2019 Annual Report of Accomplishments and Results

Connecticut
Connecticut Agricultural Experiment Station
University of Connecticut Storrs Agricultural Experiment Station
University of Connecticut Cooperative Extension System

I. Report Overview

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

1. Executive Summary (Optional)

We have reached the ultimate year of our Plan of Work and Accomplishment Report. New topics have emerged that are creating unique opportunities for research and extension to meet the needs of Connecticut's citizens. The Connecticut Agricultural Experiment Station (hereafter designated CAES) and the University of Connecticut Storrs Agricultural Experiment Station and Cooperative Extension System (hereafter designated UConn) continue to partner in efforts to address these new challenges and opportunities.

The 2019 report includes six program areas. CAES and UConn jointly address program areas 1-4. These include: (1) food safety, (2) food security and food systems, (3) human and animal health, and (4) sustainable environments. The remaining two programs areas, (5) 4-H and youth development, and (6) community and economic development, are conducted by UConn only. Both organizations address food, health, and sustainability, and all of our program areas address one or more of these. Our activities and accomplishments are cross-cutting through several planned program areas. We encourage our faculty and staff to collaborate and leverage the work of their peers and partners to increase our impact.

This report offers specific examples of successful research and public engagement programs conducted by CAES and UConn. Funds are allocated separately to the two institutions. Accordingly, we have separately detailed successes from these programs, an approach that formalizes accountability for funds received by each institution.

In addition to the specific programs reported here, we also have used capacity funds and matching funds to expand and leverage our successes across the state through competitive grant processes. The accomplishments of some of our projects were possible only because federal capacity funds and state matching funds support the research and Extension professionals who received the grants.

II. Merit and Scientific Peer Review Processes

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

Process	Updates
1. The Merit Review Process	No updates – please refer to Plan of Work.
2. The Scientific Peer Review Process	No updates – please refer to Plan of Work.

III. Stakeholder Input

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

Stakeholder Input Aspects	Updates
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	The Dean of UConn's College of Agriculture, Health and Natural Resources conducted statewide listening sessions; coordinated with CAES to ensure both organizations have access to the stakeholder input. Information gathered at these sessions drove the strategic planning process for UConn. We hosted 13 listening sessions and had input from over 500 stakeholders that generated more than 10,000 data points. Interviews were conducted with leadership from both institutions, from the northeast, funders, and peer institutions.
2. Methods to identify individuals and groups and brief explanation.	No updates – please refer to Plan of Work.

3. Methods for collecting stakeholder input and brief explanation.	No updates – please refer to Plan of Work.
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	No updates – please refer to Plan of Work.

IV. Planned Program (PP) Table of Contents

PP No.	Planned Program: Project Title or Activity
1.	Food Safety: Food Safety analyses from the Department of Analytical Chemistry
2.	Food Safety/Food Security and Food Systems: Creating a sustainable food system through agricultural production, food security and safety, and food access
2.	Food Security and Food Systems: UConn Helps New Farmers 'Bridge the Gap'
2.	Food Security and Food Systems: Understanding the apple flower microbiome for the development of biological control of fire blight
2.	Food Security and Food Systems: Hemp Testing and Analysis of CBD and THC content for Connecticut growers
3.	Human and Animal Health: Tick- and mosquito-borne disease surveillance in Connecticut
3.	Human and Animal Health: Application of protective cultures in the control of *Salmonella Enteritidis* in poultry
4.	Sustainable Environments: Fate and remediation of pollutants in Connecticut
4.	Sustainable Environments: Agrochemical Impacts on Human and Environmental Health: Mechanisms and Mitigation
4.	Sustainable Environments: The role of river interface sediments in legacy nitrogen removal at groundwater discharge zones
4.	Sustainable Environments: Hemp Research and Outreach Helps Growers Diversify Business
5.	Youth Development and 4-H: 4-H STEM develops college and workforce readiness
6.	Community and Economic Development: Trail Use Increases Health and Sustainability

V. Planned Program Activities and Accomplishments

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

No.	Title or Activity Description	Outcome/Impact Statement	Planned Program Name/No.
1.	**Food Safety analyses from the Department of Analytical Chemistry**	Contamination of food with toxic pesticides or heavy metals is of great concern to stakeholders. Dr. Nubia Zuverza-Mena and Dr. Sara Nason each have Hatch Projects focused on overall food safety concerns. Regulators, food producers, retail operators, consumers, and consumer advocacy groups want assurances that foods contain safe and allowable levels of these constituents. For low level contaminants such as mycotoxins, arsenic, and lead, toxicity can occur at parts per billion (ppb) or even parts per trillion (ppt). Accurate detection and quantification of contaminants at these levels in complex food matrices is difficult, so protocols and equipment must be validated. Acquisition of ISO 17025 Accreditation ensures the integrity of results. CAES conducts a surveillance program for both human food and animal feed. Inspectors from the CT Dept. of Consumer Protection and the CT Dept. of Agriculture collect samples, along with samples collected by FDA under the FDA Food Emergency Response Network (FERN). Technical methods have been validated using gas chromatography with triple quadrupole mass spectrometry, liquid chromatography with high resolution mass spectrometry, and/or inductively coupled plasma mass spectrometry. Results are reported back to the appropriate agency in a timely fashion for regulatory response. A total of 121 samples of food were analyzed for pesticide residues; 59 contained a total of 144 residues. Of these 59 samples, there were 3 samples that contained 5 violative residues. Of 35 animal feed samples analyzed for aflatoxins, all but two had no aflatoxins detected. Those two samples had Aflatoxin B1 below the tolerance. Separately, 20 samples of juice and juice powder were analyzed for a range of toxins/poisons/pesticides/heavy metal and found to have no contaminants of concern. With US FDA funding and support, the CAES maintained and expanded ISO/IEC 17025 Accreditation from the American	**Food Safety/1**

