NORTHEAST

Specialty Crop Water Symposium

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USDA Northeast Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

- NORTHEAST -

Specialty Crop Water Symposium

The Northeast Specialty Crop Water Symposium was co-hosted by the University of Vermont and the USDA Northeast Climate Hub.

Thank you to our event sponsors

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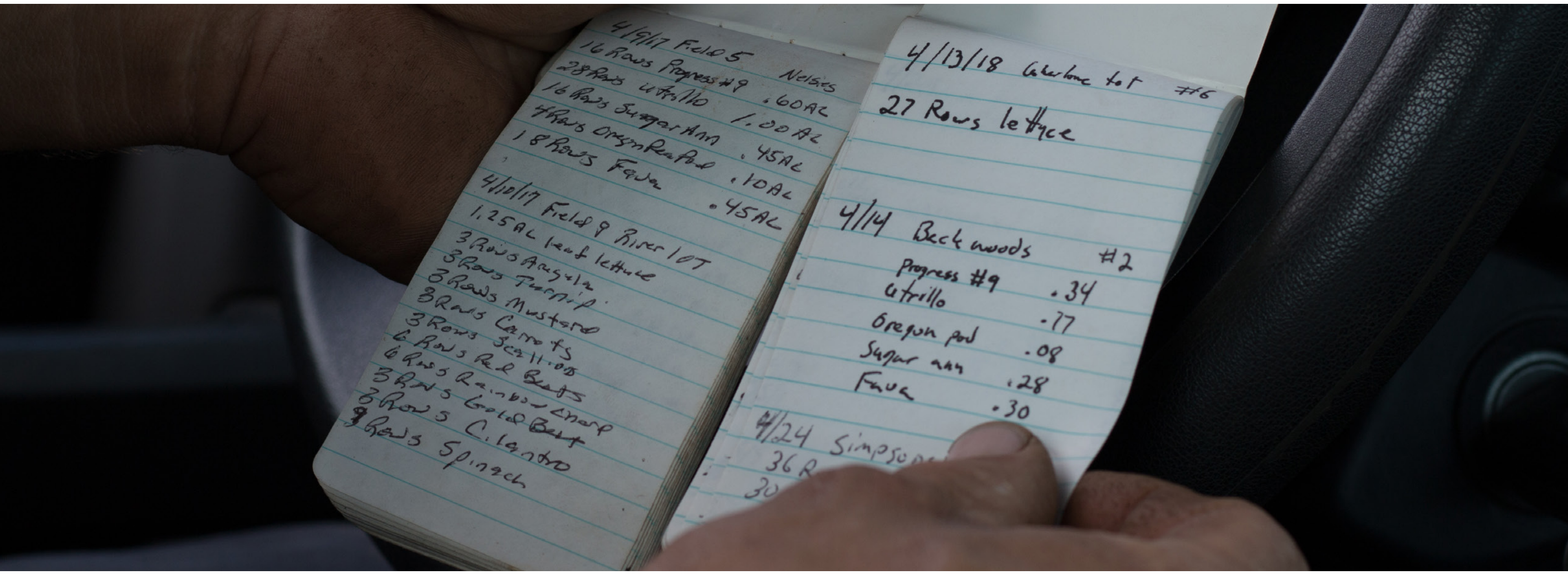

Introduction

The specialty crop industry in the northeastern United States is diverse. It includes producers of vegetables and small fruit, tree fruit, ornamental horticulture, and a variety of emerging crops such as hops, hemp, and medicinal herbs. Historically, rainfall has been sufficient to meet crop needs in this region. Among those producers who irrigate, there has been little concern about having sufficient access to water, either from groundwater or surface water sources. Though water use regulations vary across the region, state-level rules have rarely limited producers' ability to access water for agricultural purposes.

In recent years, however, precipitation patterns in the Northeast have changed. Climate models forecast that these changes will continue, likely leading to challenges for Northeast specialty crop producers. Specifically, specialty crop producers in this region must be prepared to deal with seasonal water excess or drought, sometimes in the same growing season.

In order to strategically adapt to these changes, producers will need the support of researchers and agricultural advisors who understand water resource management, water-use efficiency, agronomic water needs, and emerging technologies.

The Northeast Specialty Crop Water Symposium was conceived to bring professionals working in specialty crops and water resources in other U.S. regions or agricultural sectors together. The Symposium was held on December 19th and 20th, 2019 in Burlington, Vermont. At the Symposium, we gathered researchers and agricultural advisors focused on water and specialty crops in order to increase coordination, develop new research programs, and improve the quality of outreach. The Symposium was designed to facilitate information sharing and learning across relevant disciplines, with a focus on developing applied recommendations for specialty crop growers in this region.

William DellaCamera compares annual planting notes. The notebook on the left was logged by Nelson Cecarelli in 2017. Photo by USDA Northeast Climate Hub.

Invited speakers at the Symposium presented on a wide range of topics, from evaluation and tracking of Northeast water resources to new, innovative monitoring systems. Special emphasis was placed on rising to meet the challenges of a changing climate, as a region that has historically enjoyed agricultural water security transitions towards a different reality. Additionally, select presenters from across the United States were invited to share the characteristic challenges of their region, so that Northeast participants could learn from successful responses to these challenges. Presentation abstracts are included in these proceedings, as well as links to slides from many of the lectures.

A facilitated planning session conducted in the second half of the Symposium led to a list of high priority research and outreach opportunities. Research gaps identified by the professional participants in this session included topics such as (1) how genetic diversity and crop breeding can be leveraged to address an uncertain water future; (2) how to best characterize the relationship between agricultural climate adaptation strategies and risk reduction; and (3) an assessment of accuracy and cost effectiveness for soil moisture sensors and other farm-based adaptation approaches. Key outreach and education gaps were also identified by participants, including the need for (1) crop insurance that works better for small and diversified producers; (2) additional professional development opportunities for agricultural advisors around irrigation scheduling and strategic investments in water efficiency technology; (3) ways to better prepare for the types of extreme weather that affect the Northeast; and (4) how to optimize soil moisture monitoring across diverse crops.

Lastly, the gathering initiated an important new network of professionals working in the area of water use efficiency in Northeast specialty crops, a network which **all are invited to join**. It is our hope that the Symposium marked the beginning of a new wave of collaboration on water and specialty crops in our region, one that will continue to grow. By doing so, we collectively hope to rise to the challenges ahead of us and continue to serve the agricultural communities of the Northeast for years to come.

The Northeast Specialty Crop Water Symposium was a collaboration between the University of Vermont Extension Center for Sustainable Agriculture, the University of Vermont College of Agriculture and Life Sciences, and the USDA Northeast Climate Hub. We are grateful for the support of our sponsors. Specifically, the Symposium was made possible by the USDA National Institute of Food and Agriculture, Agricultural and Food Research Initiative Competitive Program, Sustainable Agroecosystems: Functions, Processes & Management, grant #2019-67019-29465. Additional sponsorship was provided by Onset HOBO Data Loggers and Smartrek.

> Rachel E. Schattman, Symposium organizer
> Joshua W. Faulkner, Symposium organizer
> Terence Bradshaw, Symposium organizer

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The California water system

by Dr. Doug Parker | Keynote Speaker | California Institute for Water Resources

California's Mediterranean climate has helped it become a world leading agricultural producer. The climate also attracts thousands of new residents to immigrate to the state. However, California's variable climate produces a host of challenges to meeting its agricultural, industrial and residential water needs. In response, California has created one of the largest, most complex, and advanced water storage and delivery systems in the world. This system is designed to allow California to thrive in the face of three major water challenges: geographic, seasonal, and annual variability. The system is facing new pressures in the face of climate change. Climate change will impact all three of these challenges and require new investments in infrastructure, information and data analytics, and operational design.

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About Dr. Doug Parker

Dr. Doug Parker is the Director of the California Institute for Water Resources in the University of California's division of Agriculture and Natural Resources. He coordinates water-related research, extension, and education efforts across the 10 University of California (UC) campuses, the UC Agriculture and Natural Resources (ANR) system, and other academic institutions within California. Current research and extension interests include sustainable groundwater management, reducing the risk of nitrates in California's groundwater, and climate smart agriculture.

Prior to joining the University of California, Doug worked on water quality issues related to the Chesapeake Bay as a Professor and Extension Specialist in the Department of Agricultural and Resource Economics at the University of Maryland. He has also worked on issues related to California water as a Cooperative Extension Economist at UC Berkeley. Doug obtained his Ph.D. in Agricultural and Resource Economics at UC Berkeley and bachelor's degrees in Economics and Environmental Studies at UC Santa Barbara.

Climate change in the Northeast: What history tells us about crop loss, drought, and wet conditions

By Dr. David Y. Hollinger | Keynote speaker | USDA Northeast Climate Hub + U.S. Forest Service

Farmers confront risks from weather, disease, pests, changing markets and prices, government policies, and many other factors. An important question is whether a changing climate is going to increase or decrease risk. Crop insurance is one method of reducing the risks producers face related to bad weather and other factors. In the US, most crop insurance is backed and regulated by the USDA Risk Management Agency (RMA) but sold to farmers by private crop insurance companies and agents. The government pays about 60% of the cost of this insurance, making policies attractive to many. New products, especially Whole Farm Revenue Protection (WFRP) may be particularly interesting for smaller, diversified farms, (including organic producers). These are available nationwide and cover all commodities on the farm under one policy. Costs to the producer of Whole Farm Revenue Protection drops as the number of farm commodities increases.

