablets. Visitors came from all 50 states, the U.S. Virgin Islands, and Puerto Rico. Page visit data (a total of 20,550 page views) indicates that individuals go to the site to look for information resources and search for programs and opportunities in their area. The most popular pages after the home page are the resource library (womeninag.extension.org/resource-library) with 1,618 page views and the directory of women in ag programs (womeninag.extension.org/women-in-ag-programs) with 1,462 page views. During this past year, U.S. users accessed materials and/or downloaded resources 942 times. This effort was made possible by the USDA NIFA Beginning Farmer and Rancher Development Program (Award No. 2014-68006-21873) and gift funding from Agribank and many generous small donors to WAgN. Collaborators included Iowa State University, University of Missouri Extension, Pennsylvania WAgN, the University of Arkansas School of Law, and approximately two dozen farmers, ranchers, and agricultural professionals from

around the U.S.

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

Although more than one third of all farmers and ranchers in the U.S. are women, these operators do not access available resources, including agricultural support programs, training, and other business tools, as effectively as their male counterparts. The national Women in Agriculture Learning Network is working to change that by providing information specific to this target group through its website, social media, e-newsletters, and other outreach efforts.

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

An important factor in growing and selling high-quality greens is being able to efficiently wash, cool, and dry the product. The drying step is commonly done using centrifugal force in a spinner, which spins the water off the greens through a filter basket or other porous container. Small- and medium-scale farms often find themselves stuck in the middle, where inexpensive, small-scale spinners cause a bottleneck, but it is hard to justify a more expensive industrial, stainless, restaurant-style machine to dry greens. The solution for many of these growers is to use a washing machine. Use of this equipment is not prohibited by the Food Safety Modernization Act Produce Safety Rule (PSR), which sets mandatory, science-based, minimum standards for the safe growing, harvesting, packing, and holding of fruits and vegetables grown for human consumption. However, its use as a greens spinner can present food safety concerns making proper design and management essential.

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

To improve the efficiency of washing machines used as greens spinners and prevent them from causing more problems than they solve, Andy Chamberlin and Chris Callahan from the UVM Extension Ag Engineering Program have applied hygienic design principles to reduce produce safety risks. With proper management and attention to the details of hygienic design, a washing machine greens spinner, like any other equipment, can meet the standards of the PSR [112.123(a) & (c)]. Through research, the agricultural engineers developed best practices for selecting a washing machine for conversion, standard operating procedures (SOPs) for conducting the conversion, and guidance for maintenance, cleaning, and sanitizing such conversions. These resources are available to produce growers through UVM Extension blog posts, downloadable PDFs, and YouTube videos. In addition, workshops on hands-on spinner conversion have been held so growers can bring their washing machines for help with conversion.

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

To date, 34 growers have expressed interest in improving their homemade greens spinner. Fifteen of those have already done at least one conversion. Growers have remarked on the time saved in cleaning, the ease of wash-pack cleanup using a spinner on wheels, and the cycle time improvement that comes from having a machine with a brake installed. They also have expressed thanks for the clear instructions (SOPs) provided for specific models of washing machines. Educational materials about greens spinners for farm use not only benefit growers and their customers. Produce safety enforcement personnel from around the country have

used the materials to better understand the nuance of this practice and how it can be done in such a way that complies with the federal regulations. This has eased some concerns by growers and encouraged conversations about needed improvements on specific farms in Vermont.

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

Consumers expect the food they purchase to be grown and handled so that it is safe to consume. Yet every year, the Centers for Disease Control and Prevention estimates that around one in six Americans contracts a foodborne illness with more than four million people getting food poisoning from produce. Growers have a responsibility to follow good food safety practices at each stage of production from planting, harvesting, and processing to marketing to minimize the risk of foodborne illness from greens and other produce. Innovative research such as this is a win-win situation for both the grower and the customer as it provides an alternative to expensive spinners for farms while following federal guidelines for food safety to protect the consumer. Funding was made possible, in part, by the Food and Drug Administration, Food Safety Outreach Program, and by USDA Northeast Sustainable Agriculture Research and Education.

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

The Food Safety Modernization Act (FSMA) was signed into law in 2011. It includes the Produce Safety Rule, which is the first federal standard for the production, harvest, and handling of fruits and vegetables. FSMA established that vegetable and fruit farms with annual produce sales less than \$25,000 are "not covered" by the law, and that farms with annual sales of food less than \$500,000 may be "qualified exempt" from compliance if at least half those sales are within a state, or within 275 miles of the farm, to "qualified end users," such as consumers and retailers that sell directly to consumers. The passage of FSMA led to concerns about the lack of an appropriate food safety program for the many small farms in Vermont that either were not covered or qualified exempt from FSMA.

