

New Hampshire (University of New Hampshire) Annual Report - FY2021

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Contributing Organizations

University of New Hampshire

Executive Summary

Overview

As a state that's driven by small scale agricultural activities, an abundance of natural resources that provide excellent recreational and economic opportunities, and a location near major population centers, New Hampshire faces unique challenges in the the agricultural, food, and natural resources industries. To overcome these challenges and discover new opportunities, many in these industries look to the state's public research, development, and engagement agencies—the New Hampshire Agricultural Experiment Station (NHAES) and the UNH Cooperative Extension (UNHCE)—to provide guidance that is science-based, objective, and forward-looking. The NHAES and UNHCE are both located within the University of New Hampshire (UNH) in Durham, the state's flagship, public, land-grant university, conducting instruction, research, and outreach to people beyond the formal classroom. The NHAES resides within the UNH College of Life Sciences and Agriculture and is responsible for stewarding the Hatch and Hatch-Multistate agricultural research and McIntire-Stennis cooperative forestry research programs. UNHCE is the primary outreach department of UNH, stewarding funds from Smith-Lever program as well as from county contributions. Through their synergistic activities, the NHAES and UNHCE continue to provide the people and knowledge resources that ensure economic, environmental, and societal well-being for New Hampshire.

UNHCE

UNH Cooperative Extension is the primary outreach unit for the University of New Hampshire. UNH Extension provides applied research and practical education in agriculture and natural resources as well as in youth and family development and community and economic development. The people of New Hampshire benefit from Extension programs directly as participants or indirectly through improvements to the economy, environment, and society. As a university outreach program, UNHCE has a network of professional educators located in all ten New Hampshire counties. Staff partner with stakeholders, volunteers, and faculty to design and conduct educational programs that meet societal, environmental, and economic needs.

NH AGRICULTURAL EXPERIMENT STATION

The NHAES prides itself on maintaining a gold standard of implementing capacity funds to produce rigorous, cutting-edge research that leads to scholarly, peer-reviewed research publications, and then translating and leveraging that research into additional external funding support, effective outreach activities that bring the science to individuals who can most benefit from that science, and using the research process to train the scientists of tomorrow. The research is also used by units such as UNHCE to develop educational material and demonstrations (applied research) that show how NHAES-developed science can be used within a specific environmet and/or using specific management practices.

The Station continued to be a highly productive unit in meeting its missions in 2020–2021—supporting 31 Hatch and Hatch-Multistate projects that combined for 40 peer-reviewed publications, 59 conference presentations, 17 graduate theses, 6 new germplasms, and 43 policy briefs and outreach presentations. The outcomes of these activities may require a few to several years or even decades (plant breeding) before their findings lead to innovations in agriculture and aquaculture, nutrition, climate change, natural resources or supporting rural economies. The NHAES is a leading state public research and development agency for these critical issues and supporting the economic, environmental, and societal well-being of the state and region. All of the NHAES research is locally inspired, but has global impacts.

As is the case nationally, the Station continues to emerge from the disruptions due to COVID-19 pandemic, and has faced some challenges with faculty and staff turnover during the "Great Resignation" period. This included several researcher retirements and departures, farm staff turnover at the two research dairies and the farm services unit, changes in the University structure that required hiring a new budget

and operations manager, and the departure of the long-time NHAES communications manager. The Station has been successful in rehiring most staff positions, including the communications manager.

Despite the personnel volatility and uncertainty of the post-COVID era, the NHAES had continued to support research and engagement activities of scientists and has resumed numerous events and functions that had been cancelled over the past two years. These included field days at the research dairies, farms, and greenhouses, representation at state and regional conferences, and the development of a new research publication, *Inspired*. This new NHAES biannual publication assembles 2-page research briefs that target industry specialists, but are accessible for most non-scientists. The first issue focused on dairy research produced by NHAES scientists over the past 3 years and was distributed to numerous population segments, including all dairy producers in the state, dairy processors and non-profits in the region, and multiple copies were sent to county Extension offices. Upcoming issues will focus on horticultural research, soil and water quality, agricultural and food markets, aquaculture, among others. The [dairy issue can be accessed via this link](#).

Inspired adds to the Station's already successful communications strategy, which adds significant value to the research conducted by NHAES scientists. The NHAES website has undergone significant upgrades, and the Station's direct email list grew by 13.3%, reaching over 2,500 individuals directly. Engagement on the Station's social media accounts remains high, driven in part by the resumption of several NHAES outreach events. Continuing to build the research and communications strategy remains a high priority for the NHAES to further meet the mission of getting scientific knowledge to stakeholders who can most benefit from that knowledge.

Critical Issue: Agriculture

UNHCE

How is UNHCE addressing the challenges?

Agricultural Business Management was initiated to help improve profitability and improve quality of life for agricultural producers. Programs include farm and estate planning, managing risk on the farm, marketing agricultural products, business planning, and rules and regulation. Landscape and Greenhouse Horticulture programs to help our communities to adopt better landscape design and maintenance practices enhance ecosystem services, which benefit the environment. Programs include greenhouse production and economics, nursery production research and a network for environment and weather applications in New Hampshire.

Pesticide Safety Education Program trains licensed pesticide applicators and those seeking a pesticide license on the safe and effective use of agricultural chemicals used for pest management.

The Education Center and Info Line is staffed by Extension professionals and trained volunteers. A toll-free hotline is available for questions from the public on topics related to gardening, yard and home maintenance, garden and structural pest management, nuisance wildlife, food preservation and safety and seasonal issues. Between 4,000 and 5,000 calls, emails or drop-ins are serviced. In addition, staff and volunteers write weekly garden columns for newsletters, newspapers, and social media.

Overall in 2021, the UNHCE Agriculture team has developed programs that offered over 4,713 one-on-one consultations (diagnostic services including soil tests, disease diagnostics, plant/insect identifications, site visits...), over 300 workshops primary targeting food processors, food growers, volunteers etc. Additional services included nearly 200 other direct and indirect services (applied research, IPM support including scouting and sharing pest data and IPM strategies with growers and stakeholders, invited presentations, social media, development of educational resources, newsletters...). The 2021 effort resulted in 13,557 direct adult contacts and nearly 3,015 indirect adult contacts.

Annual Progress

The UNHCE's Food and Agriculture program developed a program with the N.H. Department of Agriculture to expand CARES Act funds for farms hurt by the pandemic. Staff assisted farmers with writing applications for these funds. The 2021 highlights include:

- \$1.2M procured in new capital as specialists worked with farmers to implement business plans.
- 15 farms assisted in the development of farm transfer or succession plan, preserving 4,191 acres of farmland, and maintaining 195 jobs, generating \$13.5 million in revenue.

NH AGRICULTURAL EXPERIMENT STATION

What's at stake?

Like many northeast states, New Hampshire is characterized by a highly diversified agricultural and food system that produces, processes and delivers food, fiber, and myriad environmental services for our citizens. Increasing knowledge and technology is key to ensure continued economic well-being for those in the food supply chain as well as in context of protecting environmental quality and helping to maintain the resilience and vitality of rural communities. Both basic and applied research are needed to ensure that we address shorter term needs—such as market uncertainty, variety development, farm management practices, and policies—and longer-term needs, such as climate change.

How is NHAES research helping address the challenges?

The NHAES had 10 Hatch and 6 Hatch-Multistate projects that focused on resilient agriculture issues across a multiple disciplines and research strategies. Broadly, five projects can be categorized by their contributions to plant development, five projects relate to pest and weed management, three projects relate to animal systems, and three projects relate to sustainable aquaculture. (Note that several projects required final reports, which were completed in the REEport system).

Plant development efforts at NHAES continue to focus on capturing both short-run and long-run opportunities and value for New Hampshire and regional producers and consumers. Research programs are developing growing practices for the region (including new varieties, new crops, and season extension strategies) to increase farm profitability through diversification, improved yields, and crop quality—all aspects that decrease the risk and increase marketability of the already high-value crops produced in the state and region. These crops include strawberries (for consumption and ornamental), figs, table grapes, eggplant, cabbage, and other Brassica crops. Additionally, research continued the 75-year tradition at NHAES in squash, pumpkin, and melon breeding work.

Plant development efforts are also focusing on improving crop resilience to pest and weed pressures. Broadly, the work considers how to develop management methods that rely less on traditional chemical applications, which are costly to apply and can have health and environmental implications, and instead develop more ecologically-based strategies. Work is also conducted to identify table grape varieties with phytochemicals that increase plant disease resistance, test whether vine management strategies can raise phytochemical levels, and whether varieties with these disease-resistant traits also enhance human health. In parallel, greenhouse research is examining how soil microbes (i.e., biopesticides) could reduce fungal diseases while increasing soil health.

NHAES animal research is also addressing challenges in the dairy and aquaculture industries. For dairy producers, fertility, animal diet, and milk quality are three critical areas in which NHAES research is helping increase well-being. Scientific work is conducted on reducing dairy cow infertility by increasing the understanding of the ovarian blood vessel system after ovulation, feeding strategies to reduce methane emissions, and increasing the survival of new calves. The aquaculture research is taking steps to use science for overcoming several major barriers for salmonid and shellfish farmers in New England by quantifying the efficacy and developing management techniques to use lumpfish (a “cleanerfish”) for sustainably controlling parasites and optimizing feeding strategies for bass raised in recirculating systems. These areas of work help provide immediate insights about dairy herd and fish farm management.

How has NHAES moved science frontiers and helped increase well-being?

The NHAES projects combined for 10 peer-reviewed publications, 15 conference presentations, 8 theses, 6 new germplasms, and 25 outreach events and presentations.

Numerous advances were made within the plant development area of the NHAES research portfolio. The long-term cucurbits program made significant strides in organizing their breeding lines database and increasing seeds for over 75 advanced lines (***change in condition***). Phenotypic data for culinary traits were collected and powdery mildew resistant markers were selected to begin breeding new advanced lines with advantageous characteristics (***change in knowledge***).

Longer-term work related to kiwiberries in the northeast also made significant progress, with a 0.5-acre expansion of the breeding project. Nearly 1,000 different lines were developed or crossed and are different stages of development. The project initiated genetic mapping to lower oxalates in kiwiberries, and new work was initiated to explore herbicide options and pruning/canopy management. Additionally, through a partnership with Hartmann's Plant Nursery—the largest wholesale propagator of kiwiberry plants in the nation—the kiwiberry program has helped standardize variety nomenclature (***changes in knowledge and conditions***).

Research table grape vine training systems have different production impacts based on grape varieties and regional adaptation. Training systems were also found to be important in tomato plant production, Experiments on fig production in cool climate zones indicated that protection systems but not cultivars are important for fruit survival (***changes in knowledge***). Additionally, researchers determined that

wood fiber substrates could reduce fungal disease severity compared to plants grown in traditional peat substrates (*changes in knowledge*).

In research focusing on dairy cows, several studies on different feed mixtures and grazing management approaches indicated that some benefits may exist in feeding red clover and legumes in increasing milk quality and reducing methane emissions. However, using brown seaweed did not affect methane emissions significantly (*change in knowledge*). This year's results of the aquaculture research indicated that lumpfish can suppress sea lice in steelhead trout pens, but under specific conditions of water temperature, cleanerfish size, and hide design (*change in knowledge*). Additionally, research found that feeding efficiency of striped bass could be improved by reducing the frequency of feeding but increasing rate per feeding (*change in knowledge*).

Critical Issue: Climate change and sustaining natural resources

UNHCE

Healthy and sustainable lands, waters and wildlife are critical to NH's natural resource-based industry, tourism, recreational activities, and the quality of life experienced by our residents. Climate change not only threatens our seacoast communities but will challenge our stormwater management and impact our forestry practices and wildlife stewardship efforts. Working through Areas of Expertise that include Forest and Wildlife Stewardship, Community Natural Resource, Citizen Science, and Fisheries and Aquaculture, our staff provide research-based natural resources information and assistance to private landowners, natural resources professionals, logging and forest products industry, agencies, municipalities, local decision-makers, researchers, schools, volunteers, and organizations.

Forest Stewardship provides communities information required to ensure forests contribute to the economy. Programs include selling timber, invasive species management, town & community forest management, woodlot management, conservation training, heating your home with wood, maple production, estate management, prescribed burns, street tree care, and forest-based industry.

Citizen Science programs engage community members, leaders, and local, regional and state-wide partners to build knowledge, skills, and capacity for needs assessment, community engagement, decision-making, and action. Communities and Natural Resources teamwork to build the capacity of community leaders and volunteers to protect and manage natural resources and strengthen community resilience. Fisheries and Aquaculture programs provide technical support, permitting requirements, training, and expertise in growth and husbandry of shellfish, seaweeds, and finfish. Geospatial technologies training includes mobile mapping, LiDAR, crowdsource mapping, transitioning to ArcGIS Pro, and GIS/GPS Bootcamp.

Annual Progress

In 2021, our Climate change and sustaining natural resources team has developed programs and activities in the areas of applied research, citizen science, workshops and conferences, development of educational information, and one-on-one education. In total, our staff have implemented nearly 7000 one-on-one consultations, which includes site visits to landowners, fisherman, and natural resource professionals. Our staff led 88 public presentations as workshops, and public forums.

Natural Resources staff and volunteers work closely with public and private partners to safeguard the state's land, water, air, and living communities. In 2021:

- Our staff consulted with 1334 landowners who manage 60,184 acres
- Our work generated a \$2.9M increase in future production value of forest products including lumber, furniture, wood chips, etc....)
- Our work helped generate \$1.13 million in forest product sales and tax revenue.

NH AGRICULTURAL EXPERIMENT STATION

What's at stake?

Big problems require targeted, multi-disciplinary solutions. Advancing resilient agricultural, food, and natural resources must be balanced with addressing challenges posed by a changing climate. This balancing requires informed, strategic management and stewardship of resources, including land, water, forests, wildlife, domesticated crops and animals, social equity, community sustainability, among many others. Rigorous, forward-looking research can help identify key factors contributing to climate change, quantify those impacts, and provide data-informed insights about strategic management of natural resources to ensure long-term economically, socially, and environmentally sustainable stewardship of natural resources.

How is NHAES research helping address the challenges?

The NHAES had 8 Hatch and 1 Hatch-Multistate projects that focused on climate change issues across multiple disciplines and research strategies. The projects can be categorized by their contributions to understanding and developing effective land and soil quality management and to the study of the nexus between water and food systems. (Note that several projects required final reports, which were completed in the REEport system).

The NHAES land and soil sustainability program considers a collection of research areas, but which all center around the concept that agricultural land management is affected by and can affect climate change outcomes. Projects with a more basic science focus used cutting-edge genomic tools to characterize soil microbial physiology (i.e., growth and efficiency) and to identify genes that are differentially regulated by harsh environmental conditions and how Frankia's (a nitrogen-fixing bacteria) physiology or host plant interactions respond. The more applied NHAES side of the land and soil sustainability program is developing a foundational understanding of the role of microorganisms in soil health and function in New Hampshire agricultural landscapes. This is helping develop a deeper understanding of biogeochemical processes underlying bioavailable nitrogen (N) cycling and the broader knowledge about the interaction of land types and their interrelated, complex responses to changes in climate. Furthermore, the research program assesses the ability of using low-cost UAV sensors marketed to landowners to capture information about the water and nutrient status of their lands, which will help to inform and further refine the management strategies.

The NHAES water–food systems program focuses on the roles that agricultural and aquacultural production, behaviors, policy, and climate change play in affecting water quality. While water quality problems are known to result from a variety of human activities such as agriculture and urbanization, developing improved models of watershed systems and impacts from numerous understudied factors is helping provide a more complete understanding of how watersheds are recovering from changes in atmospheric deposition and the role of river networks in attenuating water quality problems. In addition, a portion of the program is focused on practices that complement food production with ecosystem services. Specifically, data on oyster farms is being used to quantify three major ecosystem services potentially provided by farmed oysters—water filtration, reproductive output, and habitat provision—in order to inform government permitting and licensing bodies to better structure policies that take advantage of these water–food system complementarities.

How has NHAES moved science frontiers and helped increase well-being?

The NHAES projects combined for 25 peer-reviewed publications, 28 conference presentations, 7 theses, 7 genome databases, and 5 outreach presentations and events.

Within the the genomic-based work, a key finding was the greater understanding of how the beneficial Frankia microbes aid plants' abilities to reclaim degraded land, especially land affected by salt or pollutants. The ability of the microbe to tolerate these harsh conditions influence how the plants will survive under these environments (***changes in knowledge***). Scientific gains were also made in determining that genomic markers indicative of fungal growth and efficiency in response to temperature and nitrogen availability—and the life history of those traits—are predictive of fungal growth and metabolic efficiency across a phylogenetically diverse set of fungi. Ultimately, these findings are leading to establishing a model soil system, which will enable researchers and practitioners to examine how fungal traits and genetic markers can predict fungal metabolic efficiency and soil organic matter formation and stabilization, which can make broader climate change frameworks more accurate, driving better policy decisions and actions (***changes in knowledge***).