More than 80% of the acres nationwide of major field crops (around 300 million acres) are insured under the Federal crop insurance program. Although the majority of acres are covered by this program, the majority of farmers don't use crop insurance. Nationally, about 26% of producers use insurance, but in New England and New York, less than 10% use crop insurance (NASS, 2017).

Crop insurance data can help to understand weather and climate risks faced by farmers. The Risk Management Agency collects statistics on the causes of crop losses and the payouts that they make on a county by county basis. When looked at regionally, these statistics show the average losses due to different causes. Nationwide, between 1989 and 2018, about 87% of the losses paid out were weather related. The largest source of losses was drought which represented about 37% of total losses. Drought losses were concentrated in the southern Great Plains and not common in the Northeast. Excess moisture was the next largest cause of loss, accounting for about a quarter of total losses. On an annual basis, excess moisture and flooding were the most common cause of loss for most Northeast states.

Climate models and trends suggest that parts of the country where losses are already dominated by drought are getting dryer. In other parts of the country where the top current cause of crop loss is excess moisture, models suggest that they will get even wetter.

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About Dr. David Y. Hollinger

Dr. David Hollinger is Director of the USDA Northeast Climate Hub, providing expertise on the impacts of a changing climate on agriculture and forests in the Northeast, and ways for landowners to increase climate resilience. He is a Supervisory Plant Physiologist for the USDA Forest Service and Team Leader within the Climate, Fire, and Carbon Cycle Sciences group of the Northern Research Station. His recent research interests include cost-effective and practical responses to changing climatic conditions in forests and on farms across the northeastern United States. He has led long-term research into impacts of climate on forest growth and water-use at the Howland forest in Maine and helped found the AmeriFlux network of research sites. He received a B.A. in Biology from Dartmouth College in 1977, and a Ph.D. in Ecophysiology from Stanford University in 1984.

Dr. David Hollinger helps install a weather station at Cecarelli Farms in January 2017. Photo by USDA Northeast Climate Hub.

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Water, water everywhere and not a drop to drink: Trends, impacts and adaptation tools for Northeast specialty crops

by Dr. Art DeGaetano | NOAA Northeast Regional Climate Center + Cornell University

Climate change will both directly and indirectly affect the water balance during the growing season in the U.S. This will come about due to changes in precipitation, evaporative demand, and length of growing season. Data from the most recent U.S. National Climate Assessment shows historical changes in annual and seasonal rainfall, precipitation extremes, snowpack, and growing season length in the U.S., specifically in the Northeast. The fundamental atmospheric modifications that are responsible for these changes will be discussed. Output from global climate models simulations consistent with higher concentrations of atmospheric greenhouse gases will then be presented. Collectively these show that the U.S. will become warmer and experience greater precipitation extremes. Despite this increase in precipitation, surface soil moisture will predominantly become drier.These future stresses on the water balance in the Northeastern United States will require agricultural producers to adapt. The use of data-driven decision tools is one component of successful adaptation. Several web-based tools, developed by the Northeast Region Climate Center, will be presented showing their application to fruit production, turf grass, and field and vegetable crops.

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About Dr. Art DeGaetano

Art DeGaetano is a Professor in the Department of Earth and Atmospheric Sciences at Cornell. He is also the director of the NOAA Northeast Regional Climate Center (NRCC). Art serves as a climate editor for the Bulletin of the American Meteorological Society. He also was a Principal Investigator on The ClimAID Integrated Assessment for Effective Climate Change Adaptation Strategies in New York as well as a contributor to the 2018 National Climate Assessment. He received an interdisciplinary Ph.D. focusing on Climatology and Horticulture from Rutgers University in 1989.

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Drought in the Northeast: Planning towards early warning with the NIDIS program

by Ellen Mecray | NOAA National Centers for Environmental Information

The National Integrated Drought Information System (NIDIS) works across federal agencies to coordinate information on drought and its indicators. NIDIS partners with leaders at the regional scale to deliver “drought early warning systems” (DEWS) across the nation, including one in the northeast that started in 2016. The Northeast DEWS hosted several regional meetings during the drought of 2016 to examine information and communication needs in the region, extending across New England and into New York. These information needs led to the drafting of the Northeast DEWS strategic plan which includes interagency and state-level activities such as monitoring private wells and groundwater levels, analyzing the region for improving soil moisture monitoring, recruiting and hiring a regional drought coordinator, building a dashboard of drought information for the region, and hosting monthly webinars that help keep drought risk in the forefront of preparedness discussions.

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About Ellen Mecray

Ellen Mecray is NOAA’s Regional Climate Services Director for the Eastern Region, based in Norton, Massachusetts. In this role, Mecray helps bring NOAA’s climate information to other federal agencies as well as regional, state, and local geographies and specific sectors of importance to the eastern region. Mecray is also the Federal Coordinating Lead Author for the Fourth National Climate Assessment, Northeast Chapter and an author on the Energy national chapter. She recently served as acting Director of the National Geophysical Data Center in Boulder, CO. Prior to joining NOAA, Mecray was an oceanographer with the US Geological Survey’s Coastal and Marine Geology program conducting research on urban contamination of coastal sediments. Before her federal career, Mecray taught chemistry and environmental science at the Williston Northampton School in MA. For over 20 years, Mecray’s teaching, research, and leadership have focused on efficient, cross-sectoral collaboration among inter-and intra-agency partners. Mecray holds a B.A. in geology from Colgate University and a M.S. in geological oceanography from the University of Rhode Island.

Overview of agricultural water resources in the Northeast

by Cheryl Dieter | USGS, Maryland-Delaware-DC Water Science Center

The U.S. Geological Survey has estimated water use for major categories of use, including irrigation, every five years since 1950. Total water withdrawals in 2015 for the United States (US) were estimated to be 322 billion gallons per day (Bgal/d), of which 12 percent or 38 Bgal/d were used in the northeast US (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia).

Irrigation is the second largest use of water in the US (37 percent in 2015), however, in the northeastern US only 1 percent (544 million gallons per day (Mgal/d)) of the total withdrawals are used for irrigation. However, locally, these withdrawals can be the largest use. For example, in some agricultural rural counties, withdrawals for irrigation are larger than for other categories such as public supply or industrial. Massachusetts had the largest withdrawals for irrigation in 2015 when compared to the other eleven northeast states. Massachusetts, Delaware, New Jersey, Maryland, and New York accounted for 85 percent of the total irrigation withdrawals in the northeast. In Delaware, about 14 percent of the withdrawals in that state were for irrigation, the largest percent of the northeast states.

Overall, withdrawals for irrigation in the northeast US increased from 271 Mgal/d in 1985 to 586 Mgal/d in 2010, then decreased to 544 Mgal/d in 2015. Seven states estimated increases in withdrawals for irrigation from 2010 to 2015 and 5 states estimated decreases in withdrawals. New Jersey had the largest decrease (44 Mgal/d), and Delaware had the largest increase (12 Mgal/d) during the same time period (2010 to 2015). The increases and decreases are due to various factors including changes in precipitation from year to year, changes in crop types or the number of acres irrigated, changes in irrigation methods or practices, or estimation methods.

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About Cheryl Dieter

Cheryl Dieter is a hydrologist at the US Geological Survey (USGS), Maryland-Delaware-DC Water Science Center. She has served as the USGS Water-Use Specialist for the northeast US for the past five years and has contributed to the USGS estimates of water use in the United States for 2010 and 2015. Her current research is focused on estimating water-use for the public-supply category, leading a team tasked with estimating water-use for public supply systems at finer spatial and temporal resolution than current estimates. The project is part of a USGS project to estimate components of the water budget, including water use, for the Nation at a daily timestep and watershed scale. She has also been involved with various studies related to recharge and water-supply issues in regional aquifers, ground-water flow modeling, geochemistry in aquifers, and ground and surface-water interaction.

Mt. Toby Farm in Sunderland, MA, has worked with the USDA Natural Resources and Conservation Service (NRCS) to create their conservation plan. Photo by USDA.

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Environmental and regulatory concerns related to water use in the Northeast

by Dr. Meredith Niles | University of Vermont

Agriculture is the largest anthropogenic user of water globally and irrigation demand is expected to increase with climate change. In the United States, water rights and access have been heavily studied in the Western states, but less focus has been given to Eastern water policies and practices. While agricultural water use in the East is not as significant as in the West, it is expected to shift towards greater demand in the future. As such, understanding how Eastern states allocate and regulate water is important for farmers and agricultural stakeholders. This talk provides an overview of ground and surface water policies in Northeastern states and their relevance for agriculture, including special provisions that agricultural water use has in many states. The talk will also provide an introduction to water governance and regulatory terms and frameworks, which can vary significantly by state.

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About Dr. Meredith Niles

Dr. Meredith Niles is an assistant professor in the Food Systems program and the Department of Nutrition and Food Sciences at the University of Vermont. Meredith's work focuses on the nexus of food and environment with a focus on people, behaviors and policy. Meredith's current research examines (1) farmer's adoption of sustainable practices including those related to water, nutrient management, and climate change, as well as farmers' environmental policy perceptions; (2) climate change impacts on food security, diet diversity and food systems and adaptation responses and (3) food waste behaviors and policy perceptions. Her research spans from the Northeast United States to California, New Zealand and many low-income countries in Africa and Asia. Meredith holds a B.A. in political science with honors in environmental studies from The Catholic University of America. She holds a Ph.D. in ecology with a focus on human ecology and environmental policy from the University of California- Davis. She was a Sustainability Science post-doctorate fellow at Harvard University's Kennedy School of Government where she worked with the Climate Change, Agriculture, and Food Security (CCAFS) group of the CGIAR to explore smallholder farmer experiences.