		Association for Laboratory Accreditation for these programs. The CAES programs serve as the sole surveillance and monitoring effort in the state, assuring that the food supply within CT is safe and free from chemical and heavy metal contamination.	
2.	**Creating a sustainable food system through agricultural production, food security and safety, and food access**	Contemporary food systems are shaped to generate profits and power for those who can maximize sales via the large-scale production and distribution of inexpensive food. The problem is that this system places far less value on the principles of sustainability, environmental integrity, economic vitality, and social equity. A sustainable food system can meet our needs for fresh, healthy, affordable food today without jeopardizing the ability of future generations from doing the same. This is a global issue that we are addressing locally, statewide, and regionally in New England. In Connecticut, 12% of households experience food insecurity, 33% of children are overweight or obese (more than half of whom are Hispanic and African American), an estimated one out of five residents eat no vegetables daily, 33% of our census tracts live more than a half mile from a healthier food retailer, and only 10% of our cropland is used to harvest fruits and vegetables. Our goal is to address Connecticut's food-related challenges to human health and sustainable use of natural resources through research, education, and public engagement. To do this, we focus on diverse and innovative animal and crop production systems, increasing access to nutritional and healthy food, and securing a sustainable, safe, and resilient food supply. UConn Extension outreach and training programs in agriculture and food included a multi-faceted approach to addressing the issue that includes growers, consumers, and youth. Our programs reached residents in all 169 cities and towns in Connecticut. Key program areas include agricultural production (fruits, vegetables, and specialty crops), farm marketing, food safety, new and beginning farmers, risk management, and urban agriculture. We also offered two workshops dealing with farmer stress, signs, communication, and resources that were attended by over 150 farmers and agriculture service providers. Program impacts were leveraged by several USDA grants that increased our capacity to serve Connecticut and beyond in the areas of agricultural risk management, integrated pest	**Food Safety/1** **Food Security and Food Systems/2**

		management, food safety, and new and beginning farmers. For example, the Solid Ground Training Program is offered for new farmers and funded by USDA-NIFA Beginning Farmer and Rancher Development Program Award #2016-70017-25416. We leveraged this grant funded project by collaborating with Extension educators and resources available across all programs. We also work with the Mashantucket Pequot Tribal Nation through a USDA-FRTEP grant. "There has been a substantial gain in the knowledge and skills regarding growing food, writing a business plan, nutrition, and health since we started working with the UConn Extension educators," says Jeremy Whipple, a member of the Mashantucket Pequot Tribal Nation. Our vegetable integrated pest management education was delivered to over 550 vegetable growers and stakeholders every week from May to September 2019 through 19 weekly vegetable pest alerts focusing on pests, pest management and decision making, and safe pesticide use. Farm visits, workshops, and consultations were also provided to growers. We had 474 Fruit growers and industry members receive 116 fruit messages in 2019 covering pest information, management strategies, cultural practices, meetings and educational programs. Louis Bacchiocci, one of our farmers, stated, "These emails are very helpful. Even when you know the information it serves as a great reminder of when we ought to be applying production strategies." Put Local On Your Tray promotes local food in school cafeterias and helps to connect farmer and school food buyers. Over the past year, we had 92 towns and districts take a pledge to serve locally grown products in their school cafeterias, choosing from among 15 products supplied by more than 45 farms in the project's Farmer Directory. Salli Szczesiul, the kitchen manager at the Goshen school stated: "We purchased the purple daikon radish, red beets and red apples from the farmer food hub. I roasted the beets, diced them along with the radish and beets to make a cold salad. We pre-portioned it into our 4 oz. serving cups to put on our daily rainbow tray, but also had a container of it that we could put a sample size on a student's tray to just give it a try. Younger students were a	