Progress was made in developing research-based recommendations for water–food system policies. Activities were conducted to begin collecting microbial data in streams near different land use types (forested, wetland, agricultural, etc.), which will help better understand how microbial communities are affected and affect ecosystems. Work also showed that methane concentration is higher in streams than ponds, which can enable them to be greater sinks for carbon (***changes in knowledge***). Additional research quantitatively showed that regional depositions of N can differ significantly from national models, which need to taken in climate change modeling considerations (***changes in knowledge***). The research also had real change on water–food system policies in New Hampshire—***changes in actions***. One highlight was associated with the findings that although reservoirs are generally considered to be nitrogen sinks, some reservoirs, including the Mill Pond reservoir in Durham, NH, is not a retainer of nitrogen, but can be a source of N. These results impacted a Town vote regarding the dam's removal.

Critical Issue: Food Safety

UNHCE

What's at stake?

The CDC estimates that each year about 1 out of 6 Americans or 47.8 million people get sick from foodborne illness. About 128,000 of them are hospitalized and 3,037 die. According to the 2010 publication of Georgetown University, the annual cost of foodborne illnesses is \$152 billion. For NH, the estimated annual cost of foodborne illness was \$681 million with a per-case cost estimate of \$1,892. NH restaurants are projected to record \$2.3 billion in sales between 2012 and 2022. However, more than 63,800 people and many employees have no or limited training in food safety. The UNHCE Food Safety program addresses these needs with food safety education targeting each sector of the food system, including production, food service, and consumers, with research-based educational programs, resources, and information.

How is UNHCE helping address the challenges?

Food Safety programs address food safety issues with educational activities targeting each sector of the food system, including production, food service, and consumers, with research-based educational programs, resources, and information. Food Safety Modernization Act programming includes Preventative Controls for Human Food and the Produce Safety Rule.

With the S.A.F.E. program offered online this year, our program reached hundreds of food handlers across the state with convenient education they could access directly from their homes or places of employment or volunteerism. This program meets the training requirements for schools and feeding programs receiving federal food program funds, but is valued and utilized by staff and volunteers even far beyond those required to participate.

NH AGRICULTURAL EXPERIMENT STATION

What's at stake?

Ensuring a safe food supply is critical to maintaining a healthy population and trust in New Hampshire's food producers. With New Hampshire and the region having a robust local food economy, identifying factors that can increase the risk of food safety issues and determining methods that can prevent and mitigate adverse health outcomes is critical. This is particularly critical for aquaculture products, which can harbor viruses and bacteria harmful to humans and are often consumed directly (without or with minimal cooking). Specifically, it is critical to better understand the influence that environmental and ecosystem conditions have on the emergence of pathogenic *V. parahaemolyticus* populations in the Northeast US, because illnesses caused by *V. parahaemolyticus* have become an increasingly significant public health issue in New England and threatens to become a risk to shellfish consumers in New Hampshire.

How is NHAES research helping address the challenges?

The NHAES had 2 Hatch projects that focused on research in food safety issues in aquacultural production. The projects represent both basic and applied research that seeks to better understand the survival, spread, and implications of the bacteria. The basic research used genome sequencing to determine how phage immunity—bacteria strains that have overcome the negative impacts of virus attachment that destroy the bacteria—may be contributing to the negative impacts on shellfish productivity. The applied research focused on using innovative measurement practices (and comparing to traditional methods) of the bacteria, strengthening databases of observations, and using these to understand how bacteria populations emerged more rapidly in oysters, sediments and water during a warmer than normal spring and early summer compared to the much cooler conditions. Ultimately, the work sought to identify which strains of the bacteria contained markers that have been identified as those that could cause illness to humans.

How has NHAES moved science frontiers and helped increase well-being?

The NHAES research projects combined for 1 peer-reviewed publications, 1 completed theses, and 3 conference presentations. The researchers also served on the NH Vibrio Task Force and Maine Shellfish Learning Network to inform stakeholders and policymakers.

In collaboration with state and regional organizations, the researchers used their scientific findings from previous years to develop new tools for detecting pathogenic bacteria populations and can also use environmental and biological information to predict risks of illnesses. This information has helped move forward industry in better understanding the pathogen dynamics in estuarine ecosystems and better monitor instances that can have devastating economic and human health implications (***change in knowledge and action***).

Continued research on the hypervirulent Vibrio pathogens has led to improved methods to differentiate between potential new pathogenic strains that may originate in the Gulf of Mexico and move into other regions. These new methods can significantly improve on currently approved FDA assays that cannot identify pathogens with as much specificity (***change in knowledge***). These research findings

have continued to be communicated to shellfish program managers in New Hampshire, Maine, Massachusetts, and Connecticut, where the results are being used to inform public health risk management approaches and shellfish importation strategies specific to their state conditions (*change in action*).

Critical Issue: Nutrition, Health and Wellness

UNHCE

What's at stake?

The health of New Hampshire's citizens has profound long-term implications for the state's economy and the population's well-being. Poor understanding of nutrition, inactive lifestyles, and systems-level food access issues have led to chronic public health problems such as obesity and diabetes. These issues, when not prevented and/or when untreated, result in significantly higher health care costs, loss of workforce productivity and reduced quality of life. Data from the CDC, the State of NH, and the Carsey Institute suggests that important behaviors such as physical activity and fruit and vegetable consumption are below recommended levels, particularly for lower-income youth and families. Furthermore, because New Hampshire is one of the oldest and fastest aging states in the country, the natural vulnerability and declining health of an older population will exacerbate this critical issue.

How is UNHCE helping address the challenges?

UNH Extension's Nutrition Connections places an emphasis on food and nutrition efforts that focus on the Dietary Guidelines and MyPlate, specifically, increasing fruits and vegetables and increasing physical activity. The model also places an emphasis on opportunities to reach larger numbers of people through policy, system and environmental-level change strategies. UNH Cooperative Extension Nutrition Connections staff implement nutrition and physical activity education for limited income adults and youth. Activities target physical activity, nutrition, community involvement and obesity awareness and prevention. in 2021 our team:

- Developed a \$1.5 million USDA and SAMHSA grant to help Granite Staters lead healthy, active lives, reduce healthcare costs and curb opioid misuse.
- Engaged 2,884 youth and adults in healthy living and nutrition education programs.
- Enrolled 2,665 youth in 4-H agriscience, STEM, and healthy living programs
- Reached over 600 people through mental health training and wellness education.
- Helped 249 older adults through chronic disease and pain self-management and Walk with Ease programs.
- Reached over 109,000 people via social media campaigns focused on nutrition, food safety, food access, and physical activities.

NH AGRICULTURAL EXPERIMENT STATION

What's at stake?

Trends in poor nutritional intake among Americans tracks increased incidence of chronic diseases and exposes to greater health uncertainties for evolving diseases such as COVID-19. Understanding the trends in nutrition and health behaviors across diverse populations and communities within New Hampshire and identifying factors that contribute to healthier lifestyles is critical to ensuring the long-term well-being of the state's citizens. Underrepresented and under-researched communities may be at particularly higher risk of unhealthy behavior consequences. Two such communities are being assessed by NHAES scientists.

How is NHAES research helping address the challenges?

The NHAES has 1 Hatch and 1 Hatch-Multistate project, in which researchers are using a combination of quantitative and qualitative assessment methods across a multidisciplinary spectrum that includes social, genetic, and policy assessment frameworks to more deeply understand the nutritional issues that are faced by underrepresented populations. (Note that one project required a final report, which was completed in the REEport system).

One of the primary needs for assessing food nutrition and policy issues in underrepresented populations is the development of effective measurement tools. For example, NHAES research is helping develop effective tools to assess the healthfulness of college campuses are critical to developing an understanding of disseminating information about weight gain in young adulthood and increase the sustainability of community programming to support and sustain healthier environments for college students. Similarly, the research is helping identify and measure Bhutanese-specific dietary quality, food handling behaviors, and insulin resistance as well as the population's participation in SNAP-Education programs.

How has NHAES moved science frontiers and helped increase well-being?

The NHAES research projects combined for 1 peer-reviewed publications and 10 conference and seminar presentations, a master's thesis, and contributions to the College Health and Nutrition Assessment Survey.

Work focusing on college student nutritional behaviors has worked on planning a national outreach conference to educate and train on the use of the eB4CAST tool, which helps measure the effectiveness of an intervention, quantifies the longevity, and impact of an intervention on the target population, and documents the footprint within the community of interest. Additionally, data from the College Health and Nutrition Assessment Survey identified factors such as perceived stress resulted in less favorable diets for female college students, and students with disabilities reported lower food security and higher rates of metabolic syndrome (*change in knowledge*).

The study of Bhutanese populations indicated that the group receiving SNAP-Ed lessons did not improve their dietary intake or lower cardiometabolic risk and there is a disconnect between diets and dietary targets (*change in knowledge*). The study is currently being leveraged into an NHAES-Extension collaboration to develop culturally tailored education to the diverse communities across the state.
Critical Issue: Rural Community and Economic Development

UNHCE

Community and Economic Development specialists seek to cultivate civic leaders; foster participation in community decision-making and build the capacity of communities to grow the local and regional economy.

How is UNHCE helping address the challenges?

To achieve the mission, staff provide civic leaders with training, educational resources, and technical assistance in community engagement, economic development, leadership development, and community-based natural resources stewardship.

Downtowns and Trails program is focused on training community members to leverage their town's natural resource base to create vibrant economies and enhance quality of life for all. Community and Economic Development programs seek and build local leadership to look at local assets, create a vision for the future, and identify strategies to strengthen communities. Example programs include Business Engagement and Retention, Economic Profiles, Economic Development 101, Economic Development Academy, First Impressions, Community Profiles, Main Street Academy, and Community Engagement Academy. Community and Economic Development specialists provide technical assistance and custom training to community groups as requested. Topics include civil discourse, group facilitation and working with diverse audiences.

Annual Progress

The community and Economic Development program helps cultivate civic leaders, revitalize downtowns, and grow the local and regional economy. With Extension's support, in 2021:

- Extension has helped communities receive over \$500,000 in grants and other resources to support economic development projects.
- Extensions' specialists worked in twelve municipalities
- 5 new businesses were launched as a result of our support and guidance.

NH AGRICULTURAL EXPERIMENT STATION

What's at stake?

New Hampshire's rural communities continue to evolve and contribute in different ways to the state's economic success and societal welfare. Local food systems (from production to consumption), tourism, and natural resource management continue to be critical to maintaining the vibrancy of rural communities in the state. However, with changing demographic and socioeconomic characteristics in rural communities; consolidation of the food processing sector; changes in local, state, and federal policies; and the structural changes prompted by the COVID-19 pandemic have created challenges to rural communities maintaining economic resilience. Using science-based, data-driven methods to identify key factors stressing economic and social welfare in rural communities and providing research-informed recommendations at the individual, firm, municipality, and state levels are crucial for short- and long-term community sustainability.

How is NHAES research helping address the challenges?

The NHAES had 3 Hatch-Multistate projects that focused on research in this critical area. The projects focused on analyzing socioeconomic changes and their effects on rural economies and local food supply chains. For example, identifying causes and consequences of recent rural demographic change and the demographic processes, such as migration and fertility, are critical to

understand the changing patterns of population redistribution both in New Hampshire and throughout the United States. Moreover, the increased rate of midsize farm declines continues to place local food systems at risk. And this is particularly important in New Hampshire rural communities, which have experienced a diverse set of demographic changes and have traditionally been supported by small and midsize agricultural operations.

The impacts of the recession and its aftermath on demographic change and opportunities for value-added agricultural systems helps private firms, public planners, and policy-makers by providing empirical knowledge for effectively taking advantage of those opportunities. With this knowledge, firms and policy-makers can look to additional research that can identify potential avenues for overcoming challenges and strengthening rural communities. For example, the quantification of constraints and opportunities for local agriculture in northern New England; working with local governments to deliver local services more cost-effectively, especially solid waste; examining the general role of social capital in community economic development are all instruments for informing rural community strategies; and increase value to food products produced by smaller farms. Ultimately, the goal is to identify how local agricultural systems can be made more profitable. Through increasing economic resilience in times of significant demographic and socioeconomic changes, rural communities can increase their sustainability.

How has NHAES moved science frontiers and helped increase well-being?

The NHAES research projects combined for 3 peer-reviewed publications, 7 policy papers, 3 conference presentations, and 6 outreach presentations to stakeholders.

As worries about rural demographic changes have become more well-known, much of the reason for this increased knowledge has been due to contributions of NHAES rural and community development research. Recent findings (change in knowledge) show that rural America has lost population for the first in history, a consequence of lower birth rates and increase mortality. This has serious implications for these communities—economically and socially—because these rural communities depend on natural increase (births-deaths) for much of its population increase. Perhaps more importantly, nearly 80% of the farm counties are depopulating. This has left the remaining rural population, which is older and has a higher rate of preexisting health conditions, much more vulnerable to COVID-19. These findings contributed to the W4001 multistate project to be one of the first scientific organizations to indicate this increased danger to federal and state policymakers (***change in knowledge and action***).

One way to overcome such challenges is through the identification of new opportunities or simply by increasing knowledge of missed opportunities. NHAES research helped develop a database of the state's willingness to pay for locally grown foods, which has been used both the NH Department of Agriculture, Markets, and Food and local restaurants to identify obstacles to buying from local food producers (***change in knowledge***). Additionally, the research estimated the potential for increasing local supply of produce, which would help reduce transactions costs of bringing consumers and producers together (***change in action***).

Critical Issue: Youth and Family Development

UNHCE

What's at stake?

New Hampshire youth are in critical need of positive youth development experiences where they both feel a sense of belonging and are engaged in extended and meaningful ways. Feedback from recent focus groups and key stakeholder interviews, data from the National Academy of Sciences, the National Institute of Mental Health, the Youth Risk Behavior Survey, and research by the UNH Institute on Disability and the Carsey Institute all suggest that multiple problems make up this critical issue. They include: increased needs for a workforce that is sufficiently and equitably prepared with both leadership skills and STEM content knowledge, youth who do not feel valued by their communities, rising suicide rates across the state, elevated drug misuse and overdoses by young adults, and increased levels of mental illnesses in teens such as anxiety and depression.

How is UNHCE helping address the challenges?

Youth and Family Resiliency (YFR) programs address the needs of vulnerable audiences. Programs include social, emotional, and mindful learning, and youth mental health and wellness. Science Literacy including volunteer education programs such as the UNH Marine Docent and UNH STEM Docent program can introduce science to adults and students in an engaging context and authentic manner. Additional programs include Schoolyard SITES, Sea Perch, STEM Discovery Lab and Teaching Through Inquiry, and Science Practices. 4-H Youth Development programs aim to develop self-confidence, soft skills (public speaking, writing) in youth. Programs include 4-H Healthy Living, animal science, teen leadership councils (county and state), civic responsibility, shooting sports, horticulture, military youth and families, Barry Conservation Camp, and the work of the 4-H Foundation.

Annual Progress

The YFR team reached volunteers, school and after-school program staff, community members and stakeholders through a variety of educational program, public relations, technical assistance, and workshops. We reached 384 people through educational programs and resources related to social-emotional and mental health, building community resilience, human development, and culture and diversity. We provided technical assistance to a variety of groups and coalitions around suicide prevention, social-emotional and mental health, positive youth development, substance use prevention, Multi-Tiered Systems of Support, Strategic Prevention Framework and behavioral health (194 participants). Finally, we reached over 600 people in workshops related to youth mental health, resilience and thriving, mindfulness, social-emotional and mindful learning, engaging stakeholder sin program improvement, positive youth development, grant writing, trauma and stress management.

Merit and Scientific Peer Review Processes

Updates

UNHCE

No changes relative to the Plan of Work.

NH Agricultural Experiment Station

There were several changes made to the proposal content requirements for NHAES projects. Changes related to the proposal evaluation criteria were incorporated into the assessment form that internal peer reviewers used when evaluating proposals. Changes that affected the content of the proposal were incorporated into the guidelines for individuals who wrote proposals this year.

Summary of changes to NHAES project proposal criteria:

Project directors can discuss aspects that are not required but would enhance the prioritization and merit of their proposals. These prioritization enhancing criteria include descriptions of how the project will:

- Create opportunities for interdisciplinary and/or regional or national collaboration.
- Incorporate Extension professionals as active, integrated collaborators into multiple facets of the project, including the research design, implementation, and engagement components.
- Incorporate stakeholders as active, integrated collaborators into multiple facets of the project, including the research design, implementation, and engagement components.
- Be relevant to the needs of underserved individuals, groups, or communities in the state, region, and nation.

Summary of changes to required content in NHAES project proposals:

Beginning in this year and going forward, all proposals must include a logic model that describes the anticipated activities, outputs, and impacts of the project. The logic model is based on the template provided by the USDA NIFA.

Stakeholder Input

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

No changes relative to the 2022 Plan of Work.

Methods to identify individuals and groups and brief explanation

No changes relative to the 2022 Plan of Work.

Methods for collecting stakeholder input and brief explanation

No changes relative to the 2022 Plan of Work.