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Reports from the Midwest

by Dr. Dennis Todey | USDA Midwest Climate Hub + Agricultural Research Service

The USDA Midwest Climate Hub is one of 10 hubs nationally created to address climatic issues at various time scales to help deal with current and projected changes in climate and their impacts on agriculture. In the Midwest, water is an issue for specialty crops, but somewhat different from many other regions. There are several water intensive crops grown in the region, cranberries for example. Variability in precipitation is always an issue. Changes in precipitation have often led to excess water issues rather than limited water. The additional precipitation has led to soil and nutrient loss and increased disease pressures across the Midwest. Several recent surveys have noted a lack of information available specific to the specialty crop user. The Climate Hub, hence, has worked regionally to help develop information with partners (including state Extension, state climate offices, regional climate centers and others) for specialty crop producers throughout the region. We have sought to better use climate information for specialty crop decision-making.

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About Dr. Dennis Todey

Dr. Dennis Todey is the Director of the Midwest Climate Hub in Ames. He is a native Iowan with his BS and PhD from Iowa State in Meteorology and Agricultural Meteorology. He has spent two stints in South Dakota, first completing his MS at the South Dakota School of Mines and Technology and most recently as Associate Professor and State Climatologist for South Dakota at South Dakota State University. He is well known regionally as a speaker and media source on various climate issues and is the former president of the American Association of State Climatologists.

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State of specialty crops and related water resources from the Southwest and California

by Dr. Doug Parker | Keynote Speaker | California Institute for Water Resources

California is the top specialty crop producer in the nation/world. Its Mediterranean climate produces high yields with minimal pathogen and fungal concerns. Despite construction of one of the largest, most complex water storage and delivery systems in the world, production in California is constrained by available water supplies. Water availability varies locally across the state. In response to water scarcity, California is a leader in the adoption of precision irrigation systems and methodologies. Adoption of new technologies often requires years of experimentation and adaptation. The University of California Cooperative Extension plays an integral role in this process. A recent economic analysis of the adoption of drip irrigation demonstrates the value of the technology and the research and extension involved in its implementation.

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Please see **page 6** for Dr. Doug Parker's bio.

Reports from the Northwest

by Amy Garrett | Oregon State University Extension

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About Amy Garrett

Amy Garrett has been working with Oregon State University (OSU) Extension Small Farms Program in the Southern Willamette Valley of Oregon since 2011. She has 23 years of experience in the horticulture industry ranging from landscape design to organic farming, research, and education. Drought mitigation tools and strategies for growing with little or no irrigation have become a focus in her work. The OSU Dry Farming Project she is leading has expanded over the past several years, from case studies and demonstrations to a multifaceted participatory research project with more than 30 trial hosts in the Dry Farming Collaborative in 2019.

BREAK-OUT SESSION 1

USDA NRC field specialist records Mt. Toby Farm's progress with their conservation plan. USDA Photo by Lance Cheung.

A whirlwind tour of vegetable irrigation systems on Northeast farms

by Dr. Vern Grubinger | University of Vermont Extension + Northeast SARE

Vermont, like other states in the Northeast, is home to vegetable farms producing a diversity of crops in a variety of settings. Thirty years ago, a significant portion of these farms had little or no capacity to irrigate. Since then, weather patterns have become more erratic, the availability and quality of irrigation equipment has increased, and the relative cost has gone down. Today, virtually every farm uses irrigation on their high value crops. Irrigation is used outdoors and in protected culture. It is applied to fields, beds, and containers; to annual and perennial crops; via overhead and drip, using manual and automatic controls. Irrigation water comes from ponds, rivers, springs, streams, wells, and municipal water systems.

Solid-set pipe with sprinklers are common. They are readily moved around the farm, and apply lots of water, quickly. They are also used for frost protection in strawberries, a popular crop on vegetable farms. Coverage can be variable depending on sprinkler placement, output, and wind. The sprinklers can get stuck, and if pipes leak, excess water can promote Phytophthora root rot and other diseases. Hose reels, or traveling sprinkler guns also apply a lot of water fast. They reduce labor needed to move solid set pipe. They are best suited to large crops in relatively flat fields, and traveling wheeled sprinklers are best suited to rectangular fields.

Drip irrigation is used on most vegetable farms. It wastes much less water than solid set irrigation since it puts water where needed rather than over an entire field. Drip tape type is selected based on in-row crop spacing, water supply, durability, etc. Valves can provide precise control of water application to different areas of beds, fields, containers, etc. Filters and pressure regulators are critical in drip systems. Frequent (typically annual) replacement of drip tape generates a lot of plastic waste. Variable number of drip lines are used per bed or row, and depending on soil texture and crop demand. Multiple lines per row or bed are often needed to wet the entire root zone. Fertilizers and pesticides may be applied in drip irrigation water. In greenhouses, warming cold irrigation water before application is advisable. Many growers use programmable irrigation timers, either electric or mechanical.

Gas and electric pumps are used for irrigation, with some gravity systems outdoors and much hand-watering in greenhouses.

Most growers use observation and experience to determine how much water to apply. There is a lot of interest in adoption of moisture sensors to optimize vegetable farm irrigation in the future.

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About Dr. Vern Grubinger

Vern Grubinger has been working with and learning from farmers for more than 30 years. He is the Vegetable and Berry Specialist and Extension Professor with the University of Vermont, and since 2007 he has served as Director of USDA's Northeast Sustainable Agriculture Research and Education program (SARE) which makes over $6 million in grants annually to researchers, educators and farmers. He authored the books Sustainable Vegetable Production from Start Up to Market and With an Ear to the Ground: Essays on Sustainable Agriculture; he co-authored Farms, Food and Communities: Exploring Food Systems. Vern's extension work is focused on enhancing the viability of farms by providing actionable information through conferences, fact sheets, a grower listserv, newsletters, on-farm workshops, a web site, videos and individual consultations. His applied research has focused on nutrient management, organic pest control, produce safety, and renewable energy use on farms.

Fresh delicata squash.
Photo by Dr. Rachel E. Schattman.

The Intervale Community Farm's approach to irrigation management

By Silas Branson | Intervale Community Farm

The Intervale Community Farm is a 50-acre diversified organic vegetable farm in Burlington, VT. Our soils are very sandy and drain very well, so keeping crops from drying out is a high priority throughout much of the season. Our irrigation water comes from three different wells in various places around the farm, as well as directly out of the Winooski River.

We use a variety of distribution methods in different places and situations. Overhead sprinklers supplied by aluminum pipe cover the largest portion of our crops. Smaller sprinklers require more lines of pipe and are more labor intensive per acre, but they allow for more consistent, gentle watering on sensitive crops. Larger sprinklers let us cover large swaths of field more quickly and with less pipe, but provide less consistent water and have the potential to physically damage the plants.

For crops grown on plastic mulch, both in the field and in high tunnels, we rely on drip irrigation. We also use drip irrigation on certain bare-ground crops, and in fields where our water supply is insufficient for sprinklers. Drip irrigation provides nice, even moisture and keeps the foliage dry to minimize the spread of disease, but it can be painfully slow in certain circumstances. It can also be challenging to achieve good coverage throughout a bed without using multiple lines of drip tape.

Our primary goal - and primary challenge - is to maximize the positive impact our irrigation has on crop growth and health, while minimizing the time it requires to operate and the disruption to other farm operations it causes. The rigid aluminum pipe we use in most fields has to be pulled apart and moved to allow us to do other tractor work.

We understand that the better our practical understanding of how moisture moves around the farm and how it impacts crops, the better we can target our efforts. For example: At what point is lack of moisture limiting crop growth or increasing vulnerability to pests and disease? At what point are we overwatering and inhibiting root function? What stages of growth are most critical for irrigation? Where can we get away with putting a lot of water infrequently, and where do we need to invest the time to irrigate more frequently? To what extent are we flushing nutrients out of the soil? Do different types of irrigation impact soil nutrients more or less? We want to learn more about the answers to these questions, both generally and in our specific location. Doing so will help us to irrigate more intelligently, leading to more efficient and effective food production.

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About Silas Branson

Silas Branson is a manager at Intervale Community Farm, where he has worked since 2010. One of his key responsibilities is helping to coordinate and balance the flow of irrigation with tractor work, cultivation, and planting, etc. Intervale Community Farm is a 50-acre diversified organic vegetable farm in Burlington, VT. The farm focuses on distribution to on-farm CSA shares, which are offered throughout the year.

Drip irrigation at Intervale Community Farm in Burlington, VT. Photo by Jenny Brown.

An economic case study of irrigation on the Intervale Community Farm

By Lynn G. Knight | USDA Northeast Climate Hub + USDA Natural Resources Conservation Service
Suzy Hodgson | University of Vermont's Center for Sustainable Agriculture

Over the past several decades, the impacts of climate change in the Northeast have meant more extreme weather events including heavy downpours and extended dry, hot periods throughout the growing season. This has made it more difficult to reliably grow high quality produce on the farm's sandy soils.