		little more apprehensive about trying, but there are always a handful who will exclaim, 'I love beets!' The older kids loved the heart we made from the radish, and it continues to be a hit on our rainbow tray. We either cut it into matchsticks or dice it for serving." Peter Hayward of Hayward Farms in New Hartford also values the partnerships with schools: "I have been selling to Avon schools for over ten years now and to Region 10 (Harwinton-Burlington) for over twenty years. We also have been selling fruit to the Thomaston and Canton school systems for several years. We would never be able to market our entire crop without these very important outlets." Food safety is a core component of the food systems programs. Our educators collaborate on programs and offer food safety workshops and certifications statewide to producers and processors. The food safety program collaborates with other states and organizations throughout the state including the Department of Agriculture. Our educators' partner with the Plant Diagnostic Laboratory at UConn to diagnose and serve our members. We also work with our 4-H youth development program and the Master Gardener program to reach other audiences. The impact of our combined efforts increased agriculture production and viability in Connecticut, as well as local food consumption among our residents. We are addressing Connecticut's food-related challenges to human health and sustainable use of natural resources with a collaborative effort that uses science-based research, education, and public engagement. We continue to broaden the scope of our audiences, and impact.	
3.	**UConn Helps New Farmers 'Bridge the Gap'**	Cari and Ken Donaldson had always wanted to farm. After finding a property in Willington, they established Ghost Fawn Homestead five years ago. Today, gardens and vegetable beds dot the hillside, while chickens quietly go about their day in the yard. "We are the second owner of this farm. It's just under 10 acres, and we currently have three acres in cultivation, with plans to expand," says Cari Donaldson. "New farmers don't know what they don't know, or what resources are available. UConn Extension has been really good at bridging that gap for us."	**Food Systems and Security/2**

		Farming can be a challenging profession filled with joys, discomfort, and economic risk. The Donaldsons have tapped into a suite of UConn Extension programs to help them get established as farmers, including the Solid Ground Farmer Trainings, Vegetable Crops Integrated Pest Management, Put Local on Your Tray, as well as Taste of Mansfield. "Cari has been a smart user of Extension resources and training," says Jiff Martin, associate extension educator in sustainable food systems. "As much as we want to help her family's farm business grow, her feedback also helps us grow and evolve our own programming so we can offer new farmers the types of help they really need. We've been especially interested in supporting Cari's enthusiasm for selling to schools and have leveraged resources through our Put Local on Your Tray program to assist." Put Local on Your Tray helps school districts source, serve, and celebrate local food by incorporating Connecticut-grown ingredients into school lunch menus. In the 2019-2020 school year, more than 90 school districts participated. "Stephanie Richard, the Mansfield schools' food service director, gave us an entrance into the wholesale market," Cari says. "It's a weight off our minds being able to grow for the schools. I can't say enough about UConn Extension's Put Local on Your Tray Program, and Stephanie. People are always the most excited about the fact that we grow food for the schools." "As a food service director, I find that Put Local on Your Tray is a great asset for promotional and marketing materials," says Richard. "Making arrangements with farmers, meetings, figuring out how much product we can take in and work with pulls time away from the marketing part. With Put Local on Your Tray, I am able to focus more time on building relationships with farmers and coaching my staff who work with the produce." Working with Richard also helped Cari Donaldson develop the language she needed to attract other wholesale buyers, including other schools that will begin purchasing from the farm in the fall. "Put Local on Your Tray has information that schools need to alleviate their concerns about purchasing from local farms," Donaldson says.	

		And Put Local on Your Tray isn't the only program offered by Extension to help new farmers in Connecticut. Solid Ground Farmer Trainings, for example, are for farmers with less than ten years of farming experience. Small group workshops are offered in-person with experts in soils, production, farm finances, pesticide safety, irrigation, agriculture mechanics, and more. Fact sheets, guides, videos, and online tutorials on the program's website are frequently used resources by farmers throughout the state. Charlotte Ross, project coordinator for Solid Ground Farmer Trainings, owns and operates Sweet Acre Farm in Lebanon. Before serving as project coordinator, she participated in Extension's beginning farmer trainings. Ross says, "We've learned a lot about new farmers through the Solid Ground Training Program. New farmers are as time-limited as anyone and are hungry for practical knowledge. Given the amount of information you can find online already, our training provides more than how-to instructions. They offer opportunities to have your questions answered by an expert, hands-on practice, and a chance to network with other new farmers." "You just want to farm. You don't want to be a salesman, but that's half of the job," Ken Donaldson says. "UConn Extension helps with that. The networking and assistance in finding buyers is huge and has been the most beneficial part of our involvement with Extension. We're getting better at farming each year, and that's a really cool thing." *The Solid Ground Farmer Trainings are sponsored by the USDA-NIFA Beginning Farmer and Rancher Development Program Award #2016-70017-25416.*	
4.	**Understanding the apple flower microbiome for the development of biological control of fire blight**	Flowers are important reproductive organs of Angiosperms. Flowers secrete nutrients that support the growth of an assemblage of microorganisms, including both beneficial and pathogenic members, most of which belong to the Proteobacteria phylum. These microbes are collectively referred to as the microbiome. One pathogen, *Erwinia amylovora,* causes a major disease of apple called fire blight. Damage caused by fire blight and mitigation cost is estimated at $200,000 per year. Furthermore, antibiotic and heavy metal applications for disease control cause a significant impact to the environment and human health. Manipulating the flower microbiome to promote the growth of beneficial members and restrict the pathogen would have great application by reducing costly pesticides and	**Food Systems and Security/2**