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

UNHCE

For UNHCE, specific input on staffing, budget, and program priorities is solicited through discussion at meetings. Council members are identified based on input from other council members and staff continually look for individuals who might make good council members. Roles for council members include (but are not limited to): advocacy on behalf of Extension, hiring/performance review of local staff, budget requests, and program priorities. Input from our stakeholders is used in the following ways:

- In the Budget Process
- To Identify Emerging Issues
- Redirect Extension Programs
- In the Staff Hiring Process
- To Set Priorities

NH Agricultural Experiment Station

The NHAES continues to use the emergence from the COVID-19 pandemic to more directly connect researchers with relevant stakeholders, and in this way, strengthen the direct communication among scientists and individuals for whom the implications from the science matters most. By creating and facilitating more opportunities for the researchers and the NHAES director to meet directly with stakeholders (including producer groups, consumer groups, governmental agencies, legislative bodies, and internal University administrators outside of the College of Life Sciences and Agriculture), to achieve the following:

- Alter and improve a number of standing outreach events (field days) to be more engaging with a broader cross-section of audiences.
- Engage in a collaborative NHAES / UNHCE needs assessment for climate-smart agriculture projects.
- Engage with USDA to investigate benefits of and implement a logic model in the NHAES proposal writing process, which enables researchers to develop a more holistic strategy for envisioning how research would turn into outcomes.
- Significantly increase the interactions with key members of the NH Legislature (Environment and Agriculture Committee) and NH Commissioner of Agriculture to increase understanding of how NHAES research can better reach those audiences.
- Work with the Northeastern Regional Association (NERA) of Experiment Station Directors to begin building a regional AES communications vision to broaden the reach of the research the Station develops.

Highlighted Results by Project or Program

Critical Issue

Agriculture

Data-driven decisions through utilization of financial tools and analytics

Project Director

Julien Kouame

Organization

University of New Hampshire

Accession Number

7000052



2021 - Data-driven decisions through utilization of financial tools and analytics

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

Agricultural businesses face financial risks that directly threaten the farm's financial health. Unlike larger producers, small farms are more likely to be negatively impacted by financial risks. New Hampshire agriculture comprises of small, diversified farms where profit margins are small, further highlighting the financial risk faced by the producers we serve, and increased threat to the sustainability of NH agriculture. Factors contributing to financial risk include inability to meet cash flow needs, cost, and availability of debt capital, generating lower than expected profits, and capability of generating additional equity in the farm. Financial risks can also be attributed to lack of financial understanding, which our educational programs are designed to address.

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.

Our overarching goal is to empower agricultural business owners to make data driven decisions that improve profitability of their operations. We aim to provide education that builds skills and motivation in business owners to utilize financial tools and analytics to make those data driven decisions. The three focus areas of the program are record keeping, data analysis, and management decision making.

During the 2021 program year, our team conducted multiple workshops on enterprise budgeting, cash flow budgeting, financial recordkeeping, and financial statements. These workshops targeted new and beginning, and established farmers who were interested in applying for farm loans, interested in scaling up their business, and/or interested in creating a farm financial management strategy. Some new and beginning farmers were in their early stages of farming and were simply interested in understanding farm finances. We created workshops to provide education on the topics above, which are required for USDA-FSA borrower training. In addition to workshops, our team provided one-on-one technical assistance to more established farms through a benchmarking grant, to help producers analyze their financial records and provided recommendations for improvement. Producers were able to see how they compare to industry standards. Finally, we also provided one-on-one technical assistance to producers who were developing business plans. The financial component of the business plan is critical and must be accurately developed.

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

Our target audience includes all agricultural businesses in NH, thus all commodities, all economic scales, all ages of farmers, new, beginning, and established. In some subject areas, our programming does not differentiate between commodity sector, age, or stage of farm maturity. However, in other areas, we stratify the programs we provide. We offer “new and beginner farmers” a specific curriculum to help them launch their operations, while we provide seasoned operations targeted programming to analyze their data and use it to drive management decisions. We also target mid-career farmers with educational programs. From our programs, forty-seven (47) farms increased their understanding of their business health and identified systems needed to achieve their business goals; forty-two (42) farmers increased their financial recordkeeping skills and made changes to their bookkeeping systems as a result; thirty-four (34) farms had a whole farm financial analysis completed and used this information to implement management changes, including pricing, enterprise (product) selection, size (scale) of business, size of labor force, and capital reinvestment in their operation; Ten (10) farms had in-depth financial analysis primarily for succession planning purposes, providing the farmers an understanding of true net profit, value of their assets (land, buildings, equipment), among other areas; seventy-three (73) farmers increased their knowledge and ability to develop an enterprise budget, and 13 of those farmers completed enterprise and cash flow budgets.

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

Successfully sustaining an agricultural business in the state of New Hampshire is desirable, as residents rely on farmers producing the fresh, healthy foods they love. New Hampshire residents will not have to rely primarily on a regional, national, or international food supply chain, which can be easily disrupted, as shown by Covid-19. Additionally, they do not have to rely on foods that have traveled hundreds or thousands of miles, losing the freshness and quality they love. Likewise, viable, operational agricultural businesses bring employment to their local communities, contribute to a more sustainable, friendly environment for residents, lower carbon footprint from transportation for the environment, provide outdoor experiences for families, and positively contribute to the local economy.

[Varieties and cultural practices for vegetable and small fruit production in New Hampshire](#)

Project Director

Rebecca Sideman

Organization

University of New Hampshire

Accession Number

1019868



Annual Report FY21

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

Diversified specialty crop growers in New Hampshire face several challenges including a short growing season, significant disease and insect pressure, and climate conditions that are different from major production regions where most crop selection and cropping system development takes place. However, access to abundant local direct markets favors a strong relationship between producer and consumer, permitting NH growers to market innovative crops and products that are unique to their farm or to the region, thereby differentiating themselves from other farms and from supermarkets. To enable growers to meet these challenges and take advantage of these opportunities, regionally relevant knowledge about the most effective cropping systems is needed.

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.

Use of the most effective growing practices for our region (including new varieties, new crops, and season extension strategies) can increase farm profitability through diversification and improved yields and crop quality. Therefore, our integrated research and extension effort is focused on high-value specialty crop production systems and methods of extending the growing season. The two overarching goals of the proposed project are to 1) evaluate horticultural characteristics and adaptation of vegetable and fruit varieties using an array of production systems in NH, and 2) to evaluate and/or develop new management techniques to extend the growing season, increase profitability, reduce environmental impact, or improve efficiency of vegetable and fruit cropping systems.

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

Our target audiences are commercial farmers, home gardeners, extension educators and researchers. This project had four (4) specific objectives address our two overarching goals of **1) evaluating horticultural characteristics and adaptation of vegetable and fruit varieties** and **2) evaluating or developing new management techniques to extend the growing season, increase profitability, reduce environmental impact or improve efficiency of vegetable and fruit cropping systems.**

Specific progress during the reporting period is described below:

- Rapid turnover in commercial availability of Brussels sprout cultivars coupled with dramatic differences in performance/adaptability among cultivars make it very challenging for growers outside major production regions (e.g. California) to select varieties that will consistently perform well. We initially evaluated a large collection of varieties from 2013-15 and developed clear recommendations for producers based on that work. Since that time, new varieties have been released, replacing recommended best-performers. During the 2021 season, we evaluated sixteen varieties including old standards and new releases. Our extremely wet summer created perfect conditions for *Alternaria* leaf spot, enabling us to collect excellent data on susceptibility to this important disease. As a result of this work, we now have updated recommendations for varieties and cultural practices that are well adapted for the region. We shared these results with growers in outreach presentations and are in the process of developing updated extension reports and a manuscript for publication during the coming year.
- Over the past five years, we assessed vine vigor and incidence of diseases and insect pests, and collected yield data for several seedless table grape cultivars. We have observed significant differences among varieties in incidence of powdery mildew, downy mildew, and anthracnose, as well as in fruit quality and yields. We found that the VSP vines reached harvest maturity at least one year earlier than the M-trained vines, thus increasing early yield potential; but M-trained vines have produced higher annual yields once established. As a result of this work, we now have accurate recommendations for varieties and training systems that are well adapted for the region. In the past year, we replaced a portion of the vineyard with a set of seven new seedless table grape varieties alongside 'Mars', the regional standard seedless table grape, to evaluate these new varieties' regional adaptation. We shared these results with growers, researchers, and extension professionals in outreach presentations and extension reports, and are in the process of preparing a manuscript to describe the results of our work from 2015-2020, for submission during the coming year.
- Fresh figs have the potential to be a high-value crop in temperate climates, but a feasible production system must involve low-cost winter protection and give high yields per plant that ripen during the frost-free period each year. Over the past two winters (2019-21), we measured the effects of different protection systems on overwinter survival and subsequent plant growth and fruit set for several cultivars. We demonstrated significant effects of protection system (but not cultivar) on survival, and significant effects of both production system AND cultivar on fruit set and timing of

crop set. We shared these preliminary results with growers, researchers, and extension professionals in outreach presentations and an extension report that was published in Spring 2021. We also held a field day to communicate with stakeholders about the potential for this crop. The availability of research-based information will help aspiring commercial and non-commercial fig growers evaluate the feasibility of growing this crop in cold climates, especially as more information is generated.

- This was the final year of the collaborative multi-state Northeast SARE project entitled 'Increasing grower adoption of ecologically-based pest management strategies to improve quality and yield of brassica crops'. Our original hypotheses were: 1) OMRI-approved pesticides effectively control cabbage aphid when used alone or in combination; and 2) conservation biocontrol strategies such as insectary plantings attract predators and parasitoids of brassica pests, which can reduce pest populations and crop damage. During the reporting year, we prepared a manuscript describing our results relating to insectary plantings, for submission during the coming year.
- *We also* conducted a small experiment nested within a variety trial to explore the effects of netting on Brussels sprout growth, yields, and presence of insect pests. Our hypothesis was that netting would entirely exclude insect pests without impacting the temperature within the crop canopy, and that yield and growth of Brussels sprouts would not be negatively affected. While yield was not negatively impacted by netting, we found that netting did not completely exclude insect pests: in several of the replicate netted subplots, meaningful populations of cabbage aphid, Japanese beetle, and various caterpillars were found within the netting at various points throughout the summer. This highlights several of the challenges associated with using netting to control insect pests of brassica crops, and awareness of these challenges may help growers make informed decisions about the use of netting or find solutions to these issues.
- As part of a collaborative multi-state project supported by Northeast SARE project LNE20-403, we established experiments in two sites (NY and NH) to compare alternative strategies for winter protection of strawberry, and to determine their effects on plant growth and fruit production. In each site, we established replicated split-plot experiments (one per year over a period of two years) using protection strategy as the main plot and cultivar as subplot. Primary data collection will not happen until Spring 2022; no impacts have yet resulted from this work.

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

Beyond our target audience (commercial farmers, home gardeners, extension educators and researchers), the general public may have experienced:

- increased access to locally grown, fresh, and high quality specialty crops (such as Brussels sprouts, strawberries, figs, and table grapes) because growers had the tools they need to grow these crops successfully.
- less exposure to pesticides because growers use targeted and effective pest management techniques as well as non-chemical approaches (including resistant varieties) to manage pests and diseases.

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/Problems

During the reporting year, our outreach remained limited through most of the year: we first invited a limited number of members of the public to a field day in late August, 2021. Additionally, the graduate student responsible for two components of the grape project (evaluating labor requirements of different training systems and conducting consumer preference studies) left UNH after a prolonged leave of absence, forcing us to regroup and reprioritize efforts.

Taining/professional development

Current Small Fruit Research & Outreach in NH. Oct 2020. Presentation to the NCCC212 Multistate Coordinating Committee of Small Fruit Researchers. Online Meeting.

Figs for Cold Climates – Research Update. May 2021. Presentation to the Northeastern U.S. and Canada Small Fruit Extension Group. Webinar.

Plans for next reporting period:

Strawberry. *As part of SARE LNE20-403, “Advancing Strawberry Production in the Northeast”, we will test the following hypotheses: the use of heavier weight rowcover will increase winter survival of strawberries, and earlier fall application of rowcover will increase yields of June-bearing strawberry the following year. We anticipate that cultivar will have an effect on winter survival. While the first experiments were delayed a year due to COVID-19, our first experiments were established in FY21, and the first data collection will take place during FY22.*

High Tunnel Eggplant. We will prepare and submit a peer-reviewed manuscript describing the results of this work during the next reporting period.

Table Grape. A manuscript describing performance of the original eight cultivars grown in two training systems will be submitted during the next reporting period. In 2021, we will conduct initial training for seven new table grape cultivars to the vineyard to evaluate performance (hardiness, yield, susceptibility of diseases, etc.) in our region.

Fig. We will establish a new experiment using refined crop spacing and more varieties than were established in our first round of high tunnel and outdoor experiments. We aim to characterize the production season for a wide selection of varieties, because early fruit production is key to productivity and high yields in our production system.

Peer-Reviewed Publications

Orde, KM, R Marini, K Demchak and RG **Sideman. 2021.** ‘Albion’ strawberry responds to mulch treatments and low tunnels covered with photosensitive films. *HortScience*, 56(9):1005-1014. <https://doi.org/10.21273/HORTSCI15886-21>

Orde, KM and RG **Sideman. 2021.** Winter survival and second-year spring yields of day-neutral strawberry in the Northeast are influenced by cultivar and the presence of low tunnels. *HortTechnology* 31(1):77-88. <https://doi.org/10.21273/HORTTECH04734-20>

Professional Conference Presentations

Lima, M. R. M., Chandrakala, A., & Sideman, R. G. (2021) Can Grapevine Training Systems Modulate Table Grape Composition? [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Salt Lake City, UT. <https://scisoc.confex.com/scisoc/2021am/meetingapp.cgi/Paper/136557>

Working Papers

Harris Cyper, A, C Roman, G Higgins, S Scheufele, A Legrand, A Wallingford and RG **Sideman. 2022.** A field survey of Syrphidae species and adult densities on annual flowering plants in the northeastern United States. *In revision.*

Maximizing yields and minimizing defects for Brussels sprout (Brassica oleracea var. gemmifera) with cultivar choice and topping practices.

Effects of cultivar and training system on yields of seedless table grape and susceptibility to common diseases of grape in New Hampshire.

Postharvest quality and fruit production patterns in eggplant (Solanum melongena) cultivars grown in high tunnels in New Hampshire.

Graduate Thesis Completed

None during the reporting period

Grants Submitted or Received

Submitted:

The Northeast Arugula Team (NEAT): Evaluation and mitigation of limitations to profitability for arugula production. PI: Bull, Co-PIs: McGrath, Hodgdon, Hazelrigg, Maden, Poleatewich, and Sideman. Full proposal submitted to Northeast SARE R&E Program, Oct 2021.

Introducing New Growers to Holistic Crop Management for High Tunnel Vegetables in Northern New England: A Toolkit for Success. PI: Skinner, Co-PIs: Frank-Sullivan, Hazelrigg, Sideman, Cooperators: Wallingford, Maden. Full proposal submitted to Northeast SARE R&E Program, Oct 2021.

Not Funded:

Enhancing sustainability and profitability of organic strawberry production through advances in breeding and farming systems. USDA-AFRI Organic Research and Extension Initiative. PI:Knapp, co-PIs Pincot, Fennimore, Sideman and Lloyd. \$2,030,000 (\$525,662 to UNH). (5 years) 2021-2025.

Funded:

Optimizing pest management in high tunnels to increase the resiliency of local food systems. USDA NIFA Specialty Crops Research Initiative (SCRI). PI: Ingwell, Co-PIs: Wallingford, Atallah, Wenjing, Kaplan, Athey, Sideman. \$520,278 (4 years) 2021-2025.

Other research-generated products

UNH Sideman Lab Instagram page. Provides updated, regular information about our applied research and extension activities focused on high-value specialty crop production and season extension. At the close of the reporting year, we had 882 followers (a 27% increase over last years' number), and during the reporting year, we published 38 posts.

https://www.instagram.com/unh_sidemanlab/.

Outreach events and presentations

Radio Segment with WNTK/Peter St. James, about NHDAMF-funded table grape project. May 26, 2021.

Sustainable Agriculture at UNH/Virtual Sustainable Gardening Workshop for Climate Action New Hampshire. ONLINE. 29 July 2021. 12 participants.

Guest Expert on The Veggie Beet, Great Lakes and Midwest Growers Podcast. Topic: Abiotic Physiological Disorders. July 7, 2021. Podcast available here: <https://www.buzzsprout.com/1038118/episodes/8791535>

Seedless table grapes for NH. May 2021. NH Agricultural Experiment Station Virtual Twilight Meeting, with G. Hamilton and M. Lima.

Fertilizing and Amending in the Garden and Landscape, Part 1 and Part 2. May 2021. Granite State Gardening Podcast, with Emma Erler and Nate Bernitz. Available here: <https://extension.unh.edu/blog/soil-amendments-ground-nesting-bees-mountain-laurel-and-finishing-compostaudio>

Webinar: Practical Recommendations for Managing Brassica Insect Pests. April 2021. 80 participants.

Season Extension Basics. Mar 2021. Presentation to the Small and Beginner Farmers of NH. 5 growers.

Pruning brambles and grapes. Mar 2021. Facebook Live Event. Ask UNH Extension Online Event. 500 participants.

Tunnels and figs and grapes, oh my! Expanding the options for New England farmers. Mar 2021. Invited seminar presentation at the Stockbridge School of Agriculture, University of Massachusetts. Online event. 30 faculty and graduate students.