This **case study** explores the benefits and costs of adding irrigation to a Vermont farm's production practices in order to reduce the risk of lower vegetable crop yields and quality. The Intervale Community Farm (ICF) was selected for analysis because it is one of Vermont's oldest and largest organic community supported agriculture (CSA) farms, producing a wide variety of vegetables on 25 acres. The ICF farm manager has kept good records for over 10 years, allowing for historical analysis. Starting in 2001, ICF began investing in both spray and drip irrigation equipment. During extended hot dry periods in the summer, almost all the vegetables grown on ICF's sandy soils are irrigated. Without irrigation, even in an average precipitation year, ICF would suffer diminished yields and quality without supplemental water.

Annual vegetable revenue and irrigation-related purchase records over the past 11 years were reviewed for the analysis. Costs such as operation and maintenance, pumping (primarily diesel fuel and related labor), and waste disposal costs were estimated. The benefits of avoided crop loss and the costs of purchasing and using irrigation were estimated on an annual per acre basis. Sensitivity analysis was also undertaken to illustrate "what-if" conditions. Finally, a break-even analysis value was calculated. Over time, ICF has been experiencing hotter summers and longer dry periods with the soil moisture evaporating and the plants transpiring more. To estimate irrigation needs, Cornell University's Climate Smart Farming (CSF) Water Deficit Calculator was used to model when plant stress was likely to occur. The farmer manager's recollection and records of irrigation in recent summers were used to calibrate the CSF Calculator's outputs.

The partial budget analysis shows that irrigation is profitable despite on-going infrastructure costs and variable summer weather. Overall, the cumulative net benefits per irrigated acre over 11 years was $33,121, and total farm benefits over all irrigated acres over 11 years were just over $500,000. Sensitivity analyses were conducted to identify thresholds of when irrigation was most and least needed. The benefits of having irrigation exceed its costs at ICF even if every year is on average "wet" given that rainfall does not always coincide with crop production needs. Even wet years have dry periods during critical crop growth stages when irrigation provides significant benefits. ICF's decision to invest in drip and spray irrigation over the past 16 years has been sound. The benefits of reducing losses due to summer water deficits has exceeded the costs of purchasing the equipment, running the pumps, and the additional costs of labor and materials associated with managing this system.

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About Lynn G. Knight

Lynn G. Knight is a Regional Economist with Natural Resources Conservation Service (NRCS) East National Technology Support Center (ENTSC). She is responsible for providing conservation economic technical assistance and training to 22 States, Puerto Rico and the Virgin Islands. Her background includes work with the USDA Office of the Assistant Secretary of Civil Rights conducting damage assessments, a Senior Economist with USDA NRCS in Washington DC conducting regulatory impact studies, and the State Economist for NRCS in Vermont. She also served as an economic and government policy consultant for American Farmland Trust, Winrock International, Farm Pilot Project Coordination Inc. and EnSave. Lynn holds a B.S. in Animal Science, and a M.S. in Agricultural Economics from the University of Vermont.

William Dellacamera shows off sub-surface drip irrigation lines at Cecarelli Farms in July 2018. Photo by USDA Northeast Climate Hub.

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About Suzy Hodgson

Suzy Hodgson is based at UVM's Center for Sustainable Agriculture, where she undertakes research and-outreach, writing farmer profiles, developing videos, feasibility studies, and economic case studies on farming practices as part of UVM Extension's New Farming Network, Women in Agriculture Network and the Farming and Climate Change program. Prior to UVM, she launched a mission-driven on-line business to support local food with 100+ farmers and 3000+ households. From 1992 to 2008, she worked in the UK as principal consultant with Carbon Clear, Ltd. measuring and managing carbon footprints and researching greenhouse gas protocols for carbon calculators. As Program Director at the Center for Environmental Strategy, University of Surrey, she designed, developed and managed the University's first cross-departmental cross-disciplinary MSc. in Environmental Strategy.

Spray irrigation at Intervale Community Farm in Burlington, VT. Photo by Suzy Hodgson.

On-farm irrigation monitoring and initial results from a controlled irrigation trial in Burlington, Vermont

By Dr. Rachel E. Schattman | University of Maine
Dr. Joshua Faulkner | University of Vermont's Center for Sustainable Agriculture

Historically in the Northeast United States, annual precipitation has been sufficient to meet crop water needs throughout the growing season. For growers who do irrigate, there has been little concern about having sufficient ground or surface water for field or high tunnel crops. In recent years, however, precipitation patterns in the Northeast have changed and climate models forecast that they will continue to do so (Wolfe et al. 2018). These changes translate into challenges for Northeast specialty crop growers that are distinct from those faced by growers in other regions. Specifically, specialty crop producers in this region must be prepared to deal with too much water and too little water, sometimes in the same growing season. To do so, these producers will need to understand water resource management, water-use efficiency (WUE), agronomic water needs, and emerging technologies.

In 2018, our research program delivered a survey (n=155) targeted towards vegetable and small fruit growers in Vermont and Massachusetts (Schattman et al. 2018). The goal of the survey was to better understand how and when growers were applying irrigation water. The survey results showed that most growers who irrigated their crops drew from more than one water source (wells, ponds, rivers, municipal sources), and many used more than one irrigation approach (overhead stationary, travelers, and drip irrigation). Respondents overwhelmingly decided to irrigate based on the feel of the soil or the condition of the plants. Few respondents reported using technology such as soil moisture sensors, which are proven to be more accurate in determining crops' access to water. These findings hold true across Northeast states, as confirmed by the recently released USDA-NASS irrigation survey (USDA-NASS 2019).

The results of the survey led us to question whether vegetable and small fruit growers in our region were applying enough water, too much water, or the right amount. While some states in the Northeast, such as New Hampshire, require farmers to report water usage, many states do not. Perhaps as a result, few farmers know how much water they are actually applying to their crops, or how well their applications match crop needs. To better understand what the on-the-ground situation may be, we installed water meters on 3-farms in northwestern Vermont in 2018 and 2019. We conducted rough water budgets based on evapotranspiration rates, weekly precipitation, and water applied through irrigation. Our results show that, while some farms applied roughly the right amount of water, others were dramatically under and over applying water in different zones of their farms. This finding was confirmed by soil moisture sensors installed in both field and high tunnel locations.

Monitoring on these farms did not necessarily lead to changes in farm management, however. This may be because the consequences of over- or under-irrigation remain unclear to many growers. Because changing irrigation management requires significant investments in equipment and labor, the consequences of mismanagement must be better understood before farm-management is likely to change.

To further explore these issues, we installed a 2-year field-trial at the University of Vermont Horticulture Research and Education Center in South Burlington, Vermont. The field trial was designed to measure the effects of using different "cues to irrigate" on yield, crop quality, and nutrient leaching. Treatments included a control (no irrigation applied), and plots irrigated based on "feel of soil", timers, and centiBar readings collected through a soil moisture sensor system. Plots were planted with tomatoes, cucumbers, and peppers to simulate a diverse vegetable cropping system. We harvested vegetables 2-times per week and measured yield (weight and number of fruit), quality (using the USDA Agricultural Marketing Service grading system), and nitrate-nitrogen dissolved in water (collected using lysimeter pans buried under the plots). Data collection for the 2019 season has recently concluded, and a full analysis has not yet been completed. However, initial results show significant differences in soil moisture trends between the four treatments across the season. Additionally, there was only enough leachate to collect under plots that had been watered with timers. Even in these samples, however, nitrate-nitrogen levels were low enough that they are likely not a groundwater contamination concern. We look forward to replicating the trial in South Burlington and Old Town, Maine in 2021, and sharing results at the conclusion of the study.

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About Dr. Rachel E. Schattman

Dr. Rachel E. Schattman is an Assistant Professor of Sustainable Agriculture at the University of Maine. Her research focuses on climate change perceptions and how they influence on-farm management decisions, as well as water use efficiency in northeast vegetable systems. She has been the leader on several USDA Climate Hub research and outreach projects, including a National survey with USDA field employees on their understanding of the risks associated with climate change. She has published on best practices for designing educational climate change curricula for adult learning audiences, drawing upon her history as an Extension specialist and researcher.

Please see **page 46** for Dr. Joshua Faulkner's bio.

Landscape management for improved water conservation

by Dr. Mandy Bayer | University of Massachusetts - Amherst

In the last ten years, drought has impacted communities across the United States from the frequently drought stricken southwest to the intermittently impacted northeast. This has resulted in increased interest by the public to have more sustainable landscapes that require less water inputs. Improving water conservation in the landscape requires stepping back and finding out why managed landscapes are so challenging to plant health and what can be done to improve the growing environment. Water conscious landscapes require that plant health and adaptability be considered along with typical design considerations. Soil health and plant selection are the building blocks of a successful landscape. Proper planting techniques also help to reduce plant stress and improve plant establishment. Improving irrigation applications in the landscape starts with understanding what plant and environmental factors impact plant water use. Efficient irrigation applications require appropriate scheduling, monitoring, and evaluation of the irrigation system.

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About Dr. Mandy Bayer

Dr. Mandy Bayer is an Extension Assistant Professor of Sustainable Landscape Horticulture at UMass Amherst. She has a BS in Landscape Contracting from Penn State, a MS in Crop Sciences from the University of Illinois, and a PhD in Horticulture from the University of Georgia. Her research and extension outreach focus is on increasing the sustainability of built landscapes through improved landscape establishment and maintenance and improving ornamental plant production practices. She is particularly interested in improving irrigation and fertilizer use.