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

The Community Accreditation for Produce Safety (CAPS) program was created in 2014 as a collaborative effort of UVM Extension, the Vermont Vegetable and Berry Growers Association (VVBGA), and the Vermont Agency of Agriculture, Food and Markets (VAAFM). Its purpose is to establish practical produce safety standards for small- and medium-scale farms, maintain market integrity for VVBGA farmers exempt from FSMA, provide a transparent way for growers to explain their food safety practices, reduce risk from foodborne pathogens on fresh produce, improve the quality and shelf-life of fresh produce, and build an online community where growers and service providers share information.

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

In 2020, 160 farms used CAPS resources on the VVBGA website (vvbga.org) to write or modify produce safety plans with 140 of those farms earning CAPS accreditation. Of these 140 farms, 38 also completed CAPS-Plus by completing a traceability plan, a mock recall, and passing an on-farm audit with VAAFM. The 140 accredited farms had an aggregate production of 2,865 vegetable acres, 447 fruit acres, and 1,822,000

sq. ft. of greenhouse/high tunnels representing a total of \$32.4 million in estimated aggregate annual sales.

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

Accreditation through the CAPS program reassures both customers and retail buyers that produce grown on local farms was handled using best practices to not only minimize food safety risk but also to ensure the quality of fresh produce.

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

To improve sustainable productivity of dairy herds, we need to develop a better understanding of how the diet impacts rumen function. This project is aimed at characterizing how diet profile impacts the rumen metaproteome of dairy cows. Additionally, we aim to identify milk protein biomarkers that are indicative of rumen microbial protein profiles and rumen performance to create a non-invasive approach that can be used on-farm for herd assessment of rumen health.

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

Three experiments are helping us achieve our goal:

1. In our first experiment, we characterized changes in the rumen microbial protein profile in response to fiber and starch levels in the diet. For this experiment, we utilized rumen fluid samples that were collected from cows fed either i) a high starch, low fiber diet, ii) a high starch, high fiber diet, iii) a low starch, low fiber diet, or iv) a low starch, high fiber diet. We isolated the proteins from the rumen fluid, and determined the microbial protein (rumen metaproteome) profiles and identified changes due to diet.

2. In our second experiment, we focused on rumen samples collected from cows fed the low starch, high fiber diet (representative of a control diet) and cows fed the high starch, low fiber diet (representative of a high-risk subacute ruminal acidosis, or SARA, diet). We analyzed both rumen fluid and milk samples collected from these cows at different times of day, and identified milk proteins that were affected by these two diet treatments. The abundances of these proteins are being validated as biomarkers of rumen performance.

3. In our third experiment, we artificially induced a high-risk SARA environment in the rumen, and are further characterizing and validating the impacts of these diets on the rumen and milk protein profiles.

Our goal of gaining a better understanding of how rumen microbes (and their proteins) are affected by diet is being achieved through the above activities.

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

To date, we have completed proteomic analysis of the rumen metaproteome of lactating dairy cows fed different levels of starch and fiber (experiment 1 listed above). The results have been submitted in the form of an abstract to be presented at the American Society of Animal Science (ASAS) 2022 annual meeting. Sharing these results with the scientific community. Additionally, this work has been submitted to

a leading dairy science journal for peer review to allow for broad dissemination of the work. Our aim is to widely publish results from all experiments as a means to support progression of the dairy industry.

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

As we bring the experiments to full completion, we will continue to disseminate the research through presentations and written formats, which creates an opportunity for broader impact and adoption. Validating the relationship between the rumen metaproteome and the milk protein profile will allow an avenue for immediate application of the results.

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

Mastitis is inflammation of the mammary gland resulting from intramammary bacterial infection. It is the most widespread and costliest disease in the dairy industry in the US and imposes approximately \$2 billion of economic losses annually. The major cost of the losses is the reduced milk production in infected cows, but the underlying mechanisms remain to be elucidated. This study will provide insight into the individual and combined effects of bacterial toxins and inflammatory cytokines on MEC survival and function, which will lead to the development of new interventions to reduce the damage of mastitis to the mammary gland and losses in milk production.

Major goals of the project:

(1) Characterize host mechanisms and pathogenic virulence factors associated with mastitis susceptibility and resistance to improve economic outcomes and animal welfare (ID, LA, MI, OR, PA, NJ, TN, UT, VT, WA, Canada).

(2) Identify and apply new strategies associated with the control of mastitis that can reduce the use of antibiotics in dairy herds (CT, ID, ME, MN, MO, NJ, TN, UT, VA, VT, WA, Canada).