Bountiful Brussels Sprouts: Tips for Success with a Finicky Crop. Feb 2021. Great Plains Grower Conference, St. Joseph, Missouri. Online event. 43 growers.

The viability of low tunnel vegetable production. Jan 2021. Minnesota Vegetable Growers Association Annual Meeting. Online event. 38 growers.

Exciting New Vegetable Varieties Webinar. Jan 2021. UMaine and UNH Gardening Series. Webinar.

Science Café Virtual Session #6: Climate change and food; what will we grow in a hotter, wetter, wilder world? Expert panelist. Nov 2020. ONLINE EVENT.

Selecting Varieties for High Tunnels. MOFGA Farmer to Farmer Conference. Nov 2020. ONLINE CONFERENCE.

Extension Research Reports:

Sideman RG. 2021 Research report: [Figs for cold climates.](#)

Closing Out (end date 09/07/2023)

Conservation and Utilization of Plant Genetic Resources

Project Director

Iago Hale

Organization

University of New Hampshire

Accession Number

1017760



Annual Report FY21

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

Plant genetic resources (PGR) constitute the very foundation of agriculture, and the practical utilization (i.e. deployment) of PGR is a highly place-based and decentralized process. In other words, the PGR and associated production systems needed to take advantage of emerging market opportunities, overcome production challenges, and meet the evolving needs of growers and consumers in New England will only arise through committed research efforts in this region, cognizant of its specific context. As part of the long-running Hatch-Multistate Project NE-9, dedicated broadly to the conservation and utilization of PGR for northeast agriculture, the long-term goal of this project is to develop economically viable cultivars of a new high-value crop (kiwiberry), alongside best production practices, for New England.

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 following major activities were undertaken over the past year in service to the long-term goal of this project, as part of NE009, a multistate effort to conserve, characterize, and utilize plant genetic resources:

1. **Progress in the breeding program:** The initial years of the project (2013-2017) were dedicated to the successful acquisition, characterization, and genetic deconvolution of the North American collection of kiwiberry accessions, sourced from the USDA, the nursery trade, and private individuals. Building on that initial work, the project began shifting its focus in 2018 to the breeding of improved varieties, embarking on a rolling 10-year breeding cycle, from crossing elite parents to the release of advanced lines. Despite a transition in personnel which left the project without a Vineyard Manager from March-May 2021, steady progress was made in the breeding program this past year, including:

- 320 new female breeding vines from controlled crosses, originally transplanted to the NHAES vineyard in 2017-2018, reached reproductive maturity in 2021, allowing widespread assessment of productivity and fruit quality traits, alongside 43 selections from previous years.
- 197 accessions were culled from the program, based on visual quality (berry color, morphology, and cosmetic damage), eating quality (taste and texture), and storage characteristics (shelf life).
- 11 superior lines were selected and propagated for evaluation in replicated trials, to be established in Spring 2022 at both the NH Agricultural Experiment Station (NHAES) and at Hartmann's Plant Company (HPC), as per the project's MTA with that nursery.
- 6 superior lines identified and propagated in 2020 were established in replicated trials at the NHAES and HPC.
- 242 new female breeding lines from two new populations were transplanted to the NHAES vineyard in June 2021, following molecular-based gender screening as per the marker assisted selection (MAS) protocol developed early in the project.

2. **Completed data collection for effects of harvest time and storage conditions on kiwiberry quality:** Graduate student Aislinn Mumford (MS - Agricultural Sciences) completed the second season of data collection for her master's thesis, consisting of thorough quality assessment, including near infra-red (NIR) spectroscopy and ethylene emission curves, of cv. 'Geneva 3' berries harvested at three different maturities (6, 8, and 10 °Brix), held in cold storage for varying durations (4, 6, and 8 weeks), and ripened at room temperature for various periods (3, 6, 9, 12, and 15 days). Data analysis is underway, and a manuscript reporting the results of the study is expected by Summer 2022. *The end result of this work will be needed refinement in the recommended harvest and post-harvest practices for regional kiwiberry producers and marketers.*

3. **Authored and published kiwiberry monograph:** In collaboration with colleagues Piotr Latocha (Poland) and Filip Debersaques (Belgium), an extensive kiwiberry monograph was written and published for the benefit of the global kiwiberry research and improvement community:

Latocha P, Debersaques F, Hale I (2021) *Actinidia arguta* (Kiwiberry): Botany, Production, Genetics, Nutritional Value, and Postharvest Handling. *Horticultural Reviews*, 48, 37-152

4. **Initiated genetic mapping of oxalate genes:** Using the two bi-parental mapping populations developed in 2019 and transplanted to the NHAES vineyard last year, research formally got underway in 2021 toward the objective of developing a molecular marker for low oxalate content in kiwiberry. Specifically, foliar tissue from the 235 mapping lines was collected and sent to the University of Minnesota Genome Center for DNA extraction and genotyping-by-sequencing (GBS). Sequencing data are expected by Spring 2022, and a new graduate student (Reecha Acharya, MSe Genetics) was successfully recruited to work on this project as part of her masters research. *The end result of this work will be a simple molecular marker-based method for selecting at the seedling stage against high oxalate kiwiberry lines in the breeding program, following the example of the gender marker that is now in routine use by the program.*

5. **Initiated herbicide and pruning trials:** Making use of a mature replicated yield trial in the NHAES vineyard consisting of four blocks of three different historic varieties (cvs. 'Ananasnaya', 'Meader Female', and 'Dumbarton Oaks'), treatments were applied during the 2021 season to investigate: 1) The sensitivity of kiwiberry vines to glyphosate application; and 2) The differential performance of fruiting laterals laid down at different times during the growing season. An undergraduate student (Patrick MacDonald, BS - Sustainable Agriculture and Food Systems) was successfully recruited to work on this project. *The end result of this work will be practical recommendations to growers interested in chemical weed control options in their vineyards as well as best practices for canopy management.*

6. **Concluded investigations into the Xenia Effect in kiwiberry:** Undergraduate McNair Scholar Khem Basnet (BS - SAFS) completed the analysis of his study into the reported existence of a Xenia Effect (i.e. immediate effect of pollen source on fruit quality) in kiwiberry. In short, no effect was detected in the quality of cv. 'Geneva 3' berries when comparing those fertilized with pollen from cvs. 'Meader Male' and 'Opitz Male.' *The end result of this work was confirmation that selection of male (i.e. pollenizer) varieties can be based solely on flowering time and pollen quantity, as has been the approach to date.*

7. **Ongoing Extension and outreach:** Through hands-on workshops and field days, we have actively supported regional stakeholders (producers and processors) in the cultivation and marketing of this underutilized crop. More broadly, we have continued to improve and update the content of our regional kiwiberry production guide and enterprise analysis, originally released in 2019 (www.noreastkiwiberries.com). Stakeholder response to this resource remains excellent, with nearly 8,000 unique users from 117 different countries since its release. Finally, through invited presentations at regional conferences and publication of the comprehensive monograph, the program continues to communicate its work to the larger research community.

6. **Data licensing and nursery partnership:** The project's relationship with Hartmann's Plant Company (HPC) continues, with the total number of royalty-generating 'UNH-verified' varieties increasing to seven. In 2021, the program received its first royalties from this negotiated data license with HPC. *The primary outcome of this work is the establishment of a reliable and affordable commercial source of kiwiberry vines for interested producers.*

7. **Vineyard management:** The now 1.75 acre kiwiberry research vineyard at the NHAES was well maintained over the past year, providing a venue for all the research, breeding, and outreach activities described above.

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

In accordance with its objectives, the activities of this project continued to benefit four distinct target audiences, as described below:

1. *Current and prospective kiwiberry producers*

Most immediately, the project has directly benefitted current and prospective kiwiberry producers by enabling access to genetically verified kiwiberry varieties to both commercial producers interested in diversifying their operations as well as homeowners interested in backyard fruit production. Complementing this access to verified plantstock is the project's ongoing efforts to share current best practices through a wide range of venues, including the project's continually updated online production guide (www.noreeastkiwiberries.com), hands-on pruning workshops, and responses to individual requests for information (email and phone). The project continues to invest effort in refining its recommended production practices via discrete, targeted investigations into harvest timing, postharvest handling, herbicide tolerance, and canopy pruning management. Additionally, by persevering in the breeding cycle, including advancing promising selections to replicated trials, the project's activities are essential to the long-term viability of the region's emerging kiwiberry sector. As a final note, although the project's efforts are focused on the northeast, its outputs are relevant to a far wider audience, as revealed by analytics of the online production guide (nearly 8,000 visitors from 117 countries).

2. *Kiwiberry researchers*

By integrating basic genetic research into an applied improvement (breeding) program, the project's activities benefit the broader, global kiwiberry research community. Building on its previous success in creating a *de novo* genotyping pipeline for the species and developing the first marker assisted selection (MAS) protocol for kiwiberry (gender), the project has undertaken the task of developing a MAS protocol for oxalate content, with data collection beginning in earnest this past year. The project PI continues to actively engage with the broader scientific community, this past year serving on the Scientific Advisory Board for the Tenth International Kiwifruit Symposium and publishing a peer-reviewed monograph on the species.

3. *Plant science students*

A unique stakeholder in the public plant breeding sector is the student, and it is the duty of practicing breeders in the nation's land-grant system to train the next generation of plant scientists through hands-on research in their programs. By providing the opportunity for two undergraduate and two graduate student research projects, the program's activities over the last year has directly benefitted these stakeholders, so essential to the ongoing viability of our nation's agricultural system.

4. *Nurseries*

Finally, through its innovative partnership with Hartmann's Plant Nursery, the project has directly benefitted the commercial nursery industry. Hartmann's is the largest wholesale propagator of kiwiberry plants in the nation, providing plantstock to numerous point-of-sale nurseries domestically and abroad. By genetically verifying variety identification in Hartmann's inventory, the program has made a major contribution to standardizing variety nomenclature, a first step toward building a coherent industry able to meet customer expectations of quality.

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

Beyond the four target audiences mentioned above, the project's activities are designed in the long-term to ultimately benefit the broader public, as consumers of a diverse offering of fresh, nutritious, locally-adapted, and climate-friendly produce. To accomplish this long-term goal for a novel crop that is largely unknown due to underinvestment to date requires systematic research investments and outreach efforts to simultaneously build production capacity (i.e. improved genetics, coupled with best cultural practices), producer interest, and market demand. Through its steadfast pursuit of such objectives, as described in the previous section, the project is making inexorable headway in bringing the benefits of a new crop to the broader public of consumers.

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 project encountered no notable problems over the past year, other than the ongoing general challenges of the pandemic and the three months (March-May) with no Vineyard Manager while the search for a replacement was underway. In the end, the transition of key personnel went very smoothly, resulting in solid progress on all fronts, though the program's usual outreach events were stymied by COVID restrictions. For details about student training, results dissemination, and the trajectory of future activities, please refer to previous sections of this report.

Peer reviewed publications

Latocha P, Debersaques F, Hale I (2021) *Actinidia arguta* (Kiwiberry): Botany, Production, Genetics, Nutritional Value, and Postharvest Handling. *Horticultural Reviews*, 48, 37-152

Other research-generated products

UNH Undergraduate Research Conference Poster – Basnet, K (2021) The Effect of Pollen Source on Fruit Quality: An Investigation of the Xenia Effect in Kiwiberry (*Actinidia arguta*). April 24, 2021

Royalty-generating data license agreement between UNH and Hartmann's Plant Company for two additional genetically-verified *Actinidia* spp. varieties (cvs. 'Krupnoplodnaya' and 'Hardy Red'). February 18, 2021

Outreach events and presentations

Winter pruning demonstration for regional producers, NHAES Kiwiberry Vineyard. COVID restricted – three producers. March 6, 2021

Summer pruning demonstration for regional producers, NHAES Kiwiberry Vineyard. COVID restricted – four producers. July 24, 2021

Other outreach materials

Ongoing hosting and updating of the project's online production guide: www.noreastkiwiberries.com

Critical Issue

Climate change and sustaining natural resources

Forest Stewardship on Private Lands in New Hampshire

Project Director

Julien Kouame

Organization

University of New Hampshire

Accession Number

7001952



2021 - Results

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

Forests are critical to sustaining New Hampshire's forest products industry and forest-related tourism and recreation which contribute more than \$2 billion to the economy. New Hampshire's forests also provide habitat for wildlife, protect water quality, and help to define the character of our communities. Increasing population, fragmentation of the resource base, and changes in land ownership all affect the ability of New Hampshire's forests to meet the diverse needs of the people. Each year, New Hampshire loses approximately 13,000 acres of forest land. With increased pressures on our forest lands, comprehensive management and planning for the future are critical to maintaining the resource base and the benefits it provides. Eighty percent of New Hampshire's forestland is owned by approximately 120,000 private forest landowners. Education about forests and land stewardship is key to informed decision-making by these landowners, yet a recent study found that 73 percent of New Hampshire landowners (owning 10+ acres) don't have a plan for managing their land. This program endeavors to increase the amount of permanently protected land to provide habitat for wildlife, protect water quality, maintain our forest-based economy and help to define the character of our communities, and increase the amount of land managed using good forest stewardship practices.

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.

UNH Cooperative Extension motivates private landowners to actively manage their land for long-term stewardship of natural resources and motivates communities to plan, protect, and manage their natural resources. We strive to maintain significant open space, including large, contiguous blocks of intact forest that remain under long-term consistent management.

1. Private forest landowners identify objectives for their woodland, seek professional forestry assistance, and adopt best management practices in keeping with their objectives while maintaining or enhancing environmental quality
2. Professionals that manage private forest lands use improved forest stewardship practices. Because of UNH Cooperative Extension intervention, 100 licensed foresters increase skills and knowledge by attending natural resources workshops resulting in improved practices and 200 professional loggers increase skills and knowledge through the NH Certified Professional Logger program resulting in improved practices.
3. Communities identify and protect productive forests that contribute to water quality and the economy. 5 communities engage in natural resource inventories or community-wide conservation planning.
4. 500 volunteers in conservation (Coverts and Natural Resource Volunteers) extend the reach of the UNH Cooperative Extension Forestry and Wildlife program in their own communities, helping UNH Cooperative Extension achieve the above objectives.

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

- 9,535 acres of forest management plans written using the NH Forest Stewardship standards
- 94 forest owners received federal or state financial incentives for implementing conservation practices, including management plans
- 168 new landowners hired a forester or natural resource professional for the first time in 10 or more years
- 180 licensed foresters increased skills and knowledge by attending at least one natural resources workshop.
- 247 professional loggers increased skills and knowledge by attending at least on the workshop through the NH Certified Professional Logger program.
- 953 volunteers in conservation (Coverts and Natural Resource Volunteers) extend the reach of the UNH Cooperative Extension Forestry and Wildlife program in their own communities, by actively managing over 145,000 acres and reaching out to over 15,140 people.

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

1. Using economic modeling, we conclude that technical recommendations from Extension foresters' site visits resulted in approximately \$341,000 of additional revenue for forest landowners, \$962,000 of additional annual total production value, and \$34,100 of additional tax revenue to municipalities this fiscal year.
2. Eleven direct e-newsletters, titled *Forestry News for Foresters* were sent informing foresters and other natural resource professionals about educational and other opportunities. This low-key communication method has proven to be appreciated and valued by the New Hampshire forestry community

Closing Out (end date 09/07/2023)

[The response of water quality and aquatic ecosystem function to changing land use and variable climate in New England.](#)



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

The problem being addressed is how land use change, including agriculture and urbanization, influences water quality and the functioning of streams and ponded waters, including both human reservoirs and beaver ponds. In addition, we are trying to understand how climate variability (floods and droughts) interact with land use change to further impact these water bodies.

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.

One of the major activities completed over the past year included measurement of water quality and water chemistry in roughly 50 streams distributed across a range of land use types (forest, wetland, agriculture, suburban) and intensity (from 0 to 80% land use change) to characterize land use -water quality relationships during summers. Along with these measurements, we also collected sediment samples at each sample site to quantify the microbial communities which we will then relate to the chemistry. Microbes drive most of the major biogeochemical processes in streams (metabolism, decomposition, denitrification, etc) that influence water quality, so our goal with the microbial measurement is to determine how the communities differ with land use change. These analyses are still ongoing. In the coming year we expect to measure how rates of some of ecosystem processes vary with microbial and chemical difference, and evaluate whether the microbial community is an important driver of variation.

We recently completed two modeling studies that were informed by our prior measurements. These include a paper published by a former masters student (Tao Huang, MS 2017) on bacteria pathogen fluxes through river networks. After a long review process, this was finally submitted last year and published (Huang et al. 2022). Pathogen inputs are high where there is anthropogenic land use, including both agriculture and urban areas. The study found that the river system, regardless of watershed size, is important for filtering pathogen sources at low flow conditions, while at high flow, small watersheds or sources close to the basin mouth are unable to filter most pathogens out.

We wrote and submitted a study (Wollheim in Review) demonstrating that the cumulative function of all surface waters increases faster than watershed area. This occurs because large rivers contribute disproportionately to the total surface area of all flowing waters in a river network. This is especially true during high flow conditions, suggesting that large rivers will become more important if storm size increases.