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Evaluating wood-based biochar in field production of woody ornamentals in Long Island nurseries

by Mina Vescera | Cornell Cooperative Extension - Suffolk County

Suffolk County, New York, located on the East End of Long Island, is home to over 550 agricultural and horticultural producers. Less than 50 miles east of NYC, it's the leading county in New York in total value of horticultural commodities sold. The intensity of agricultural production and the susceptibility of the region's sandy soils to leaching, make the ground and surface waters of Long Island vulnerable to contamination. Producers must adopt best management practices that minimize potential agricultural inputs to waters to ensure the sustainability of Suffolk's agriculture industry. Biochar, a carbon-rich material intended for soil application, is a relatively new product for the ornamental horticulture industry. Its large surface area and high porosity decrease soil bulk density and increase porosity, enhancing water and nutrient retention.

However, understanding of the application and impacts of biochar on nutrient and water retention in field and container nursery crops is limited, with currently no recommended application rates of biochar in ornamental production. This knowledge gap limits larger scale adoption by the nursery industry.

A trial was installed in spring 2019 and will continue through the 2021 growing season. One objective of this on-going trial is to test the impact of three rates of biochar (5, 10, and 15 tons/A) on nutrient availability, soil water retention, and plant response in commercial field production of California privet (Ligustrum ovalifolium) and Douglas fir (Pseudotsuga menziesii). Time Domain Reflectometry (TDR) and soil water potential sensors were installed to record soil moisture levels, along with lysimeters to collect data on soil nitrogen. Foliar sampling and plant health evaluations were conducted to record plant response.

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About Mina Vescera

Mina Vescera is an Extension Educator and Nursery and Landscape Specialist for Cornell Cooperative Extension of Suffolk County. She holds a Bachelor of Science degree in Forestry from the University of Massachusetts at Amherst and a master's in Plant Science from the University of Rhode Island at Kingston. Prior to joining Cornell Cooperative Extension, Mina spent eleven years in Downeast Maine working as an estate gardener on Mount Desert Island and managing her own company, Sundew Gardening Services, specializing in native and organic gardening. She also worked for Acadia National Park as an Interpretive Ranger giving informational nature tours. Mina loves to foster appreciation for plants, and to share her passion for growing and caring for plants.

James Lipscomb and Sons participate in USDA FSA NAP program for their sod operation. They have also received technical and financial assistance from USDA NRCS utilizing the EQIP program to install irrigation. USDA Photo by Preston Keres.

Using alternative irrigation water sources in ornamental crops and urban landscapes

by Dr. Raul I. Cabrera | Rutgers University
Dr. James E. Altland | USDA Agricultural Research Service

Scarcity of, and competition for, good-quality resources is challenging the sustainability of green industry activities (ornamental nursery/greenhouse crops and landscape plantings). The aesthetic demands placed on ornamental crops require the use of good quality water sources, and their non-edible nature puts them at a disadvantage against food crops in scarce and competitive water availability scenarios. The severe seasonal and/or prolonged droughts experienced across the country in recent years, even in those regions with historically high annual precipitation, are also impacting local regulations and ordinances regarding the use of valuable municipal potable water to irrigate residential and public landscapes.

Altogether, this points to the need for the green industry to consider an imminent and significant use of alternative and/or poor-quality irrigation water sources, in addition to reuse of captured runoff and drainage effluents, and the best management practices that can lead to their successful use. These non-traditional sources include stormwater/rainwater, agricultural tailwaters, brackish aquifer water, municipal reclaimed water (MRW), A/C condensates and residential greywater. The successful use of these alternative irrigation sources relies on the characterization of the chemical quality and suitable monitoring of each source, accounting for their spatial, temporal, and management-related variability, and the requirements and/or tolerances of the crops/plantings where they are used.

Common among these non-traditional sources are challenges associated with high concentrations of total soluble salts and undesirable or toxic specific ions (mainly sodium, chloride, boron, bicarbonate-alkalinity) that can significantly, and negatively, reduce the growth and aesthetic quality of plants. In general, woody plants tend to be more susceptible to these chemical properties of irrigation waters, particularly when applied through overhead irrigation systems, whereas ornamental grasses and turfgrass species are among the most tolerant. There are various treatment and management approaches that can reduce the effects of undesirable chemical properties of alternative water sources, including blending with good-quality sources, adoption of the most suitable irrigation systems to each water, and/or modifications to existing ones. In addition, sensible changes can be made over time in the palette of ornamental crops and landscape plant materials being grown (with reduced supplemental irrigation requirements and tolerance to salinity and specific ions).

The use of these alternative water sources is subject to various local, regional and/or federal regulations, most of which are focused on their potential contact and impact on human health. In addition to their effects on horticultural factors (e.g., plant growth, aesthetic quality) and soil physicochemical properties, there are emerging concerns about their impact on soil biological properties, especially in natural ecosystems neighboring the crop/urban areas where they are applied.

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About Dr. Raul I. Cabrera

Raul has a BS in Horticulture from Universidad Agraria “Antonio Narro” (Saltillo, Mexico), and a MS in Plant Physiology and PhD in Plant Biology from the University of California at Davis. He has worked as Assistant Professor and Extension Specialist in Nursery Crops Management at Rutgers University (1994-1999), then as Associate Professor of Ornamental Horticulture with Texas A&M University, and 4 years ago he returned to his old position in Nursery Crop Production at Rutgers University, where he is serving as Associate Professor and Extension Specialist. His areas of expertise and interest in research and extension focus on the applied physiology and management of ornamental crops and plants (floriculture, nursery and landscape), particularly in the topics of nutrition/fertilization) and water/irrigation management.

Kitayama Brothers, Inc. hydroponic greenhouses use micro irrigation with sterile reclaimed water. This is one of the water saving systems the family uses. USDA Photo by Lance Cheung.

Overview of the tree fruit and vineyards session

by Dr. Terence Bradshaw | University of Vermont

Tree fruit and grapes are perennial, deep-rooted crops with unique water needs compared to annual crops. Traditionally, orchards in the northeast were grown on vigorous rootstocks that produced large trees with low tree density per acre. Apple, and to a lesser degree, peach, pear, and other stone fruit orchards, have evolved toward higher tree densities on dwarfing rootstocks which have reshaped the entire architecture of the crops. Where orchards and vineyards were once rarely irrigated in the region, changes in tree form and vineyard planting systems, and greater variation in annual rainfall have led to increased need for irrigation. At the same time, excess moisture events have also increased the need for subsurface drainage systems in orchards and vineyards. The systems used and climate change have led to the paradoxical situation of these perennial crops having issues with both too much and too little water, sometimes in the same season.

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About Dr. Terence Bradshaw

Dr. Terence Bradshaw is a Research Assistant Professor of specialty crops production and the Director of the UVM Fruit Team and the Horticulture Research and Education Center. He has conducted research on organic apple production systems specifically since 2006, and on components of sustainable agroecosystems including cultivar / rootstock evaluation and alternatives to synthetic pesticides for use in organic production since 1995. In 2014, he founded the Catamount Education Farm at UVM, which includes ten acres of vegetable and fruit plots for use in teaching and research programs.

Seasonal water use of apples and grapes

by Dr. Alan N. Lakso | Cornell University

The water balance of an orchard or vineyard in the Northeast (NE) is a complex of weather, soil and plant-related variables that are all integrated by the plant to determine the water use. All of these factors are particularly variable in the NE as our glaciated soils are so complex, the weather, crop types, management and market demands are so variable. Soil water is the buffer to support the crop during droughts. Measuring water use is difficult as an orchard/vineyard is a 3-component system consisting of the crop, cover crops, and open soil. The potential water use by the fruit crop depends strongly on the fraction of available radiation intercepted. This is strongly affected by plant age, stage of development, leaf area and canopy management, all of which varies greatly. The cover crop may use 30-60% of the total water. Unstressed mature apple trees use about 1 acre-inch per week in mid-summer, while grapes can vary from about 0.6 acre-inches per week for narrow wine grape canopies to up to 1.2 acre-inches for Concord grapes.

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About Dr. Alan N. Lakso

Dr. Lakso is a Professor Emeritus at Cornell University in the Horticulture Section. Over 45 years of research on fruit crop physiology, he has focused on the interactions of crop development, environment and cultural practices with experimentation and mechanistic modeling. In retirement, he is continuing several research projects and has co-founded a tech start-up to commercialize an innovative plant drought stress sensor.

The network for environment and weather applications (NEWA) apple irrigation (ET) model

by Jon Clements | University of Massachusetts - Amherst

The Network for Environment and Weather Applications (NEWA) Apple ET/Irrigation Model provides a daily estimate of evapotranspiration, rainfall, and water balance for apple orchards that have a NEWA weather station. In addition to the weather data provided by the NEWA weather station, it expects user input of apple green tip date, tree spacing, and age of orchard (1-4 years or mature). The user can also enter irrigation records (gallons per acre) and adjust rainfall (if, for example, a weather station failure occurs) and recalculate the estimate of water use/balance. This NEWA apple orchard-specific ET model was developed at Cornell University due to inadequacies of the standard grass model (based on the Penman-Monteith equation) because apple tree water use is much more sensitive to temperature and humidity (Dragoni and Lakso, 2011). Therefore, it estimates apple water use as a fraction of the water use of a standard reference grass, but it also adjusts seasonally for relative canopy development and water availability to the root system. The NEWA apple irrigation model is a general model and does not take into account variations in soil characteristics, tree conditions (except for young trees), or cultural practices. In addition to being available on the **NEWA website**, the apple irrigation model is available on the **Malusim app** (iOS and Android) using a NEWA data feed but also providing a mobile interface for current apple orchard water status and assistance with irrigation scheduling.