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

Methods: The left and right sides of the 4th pair of mouse mammary glands were alternatively injected with either lipopolysaccharide (LPS, Escherichia coli O55: B5, 50 µL of 0.4 mg/mL) or sterile PBS through the teat meatus 3 days postpartum (n = 9). The 4th glands were individually collected 12 h after LPS injection and analyzed to identify gene expression changes by RNA sequencing and real-time PCR, and the plasma was collected before and after LPS challenge and analyzed to determine the levels of 32 cytokines.

Results: Transcriptome analysis showed that in addition to strong pro-inflammatory responses, which included granulocyte and monocyte migration and cytokine production and signaling, the LPS-treated glands exhibited strong ubiquitin-mediated and immunemediated proteasome activation and an increase in nitric oxide-mediated oxidative stress. Furthermore, LPS induced a down-regulation in vesicle membrane, vesicle-mediated trafficking, and metabolic processes of amino

acids and other organic molecules in the mammary gland. Of the 32 cytokines analyzed, the levels of 24 (mainly IL-6, G-CSF, MCP-1, RANTES, MIG, MIP-1b, KC, MIP-2, IP-10, and TNF α) were increased or tended to increase in the blood after LPS treatment, and only the levels of IL-9 were decreased. In the mammary gland after LPS challenge, the levels of IL-5, IL-6, IP-10, LIF, MCP-1, MIP-2, and TNF α were significantly increased, and the levels of INF γ , IL-2, IL-4, IL-10, and IL-12 (p40) were decreased.

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

Our findings provide candidates of biomarkers and targets to diagnose and treat mastitis in cows.

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

The results have been published in a peer-reviewed scientific journal which is accessible by general public (citation below). The findings have also been presented in scientific meetings, including the ASAS Lactation Biology conference.

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

One graduate students (Christian Lolande) and one undergraduate student (Sophia Sinibaldi) have been trained in the project.

During next reporting period, we will study the effects of LPS and cytokines on metabolism and milk synthesis in mammary epithelial cells.

Publication:

Miyuki Takashima, Christian Lalonde, Laura Olszanski, and Feng-Qi Zhao. (2021). Localized and systemic inflammation mediators in a murine acute mastitis model. *Journal of Inflammation Research* (IF: 6.922) 14:4053–4067. doi: 10.2147/JIR.S313799

Approved as of Jul 12, 2022

Comments

Executive Summary

The FY21 Vermont Annual Report of Accomplishments was organized by critical issue, well-written, clear, and highlighted multiple high-impact projects. The report clearly demonstrated how the Vermont Agricultural Experiment Station (AES) and University of Vermont Extension (EXT) activities form a complementary approach to protect and enhance quality of life. In FY21, AES and EXT were prepared for pandemic pivots to conduct research, recruit, and deliver programs.

Across the seven critical issues in Vermont: 1) Sustainability of Vermont agriculture, food, and forests; 2) Resilience of families and individuals; 3) Development of communities; 4) Stewardship of the natural environment; 5) Foundational and exploratory research in

agriculture; 6) Nutrition, food safety and food security; and 7) Animal health and production, I was impressed by the following totals.

- “42 AES faculty conducted 28 Hatch and 14 Hatch Multistate projects”.
- “EXT offered 300 significant educational events (educational programming of six or more hours), serving 3,175 non-traditional students. In total, [Development of Communities] programs delivered 7,484 educational events (i.e., workshops, classes, consultations, presentations) that directly reached 13,283 participants. An additional 2,783 contacts engaged with the 58 publications produced by these educators”.
- “[Stewardship of the Natural Environment] programs delivered 1,184 educational events (i.e., workshops, classes, consultations, presentations) that directly reached 57,727 participants. An additional 21,310 contacts engaged with the 123 publications produced by these educators”.
- “Together [Resilience of Families and Individuals] programs delivered 7,792 educational events (i.e., workshops, classes, consultations, presentations) and directly reached 12,861 participants, including 7,348 children and youth. 4-H volunteers continue to be a critical component of our program, and this year contributed 4,648 hours of service. At an hourly rate of \$24.60 in Vermont (lower than the national rate of \$28.54) the value of that volunteer time totals \$114,341”.
- “In total, [Sustainability of Vermont Agriculture, Food, and Forests] programs delivered 4,641 educational events (i.e., workshops, classes, consultations, presentations) that directly reached 34,110 participants. An additional 32,946 contacts engaged with the 247 publications produced by these educators”.

Highlights of multiple collaborations with other colleges and universities within the United States of America, as well as promoting American agriculture and agritourism to 66 nations around the world is evidence of AES and EXT commitment to collaboration to solve agricultural issues. Consultation with stakeholders and involvement of the community in decision-making is seen throughout the Annual Report . This year I appreciated learning that EXT farms, offices, and training facilities are leased from private landowners and the reach of *Across the Fence* is over 15,000 households a day. I commend the use of this resource disseminating the results of legume cover crop research showing the increases in soil fertility and crop yields when planting winter tolerant peas as cover crops or double crops.