We quantified greenhouse production in several streams in New Hampshire (Dube Br. in Madbury and College Br. in Durham) and Massachusetts (Robison 2021 PhD Dissertation, Robison et al. 2021). Robison et al. found that streams are a more concentrated source of methane than ponded waters and are unique in that a greater proportion is emitted via diffusion rather than via bubbles (ebullition). Robison et al. suggest the mechanism for this difference is the fact that water regularly moves into the sediments that prevent the buildup of bubbles. This research helped us receive a DOE FICUS award in collaboration with Emil Ruff at the Marine Biological Laboratory. As a result of the FICUS award, we extended measurements into beaver ponds to evaluate how these systems, which have expanded greatly over the last twenty years, differ as greenhouse gas sources and nutrient sinks. We collected samples of methane and carbon dioxide to quantify both amounts and isotopic ratios, to evaluate whether the food web is being fueled by methane (i.e. anaerobic sources), which has important implications for sources and fate of methane to the atmosphere. Analyses are being conducted at DOE Labs through the DOE FICUS award.

We contributed water quality and process measurements from Mill Pond in Durham NH to the VHB Dam Feasibility report prepared for the town of Durham, as part of their consideration on what to do about the Mill Pond Dam. Our data clearly demonstrated the pond created by the dam is the cause of the low oxygen conditions and higher water temperatures compared to the river entering the pond. We also reported that the pond is not retaining much nitrogen and may in fact be an additional source of nitrogen to the system via internal biological processes (n-fixation). N-fixation is clearly occurring because the water is often well undersaturated for N₂ gas. The measurement of dissolved N₂ gas (as the ratio of dissolved nitrogen gas to argon gas, N₂:Ar) is now possible at UNH thanks to an AES equipment grant received in 2017. Overall, these results help understand the ecosystem processes in Mill Pond, on the Oyster River, as it fills in with sediments, becomes shallower, and oxygen conditions deteriorate.

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

The major target audiences for this work were the consulting firm VHB, officials of the Town of Durham, and the Piscataqua Region Estuarine Partnership, which coordinates activities and information flow to a number of other stakeholders of Great Bay. These other stakeholders include multiple towns throughout the watershed of Great Bay and the Great Bay National Estuarine Research Reserve.

VHB included research from my lab as part of its Dam Feasibility Study, summarizing the results in an executive summary, and the data itself in an appendix. This was shared with Durham town officials and was presented at the Town Council meetings as part of the councilors deliberations on their vote on whether to remove the dam and restore the river, or to repair the dam. We participated in these meetings to clarify any questions the Town Council had. The town council voted 7 to 2 to remove the dam. A citizen petition successfully forced the town to vote on whether to accept the town council decision, which took place in a referendum in March 8th, 2022.

I serve as co-chair (with Dr. Bonnie Brown) on the PREP Technical Advisory Committee, which meets at least monthly. I regularly contribute knowledge gained from this research to help interpret monitoring data, to improve on or plan new monitoring efforts, and to explore management strategies. On the basis of my research on nutrient dynamics in New England watersheds, I was also asked to serve on the Portland Area Nutrient Group (PANG), which is developing nutrient criteria for Casco Bay to aid in their management of that resource. In both of these settings, I regularly share insights gathered from my AES work on nutrient sources, transport and fate to help improve management of these ecosystems. PANG is now finalizing the nutrient criteria targets.

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

The Seacoast public learned more about the factors controlling watershed water quality over the past year. I was featured in a You Tube video created by elementary school science coordinator Ellen Ervin, discussing the water quality of College Brook ("Learning about Watershed Ecosystems", <https://www.youtube.com/watch?v=jFHwhO2a5tU>). The video had 367 views as of 2/27/22. As part of the discussions in Durham regarding the removal of Mill Pond dam, several people referenced this video over social media. I participated in a site walk for the Town of Durham's Conservation Commission as they considered redevelopment plans for the Mill Plaza, which drains directly into College Br., sharing my insights into the factors controlling flow, nutrients, sediments, and storm responses. The decision on how to redevelop continues to be ongoing, in part because the proposed development did not adequately consider the potential restoration of riparian zones along College Br. to help improve water quality. My contributions to the Durham Town Council meetings as part of the feasibility study are publicly available via recordings. Here I contributed my insight into the water quality of Mill Pond, which helped town councilors decide on how to vote regarding whether to remove the dam. I noted how the Mill Pond has impaired water quality, likely due mostly to the fact it is a reservoir on a river, and that it is unlikely that improved watershed management (although necessary for Great Bay) would help alleviate this declining water quality. Although only one of many considerations in the decision, the Town Council vote 7 to 2 to remove the dam.

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.

Peer Review Publications

Huang T., Wollheim W.M., Jones S.H. Removal of Fecal Indicator Bacteria by River Networks. *Water In Review*, 14, 617. <https://doi.org/10.3390/w14040617>

Mulukutla, G. K., W. M. Wollheim, J. E. Salisbury, R. O. Carey, T. K. Gregory, and W. H. McDowell. In Review. High-Frequency Concurrent Measurements in Watershed and Impaired Estuary Reveal Coupled DOC and Decoupled Nitrate Dynamics. *Estuaries and Coasts* 45:445–461

Robison, A.L., W.M. Wollheim, B. Turek, C. Bova, C. Snay, R.K. Varner. 2021. Spatial and temporal heterogeneity of methane ebullition in headwater streams and the impact on sampling design. *Limnology and Oceanography*. <https://doi.org/10.1002/lno.11943>

Wollheim, W. M., T. K. Harms, A. L. Robison, L. E. Koenig, A. M. Helton, C. Song, W. B. Bowden, and J. C. Finlay. In Review. Superlinear scaling of riverine biogeochemical function with watershed size. *Nature Communications* 13:1230

Wollheim, W.M. 2020. RE: Scientists and Disinformation on Social Media. eLetter response to editorial by H. Holden Thorp. *Science*. 368 p 1405. <https://science.sciencemag.org/content/368/6498/1405/tab-e-letters>

Li W., L. Qiuliang, H. Yen, W. M. Wollheim, L. Zhai, W. Hu, L. Zhang, W. Qiu, J. Luo, H. Wang, T. Ren, H. Liu. 2020. [The overlooked role of diffuse household livestock production in nitrogen pollution at the watershed scale](https://doi.org/10.1016/j.jclepro.2020.122758). *Journal of Cleaner Production*. 272. 122758 <https://doi.org/10.1016/j.jclepro.2020.122758>

Professional Presentations

Wollheim, W.M. 2021. Scaling cumulative function of aquatic networks. *Natural Resources and the Environment Seminar Series*. University of Connecticut. Storrs CT. September 2021

Wollheim, W.M. 2021. Scaling cumulative function of aquatic networks. *Water and Environment Seminar Series*. Helmholtz-Zentrum für Umweltforschung-UFZ June 2021.

Balch, E., W.M. Wollheim, A. Wymore, A. Lightbody. Taking nitrogen by storm: Insights from sensors and spatial sampling. Poster at AGU Annual Meeting, December 2020.

Bobyock, J, W.M Wollheim. 2020. The Impact of Water Withdrawals on Summer Low Flows in the Ipswich River Watershed, MA, USA. Poster at AGU Annual Meeting, December 2020.

Robison, A.L., W.M. Wollheim, A. Cotter, C. Perryman, J. Mackay, J. Ernakovich, P. Clarizia, and R.K. Varner. Methane dynamics in headwater streams: integrating gas fluxes, isotopes, and microbial community data. *Association for the Sciences of Limnology and Oceanography*. June 2021.

Robison, A.L., W.M. Wollheim, L.E. Koenig, J.D. Potter, L.E. Snyder, and W.H. McDowell. The impact of storms on CO₂ emissions from streams and rivers. *Society of Freshwater Science*. May 2021.

Robison, A.L., W.M. Wollheim, L.E. Koenig, J.D. Potter, L.E. Snyder, and W.H. McDowell. Storms disproportionately contribute to CO₂ efflux from streams and rivers on annual timescales. *American Geophysical Union Fall Meeting*. December 2020.

Robison, A.L. and W.M. Wollheim. Carbon emissions from headwater streams: an overlooked source in landscape greenhouse gas budgets. *Graduate Climate Conference*. October 2020.

Strzempko, Jessica, W.M. Wollheim 2020. Characterization of Wetland Scaling and Influence in the Ipswich and Parker River Watersheds of Northeastern Massachusetts. *American Geophysical Union Fall Meeting*. December 2020.

Whitney, C.T., W.M. Wollheim, M. Palace, C. Herrick. Using High-Resolution Remotely-Sensed Data to Assess Beaver-Related Land Cover Change in Northeastern Coastal Watersheds. Oral presentation given at the *Society for Freshwater Science Annual Meeting*. Virtual. May 2021.

Whitney, C.T., W.M. Wollheim, M. Palace, C. Herrick. Assessing The Expansion of Beaver in Northeastern Coastal Watersheds Using High-Resolution Remotely-Sensed Data and the Implications for Biogeochemical Fluxes. Poster given at the American Geophysical Union Fall Meeting. Virtual. December 2020.

Graduate Theses

Robison, A.L. 2021. Carbon emissions from streams and rivers: Integrating methane emission pathways and storm carbon dioxide emissions into stream and river carbon balances. PhD Dissertation. University of New Hampshire.

Balch, E.C. 2020. Taking nitrogen by storm: spatial and temporal controls on nitrogen processing in a small stream. M.S. Thesis. University of New Hampshire.

Bolster, D. 2020. Quantifying the effects of land use and flow regime on metabolism of New England Streams. M.S. Thesis. University of New Hampshire. 101pp.

Grants Awarded

2021-2023 NOAA, Seagrant, Long Island Sound Study: Can Watershed Land Use Legacies Inform Nitrogen Management? (w/ PI Ashley Helton at UCONN) UNH portion: \$129,954

2021-2024 NSF-Hydrology: Collaborative Proposal: Plastic Spiraling In River Networks (Plastic-SiReN): Determining the controls of watershed plastic fluxes using a field and modeling approach. \$429,900

2021-2022. DOE-FICUS: Assessing the contribution of sediment bioirrigation to the oxidative removal of methane from a fluvial wetland. (w/ PI Emil Ruff, MBL) Budget is for analysis at DOE labs.

Grants Submitted

2022-2027. NSF CoPe: Large-Scale CoPe: SECURE: Sustainable, Equitable Coastlines in Urbanizing Regional Environments. (w/ PI Jen Bowen, Northeastern University) UNH portion \$1,108,775 (pending)

2021-2025. NSF SCC: NitroSen: Smart and Connected Landscaping Using Low-cost Nitrogen Sensors Towards a Healthy Great Bay. (w/ PI Shaad Mahmud in CEPS). (rejected)

Outreach Presentations

Balch, E., G. Mulukutla, W.M. Wollheim. Fate of N in a small reservoir: Insights from sensors & spatial sampling in Mill Pond, Durham NH. Poster at NH SeaGrant Symposium. January 2021.

Wollheim, W.M. College Br. Flooding 2013-present. Presented to the Durham Conservation Commission, November 2020.

Project Director

Andre Brito

Organization

University of New Hampshire

Accession Number

1017808



Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises

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

Agriculture is under increasing scrutiny regarding its role in global greenhouse gas emissions. In the United States, enteric fermentation by ruminants is the largest source of anthropogenic methane (CH₄) emissions. Forage-based diets have been linked to greater enteric CH₄ emissions than grain-based diets. On the other hand, forages and particularly pasture are the cheapest feed sources in dairy farms in the United States and high-forage diets have been shown to improve cow health. However, the growing season in the Northeast is short, with forage production declining when the weather cools down later in the fall. Therefore, our project is advancing knowledge regarding the use of forage canola, which is a highly productive annual forage crop with potential to extend the growing season while benefiting milk production and reducing enteric CH₄ emissions due to its high digestibility and nutritive value. We are also interested in the impact of legume-grass mixtures and seaweeds on milk production and composition, nutrient utilization, and enteric CH₄ emissions in lactating dairy cows.

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.

Forage Canola Study

We evaluated the effect of partially replacing baleage (film-wrapped silage) with forage canola (CAN) herbage on ruminal fermentation profile and methane (CH₄) production. Twelve multiparous and 8 primiparous mid lactation organic-certified Jersey cows were paired by parity, milk yield, or days in milk and, within pair, randomly assigned to control (CTRL) or CAN in a randomized complete block design. Cows in the CTRL diet were kept in confinement, while CAN cows stayed in the barn during the day and had access to pasture from 6 pm to 5 am. Diets were formulated to yield [dry matter (DM) basis] 60:40 forage:concentrate ratio, with 67% of the baleage replaced by grazed CAN in the diet DM. The experiment lasted 7 wk (2-wk covariate) with sample collection done during wk 3 and wk 5. Ruminal fluid was collected using a stomach tube, and gaseous fluxes were measured using 2 GreenFeed units. Daily herbage allowance averaged 19 kg of DM/cow. There was no diet effect on DM intake, but cows in the CTRL group tended to have greater milk yield (21.2 vs. 20.1 kg/d; $P = 0.10$) than those in the CAN group. Enteric CH₄ production (436 vs. 295 g/d; $P < 0.01$), CH₄ yield (20 vs. 14.1 g/kg DM intake; $P < 0.01$), and CH₄ intensity (16.0 vs 11.5 g/kg energy-corrected milk; $P < 0.01$) decreased with feeding CAN vs. CTRL. While ruminal total volatile fatty acids concentration and the molar proportions of propionate and butyrate increased, those of acetate, isobutyrate, and isovalerate, and the acetate:propionate ratio decreased in CAN vs. CTRL ($P < 0.01$). These shifts in ruminal fermentation likely explains the reduction in methanogenesis in cows grazing CAN as metabolic pathways favoring propionate formation decrease H₂ used for CH₄ synthesis. Glucosinolates present in CAN may also have been involved on CH₄ suppression.

Seaweed Study:

This study investigated the effects of the brown seaweed *Chondrus crispus* on milk yield and composition and enteric CH₄ emissions in dairy cows. Six primiparous and 12 multiparous early- to mid-lactation organic-certified Jersey cows were fed (DM basis) incremental amounts of *C. crispus* (0, 3, and 6%) in a replicated 3 × 3 Latin square design. Experimental periods lasted 24 d, with 14 d for diet adaptation and 10 d for data and sample collection. Diets were fed as total-mixed rations. The control diet (0% *C. crispus*) consisted of (DM basis) 65% grass-legume baleage and 35% concentrate mix, with baleage being replaced with 3 or 6% *C. crispus* in the remaining 2 diets. Gaseous emissions were measured using 1 GreenFeed unit. Orthogonal polynomial contrasts were used to test linear and quadratic effects in response to incremental levels of *C. crispus*. While increasing *C. crispus* linearly decreased DM intake (from 19.7 to 17.0 kg/d; $P < 0.01$), feed efficiency, calculated as 4% fat-corrected milk/DM intake (from 1.19 to 1.37; $P < 0.01$) and energy-corrected milk/DM intake (from 1.28 to 1.47; $P < 0.01$), increased linearly. In contrast, yields of milk, 4% fat-corrected milk, and energy-corrected milk, and concentrations and yields of milk fat and protein were not affected by diets. Feeding incremental amounts of *C. crispus* decreased CH₄ production (from 383 to 351 g/d) linearly ($P < 0.01$). However, CH₄ yield (g/kg of DM intake) and CH₄ intensity were not affected by diets. Collectively, our results suggest no benefits of feeding *C. crispus* at 6% of the diet DM.

Alfalfa- vs. Red Clover-Grass Mixture Study:

Eighteen multiparous and 2 primiparous mid-lactation organic-certified Jersey cows were blocked in pairs by days in milk or parity and, within pair, assigned to treatments in a randomized complete block design to investigate the effects of 2 legume-grass mixtures on DM intake, milk yield and composition, milk fatty acids (FA), and enteric CH₄ emissions. Two fields were planted with alfalfa (ALF-GR)- or red clover (RC-GR)-grass mixture with a 79:14:7 legume:meadow fescue:timothy seeding rate (% total). Forages were harvested as baleage, with second and third cuttings used in the study. The botanical composition (DM basis) of second-cut ALF-GR or RC-GR swards averaged 65 vs. 80% legume, 17 vs. 15% grasses, and 18 vs. 5% weeds, while that of third-cut ALF-GR or RC-GR averaged 84 vs. 96.5% legume, 3 vs. 2.3% grasses, and 13 vs. 1.2% weeds, respectively. Diets, fed as total mixed rations, were formulated to contain (DM basis) 65% second- and third-cut ALF-GR or RC-GR (32.5% of each cut) and 35% concentrate. The study lasted 9 wk (2-wk covariate) with sample collection done at wk 4 and 7. Methane was measured using 1 GreenFeed unit. No diet effects were observed for DM intake, yields of milk and milk protein, and concentrations of milk fat and protein. Milk fat yield tended to be greater ($P=0.06$) in cows fed ALF-GR than RC-GR. Significant diet by wk interactions were observed for milk urea N concentration, which decreased more pronouncedly in cows fed RC-GR in wk 4 than 7. A significant diet by wk interaction was also observed for CH₄ production, with cows fed RC-GR vs. ALF-GR having lower CH₄ production (380 vs. 424 g/d) in wk 4 but no change in wk 7 (mean = 416 g/d). Diets did not affect CH₄ yield (mean = 21.4 g/kg of DM intake) and CH₄ intensity (mean = 15.2 g/kg of energy-corrected milk).