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About Jon Clements

Jon Clements has been an Extension Tree Fruit Specialist at the University of Massachusetts Amherst for 20 years where he has advised on sustainable production practices of apples, pears, peaches, and cherries including horticulture and pest management. Before that, he was a Michigan State University Berrien County Extension Horticulture Agent, and a research technician at the University of Vermont where he received his M.S. in Plant and Soil Science. Clements is on the Board of Directors of the International Fruit Tree Association and is the Massachusetts State Coordinator for the Network for Environment and Weather Applications (NEWA). He also runs the University of Massachusetts RIMpro Advisory Service, a cloud-based disease and insect management decision support application for apples, pears, peaches, and grapes. He has long been an advocate for user-friendly, decision support applications to help Northeast orchardists make information-based integrated pest and crop management decisions.

Flooded orchard in spring.
Photo by Dr. Terence Bradshaw.

Can we predict wild blueberry plant stress using drones?

by Dr. Lily Calderwood | University of Maine
Dr. Matt Wallhead | University of Maine
Dr. John Zhang | University of Maine

Maine wild blueberry requires an average of 0.5 to 1.0 inches of water per week, yet the well-draining wild blueberry soil varies between production regions and within fields. Given recent advances in technology, it may be possible to identify specific areas of a field or individual plants that exhibit water stress using a drone. The objective of this preliminary study was to compare wild blueberry plant stress using an Unmanned Aerial Vehicle (UAV) drone and ground collected data in irrigated and non-irrigated fields. During the season of 2019, ground measurements and drone flights took place on four dates (peak bloom on June 4, green fruit on July 3, color break on July 25, and pre-harvest on August 14) in Deblois, Maine. Thermal imagery and ground data indicated that the irrigated field was cooler than the non-irrigated field; however, NDVI imagery indicated that healthier plants were in the non-irrigated field. Imagery and index calibration are still underway, yet preliminary results show the wide-ranging potential uses of this technology in quantifying the plant-soil-atmosphere dynamics of wild blueberry.

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About Dr. Lily Calderwood

Dr. Lily Calderwood's is the Wild Blueberry Specialist and an Assistant Professor of Horticulture at the University of Maine. Her research and education program aims to provide whole farm approaches to lowbush (wild) blueberry production. Current projects include organic blueberry fertility and weed management, a lowbush blueberry weed survey, biological control of weeds, pest and crop decision-making tool needs assessments, aging farmer interviews, and the improvement of blueberry quality measures. Her program is focused on connecting farmers to stakeholders through applied research and education.

The flowers of this blueberry plant will become sweet tasting fruit as they mature. USDA photo by Scott Bauer.

Water and soil management for strawberry production

by Nate Nourse | National Clean Plant Network + New England Vegetable Growers Association

Protected, soilless strawberry production solves most issues growers face. In North America, it is now common practice to build fifty acre greenhouse ranges for berry production. The growing techniques and technology used in these ranges are easily adapted to smaller, less sophisticated structures. Protected plasticulture and matted row strawberry production might seem more affordable, but weed and soil issues remain. There is no one size fits all solution to small scale strawberry management. Every grower has their own unique management practices and favorite strawberry varieties. Most have limited water resources and heavy, rocky soils. Because of this, the majority of June bearing strawberry growers in the Northeast are utilizing a matted row system. Consistency and yields have always been highly variable.

30 years ago, European growers realized the matted row system was no longer sustainable. Most adopted plasticulture production that was more intensive, yields doubled and were more consistent. For the last 10 years, European growers have adopted different soilless systems because Phytophthora Root Rot couldn't be easily managed with pesticide application restrictions during the harvest or growing season. Most are moving to either bag- or trough-soilless 'hydroponic' systems with or without protected covers. The most successful systems utilize at least two liters of media per plant. Today, the Netherlands has the highest most productive and efficient growing systems in the world.

Soilless systems are annual plantings of June and Everbearing strawberry varieties. The plants are dormant large crowns and multiple branch 'waiting bed' plants. They produce 1-2 pounds per plant in the growing season. The soilless mix is replaced every three years. The everbearing varieties grow the entire growing season. The June bearing are planted every two weeks to have continuous production for twelve to twenty weeks.

Any area can be used in a soilless system, and growers can expect higher yields on a minimal footprint. There is immediate organic potential because the typical wait period on certifying organic fields is avoided. There are low tech options for soilless growing. This approach eliminates weeding and the need for mulch. It also allows for programmed harvest and maximum season extension. Winter hardiness is a non-issue, and ther berry crops are equally successful in this system. The maximum nitrogen requirement is 60ppm per day. A reliable water source is required, as this system uses 20-25% more water than field grown approaches. The maximum daily water requirement is 0.13-0.18 gallons per plant per day.

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About Nate Nourse

Nate Nourse was formerly the Berry Production Specialist and Sales Director at Nourse Farms, and is a founding member and current Chairman National Clean Plant Network, Tier II Berries. He serves as an Executive Board Member New England Vegetable Growers Association, and is the past President of the North American Strawberry Growers Association. He is also the past President North American Raspberry Blackberry Growers Association and a founding Executive Board Member National Berry Crops Initiative, and a council member of the United Fresh Produce Association Government Relations.

Day-neutral starwberries with black plastic mulch at a University of New Hampshire research farm. Photo by USDA Northeast Climate Hub.

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Automated irrigation based on soil moisture monitoring in blueberry production

by Ben Waterman | Waterman Orchards

Northern highbush blueberry plants have shallow, sparsely-developed root systems, making plants relatively vulnerable to drought stress. Keeping plants sufficiently watered is critical for sustained production of quality fruit. Extension recommendations advise blueberry growers to be prepared to apply up to 4" of irrigation water per week. That is a lot! Yet with that amount of watering, there is potential to overwater, causing a host of other problems. Several of our blueberry fields are on very sandy soils, making it especially challenging to irrigate without over or under watering. Too dry conditions cause bushes to become stunted from drought stress, but too wet conditions cause leaching of soluble nitrogen, which is a precious commodity in organic production. Both unwanted scenarios produce inferior fruit. To address these issues and find the "drip irrigation sweet spot", in 2017 in partnership with USDA NRCS, we installed an automated drip irrigation system using tensiometers with electrical switches on their gauges (Irrometer brand), wired to solenoid valves (Galcon brand) with "rain sensing circuits" that control opening or shutting based on soil moisture status. We have not quantified the benefit, but can say that the system has been a total game-changer for our operation. It has saved significant time (compared to manually operating valves based on guessing soil moisture content), saved money (theoretically from eliminating fertilizer nitrogen losses), and improved our berry quality and marketable yields (berries from this field have since become bodacious!). Additionally, we have the peace of mind that we are producing as good environmental stewards.

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About Ben Waterman

Ben and Stacey Waterman met while they were studying soil science and agronomy at the University of Maryland. Their mentor was sustainable agriculture guru Dr. Ray Weil, a co-author of the Nature and Properties of Soils, a comprehensive soil science text used in universities throughout the country. The Watermans served together in the U.S. Peace Corps in Malawi, where they learned the language of Chitumbuka, and volunteered as national parks, forestry and agricultural extension agents. Shortly after returning from Malawi, the Watermans bought the farm, where they built an off-the-grid homestead. They established Waterman Orchards, initially "Waterman's Berry Farm" in 2009.

The impact of water on disease pressure

by Dr. Alicyn Smart | University of Maine

Fluctuations in rainfall intensity and quantity throughout the growing season can influence disease pressure on field crops. High moisture levels can result in an increase in root pathogens called water molds, which rely on water to disseminate. Too much water can also cause abiotic diseases, which in some cases can result in loss of yield. Fungi and bacteria both require specific levels of moisture and relative humidity for them to cause disease and to multiply. With more moisture, there is more disease pressure from both these types of pathogens.

In contrast, during periods of drought, there is a reduction of water molds, bacteria and fungal diseases in general. It is also common during droughts to have plants recover from fungal diseases, which are caused initially by too much moisture. Although prolonged periods of drought can also cause the plant to become stressed. Come learn how water might influence your plants in ways you may never have thought of!

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About Dr. Alicyn Smart

Dr. Alicyn Smart is an Assistant Extension Professor and Director of the Plant Disease Diagnostic Laboratory at the University of Maine. Alicyn addresses 1,000 inquiries that come through the lab each year pertaining to plant diseases. Her research is on Verticillium wilt on strawberries and potatoes. She is specifically looking at improving disease identification and distribution across Maine. She is also performing research comparing biological fumigant management to synthetic fumigants management in potato production.

Grapes and apples: Factors affecting water use, performance and quality

by Dr. Alan N. Lakso | Cornell University

Water use models used in arid climates estimate water use include a reference evapotranspiration rate (ETo) derived from a grass crop. These models then assume another crop is a consistent fraction, or crop coefficient (Kc), of the ETo regardless of climate. This approach was found not to be accurate for apples in the north-eastern climate as the ETo calculation is driven by radiation and is almost insensitive to humidity. When the weather is hot and dry, the Kc of the trees was similar to arid climates, but when it is cool and humid, the KC may be 50% lower. Based on direct measurements and unique stomatal behavior of apples, we developed an apple-specific water use model that is available online at Cornell. For grapes, highly productive native variety vineyards intercept a lot of radiation and use a large amount of water, while lower-yielding wine grapes can and ideally need less water. White wine varieties are best with more water while red varieties require some regulated stress.