		positively impacting the environment. In one study, open apple flowers were treated with different bacterial strain mixtures to determine if the microbiome on flower stigmas was affected and whether disease was affected. Sequencing of the 16S rRNA amplicon determined if the structure and composition of the microbiome was significantly altered. Our results showed that the microbial treatments using different strains/strain mixtures resulted in unique microbiome structures, with increased representation of the inoculated strains in the taxonomic makeup. We also showed that microbiome manipulation indeed influenced the occurrence of fire blight, although the level of disease suppression was strongly dependent on individual bacteria being present in the mixtures. Compared to treatment with single strains, *Pantoea-Pseudomonas* based strain mixtures produced more predictable, structurally stable microbiomes and better disease control. Increasing the number of strains in the strain mixture increased the taxonomic diversity, although did not provide extended disease protection. Findings from this study suggest the microbiome on flower stigma can be manipulated through artificial microbial inoculation. Due to a flower's short life span yet importance in plant disease infection, even a short-term influence on microbiome composition may result in significant change in disease susceptibility.	
5.	**Hemp Testing and Analysis of CBD and THC content for Connecticut growers**	In December of 2018, the Federal government passed The Agricultural Improvement act, which removed low level THC containing *Cannabis sativa* from the list of Schedule 1 drugs. The bill defines *Cannabis sativa* plants with $\leq$0.3% total delta-9 THC based on dry weight as "hemp," and all other varieties as "marijuana," which remains illegal at the federal level. THC is the primary psychoactive component of *Cannabis sativa*, so it is important for producers to verify that the THC content is low to prevent consumers from accidentally ingesting THC while using CBD-containing products. Based on this new law, the CT Department of Agriculture (DoAg) licenses growers in the State who wish to grow low-THC varieties of hemp. CAES is working with the DoAg to certify the raw agricultural commodity of hemp as a legal crop for harvest, transport, and processing. Accurate detection and quantitation are especially critical for this work, both to protect consumers and the livelihood of growers in the state. Dr. Jason White and the CAES Department of Analytical Chemistry is committed to ensuring the quality of THC test results through accreditation to the ISO 17025 standard. The hemp program was initiated in the spring of 2019 by the DoAg with the requirement that hemp samples be certified as low THC prior to harvest. Because this was a new program, neither	**Food Security and Food Systems/2**

		private nor public laboratories were ready to test samples. The CAES worked in partnership with DoAg, and private labs, to develop a standard drying protocol and reporting format for consistency across labs. In addition, CAES developed a complete testing protocol for low level THC following the quality management system already in place that met the ISO 17025 standard. The testing protocol utilizes gas chromatography with flame ionization detection for the analysis of low levels of total delta-9 THC. All results were reported back to growers within one or two business days to facilitate a timely harvest. To date, CAES has processed 101 samples of hemp, 50 of which came directly from growers as pre-harvest test samples, while 51 came from DoAg. Of the 50 samples that came from growers, 9 failed (18%), while of the 51 samples that came from DoAg, 15 failed (29%). The DoAg samples were both routine spot checks, as well as follow-up samples, which explains the higher failure rate. Of the 36 growers that had samples tested at CAES, 7 of them had failed samples. The relatively high failure rate is most likely due to the genetic variability of the *Cannabis sativa* varieties planted. As THC is psychoactive, it is imperative that consumers not accidentally ingest this chemical. Furthermore, given the structure similarity to CBD, there is a significant risk of concentrating THC along with CBD during processing. Accurate testing for THC is critical to maintaining the safety of CBD products and viability of the crop for growers.	
6.	**Tick- and mosquito-borne disease surveillance in CT**	There were 33,666 confirmed and probable Lyme disease cases reported to the CDC in 2018. Drs. Armstrong, Molaei, Gloria-Soria, and Stafford have Hatch projects address tick and mosquito surveillance. The prevalence of infection in 3,153 human parasitizing blacklegged ticks in Connecticut tested by the CAES Tick Testing Laboratory (TTL) was 37.1% for the Lyme disease agent, 11.1% for anaplasmosis, and 11.3% for babesiosis. Coinfections with Lyme disease and anaplasmosis agents were identified in 5.8%, Lyme disease and babesiosis in 6.2%, anaplasmosis and babesiosis in 1.6%, and with all three disease agents in 1.2%. The percentage of submitted lone star ticks, which are associated with at least six human diseases including ehrlichiosis and red meat allergy, has increased from 0.2% in 1996 to 3.2% in 2018. Meanwhile, outbreaks of mosquito-borne diseases continue to pose serious risks to the public. Since the emergence of West Nile virus in 1999, more than 40,000 human cases and 1,900 deaths have been reported; more than 3 million human infections are estimated with an estimated case fatality rate in New England of 33-50%. In 2019, the U.S. experienced the largest outbreak of EEE in more than 50 years accounting for	**Human and Animal Health/3**