Red Clover- vs. Legume-Grass Mixture Study:

Sixteen multiparous and 4 primiparous mid-lactation organic-certified Jersey cows were used to investigate the effects of partially replacing red clover (RC) with a legume mix (LM) on milk yield and nutrient utilization. Cows were blocked in pairs by days in milk or parity and, within pair, randomly assigned to treatments in a crossover design. Each experimental period lasted 24 d, with 14 d for diet adaptation and 10 d for sample collection. Two fields were planted with RC- or alfalfa-grass mix consisting (% of total) of 79:14:7 legume:meadow fescue:timothy seeding rate. Forages were harvested as baleage, with second and third cuttings used in the present study. Diets were formulated to yield a 60:40 forage:concentrate ratio and fed as total mixed rations twice daily. Based on the botanical composition of each field, the forage portion of the treatments contained (% of diet DM): (1) 41% RC, 5% white clover, 9% weeds, and 5% grasses (RC diet), and (2) 21% RC, 10% white clover, 12% alfalfa, 11% weeds, and 5% grasses (LM diet). Cows fed RC had greater DM intake (21 vs. 20.4 kg/d; $P=0.01$) than those fed LM, but no significant differences were observed for milk yield, and concentrations and yields of milk fat and protein. In contrast, digestibilities of DM, organic matter, and neutral and acid detergent fiber increased ($P<0.05$) with feeding RC vs. LM. Cows fed the RC diet had greater N intake (605 vs. 591 g/d; $P=0.01$) than cows fed the LM diet, but no differences were observed for milk and plasma urea N concentrations, milk N efficiency, and urinary N excretion. Both CH₄ production (mean = 393 g/d) and CH₄ intensity (mean = 14.6 g/kg of energy-corrected milk) did not differ between diets. Contrarily, cows fed RC had decreased CH₄ yield (18.8 vs. 19.6 g/kg of DM intake; $P=0.03$).

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

We are directly serving organic and conventional dairy farmers across the Northeast region and beyond. We are also serving extension educators, industry personnel (e.g., organic milk processors, nutritionists, veterinarians), and the academic community (e.g., graduate students, undergraduate students, fellow scientists) regionally, nationally, and internationally. Our team presented project results in scientific conferences, farmer-oriented symposiums and workshops, and webinars regarding the impact of forage canola, seaweed supplementation, and legume-grass mixtures on production performance, nutrient utilization, and enteric methane emissions in lactating dairy cows. The impacts of our research include scientific-based information to guide dairy farmers decision on how to optimize the use of annual forages to extend the grazing season, and fine-tune dairy diets via seaweed supplementation and best legume-grass mixtures to improve milk production and composition, farm profitability, and nutrient utilization in their dairy enterprises.

The following presentations were delivered:

1. **A. F. Brito** and K. V. Almeida. "Nutrient Movement in the Environment: Confinement versus Grazing Systems". American Society of Animal Science-Canadian Society of Animal Science-Southern Section of the American Society of Animal Science ASAS Annual Meeting & Trade Show, Louisville, KY (July 14-17, 2021; hybrid conference).
2. **A. F. Brito**. "Feeding Legumes to Organic Dairy Cows". University of Vermont 2021 Online Dairy Education Series (March 18, 2021; webinar).
3. **A. F. Brito**. "The role of Legumes in Forage Mixtures: Effects on Your Bottom Line". University of New Hampshire Cooperative Extension Dairy and Livestock Crops Virtual Field Day (January 27, 2021; webinar).

4. **A. F. Brito.** “Alternative Feeds for Lactating Dairy Cows”. Guest lecture (Ruminant Nutrition course): Parana State University, Marechal Cândido Rondon, PR, Brazil (November 23, 2020; virtual presentation).

5. **A. F. Brito.** “Nutrition for Organic Milk Certification” (Portuguese title: “Nutrição para Certificação de Leite Orgânico”). MilkPoint Experts – Feras da Nutrição e Reprodução (November 10-12, 2020; virtual conference).

6. **A. F. Brito.** “The role of Legumes in Forage Mixtures: Effects on Your Bottom Line”. 2020 Northeast Organic Dairy Producers Alliance Hybrid and Virtual Field Days (October 8 and 29, 2020; YouTube video webinar; https://www.youtube.com/watch?v=ZjMb0zl_qus; <https://nodpa.com/p/114/Field-Days-2020-Hybrid-and-Virtual-NODPA-Field-Days>).

7. **A. F. Brito.** “Production of Organic Milk” (Portuguese title: “Sistema de Produção de Leite Orgânico”). Guest lecture (Dairy Study Group): Federal University of Minas Gerais, Belo Horizonte, MG, Brazil (October 6, 2020; virtual presentation).

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

There is a growing concern from governments and the public at large about the environmental impact of livestock systems. Our research is investigating dietary strategies to improve nutrient utilization by reducing enteric methane (CH₄) emissions and N excretion to the environment. We are working with forage canola, seaweed supplementation, and specific legume-grass mixtures to achieve the goal of reducing the environmental impact of dairy systems. The impacts of our research include delivery of enteric CH₄ and N output data for inventory purposes while guiding policy makers to make decisions on how to implement specific regulatory measurements, if needed, and development of carbon markets in the future. Another impact is education of the general public on how nutrition and management of dairy cows can be used to curb CH₄ and N emissions to the environment.

The following media covered work done with seaweed supplementation to dairy cows:

1. CN BC: <https://www.cNBC.com/2021/10/12/seaweed-could-help-cow-farts-contribute-less-to-climate-change.html>
2. Scripps: <https://www.thedenverchannel.com/news/national/could-feeding-cows-seaweed-be-the-key-to-combating-climate-change>
3. CGTN: <https://www.youtube.com/watch?v=c6oKAMTiRAA>
4. Valley News: <https://www.concordmonitor.com/Researchers-look-to-seaweed-and-algae-to-limit-cow-methane-emissions-43901102>
5. WBUR: <https://www.wbur.org/news/2022/04/22/cows-methane-global-warming-climate-change-seaweed>
6. NHPR: <https://www.nhpr.org/nh-news/2022-04-24/cow-burps-drive-global-warming-unh-scientists-think-feeding-them-seaweed-could-help>
7. NHPR: <https://www.nhpr.org/nh-news/2021-10-29/could-feeding-seaweed-to-cows-help-reduce-greenhouse-gas-emissions>

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 changes in our project approach and methods, with research and outreach components advancing as planned. Outreach activities such as presentations, dairy producer meetings, field days, farm tours, videos, webinars, popular-press articles, and peer-reviewed papers featuring project results have been delivered in collaboration with University Extension. Specifically, project results have been disseminated to dairy farmers, dairy nutritionists, extension educators, dairy industry personnel, students, and the large scientific community.

Peer-Reviewed Papers:

1. Billman, E. D., I. A. de Souza, R. G. Smith, K. J. Soder, N. Warren, F. A. Teixeira, and **A. F. Brito.** 2021. Winter annual forage mass–nutritive value trade-offs are affected by harvest timing. *Crop For. Turfgr. Mgmt.* 2021;e20113. <https://doi.org/10.1002/cft2.20113>.

2. Snider, M. A., S. E. Ziegler, H. M. Darby, K. J. Soder, **A. F. Brito**, B. Beidler, S. Flack, S. L. Greenwood, and M. T. Niles. 2021. An overview of organic, grassfed dairy farm management and factors related to higher milk production. *Renew. Agric. Food Sys.* 1–9. <https://doi.org/10.1017/S1742170521000284>.

3. Zang, Y., L. H. P. Silva, Y. C. Geng, M. Ghelichkhan, N. L. Whitehouse, M. Miura, and **A. F. Brito**. 2021. Dietary starch level and rumen-protected methionine, lysine, and histidine: Effects on milk yield, nitrogen, and energy utilization in dairy cows fed diets low in metabolizable protein. *J. Dairy Sci.* 104:9784–9800.

4. Zang, Y., R. A. V. Santana, D. C. Moura, J. G. B. Galvão Jr., and **A. F. Brito**. 2021. Replacing soybean meal with okara meal: Effects on production, milk fatty acid and plasma amino acid profile, and nutrient utilization in dairy cows. *J. Dairy Sci.* 104:3109–3122.

Peer-Reviewed Abstracts:

1. **Brito, A. F.**, and K. V. Almeida. 2021. Nutrient movement in the environment: Confined versus grazing systems. *J. Anim. Sci. (Suppl. S3)* 99:192.

2. Sacramento, J. P., L. H. P. Silva, D. C. Reyes, Y. Geng, and **A. F. Brito**. 2021. Feeding legume-based forages: Effects on milk yield, nutrient digestibility, and methane emissions in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:307.

3. Sacramento, J. P., L. H. P. Silva, D. C. Reyes, Y. Geng, and **A. F. Brito**. 2021. Feeding legume-based forages: Effects on N utilization in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:306–307.

4. Reyes, D. C., E. A. Latham, R. C. Anderson, J. P. Sacramento, L. H. Silva, Y. Geng, and **A. F. Brito**. 2021. Feeding a novel probiotic and nitrate: Effects on CH₄ emissions and rumen fermentation in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:298.

5. Reyes, D. C., E. A. Latham, R. C. Anderson, J. P. Sacramento, L. H. Silva, Y. Geng, and **A. F. Brito**. 2021. Feeding a novel probiotic and nitrate: Effects on milk yield and nutrient utilization in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:298.

6. Almeida, K. V., L. H. P. Silva, J. P. Sacramento, D. C. Reyes, R. G. Smith, N. Warren, and **A. F. Brito**. 2021. Effects of seeding intensity and cutting on the nutritional quality of grass-legume mixtures. *J. Dairy Sci. (Suppl. 1)* 104:249.

7. Silva, L. H. P., J. P. Sacramento, D. C. Reyes, Y. Geng, M. Ghelichkhan, S. L. Dillard, K. J. Soder, and **A. F. Brito**. 2021. Ruminal fermentation and methane emissions in Jersey cows grazing forage canola. *J. Dairy Sci. (Suppl. 1)* 104:127.

8. Silva, L. H. P., Y. Zang, M. Ghelichkhan, Y. Geng, S. L. Dillard, K. J. Soder, and **A. F. Brito**. 2021. Diversity of the ruminal microbiota in Jersey cows grazing forage canola. *J. Dairy Sci. (Suppl. 1)* 104:127.

9. Lange, M. J., L. H. P. Silva, M. Ghelichkhan, M. A. Zambom, and **A. F. Brito**. 2021. Feeding alfalfa- or red clover-grass mixtures: Effects on methane emissions and plasma amino acids in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:101.

10. Lange, M. J., L. H. P. Silva, M. Ghelichkhan, M. A. Zambom, and **A. F. Brito**. 2021. Feeding alfalfa- or red clover-grass mixtures: Effects on production and milk fatty acids in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:101.

11. Reyes, D. C., J. P. Sacramento, Y. Geng, L. H. Silva, N. Price, C. Quigley, and **A. F. Brito**. 2021. Effects of the brown seaweed *Chondrus crispus* on milk yield and enteric methane emissions in dairy cows. *J. Dairy Sci. (Suppl. 1)* 104:100.


Papers Under Review and Actively Working Papers:


1. Andreen, D. M., E. D. Billman, **A. F. Brito**, and K. J. Soder. Effect of incremental amounts of *Asparagopsis taxiformis* on ruminal fermentation and methane production in continuous culture with orchardgrass herbage (Submitted to *Animal Feed Science and Technology*).

2. Billman, E. D., I. A. Souza, R. G. Smith, K. J. Soder, N. D. Warren, and **A. F. Brito**. Identifying optimal early-season harvest timing in annual fall forages (Submitted to *Crop, Forage & Turfgrass Management*).

3. Zang, Y., L. H. P. Silva, Y. C. Geng, M. J. Lange, M. A. Zambom, and **A. F. Brito**. Replacing ground corn with soyhulls plus palmitic acid in low metabolizable protein diets supplemented or not with rumen-protected amino acids: Effects on production performance and nutrient utilization in lactating dairy cows (Expected submission to the *Journal of Dairy Science*: May 2022).

4. Lange, M. J., L. H. P. Silva, M. A. Zambom, and **A. F. Brito**. Feeding alfalfa- or red clover-grass mixture baleage: I. Effects on milk yield and composition, milk fatty profile, plasma concentration of amino acids, and urinary excretion of nitrogenous metabolites in dairy cows

5. Silva, L. H. , M. J. Lange, M. A. Zambom, K. J. Soder, and **A. F. Brito**. Feeding alfalfa- or red clover-grass mixture baleage: II. Effect on ruminal fermentation profile, diversity and abundance of ruminal microbiota taxa, and energy utilization in dairy cows (Expected submission to the Journal of Dairy Science: July 2022).

6. Sacramento, J. , K. V. Almeida, A. S. Oliveira, D. C. Reyes, and **A. F. Brito**. A meta-analysis and meta-regression to compare feed and milk N efficiency of Holstein and Jersey cows (Expected submission to the Journal of Dairy Science: October 2022).

7. Almeida, K. V., A. S. Oliveira, D. C. Reyes, A. Rahman, E. A. Cruz, A. Konopka, P. J. Kononoff and **A. F. Brito**. Predicting of dry matter intake of lactating Jersey cows. (Expected submission to the Journal of Dairy Science: December 2022).

Critical Issue

Food Safety

Ecosystem Variation and Pathogenic *Vibrio parahaemolyticus* Population Dynamics in Estuarine Shellfish

Project Director

Stephen Jones

Organization

University of New Hampshire

Accession Number

1020175



Annual Report FY21

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

The frequency of vibriosis, mainly shellfish-borne, in the Northeast has increased over the past decades and is now tracking increasing *V. parahaemolyticus* populations in New England's estuarine ecosystems. Management of this public health issue using total *V. parahaemolyticus* populations is limited and requires the use of new tools to track the actual pathogenic strains in time and space. Another key management tool, predictive models for forecasting risk conditions, require focused research to enable capture of finer temporal and spatial scale variations in *V. parahaemolyticus* populations, both in terms of total concentrations and strain diversity.

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 numbers of producers and overall production associated with oyster aquaculture in northern New England continue to increase, yet the associated economic benefits remain threatened by the progressive northward emergence and persistence of *Vibrio parahaemolyticus*-borne illnesses in shellfish consumers, mainly oysters. All oyster producing New England states have initiated monitoring programs to track some aspects of *Vibrio* populations and are instituting increasingly more stringent management practices on farmers to reduce public health risks. There are significant limitations that remain on the effectiveness of management strategies due in part to our lack of understanding of key aspects of how these naturally occurring bacteria persist and cause illnesses in shellfish consumers. In collaboration with state and regional management agencies and industry, we have recently developed new tools for both detecting pathogenic *V. parahemolyticus* populations and models based on environmental and biological conditions for predicting risks of *Vibrio*-borne illnesses. Application of these new approaches are informing our understanding of pathogen dynamics in estuarine ecosystems to address long-standing scientific questions about how and why these pathogens emerge and proliferate to address growing regional concerns by industry and consumers.

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

The target audiences for this project includes the shellfish industry and oyster grower groups, public health and resource management regulatory agencies, non-government environmental groups, students, public citizens, extension specialists and fellow scientists interested in shellfish safety. We continue to apply our research directly with the shellfish industry, including oyster farmers in NH, ME, MA and CT, as well as with the shellfish program managers in those states. The use of our new

pathogen detection methods applies around the region are helping state agencies to manage shellfish harvesting practices and timing, what shellfish seed sources are safe, and sharing findings between states across the region. Public health agencies are also better able to understand which *V. parahaemolyticus* strains are causing illnesses, where and when they occur and how to trace the sources of outbreaks. We continue to present our research at the Northeast Shellfish Sanitation Association, National Shellfisheries Assn., World Aquaculture Society, Northeast Aquaculture Convention and Exhibition/Milford Seminar, and the International Conference on Molluscan Shellfish Safety and International Conference on the Biology of Vibrios meetings to enable sharing findings and new ideas with fellow scientists. We also continue to help the State of NH and the NH Vibrio Task Force to modify policies to best manage shellfish-borne human illnesses from *Vibrio parahaemolyticus* infections.

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

Our outreach to groups outside of the seafood industry and management agencies provides a balanced message of the well-managed and engaged industry to eliminate public health risks, and the benefits of consuming safe regional shellfish while bringing attention to the importance of knowing how to handle and consume what is often a raw, uncooked product. We share our findings with fellow marine scientists and the public at local meetings of the Piscataqua Regional Estuaries Partnership and the Great Bay National Estuarine Research Reserve. We continue to provide information on the public health significance, ecology, and management of pathogenic *Vibrio* species to environmental groups, students/universities and the public via seminars, classes, and small group meetings and discussions, and in press releases.

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.

Overall, we did a great job getting lab and field work completed despite a two month delay in allowed field work and severe restrictions on both types of activities at UNH due to COVID-19 safety-related guidelines. In terms of **Changes**, we were able to apply newly developed markers for pathogenic Vp that were more specific than the markers we had proposed to study and included to broaden our study's scope. In terms of **Problems**, we were challenged in completing all proposed lab and field work due to continued restrictions on both types of activities at UNH due to COVID-19 safety-related guidelines.