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Please see **page 33** for Dr. Alan N. Lakso's bio.

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Modifying microclimates using trees and shrubs: Enhancing specialty crop water use through agroforestry applications

by Kate MacFarland | USDA National Agroforestry Center

Research on how agroforestry practices influence specialty crop water use has largely focused on regions that are drier and more windblown than the northeast United States. However, there are opportunities to borrow agroforestry practice designs and research results to meet the increasing water challenges that specialty crop farmers face in the northeast, while also using agroforestry to provide other benefits such as reducing other climate risks and diversifying income streams.

While the northeast is likely to maintain water supplies sufficient for agriculture, much of the region lacks infrastructure for water supply and delivery. Developing "green infrastructure" approaches with trees and shrubs can complement other efforts to develop irrigation systems, ponds, and other water management infrastructure. Agroforestry, defined as the intentional integration of trees and shrubs into crop and animal farming systems, can be designed to enhance water use efficiency and irrigation efficiency. This improvement comes through changing microclimates to increase humidity, reduce evapotranspiration, reduce soil moisture evaporation, and increase water infiltration.

Agroforestry practices can be designed to be multifunctional, providing these water use benefits while also providing other benefits to specialty crop producers such as enhanced pollination, increased crop yield and quality, and improved soil health, making the investment of money and space in trees and shrubs more profitable. For example, yield increases in the sheltered zone of a windbreak are found within 10 times the tree height. Within this sheltered zone, the average yield increases of vegetable and specialty crops ranges from about 5% to approximately 50%. For diversified growers, these practices may prove particularly beneficial when designed to include tree and shrub species that provide additional crops, such as fruits, nuts, or wood products.

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About Kate MacFarland

Kate MacFarland is the Assistant Agroforester for the USDA National Agroforestry Center (NAC). She is part of the outreach and education team at NAC, serving as the liaison to the Northeastern, Mid-Atlantic, and Northwestern regions. She provides leadership for national and regional workshops and trainings, develops outreach materials for science delivery to a range of technical and general audiences, and supports the integration of agroforestry into USDA programs. Kate is also involved with NAC's human dimensions research.

A windbreak protecting an okra and brassica crop.
USDA National Agroforestry Center photo by Richard Straight.

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Improving water use efficiency practices and technology in vegetable systems

by Dr. Joshua Faulkner | University of Vermont's Center for Sustainable Agriculture
Dr. Rachel E. Schattman | University of Maine

Climate change is expected to lead to increased water withdrawals for irrigation in Northeastern agriculture and increase the need for efficient irrigation systems among vegetable producers in the Northeast. Other factors will also contribute to the need to use water more efficiently, including unreliable sources and nascent regulatory concerns. Anecdotal observations by agricultural service providers working in the vegetable sector in Vermont indicate that there is generally little known about how much water is used for irrigation, how efficiently that water is used, and what tools are available to improve management.

To further investigate these concerns, flow meters were installed on irrigation systems on several vegetable farms in Vermont during the 2018 and 2019 growing seasons. Water usage data was collected on a weekly basis, along with evapotranspiration and precipitation. Weekly water balances indicated that water usage related to crop demand was highly variable throughout the season and amongst high tunnels and outdoor production areas. Soil moisture sensor networks from three manufacturers were also trialed on the same farms. Farmer feedback and researcher observations included a perceived high-cost of equipment for all systems, variation in reliability amongst systems, and a need to devote labor resources to learning and managing the technology. Technology for improving water use efficiency is available, but our experiences have indicated that additional education and outreach, and possible improvements in technology usability and associated costs, may be necessary to increase farmer adoption in the Northeast.

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About Dr. Joshua Faulkner

Dr. Joshua Faulkner is a Research Assistant Professor for University of Vermont Extension. He has coordinated the Farming and Climate Change Program in UVM Extension's Center for Sustainable Agriculture for the past six years. He conducts applied research, outreach, and education on soil, water, and nutrient related issues across the state and region. He also works with farmers on practices and innovative solutions to improve the management of these resources and enhance farm resilience to climate change. His focus spans across all agricultural sectors, and from the farmstead to the watershed scale.

Please see **page 26** for Dr. Rachel E. Schattman's bio.

Irrigation pipes ready to be installed at the Intervale Community Farm in Burlington VT. Photo by Dr. Rachle E. Schattman.

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Technology for improved water use efficiency

by Dr. Mandy Bayer | University of Massachusetts - Amherst

Water use efficiency in physiological terms is the ratio of water used in plant metabolism to water lost by the plant through transpiration. In terms of irrigation it is the ratio of water applied via irrigation available to the plant to the amount of water applied. Improved irrigation application techniques such as drip or cyclic irrigation can improve irrigation efficiency; however, technology can allow for irrigation decisions to be based on data. Soil moisture sensors are used to monitor the water availability in soils or substrates. These sensors can be further used to automate irrigation based on soil or substrate water content and a programmed water content threshold at which irrigation occurs. Soil moisture sensors can be used along with a weather station that monitors environmental conditions so irrigation volumes and thresholds can be based on changing plant needs due to growth and environmental conditions. Applying irrigation more effectively also allows for reduced fertilizer applications because the fertilizers are not leached away from the plant. This data can also be used to control plant growth and production timing. There is also the potential for reduced irrigation during production to aid plants during landscape establishment and in the retail setting.

Infrared temperature meters allow growers and landscapers to monitor plant health by measuring leaf or soil temperature. Normalized difference vegetation index (NDVI) is another method in which plant stress can be monitored based on light reflection. NDVI is the ratio between the difference and the sum of the reflected radiations in the near infrared and in the red wavelengths. Drones can be used along with NDVI and infrared sensors for large scale plant stress monitoring. Surfactants, wetting agents, and hydrogels are used to improve soil or substrate wetting and/or to improve water retention. Irregular wetting of soils or substrates can be problematic due to channeling and dry spots. Wetting agents and surfactants help to alleviate soil water repellency and to make irrigation applications more even throughout the soil or substrate. Hydrogels are polymers that are grouped in two classes: soluble and insoluble. The insoluble forms absorb water and swell. As the soil dries water is released from the polymers. The effectiveness of these products can be variable. Current research is looking at the effectiveness and impact on plant grown for different substrates, different polymers, and the effect of plant nutrition.

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Please see **page 27** for Dr. Mandy Bayer's bio.

Water management in the Northeast - Perspectives over 40 year and a look forward

by Dr. Alan N. Lakso | Cornell University

Based on 40 years of research on fruit crop physiology supporting fruit production, several conclusions have been reached. A narrow focus of research limits the possible explanations of complex phenomena; for example an apple-specific evapotranspiration (ET) model was only possible by studying carbon as well as water relations. High value fruit crops allow growers to manipulate water use and crop stress instead of relying only on genetics. Root systems of fruit crops in humid climates are large but erratic so soil moisture is often a poor measure of plant water stress. Instead of managing soil moisture, it is preferable to optimally manage crop stress. A major limit to growers' ability to manage stress is the lack of modern methods to measure plant stress in the field. The currently used pressure chamber is a good measure, but it is manual, slow, requires technical labor, and gives very limited data. At Cornell we have developed a microtensiometer chip that can be embedded in the trunk of trees and vines to monitor continuously and wirelessly the stem water potential. This new sensor opens the possibility to much more precisely know and manage crop water status, especially integrated with SPAC models that integrate weather and soil data with remotely sensed data.

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Please see **page 33** for Dr. Alan N. Lakso's bio.

VIEW MY SLIDES

FSMA: Irrigation and produce safety update

by Chris Callahan | University of Vermont

The Food Safety Modernization Act (FSMA) represents the most significant overhaul of food safety regulation in four decades. The act authorized the Food and Drug Administration to develop seven rules related to food safety. One of these is the Produce Safety Rule (FSMA Final Produce Safety Rule: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption. 21 CFR Parts 11, 16, and 112.) This regulation incorporates a series of preventive measures into the production of raw agricultural commodities. Not all farms are covered and not all crops are covered. For example, farms below a certain level of overall food sales or with a majority of sales to certain end users are considered “qualified exempt.” Crops that are either rarely eaten raw or which are destined for a process that involves a “kill step” are not covered.

For those crops and farms that are covered by the rule, the sources and uses of water are both critical produce safety elements. Water is an important part of specialty crop production, and it is also an important factor in the survival and growth of the human pathogens that we aim to control. Water sources and applications have been noted in some of the investigations associated with prior foodborne pathogen outbreak investigations.

In the context of FSMA, water is considered as either pre-harvest agricultural water (irrigation, spraying, dust control, hand-washing at field, etc.), or post harvest agricultural water (washing, ice, hand-washing in packing house, etc.), and the requirements differ. The requirements for agricultural water as originally published in the final rule are under review, compliance dates have been extended, and, in practice, enforcement officials (FDA and/or state inspectors) are currently provided “enforcement discretion.” However, the general nature of the requirements use generic E. coli as an indicator contaminant and aim for a statistical mean and variation threshold in pre-harvest agricultural water while requiring zero in a 100 mL sample of post-harvest agricultural water. In this session we will discuss the current requirements under FSMA, how this impacts the use of water on Northeast specialty crop farms, co-management opportunities, and future trends.