		at least 38 human cases and 15 deaths. In order to better understand the role of the Asian Tiger Mosquito, *Aedes albopictus*, in transmission of Zika, chikungunya, and other arboviruses, the CAES completed blood meal analysis of over 900 engorged mosquitoes and identified several mammalian hosts, a few reptilian hosts, and a few avian hosts. Activities focused on the success of control methods were coordinated with public health officials and a tick IPM working group. Public forums on mosquito-borne and tick-borne diseases were held. CAES partnered with the CDC-funded Northeast Regional Center for Excellence in Vector-Borne Diseases and held a "boot camp" for public health officials on mosquitoes, ticks, and their associated diseases.	
7.	**Application of protective cultures in the control of Salmonella Enteritidis in poultry**	*Salmonella enterica*, responsible for non-tyhoidal salmonellosis (NTS), is a significant worldwide public health concern. According to the Centers for Disease Control and Prevention, there are approximately 1.2 million illnesses, 23,000 hospitalizations and 450 deaths attributable to foodborne Salmonellosis in the U.S. each year. CDC reported that *S. enteritidis* was the most commonly isolated serotype of all Salmonella contributing to 27% of all single etiology outbreaks reported. Chickens serve as natural hosts for *S. Enteritidis*, with meat and shells eggs being the most commonly implicated vehicles in outbreaks. In light of the high incidence of NTS and the increase in emergence of multidrug resistant *S. Enteritidis* strains a UConn Hatch project lead by Mary Anne Amalaradjou, investigated the antimicrobial potential of 3 probiotic species in attenuating *S. Enteritidis* virulence and infection using an in vitro tissue culture model. Study results revealed that culturing of *S. Enteritidis* in the presence of each probiotic culture significantly downregulated all four Salmonella virulence genes compared to control. This research project screened, identified and characterized candidate probiotic strains to control Salmonella. Specifically, *L. rhamnosus, L. delbrreuckii* and *L. paracasei* were phenotypically and genotypically characterized and identified to 1) inhibit Salmonella survival in culture media and on eggs, 2) reduce Salmonella adhesion and invasion in chicken cecal cells and 3) modulate virulence in human intestinal cells in vitro.	**Human and Animal Health/3**
8.	**Fate and remediation of pollutants in Connecticut**	Pollution affects safety and health and directly threatens the vitality and sustainability of the natural ecosystem. Dr. Pignatello has several projects, including Hatch, designed to address remediation of contaminated soils. Broad issues related to analytical techniques for measuring pollutant levels, understanding the fate and biological accessibility of	**Sustainable Environments/4**

		pollutants in the environment, and the development of novel methods for removing pollutants from waste streams and contaminated water and soil have been addressed. Projects on fate and remediation of chemical contaminants carried out in 2019 included i) interactions of contaminants with environmental particles, ii) trapping of excess nutrients in wastes and wastewaters, iii) treatment of contaminated water, iv) chemistry of the natural environment; and v) analytical methodology for measuring pollutants in contaminated systems. It covers many types of pollutants, including nutrient ions, industrial solvents and chemicals, fumigants, insecticides, herbicides, pharmaceutical compounds, personal care products, engineered nanomaterials, per- and polyfluorinated alkyl substances (PFAS), and greenhouse gases. Examples of the above project topics are as follows. In one, we looked at the effects of air present during pyrolysis of biomass on the adsorptive properties of the chars that are formed. The results contribute to our understanding of the behavior of black carbon in the environment and aid in the design of biochars for application in agriculture and environmental remediation. A series of biochars modified by attachment of a cationic polymer to their surfaces shows high potential for removing phosphate ions from animal wastes and wastewaters. Air present during thermal pyrolysis of woody biomass enlarges pores and increases surface area, properties that lead generally to increased adsorption of organic compounds. Hot air oxidation also populates char surfaces with carboxyl and hydroxyl groups, which favors specific interactions with certain compounds. Another study dealt with the chemistry of drinking and re-use water treatment using peroxymonosulfate (PMS), a chemical oxidant under consideration for use in water treatment. Normally, PMS is activated by the input of energy or reducing agents, but we showed that PMS can react directly without explicit activation with a number of antibiotics, pharmaceuticals, phenolics, and other compounds. PMS also holds promise for deactivation of proteinaceous contaminants because it oxidizes all proteinogenic amino acids (except cysteine) within seconds to a few hours at pH 7.	
9.	**Agrochemical Impacts on Human and Environmental**	Arsenic is a known carcinogen. Groundwater contamination by arsenic at levels exceeding EPA standards is widespread in New England. The source(s) of the arsenic is poorly understood. Possibilities include natural sources (leaching of arsenopyrite from rock) and historic and recent anthropogenic sources (lead arsenate as an arsenical insecticide on	**Sustainable Environments/4**