The project had served as an opportunity for several undergraduate and graduate students to learn how to conduct research in the field, laboratory and with computers. The UNH Illumina high throughput sequencing facility has become a powerful tool for our studies of pathogenic *Vibrio* species. Through the work of students on this and other related projects, we have continued to develop analysis pipelines for effectively analyzing the genomic content of microbial communities and strains of pathogenic and non-pathogenic *Vibrio* species. Students have learned and helped to optimize protocols and baseline work for these microbial analyses that are being used both for ongoing project data analysis and for the training of undergraduate students. The findings from a recent graduate student-Meghan Hartwick- PhD dissertation has provided the basis for continued sophisticated statistical protocols she developed to analyze microbial communities and both total populations and different strains of *V. parahaemolyticus* in oysters and other ecosystem matrices to understand how to predict their ecosystem dynamics and variability. Former UNH undergraduate student Elizabeth Martin is now an employee of the NH Shellfish Program in the NH Dept. of Environmental Services and works parttime with us to enable collaborative shellfish safety research between UNH and the State of NH. For the summer of 2021 and the ensuing fall semester, one UNH graduate student and 4 UNH undergraduate students including Shelly Lancaster, who was awarded a Doyle Fellowship from the NH Sea Grant Program, worked all lab and field tasks associated with this and a few related projects while actively interacting with NH oyster growers and learning about their research needs and knowledge about growing oysters in the Great Bay estuary.

The project results have been disseminated through a variety of mechanisms to a variety of interested communities. We have continued to work with extension specialists from UNH to inform oyster farmers in NH and the Northeast about harvest management options to reduce risks from pathogenic Vibrios to consumers. We have continued to inform the NH Shellfish Program Manager and regional US FDA personnel directly and in several local, regional and national meetings about our research findings to help them optimize best management practices for oyster growers to reduce risks from Vibrios in their harvest practices. Shellfish growers of New Hampshire were the audience for a presentation that included project findings at the NH Marine Aquaculturists annual meeting held by NHDES and NHDHHS in February 2021, while international and national shellfish industry, researchers and shellfish safety scientists in regulatory agencies were the audiences for presentations by the PI at the National Shellfisheries Association meeting in February, 2021. Several meetings with regional (NH, ME, MA, CT) shellfish resource and public health agencies were held during the past year to discuss ongoing and emerging issues and to provide them with research findings from this and related projects at UNH. One ongoing meeting has been with the NH interagency Vibrio Task Force, who continue to prohibit shellfish seed importation from regional areas outside of NH where *V.*

parahaemolyticus illnesses have occurred, based to a large degree on our ongoing research results. The research findings were also disseminated to fellow UNH scientists, students and administrators through departmental seminars presented by MS student Anna Early in the Molecular, Cellular and Biomedical Sciences Department during the reporting period. Our research findings have also served to inform public health and resource agency personnel, shellfish growers, students and public citizens about risks and how to avoid them so as to enjoy shellfish consumption.

During the upcoming 2022 field season, we plan to complete delayed analyses, conduct our planned sampling for 2022; Explore optimal use of plankton analyses with UNH colleagues and the NH Shellfish Program to inform sampling for 2022; Compile all data and begin data interpretation based on proposed and newly published analytical and statistical approaches (Hartwick et al. 2019; 2021); Write papers on new detection methods, population diversity, ecological mechanisms of persistence and pathogenicity, and other project-related topics.

Provide a summary of the requested information.

The following relates to my NHAES project:

Peer reviewed publications

Hartwick M, A Berenson, CA Whistler, EN Naumova, SH Jones. 2021. The Seasonal Microbial Ecology of Plankton and Plankton-Associated *Vibrio parahaemolyticus* in the Northeast US. Appl. Environ. Microbiol. 87:e02973-20. <https://doi.org/10.1128/AEM.02973-20>.

Professional conference presentations

Cheryl A. Whistler*, Jillian Means, Randi Foxall, Meghan Hartwick, and Stephen Jones. Phage-host interactions shaped the native ST36 population succession in the Pacific and governed successful invasions into the North Atlantic. National Shellfisheries Association 113th annual meeting- Virtual, March 22, 2021.

Meghan Hartwick*, Audrey Berenson, Cheryl A. Whistler, Elena Naumova and Stephen Jones. The seasonal ecology of *Vibrio parahaemolyticus* in the Great Bay estuary. National Shellfisheries Association 113th annual meeting- Virtual, March 22, 2021.

Loren A. Launen*, Randi Foxall, Anna L. Early, Brian M. Moore, Katherine A. Kiley, Sarah E. Sanders, Stephen Jones, and Cheryl Whistler. Cool waters run deep - phylogenetic characterization of *Vibrio vulnificus* from the Great Bay Estuary of New Hampshire reveals unique environmental sequence types. National Shellfisheries Association 113th annual meeting- Virtual, March 22, 2021.

Graduate theses completed

Fogarty, Sean. 2021. Water Quality and Food Safety in Recirculating Aquaponics. MS Thesis in the Agricultural Sciences Program, University of New Hampshire, Durham, NH.

Grants submitted and/or received

-Assessing Ocean Acidification as a Driver for Enhanced Metals Uptake by Blue Mussels (*Mytilus edulis*): Implications for Aquaculture and Seafood Safety. \$188,826 (UNH subcontract. NOAA Ocean Acidification Program. S. Jones co-PI.

- Contaminants of Emerging Concern: defining a strategic role for Sea Grant. Awarded, being set up at UNH. S. Jones co-PI.

Outreach events and presentations

I continue serving as an expert on shellfish safety for the Maine Shellfish Learning Network, 2020-21.

I continue serving as a member of the NH *Vibrio* Task Force to inform State agencies about the status of *Vibrio spp.* populations and strain diversity in NH coastal waters and shellfish to eliminate risks of shellfish-borne human illnesses from *Vibrio parahaemolyticus* and other *Vibrio spp.* infections.

I served as the NH representative as part of a regional ocean acidification extension group and worked explicitly with regional shellfish upweller operators and offshore mussel producers

Youth Mental Health First Aid

Project Director

Julien Kouame

Organization

University of New Hampshire

Accession Number

7000028



2021 - Youth Mental Health First Aid

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

One in 6 youth aged 6-17 experience mental illness annually^[i]; and 35% of individuals with mental health conditions begin to have symptoms by age 15^[ii]. One-third of youth in New Hampshire (33.6%) felt sad or hopeless almost every day for the past two weeks^[iii]. Twenty percent of NH youth have been electronically bullied⁴. Suicide is the second leading cause of death for teens aged 15-19^[iv], and 18.4% of NH youth have seriously considered suicide⁴. Social isolation for youth is associated with negative physical and psychological issues, such as depression, suicide, low self-esteem, abuse, psychological distress, and heart disease

[i] Whitney, D. G., & Peterson, M. D. (2019). US national and state-level prevalence of mental health disorders and disparities of mental health care use in children. *Journal of American Medical Association, Pediatrics*, 173, 389-391. doi:10.1001/jamapediatrics.2018.5399

[ii] Schaefer, J. D., Caspi, A., Belsky, D. W., Harrington, H., Houts, R., Horwood, L.J., Moffitt, T. E. (2017). Enduring mental health: Prevalence and prediction. *Journal of Abnormal Psychology*, 126, 212-224. doi:10.1037/abn0000232

[iii] Center for Disease Control (2020). *Youth Risk Behavior Surveillance Survey*. Retrieved from <https://www.cdc.gov/healthyouth/data/yrbs/results.htm>

[iv] Center for Disease Control (2020). *Adolescent health*. Retrieved from <https://www.cdc.gov/nchs/fastats/adolescent-health.htm>

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.

Through a contract with the NH Department of Education, Bureau of Student Wellness, UNHCE trained NH professionals and community members to become instructors for the Youth Mental Health First Aid (YMHFA) and teen Mental Health First Aid (tMHFA) programs. We also delivered four YMHFA courses for community partners and citizens. These courses introduce participants to the unique risk factors and warning signs of mental health problems and substance abuse disorder, builds understanding of the importance of early intervention, and teaches individuals how to help an adolescent in crisis or experiencing a mental health challenge.

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

From the trainings hosted by UNHCE, 33 people were trained to become YMHFA instructors, and 18 people were trained to become tMHFA instructors. Fifty-nine community partners and citizens attended one of the four YMHFA trainings held by UNHCE instructors. Of the 59 participants, 27 completed post-evaluation data; 100% feel confident they can:

- Recognize the signs a young person may be dealing with a mental health problem, substance use challenge, or crisis

- Reach out to a young person who may be dealing with a mental health problem, substance use challenge, or crisis

- Ask a young person if they're considering killing themselves

- Actively, compassionately listen to a young person in distress
- Offer a distressed young person basic “first aid” level information and reassurance about mental health and substance use challenges
- Assist a young person who may be dealing with a mental health problem, substance use challenge, or crisis in seeking professional help
- Assist a young person who may be dealing with a mental health problem, substance use challenge, or crisis to connect with the community, peer, and personal supports
- Recognize and correct misconceptions about mental health, substance use, and mental illness as they encounter them

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

Further, 92% said this course helped them feel better prepared for work. 100% said they benefitted from the course and that they would recommend it to others.

Critical Issue

Rural Community and Economic Development

Tourism & Outdoor Recreation

Project Director

Julien Kouame

Organization

University of New Hampshire

Accession Number

7000037



2021 - Tourism and Outdoor Recreation

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

Tourism and outdoor recreation continue to grow in New Hampshire. In fact, the state continued to see increased demand for access to outdoor recreational amenities and visitor services during the COVID-19 pandemic. Research shows that stay-at-home orders and social distancing recommendations by Federal, state, and local governments have had the effect of sending more people onto trails and into our waterways to find exercise, recreation, solace, and health. At the same time, tourism, and hospitality businesses—such as restaurants and lodging—have been negatively impacted by the pandemic. Roughly one in five hospitality-sector businesses were forced to close during the pandemic due to lost revenues and labor shortages. As a result, the increased demand for tourism and recreation amenities is not being matched by the industry’s capacity to serve the demands of visitors and recreators. Thus, Cooperative Extension has expanded programming to help communities and regions identify and leverage and promote their natural, cultural, historic, and recreational assets for economic benefit, while also helping communities to better support businesses that cater to tourists and recreators.

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.

Through formal program development and delivery, technical assistance, research and engagement, Extension's Community and Economic Development Program has developed a series of programs to help New Hampshire communities sustain and grow their outdoor recreation economy through the following educational efforts:

- *Destination Development:* UNH Extension assists New Hampshire counties and regions in enhancing and promoting their region to draw visitors, recruit and retain businesses, and enhance quality of life for residents. The process begins with comprehensive assessment of natural, cultural, recreational, and historic resources and seeks to engage diverse stakeholders in a process to target efforts to enhance and promote the region for the betterment of all.
- *Trails and Downtowns:* This year marked year three of Downtowns & Trails, a program that helps towns leverage their natural amenities to support local businesses and the economy.
- *Trainings:* Workshops, conference presentations, and webinars on a range of tourism and recreation topics were provided to multiple communities in partnership with UVM Extension, Lakes Regional Planning Commission, Sullivan County, and the NH State Tourism Council.
- *Economic Analysis:* Extension is working on three statewide economic impact studies, including the NH Statewide Rail Trail Economic Impact study for the NH Department of Transportation.
- *Trail Planning and Development:* UNH Extension helps communities and regions with recreation planning, particularly with respect to multi-use trail planning and development.

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

The following are some community specific highlights:

- **Northfield Trail Network:** Trails and Recreation Committee completed a Master Trail Plan and secured an additional \$50,000 in grant and other resources to build out a network of high-quality trails, as well as promote the trails and trailside amenities to visitors.
- **Sullivan County Destination Development:** As a result of the destination development program that Sullivan County launched, a destination management organization was formed (Sugar River Destination Council) to market and promote the region's assets to visitors. The organization has raised nearly \$100,000 in resources to promote the region and initiate projects that link the regions amenities with visitor and resident services.
- **Derry Downtown Revitalization:** Following the First Impressions program conducted last year, the town has since implemented major infrastructure improvements to Hood Park. Improvements include installation of new benches and signage promoting businesses and other attractions, as well as plans to expand pickleball courts, hockey boards, backboards, a fishing dock, improved playground areas, new lighting, and improved landscaping.
- **Portsmouth to Hampton Rail Trail:** Extension launched efforts to enhance a partly developed rail trail between Portsmouth and Hampton and has assisted in a grant application that, if funded, would provide resources to build out trailheads and provide wayfinding from downtowns to the trail.

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

Efforts to leverage and wisely utilize natural, cultural, recreational, and historic assets of a place or region not only make that place more attractive to visitors and to businesses that might relocate, but it also enhances quality of life for people living in a place, thus resulting in improved sense of pride, better physical health, and greater sense of community well-being.

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.

Challenges, Issues, Obstacles, Opportunities: While some sectors have weathered the pandemic well, the hospitality sector was hard-hit. One in five hospitality businesses closed their doors and the remaining hotels, restaurants, and visitor services are struggling to retain and attract workers. While efforts to improve regions to draw visitors are important to generating local economic activity, there are significant workforce shortages in the tourism/hospitality sector. Work is needed to upscale jobs in the hospitality sector, train workers in the outdoor recreation space, and address obstacles to workforce (such as lack of affordable housing).

Business and Entrepreneurship

Project Director

Julien Kouame

Organization

University of New Hampshire

Accession Number

7000036



2021 - Business and Economic Development

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

New Hampshire communities continue to experience deep impacts due to the pandemic and some sectors were hit disproportionately hard, including restaurants, lodging, and manufacturing. In fact, it is estimated that one in five Main Street businesses in New Hampshire have closed permanently over the past two years. As we emerge from the pandemic, Extension seeks to help community and business leaders to adopt effective and proven tools and strategies to support business and economic development, particularly considering supply chain challenges, workforce shortages, and the debilitating effects of inflation on communities, consumers, families, and businesses.

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 the above need, Extension expanded its suite of business and economic development-focused programs this past year to help grow and sustain businesses and cultivate new entrepreneurs. These programs include:

- ***ResiliencyAcademy*** helped dozens of communities develop strategies for making their community more vibrant and resilient, including during the pandemic. This is a partnership between UNH Extension and the NH Small Business Development Center.
- ***Seafood Entrepreneur Accelerator*** provides fishermen, aquaculturalists, and seafood vendors with training and coaching to help them adapt their enterprises to current challenges, changing markets, and new opportunities. This is a partnership between UNH Extension and NH SeaGrant and is working with the first cohort of entrepreneurs at present.
- ***Business Retention and Expansion Program*** continues to connect civic and municipal leaders with local businesses to better understand business needs and challenges and jointly develop and implement solutions to these challenges. The program was conducted in one community in 2021.
- ***1 Million Cups Central NH*** and ***Twin State Innovation*** are two monthly networking events that brought existing and potential entrepreneurs together this past year and connected them with each other and with business resources to help them address the challenges and opportunities they face.

- **Community Changemaker Challenge** exposed students from five high schools to a core set of entrepreneurial skills and resources through a pitch competition that entailed mentoring, technical support, and financial support to winning pitches. This is a partnership between the Sustainability Institute at UNH and UNH Extension.
- **Regional Economic Development Planning** support was provided to two economic development jurisdictions in New Hampshire recently designated by the state as Comprehensive Economic Development Regions (CEDRs). Extension helped guide these regions—Seacoast and South-Central CEDRs) through a strategic planning process to identify key challenges and opportunities for consideration for funding by the state and Federal government.
- **Renewable Energy for Remote, Islanded Communities** is a project funded by the US Economic Development Administration for which Cooperative Extension is engaging remote and islanded communities in applied research to better understand their energy needs and challenges and help them implement renewable energy systems that save money and reduce reliance on fossil fuels in the long-term.

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

1. With UNH Extension's support, the 'Making Matters' Makerspace North of Concord secured over \$200,000 in grants this past year that enabled the makerspace to expand the footprint, purchase new equipment, and incubate two new businesses.

2. As a result of Extension's efforts to grow businesses and support entrepreneurs, the following impacts were achieved:

- The Changemaker Challenge engaged over a dozen student groups from high schools around the state to pitch ideas for social enterprises. Over \$10,000 in awards were provided to winners to help them launch their enterprises, which included a low-cost water distillation system for towns.
- Seafood enterprises are working to pivot their business because of Extension's efforts to support entrepreneurs via the Business Retention and Expansion Program and the Seafood Entrepreneur Accelerator.

1. As a result of Extension's community-based programs, the following impacts were achieved:

- Extension led the formation of a countywide effort to forge regional identity that led to the formation of the *Sugar River Destination Council* in Sullivan County. The Council has secured over \$50,000 in grants to market and promote the region and support local economic development efforts.
- In Grafton County, Extension is currently helping the County Administrator conduct a feasibility and engineering study to build a solar-driven microgrid energy system that could power the county jail, nursing home, and other county offices.
- Projects that resulted from Extension's First Impressions program in Derry, NH include installation of new benches and signage promoting businesses and attractions, as well as plans to expand pickleball courts, hockey boards, a fishing dock, playground areas, new lighting, and improved landscaping.
- UNH Extension led a coalition of seacoast economic development leaders to forge the *Gulf of Maine Blue Economy Catalyst*, a proposed project that would support expansion of marine-related industry, including aquaculture, marine renewable energy, advanced manufacturing, and coastal resilient infrastructure. A major Federal grant proposal is in the works.