I also found the Community Accreditation for Produce Safety (CAPS) program highlighted results striking. The 140 farms earning accreditation represent an estimated \$32 million dollars in sales generated from 2,865 acres of vegetable production, 417 acres of fruit production, and 1,822,000 square feet of greenhouse production.

Lastly, I want to draw particular attention to the multidisciplinary collaborations across the Developing of Communities and Stewardship of the Natural Environment issues to support the Abenaki and other local indigenous people to preserve the black ash trees cultural an environmental significance and protect it from invasive pests such as the emerald ash borer.

Thank you for sharing the critical ongoing work to meet the changing needs of Vermont citizens, communities, and organizations.

Merit and Scientific Review Process (only updates are required):

The proposed updates ensure alignment with the critical issues and result areas identified by Vermont stakeholders. I recommend approval.

Stakeholder Input Process (only updates are required)

The proposed process is thorough and well developed for gathering input from traditional groups and individuals. Future directions may include approaches for gathering input from non-traditional groups and individuals and/or emerging audiences in Vermont. I recommend approval.

Highlighted Results (formerly: Accomplishments and Impacts)

Sustainability of Vermont agriculture, food, and forests

Community Accreditation for Produce Safety (CAPS) program supported berry and vegetable growers meet produce safety requirements by accrediting 140 farms. These farms represent an estimated \$32 million in total annual sales of fruits and vegetables.

Agritourism Program will host a hybrid International Workshop on Agritourism in Burlington, VT August 30 – September 1, 2022. Leading up to the conference, nine virtual agritourism webinars were held on a variety of topics between September 2020 and May 2021, engaging 1,704 participants from 66 countries.

Resilience of families and individuals

4-H World Changers collaboration with Marion County Ohio 4-H has benefited more than 125 youth from Vermont, Ohio, and other states, supporting youth who are excited and passionate about learning web design, game design, coding languages and more.

Development of communities

The black ash, an integral part of Vermont's environmental habitat, has deep cultural significance for the Abenaki and other indigenous people who use splints from these trees for basket making. The arrival of the emerald ash borer in the state has put all ash trees at risk, prompting the Vermont Urban and Community Forestry program and others to support efforts of local indigenous people to harvest black ash for splints for baskets and to save seeds to preserve the genetic diversity of local trees for future replanting.

Stewardship of the natural environment

While irrigation is widely used on Northeast vegetable farms, few growers rely upon soil moisture sensors to schedule irrigation. Many farmers over-irrigate, causing nutrient leaching, or under-irrigate, leading to decreased yields and quality. Researchers at the UVM Center for Sustainable Agriculture's Farming and Climate Change program and the University of Maine, conducted a survey of New England vegetable growers to ascertain how farmers make decisions about when and how much to irrigate.

Foundational and exploratory research in agriculture

Improving Forage and Bioenergy Crops for Better Adaptation, Resilience, and Flexibility research aims to improve the rotational value of pea as a legume cover crop due to its contributions to food security, resilience against climatic change and fluctuations, and to nutrient management. This project trailed over 20 cultivars of winter tolerant peas as legume cover crops in Vermont and are taking a few forward as potential double crops.

Double cropping, although common in more tropical or southern areas, is novel in Northern New England, and may greatly improve vegetable farm finances and productivity.

Nutrition, food safety and food security

Soft washed rind cheeses are known for their formation of yellow-orange smears at the cheese surface. Evaluation of crystals and their relationship to grittiness in soft washed rind cheeses: Survey of the U.S. marketplace's previous work demonstrated that cheese smears induce the nucleation and growth of brushite, calcite, ikaite and struvite crystals, which may be responsible for the textural defect known as grittiness. Currently, there are no known strategies to prevent grittiness defect in this cheese variety. Therefore, the specific objective of this project was to determine the relationship between grittiness and the types and sizes of crystals in soft washed rind cheeses. Through our research, it was determined that a key to preventing grittiness is to limit crystal growth to less than 66 microns. Research also strongly suggests that grittiness may be controlled/prevented by controlling atmospheric levels of carbon dioxide and ammonia.

Animal health and production

Mastitis is inflammation of the mammary gland resulting from intramammary bacterial infection. It is the most widespread and costliest disease in the dairy industry in the US and imposes approximately \$2 billion of economic losses annually. The major cost of the losses is the reduced milk production in infected cows, but the underlying mechanisms remain to be elucidated. The Mastitis Resistance to Enhance Dairy Food Safety study provides insight into the individual and combined effects of bacterial toxins and inflammatory cytokines on bovine mammary epithelial cell survival and function. This will lead to the development of new interventions to reduce the damage of mastitis to the mammary gland and losses in milk production.

Other (if applicable):N/A