	Health: Mechanisms and Mitigation	apple orchards and other crops; organoarsenate in chicken manure used for fertilizer for corn and other agricultural applications). Irrespective of the source, once dissolved in groundwater arsenic is transported as arsenate or arsenite and its source remains unknown. A UConn Hatch Multistate project lead by Dr. Gary Robbins, is evaluating whether sources of arsenic are anthropogenic by determining if there is an association of arsenic in ground water with bacteria communities that are commonly associated with fertilizers used on active or former farmland. Using ArcGIS to analyze historic aerial photographs from the 1930s -1950s, they developed a methodology for locating historic fruit orchards where lead-arsenate was likely to be used. A field screening method for arsenic using a portable XRF that was calibrated using laboratory standards was developed which was used to screen and sample soils on historic and existing apple orchards where lead-arsenate was used as a pesticide in the past. Over 100 soil samples were collected from various locations throughout eastern Connecticut to analyze for leachability of arsenic under various conditions (acid rain, phosphate, etc.). We found that significant levels of arsenic still remain in former orchard soils despite the fact that many decades have passed since it was used. Based on a preliminary sampling and GIS analyses, there appears to be an association between arsenic contamination in bedrock groundwater and past usage of lead-arsenate as a pesticide. More work is being done to further evaluate this relationship. We developed: 1) a consistent methodology to collect and analyze samples for environmental bacteria that may be associated with arsenic impacted recharge areas and 2) a standard method to perform DNA sequencing on bacteria communities in soil and groundwater. The resolution of this issue impacts evaluation of contamination risk to water wells, the need for filters on drinking water and water used for irrigation, and possible approaches for remediating the problem on active and past farmland.	
10.	**The role of river interface sediments in legacy nitrogen removal at**	Nitrogen is a natural part of the aquatic ecosystem that supports the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water. However, when too much nitrogen enters the watershed, the water can become polluted. Human activities, including fertilizer and livestock production, have	**Sustainable Environments/4**

	groundwater discharge zones	increased reactive nitrogen (N) loading to land surfaces. N not removed by surface processes infiltrates to ground water. N applied to agricultural land surfaces as long as 60 years ago can still be detected in groundwater. Legacy N contributes to widespread N pollution, particularly in agricultural watersheds, yet is often unaccounted for in most N management plans. Groundwater travel times of decades, spatially extensive groundwater discharge zone, large changes in agricultural land use, and complex patterns of N loading from ground to surface waters suggest legacy N transport and processing is likely an important component of N dynamics in the Long Island Sound (LIS). Understanding and accounting for legacy N at the watershed-scale is important to water quality management plans. We are studying the role of stream interface sediments in reducing legacy N load to surface water. A UConn Hatch project lead by Ashley Helton focuses on the Farmington River watershed, that is located within the LIS watershed and has experienced substantial land cover changes including a 38% reduction in agriculture and a 19% gain in urban land cover between 1973-2011. The research goal is to quantify ecosystem function (N removal through denitrification) within stream interface sediments, that directly connect agroecosystems to their receiving waters. Stream interface sediments may play a particularly important role in reducing legacy N transport to LIS. The long-term goal is to develop a robust, watershed-scale approach for quantifying spatial patterns of groundwater discharge and legacy N flux and attenuation at the groundwater-surface water interface. In addition, this project will develop recommend land-use practices such as wetland restoration, construction of riparian buffers to assist in meeting water quality goals.	
11.	**Hemp Research and Outreach Helps Growers Diversify Business**	Hemp became a regulated agricultural commodity in Connecticut in 2019, and under the Connecticut Department of Agriculture Hemp Research Pilot Program, certified growers began growing the crop. The decision to grow hemp was seen as a possible income stream for many agricultural producers who are challenged to keep their farm operations viable. For others, hemp was a way to diversify, and support a new sector of agriculture. UConn responded to the demand for research and extension related to hemp by coordinating a team from the College of Agriculture, Health and Natural Resources. Faculty	**Sustainable Environments/4**

		are researching different areas of hemp production, bringing that research to growers, and helping growers with best management practices. The UConn Hemp Extension and Outreach Program assists commercial hemp producers by providing information on production techniques and pest management. The program emphasizes healthy soils, balanced plant nutrition, pest identification, and preventative management strategies. The program offers training and field visits for hemp growers. Under the Extension Program, we served over 400 growers and prospective growers. In June of 2019, UConn Extension organized a hemp growers meeting that featured presentations on (i) A Quick Update in CBD Hemp Research by Gerald A. Berkowitz, UConn; (ii) Growing Hemp in Field: What We Know about Cultural Practices by Shuresh Ghimire, UConn; (iii) Growing Hemp in Controlled Environment by Shelley Durocher-Nesta, UConn; (iv) Seed Sources, Dioecy, Feminized Seed, and Pollen Drift: Things to Consider by Jessica Lubell-Brand, UConn; (v) Regulatory Update by Carole Briggs and Wayne Kasacek, Connecticut Department of Agriculture; and (vi) Pre-harvest Sampling and Testing by Wayne Nelson, Connecticut Department of Agriculture. The meeting was attended by 170 current and prospective hemp growers. We had forty-seven participants (28%) complete the evaluation form. Of those that completed the evaluation forms, 85% rated Excellent or Good for the amount of new information they learned at the meeting. In February of 2020, UConn Extension partnered with USDA NRCS and CT Resource Conservation and Development to organize the Connecticut Hemp Conference and Trade Show. The goal of the conference was to bring together advocates, cultivators, and businesses interested in the industry. The conference covered healthy soils practices, local policy and regulations, Connecticut field trial results, as well as innovative production markets. The event was a valuable resource for local producers and farmers seeking connections in the state as well as knowledge about local issues and opportunities. The meeting was attended by 255 current and prospective hemp growers. We had thirty-one participants (12%) complete the evaluation form. Of those that completed the evaluation forms, 82% rated Excellent or Good for the amount of new information they learned at the conference.	