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

UNH Cooperative Extension engages community leaders, civic leaders, and businesses to help them identify economic challenges and opportunities and link to local, regional, and state assets to overcome these challenges. Results of Extension's efforts include effective and informed leadership at the local level, data-driven strategies to grow business and the local economy, and improved services for New Hampshire residents.

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.

Challenges, Issues, Obstacles, Opportunities:

New Hampshire continues to face economic challenges resulting from COVID-19. Although the state's overall unemployment rate dropped to around 4% across in August of 2021 from its peak of 17%, some sectors haven't recovered due to the millions of dollars in COVID-related lost revenues. In fact, one in five of the state's service sector businesses permanently closed, while many remaining businesses can't find labor. Further, because wages in this sector are the lowest across all industry sectors—with nearly half of jobs under \$17 per hour—many service sector employees cannot find affordable housing. The region's economic crisis is not a lack of jobs, but a lack of quality jobs for people with diverse cultural and socioeconomic backgrounds and Extension's role is to weave together the ecosystem of services and supports to help people and businesses overcome these challenges and thrive.

[Social, Economic and Environmental Causes and Consequences of Demographic Change in Rural America](#)

Project Director

Kenneth Johnson

Organization

University of New Hampshire

Accession Number

1013434



Annual Report FY21

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

A major goal of the W-4001 Project is to document nonmetropolitan(rural) population change, examine the dynamics of these changes and investigate their social, economic, and environmental causes and consequences.

Rural populations are changing in both size and structure. Such changes in population size and characteristics affect a wide range of social and economic outcomes. Recently, the impact of the COVID-19 pandemic has exerted a significant impact on rural demographic trends. The initial impact of the pandemic has been on mortality, however, it is likely that fertility will be impacted as well. Thus, it is imperative that we examine the causes and consequences of recent rural demographic change and the demographic processes, such as the pandemic, migration and fertility, which account for changing patterns of population redistribution both in New Hampshire and throughout the United States. Demographic change in rural America is far from monolithic. To analyze longitudinal rural demographic change over such a vast and diverse region, researchers need to be cognizant of the complex interplay between migration and natural increase that influences contemporary rural population redistribution trends and of the social, economic and environmental forces that both influence demographic change and are impacted by such population change. The economic shock of the Great Recession and its aftermath has had serious implications for population change, fertility and migration trends in New Hampshire and rural America more generally. More recently, the COVID-19 pandemic and its social, economic and epidemiological repercussions have significant implications for demographic trends in New Hampshire, New England and the U.S. This NHAES project examines recent New Hampshire demographic trends in both rural and urban areas. As part of the larger W-4001 multistate project, it also helps us to understand how the patterns of demographic change in New Hampshire fit into the broader regional and national patterns of rural demographic change. This research is important because New Hampshire has long depended on fertility and an influx of well educated, high income migrants to expand its human capital base. There is significant evidence that these demographic processes were disrupted by the Great Recession and the COVID-19 pandemic and that this has significant implications for the state's future. Analysis of the impact of the recession and its aftermath on demographic change

contributes information about population change to planners and policy-makers and expands the scientific knowledge base by empirically delineating the demographic processes (migration, fertility, mortality) that have been disrupted by the turbulent economic conditions of the last decade. This demographic analysis is essential to New Hampshire because it provides important new information to state policy makers, planners, concerned citizens and local stakeholders that will facilitate actions to enhance the social and economic development of the state, aid in developing comprehensive plans to guide future landscape development, and protect the state's abundant natural resources.

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 critical goal of this project is to document nonmetropolitan demographic change and disseminate information about these demographic trends in rural America to critical academic and policy audiences.

The W-4001 research team was recently awarded the *National Excellence in Multistate Research Award* by the Association of Public and Land-Grant Universities and the USDA. This prestigious and highly competitive award underscores the important work that w-4001 researchers are doing to accomplish the goals of their project. I contributed to this by doing research on demographic change in rural America, as well as regional demographic trends in New Hampshire and New England.

Major research findings from my research relevant to this goal include:

1) My recent research suggests that rural America suffered an overall absolute population loss between 2010 and 2020. This is the first time in history that nonmetropolitan –rural—America has experienced an absolute population loss. This population loss is due to a slowdown in net migration as well as diminished natural increase in both rural and urban America--though rural America has been more significantly impacted. The Great Recession significantly reduced fertility rates in the U.S. and my recent analysis indicates they have not recovered in the post-recessionary period. As a result, nearly 600,000 fewer babies are being born annually now compared to the number that would have been born had pre-recession fertility trends continued. This has serious implications for rural America, which depends on natural increase (births-deaths) for much of its population increase.

2) The decline in the birth rate coupled with increase mortality in rural areas resulted in deaths exceeding births in 54% of all nonmetropolitan counties between 2010 and 2019, according to my recently published research. Such natural decrease is the ultimate demographic consequence the population aging, low fertility and diminishing proportion of women of childbearing age in many nonmetropolitan counties. The advent of COVID is likely to increase the percentage of rural counties with natural decrease to over 60 % in the 2021.

3) Nearly a third of all rural counties in the U.S. are depopulating. That is, they reached their maximum population by 1950 and lost at least 25% of that peak population by 2010. My recent analysis suggests that population losses in rural areas have accelerated since 2010, which makes continued depopulation likely for more nonmetropolitan counties. Such depopulation is far more common in remote rural counties than in those adjacent to metropolitan areas.

4) The rural population is at higher risk from COVID-19 because it is older and has a higher rate of preexisting health conditions. This has significant implications for future demographic change. Nearly 32 percent of rural counties are at high risk of serious health repercussions compared to just 7 percent of metropolitan counties. Recent evidence suggests that although rural America was spared from the first wave of the pandemic, rural areas are experiencing a disproportion share of new cases and deaths. New Hampshire rural areas are at higher risk of COVID-19 because they have older populations and more limited access to comprehensive health care facilities.

7) Rural America is becoming more racially and ethnically diverse. The growth of the Hispanic population has been particularly important to rural demographic change. Hispanics represented just 7.6% of the rural population in 2010, but they produced 63% of the entire rural population gain between 2000 and 2010. Recent analysis suggests that the contribution of minority populations to rural growth accelerated between 2010 and 2020.

4) The Great Recession "froze people in place". This had the effect of reducing migration in rural areas. The demographic implications this had for specific rural areas differed in regions with histories of rapid population increase through migration (recreational, retirement and metro fringe counties), here the rate of population increased slowed because of the economic situation reduced migration. There is increasing evidence that migration is pickings up again, at least in these rural areas. It is not clear yet how the COVID-19 pandemic will impact future migration patterns to rural America.

5) In rural areas with histories of population loss or slow growth (Farm areas), there is no evidence of population gains and nearly 80% of the farm counties are depopulating.

8) The complex patterns of demographic change in rural America underscore the continuing need to develop methods to delineate and track future trends.

Impacts

1. Engaged in technical discussions about rural demographic data needs, issues and concerns with Census Bureau staff while participating in the Summer at the Census program which included an invited presentation on "Population Redistribution Trends Along the Rural-Urban Continuum" in an invited Seminar attended by more than 90 Census Bureau staff.
2. Engaged in research and policy discussions with staff, legislators, NGOs, public and media to provide insights into raised awareness of recent rural demographic trends and first finding from the 2020 Census in New Hampshire, New England and the U.S. and the policy challenges the state, region and nation will face in light of these changes. Accomplished this through numerous presentations, conversations and publications and media interviews.
3. Educate the public and media through frequent interaction with major media outlets discussing recent demographic trends in rural and urban America.

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

The target audience for the W-4001 project includes state and federal planners and policymakers, academic and professional colleagues, the media and general public interested in the social, economic and environmental causes and consequences of demographic change in rural America.

Although the COVID-19 pandemic has diminished the opportunities for interaction, I have been able to further the project's goal of disseminating information about my findings in the W-4001 project in the past year by: 1) speaking about rural and urban demographic trends as a Summer Scholar at the U.S. Census Bureau; 2) presenting an analysis of New Hampshire's Changing Demographic Trends to the New Hampshire State Legislative Joint House-Senate Economic and Fiscal Orientation

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

An important goal of the W-4001 project is to provide information about demographic change in rural America to constituencies that have rural interests or concerns.

I have helped to inform these interested groups by: 1) doing invited presentations on New Hampshire demographic trends to: the New Hampshire Charitable Association Board; Black Heritage Trail Board of Directors; and to The Stay, Work, Play Advisory Board. webinars on New Hampshire Demographic Trends, COVID-19 and Why Migrants Moved to New Hampshire; 2) Presentations to the NHAES on Hatch Multistate Project w-4001, and on the Translation of Research for Public and Policy Audiences to the Interdisciplinary Network on Rural Population Health and Aging, National Institutes on Aging; 3) Frequent and numerous interactions with the media to discuss New Hampshire demographic trends, Covid-19 and its demographic implications and rural demographic trends; 4) Presented papers on rural demographic trends at the Rural Sociological Society and Population Association of America.

In addition to the publications, academic presentations and dissemination of results through presentations of results to policy and stakeholder audiences, I have also have extensive discussions with the media about rural population change and the impact of these demographic trends in the state of New Hampshire. This includes numerous media mentions of my work in the past year. These media mentions include major national media such as the *Wall Street Journal* (5 times); *New York Times*; *Washington Post*; *NPR* and *USA Today*. I have also spoken with numerous regional and local media. All these activities with the media help disseminate my findings from W-4001 to communities of interest.

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.

COVID-19 significantly diminished my ability to disseminate the results of my research to target audiences and academic colleagues by limiting travel and conference attendance. In addition, the official W-4001 meeting scheduled for Las Vegas had to be cancel. We met online instead. I typically do 4-6 presentations of my results to target audiences over the course of the year. To some extent, I made up for this with more virtual presentations, but this does not give me as much opportunity for interactions with audiences. Also, the cancelation of several professional meeting and the W-4001 annual meeting curtailed my opportunities to meet with colleagues to discuss research. I also changed the focus of my research to examine the impact of COVID on rural America and to respond to more media questions about it.

Additional NHAES Information

Publications:

Johnson, Kenneth M. 2020. "As Births Diminish and Deaths Increase, Natural Decrease Becomes More Widespread in Rural America." *Rural Sociology*, 85(4): 1045-1058. DOI: 10.1111/ruso.12358.

Johnson, Kenneth M. 2021. "New Census Data Reveal Modest Population Growth in New Hampshire Over the Past Decade." *Carsey Research National Fact Sheet*. 41.

Johnson, Kenneth M. 2021. "7.6 Million Fewer Births and Still Counting." *Carsey Data Snapshot*.

Johnson, Kenneth M. 2021. "Deaths Exceed Births in a Record Number of States in 2020." *Carsey Data Snapshot*.

Johnson, Kenneth M. 2021. "2020 Census Reflects Lagging U.S. Population Growth." *Carsey Research National Issue Brief* 154.

Johnson, Kenneth M. 2020. "New Hampshire's Estimated Population Gain is the Largest in New England." *Carsey Data Snapshot*.

Johnson, Kenneth M. 2020. "Migration Gains to New Hampshire From Other States Are Growing, With the Largest Gains Among Young Adults." *Carsey Data Snapshot*.

Johnson, Kenneth M. and D.J. Scala. 2020. "Voting and Attitudes Along the Red Rural-Blue Urban Continuum." *Carsey Research National Issue Brief*. 152.

Presentations:

Johnson K.M. 2021. "Population Redistribution Trends Along the Rural-Urban Continuum, 200 to 2020: The Great Recession and Its Aftermath." Invited Presentation as Summer Scholar at the Census Bureau Seminar, U.S. Census Bureau, Washington, D.C.(Virtual). August, 2021.

Johnson K.M. "Research on COVID in Rural and Urban America." Presenter and Panel Member at the Annual Meetings of the Rural Sociological Society. Virtual. July, 2021.

Johnson K.M. 2021. "The Incidence of Natural Decrease Continues to Grow in Subareas of the United States." Paper presented at the Annual Meetings of the Population Association of America. St. Louis, MO (virtual). May, 2021.

Lichter, D.T and K.M. Johnson. 2021. "Opportunity and Place: Latino Children and America's Future." Paper presented at the Annual Meetings of the Population Association of America. St. Louis, MO (virtual). May, 2021.

Johnson, K.M. 2021. "Hatch Multistate Project W4001: Social, Economic and Environmental Causes and Consequences of Demographic Change in Rural America". Invited Presentation to New Hampshire Agricultural Experiment Station On-Boarding Seminar. Durham, N.H. (Virtual) March, 2021.

Johnson, K.M. 2020. "Translation of Research for Public and Policy Audiences." Invited Webinar, Interdisciplinary Network on Rural Population Health and Aging, National Institutes on Aging. Pennsylvania State University, State College, PA. November, 2020.

Meetings with stakeholders

Johnson K.M. 2021. "Demographic Trends in New Hampshire: First Insights from the 2020 Census." Invited Presentation to The Stay, Work, Play Advisory Board. Concord, NH (virtual). September, 2021.

Johnson K.M. 2021. "The Changing Demographic Trends of New Hampshire: First Insights from the 2020 Census." Invited Presentation to The Black Heritage Trail Board of Directors. Portsmouth, NH (virtual). August, 2021.

Johnson K.M. 2021. "The Changing Demographic Trends of New Hampshire." Invited Presentation to New Hampshire Charitable Foundation Board of Directors. Manchester, NH (virtual). June, 2021.

Johnson, K.M. 2021. "New Hampshire's Changing Demographic Trends." Invited Presentation to New Hampshire State House Ways and Means Committee and Finance

Critical Issue

Youth and Family Development

4-H Project

Project Director

Julien Kouame

Organization

University of New Hampshire

Accession Number

7000026



Supporting 4-H Volunteers at a time of Covid

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

2020-2021 continued to be a challenge for many of our 4-H volunteers. Many volunteers chose not to volunteer or were limited in their capacity to volunteer with 4-H. In the annual volunteer survey, 30 % of the survey respondents indicated they had zero hours of volunteering this year. Survey respondents also indicated they have been impacted by the Covid-19 pandemic restrictions, health concerns, or have experienced feelings of being overwhelmed. Others indicated a frustration about UNH 4-H Covid guidelines and the inconsistency with the CDC or local guidelines. Volunteers also felt the lack of in-person programming impacted their ability to connect or feel a sense of belonging to 4-H. Finally, 4-H volunteers were impacted by the high percentage of 4-H staff retiring from the program; this impacted connections, communication, recruitment, and retention of volunteers within those counties.

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.

Volunteers who engaged in training both in-person and virtually indicated how important it was to gain new skills and feel connected to 4-H. Led by the NH 4-H Volunteer Field Specialist in collaboration with 4-H staff. Over NH three hundred 4-H volunteers engaged in training,

- 4-H Covid-19 guidelines for programming

- Askable Adults

- 4-H Thrive Model

- 4-H Northeast Regional Cloverbud Connections

- o 4-H Northeast Regional Youth Mental Health

- o 4-H Makers (virtually club)

o County programs provided outreach to volunteers to provide relevant support with online or in-person programming. Entering this year, we had anticipated some of the challenges. The first continued our targeted outreach by staff to engage the volunteers with personal phone calls and emails to see what was needed. We utilized in-person and virtual training to keep connected with our volunteers and support their learning and engagement with 4-H. We also communicated the most current UNH Covid-19 guidelines so volunteers could safely conduct programming. Lastly, knowing that volunteer recruitment and retention was down, we looked at new ways to engage volunteers. We piloted new recruitment strategies and onboard processes to reduce the time it takes to onboard new volunteers. Staff also recognized volunteers' accomplishments through social media and small group gatherings to build connections and create a sense of belonging.

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

The recruitment of new volunteers yielded mixed results, with 64 new volunteers down from 74 last year. Using social media paid to post to engage over 40,000 views and 1000 clicks, we engaged 30 new volunteers, with 50 % completing the process through orientation. The feedback from folks who didn't complete the process was mainly pandemic-related issues such as not the right time, just overwhelmed, or just didn't have the time to volunteer anymore. We continued to improve our onboarding process by adding asynchronous training to support varying schedules and family needs volunteers using the 4-H online portal.

Retention of volunteers was also down. However, staff did increase the level of outreach and connection with volunteers. Many volunteers indicated they again were overwhelmed, couldn't get youth interested during the pandemic, or were frustrated with the pandemic guidelines.

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

The lessons learned from the 2021 implementation are the fundamental public benefit. Based on the 2021 results, our NH 4-H state plan is shifting its focus toward increased recruitment of volunteers. Also, we will continue to provide and increase the number of in-person and online training provided to 4-H volunteers. Additionally, we will be working with our volunteers to introduce the 4-H Thriving Model, focusing on their work around the development context within the model. In the 2021-2022 program year, we will continue creating a community where volunteers feel supported and provide new staff with the tools to support and manage their current and new volunteers.

Type

Projects / Programs without a Critical Issue

Not Provided

Projects / Programs

0