		Research areas address different aspects of hemp production: • We are developing genetic transformation and gene editing technologies for hemp plants to improve composition and quantity of various cannabinoids, and to develop other traits beneficial to medicinal and industrial applications. • We are developing tissue culture micropropagation systems for hemp. We are also breeding polyploid hemp and optimizing feminized hemp seed production practices. Research and extension efforts will continue addressing the needs of Connecticut's hemp growers and respond to emerging issues in the field.	
12.	**4-H STEM develops college and workforce readiness**	Youth across Connecticut are being introduced to science, technology, engineering, and math (STEM) through educational and engaging 4-H programs. 4-H youth across the state completed 16,106 STEM projects in 2019, helping them develop college and workforce readiness preparedness. The UConn 4-H program offers educational outreach statewide through traditional 4-H clubs, afterschool activities, and programs for other organizations, including libraries. One example is the partnership with the Sprague library. "I cannot say enough about the programs 4-H offers libraries," says Elizabeth Bezanson, the Sprague Public Library Director. "The 4-H educators are always extremely personable and well prepared for any number of participants or age group. Activities are engaging for our participants and, particularly in our town, expose kids to science-related concepts that they may not otherwise encounter on their own, at home, or even at school." "The Sprague Public Library invested in our own Ozobots and we were obviously excited when Ozobots were part of the 4-H program offering because the staff learned quite a bit about facilitating an Ozobot program," Elizabeth says. Ozobots are tiny robots that incorporate physical and digital aspects to teach youth how to code and is one of many programs 4-H has to teach science, technology, engineering, and math skills. "It was a great kickoff to our regular Ozobot programs. I think this speaks to the 4-H curriculum; it is trendy, current, and relatable. From a library standpoint, it is always a	**Youth Development and 4-H/5**

		blessing to have a quality program that centers around a particular story or book that comes to us fully prepared and ready to go. Partnering with UConn 4-H is a win-win for us!" The United States ranks 27th among developed nations with college students receiving science or engineering degrees. We are 38th out of 71 countries in a measurement of math, science, and literacy skills in 15-year-olds. It is critical to engage youth in STEM related fields of study and introduce them to possible career opportunities in these areas. Nearly all of the 30 fastest growing occupations in the next decade will require at least some background in STEM. Women and minorities are under-represented in science careers and a diverse pool of trained scientists is needed to frame and solve problems and educate others. Statistics show that 63 percent of high school graduates are not prepared for college-level science and 57 percent are not prepared for college level math. Only one in five STEM college students feel their K-12 education prepared them for STEM college courses. 4-H programs provide youth with hands-on, engaging STEM experiences that build excitement around STEM topics and careers. In a survey of 4-H youth, the team found that 83% of participants learned new things about science through 4-H. 4-H members state that they benefit from participating in the 4-H Robotics Program by gaining the skills to reach their full potential. For example, Connor Hall, one of our 4-H members stated: "Teaching at a Lego EV3 4-H Robotics camp helped me to gain valuable experience teaching middle-school children and serving the community. The kits that 4-H provided the camp enabled me to optimize the kids' experience and allowed me to teach at my full potential. I am grateful for the resources and experience that 4-H robotics has given me and am excited to continue working with 4-H in the future!" "4-H robotics has taught me how to be a leader and convey my ideas to others," says Deidra Hall, one of our volunteers. "Through this program I have taught almost fifty children how to complete simple designs and programming of their various robots. This has allowed me to grow in the field of STEM and engineering, learning how to address issues, troubleshoot, and help students perfect designs they are given to work with."	

		"4-H robotics has provided many leadership opportunities for me especially as robotics superintendent," says Caleb H., another 4-H member. "I've created robotics challenges, hosted workshops, and serve as a judge for younger 4-H'ers, including my siblings. I look forward to continuing to support and promote STEM learning for 4-H'ers." Curriculum for all of our 4-H programs are targeted to the community needs. Our UConn 4-H team members work statewide providing programs to 154 of the 169 towns and cities in Connecticut. 4-H group enrollment programs serve 106 of our cities and towns. More information on our programs is available at 4-H.uconn.edu.	
13.	**Trail Use Increases Health and Sustainability**	Obesity is increasingly affecting Connecticut residents. Statistics report that 20% of children and 36% of young adults are afflicted by obesity (Poulin & Peng, 2018). Connecticut's bounty of natural and physical amenities, greenways, multi-use paths, parks, and forested areas are some of the state's greatest assets for encouraging physical activity. The Department of Energy and Environmental Protection (DEEP) estimates that there are over 2,000 miles of multi-use trails within Connecticut State Parks and Forests alone, and over 3,000 miles including those not in the park system. Connecticut is the only state in the nation with an entirely state funded recreational trails building program. Additionally, answering a growing demand from the young workforce for alternatives to car-based transportation, as well as the potential improvements to public health and community quality of life, Connecticut has vowed to invest billions of dollars in infrastructure, including $100 million during the five-year ramp period on pedestrian and bicycle paths. UConn Extension is introducing new people to the trails in our state as another source of health through exercise, recreation, and transportation. The Connecticut Trail Census is a project supported by USDA-NIFA and external funding. It has two dedicated staff members, and has grown to encompass another project, the PATHS team. PATHS (People Active on Trails for Health and Sustainability) is an interdisciplinary team of UConn Extension educators, faculty, and staff committed to understanding and promoting the benefits of trails and natural resources for health, community and economic development; and implementing a social ecological approach to health education. One of the partners is our Expanded Food and Nutrition Education Program (EFNEP), and through that partnership the team is accessing audiences that might not otherwise be reached.	**Community and Economic Development/6** Human and Animal Health/3 Sustainable Environments/4

		We are introducing new people to the trails in our state as another source of exercise, recreation, and transportation. Our team works in a wide variety of departments and disciplines including public health and education, nutrition, community development, and landscape architecture. Target audiences for these projects include trail and land use decision makers, trail advocates, current trail users, prospective trail users, urban residents, rural residents, and families with children. We have created multiple resources and hosted events for the program. Resources created include a website, list serve, and a trail etiquette brochure about sharing the trail. Community maps are being developed to connect people to trail resources, and research is being conducted in several areas. The goal of the PATHS Outdoor Education Program Pilot is to increase use of parks and multi-use (bicycle and pedestrian) trails by low-income families in Connecticut and enhance the health outcomes of the collaborative PATHS team that includes Extension's EFNEP program and community development programs. The PATHS pop-up outdoor recreation day events involved the development of "pop up" play spaces to include food demonstrations, educational material distribution, a bicycle fleet for youth with helmets and Bicycle Safety Clinics (by League of American Bicyclists Certified Instructors [LCI] offered in partnership with BikeWalkCT), games and active toys. The two pop-up events were held at existing park or trail sites in partnership with local organizations. The events provided an opportunity for trail safety and advocacy organizations to distribute information about bicycle and pedestrian safety and health education. Sites were in Meriden and Groton, both of which have existing outdoor recreation amenities, EFNEP education programs, and community partners with capacity. One event was held at the Farmers' Market in Meriden, partnering with the Meriden Community Health Center, Meriden Farmers Market and BikeWalkCT where youth and families tried nutritious and tasty recipes, PATHS team members and volunteers provided free bicycle helmets for youth, and BikeWalkCT provided bicycle education and bicycles for youth to try. 75 youth and parents participated in the event. A second similar event was	

		held in Groton in partnership with the Groton Chamber of Commerce Fall Festival and reached 300 youth and parents. These are the first of many programs being offered statewide. We have a multi-faceted approach to promoting the benefits of trails and natural resources. Educational street sheets compile a list of outdoor recreational amenities in the vicinity of the EFNEP site, and we added parks and trails to existing educational street sheets provided by the EFNEP educators. Other locations on the street sheets include food, housing, and social services resources for low-income families. These sheets were developed for Meriden and Groton and shared at the pop-up events, along with other pre-existing maps of local trails and public spaces. Families participating in the events reported that they are more comfortable accessing and using trails after attending a pop-up event. Where applicable, data from our EFNEP program shows that participants lead a healthier lifestyle and make behavior changes as a result of our programming. Resources are available for families and residents at https://cttrails.uconn.edu/ and the trail census data is available at https://cttrailcensus.uconn.edu/ to help informed decision making and promote resident participation in trail monitoring and advocacy through the volunteer program. The Connecticut Trail Census now involves data collection on 21 sites, with 42 volunteers donating 661 hours over the last year. The ten-person advisory committee for the trail census donated 20 hours each to the project. The Census documented approximately 24,589 users per week on participating trails in 2019. The Trail Census has grown since the project started, and data has been used to allocate funding, encourage trail users to volunteer with their local trails, and prioritize trail maintenance projects. The trails projects are working synergistically to enhance health outcomes among our residents, advocate for trail use, and assist decision makers in further development of our natural resources.	