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About Chris Callahan

Chris Callahan is the Associate Extension Professor of Agricultural Engineering at the University of Vermont. His work focuses on the application of the engineering practice to food systems. Specific engagement is with food producers, processors, and distributors to improve efficiency, quality, safety, and cost control through the integration of technology, systems integration, and process controls. Research and educational programming includes covered growing systems (e.g. greenhouses, high-tunnels), postharvest practices and storage (e.g. water management, environmental control, drying systems, humidification systems, refrigeration systems), energy use in the food system (e.g. farm-based biofuels, renewable energy systems, energy efficiency measures), and development of specialized harvest and postharvest equipment (e.g. hops harvesting, hops drying, meat curing). This work has led to a number of technical innovations that are either in application for patent or have been made available as open-source for public adoption.

Irrigation pond at apple orchard.
Photo by Dr. Terence Bradshaw.

VIEW MY SLIDES

Low cost data logger system for on-farm research

by Dr. Harry Schomberg | USDA Agricultural Research Service
Scott Anderson | Acclima

Arduino was designed as a low-cost microcontroller development board for prototyping internet of things (IOT) projects. We developed an Arduino-based microcontroller wireless network data logging system for on-farm collection of soil water data. The microcontroller boards included embedded LoRa® radio transceivers for data communication that facilitated communicating data between nodes (data logger) and a gateway (data hub). A cellular module on the gateway allowed transferring data to a web host server. A web-based application provided researchers near real-time access to data through a visualization dashboard. Farmers were also provided direct access to their data via the web. This low-cost system DIY approach provided an economical method for collecting data from multiple sites. Beginning in 2018, working with Acclima, an improved version of the system was developed and tested in summer of 2019. These units incorporated improved electronics and an enclosure with a surface mount solar panel. Additional improvements continue to be made and Acclima plans to have a commercial version available in late 2020

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About Dr. Harry Schomberg

Dr. Harry Schomberg is a Research Ecologist in the Sustainable Agricultural Systems Laboratory at the USDA ARS Beltsville Research Center in Maryland. His current research focuses on understanding and improving nutrient and water use in agronomic cropping systems. As a member of a team conducting on-farm research to increase cover crop utilization, he led development of a low-cost data logging system for continuously monitoring soil water content based on the Arduino electronic prototyping platform. His past research activities have focused on improving conservation cropping systems, crop residue management, nutrient management and understanding and modeling crop residue decomposition and N mineralization.

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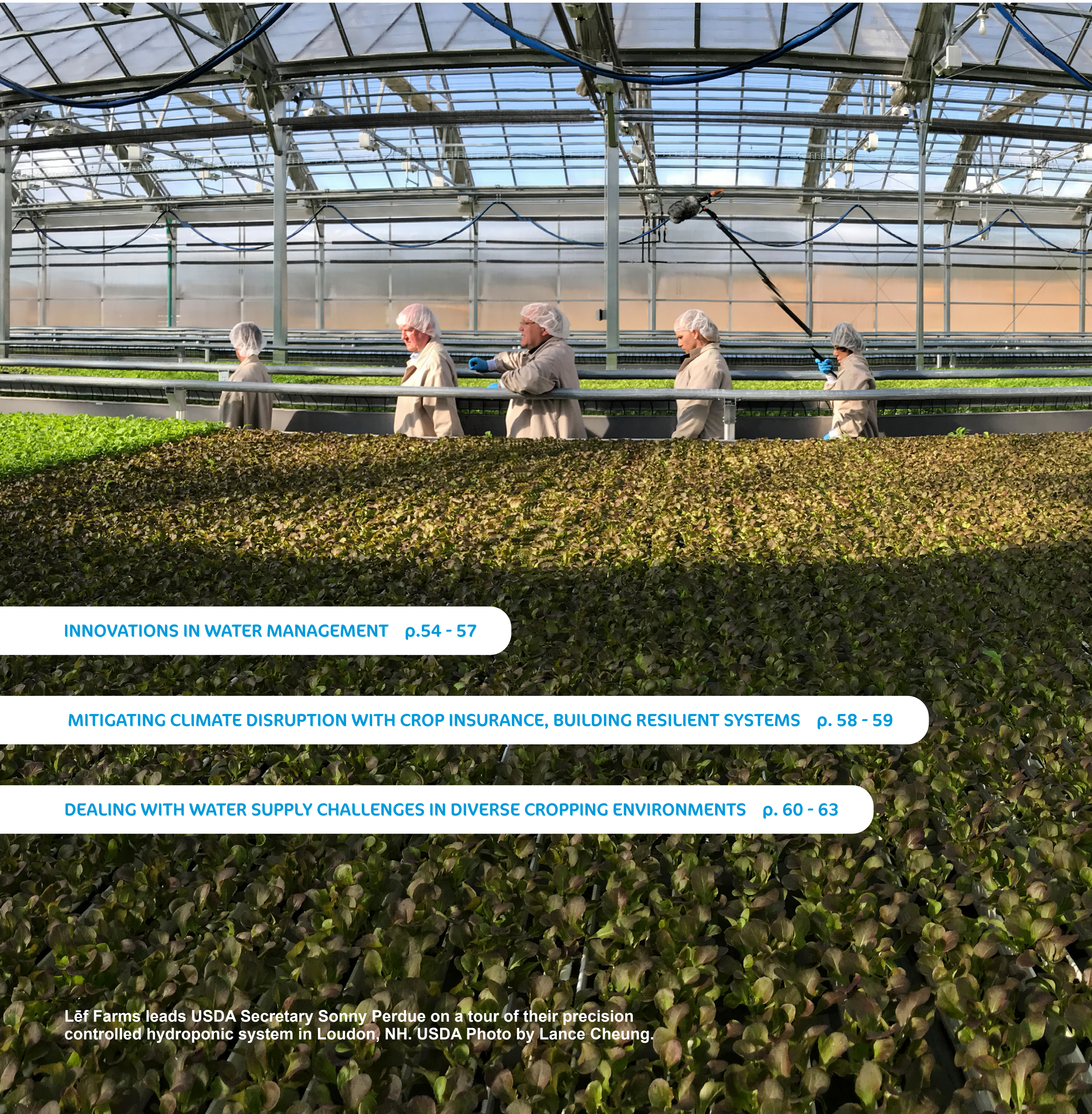
About Scott Anderson

Scott Anderson began his electrical engineering career as a product development engineer at the Microwave Division of HP in Palo Alto in 1967. As HP expanded its operations he wound up at Disc Memory Division in Boise where he became the R&D manager for the division. In moving to Idaho he purchased a 6 acre horse pasture on the Boise River near Meridian where he built a home for his family, planted a 100+ tree mixed orchard, cleared a large garden plot and bought a Jersey cow. Six of his seven sons became engineers after having the experience of early morning cow milking. The seventh son became an accountant after learning how to catch a few trout while the milker was running. Four daughters also learned how to provide the family with dairy products and fruit. In 1995 he retired from HP and began doing research on how to control irrigation in his diverse crops of peaches, raspberries, black currants, vegetables, grapes, pastures, etc. This study led to the development of several patents in Time Domain-based soil moisture sensing and the founding of Acclima, Inc. Now, in his 80th year, Scott is the full-time president of Acclima and also runs the orchard, garden and cow milking. He and his wife Diane preside over a family of more than 100 souls.

Apples growing at Apex Farm orchards in Shelburne, MA.
USDA Photo by Lance Cheung.

BREAK-OUT SESSION 2



Lēf Farms leads USDA Secretary Sonny Perdue on a tour of their precision controlled hydroponic system in Loudon, NH. USDA Photo by Lance Cheung.

IoT-based precision irrigation systems for specialty crops

by Dr. Long He | Pennsylvania State University - Fruit Research and Extension Center

Irrigation helps grow agricultural crops in dry areas and during periods of inadequate rainfall. Proper irrigation could improve both crop productivity and produce quality. Until today, most irrigation for tree fruit and vegetable crops has been applied based on grower experience or simple observations, which may lead to over-irrigation or the ineffective under-irrigation. The decision making for properly timed irrigation at proper timing for appropriate periods is critical. An internet of things (IoT) based irrigation system was developed for applying water to the crops. In the system, water content sensors and water potential sensors were used to monitor soil water status. Solenoid valves were used to control when irrigation water was turned on/off. Lora (Long Range) technology was used for wireless communication for the IoT system. The outcomes from this study provided guiding information for a new automated irrigation system with precision scheduling.

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About Dr. Long He

Dr. Long He is an Assistant Professor and Extension Specialist at the Fruit Research and Extension Center at Pennsylvania State University. He has 10 years of experience with agricultural mechanization and automation for specialty crop production. He received his Ph.D. degree in Mechatronics Engineering at Yanshan University in China. His current research interests include agricultural automation and precision agriculture, and he has been working on a variety of related projects including robotic hop twining, mechanical apple and cherry harvesting, robotic apple bin handling during harvesting, robotic fruit tree branch pruning, precision irrigation for specialty crops, and mechanical mushroom harvesting.

VIEW MY SLIDES

A novel shallow well technology to provide sustainable and economical water supply for agricultural and domestic use

by Joseph Ayotte | U.S. Geological Survey New England Water Science Center

In northern New England, about 40 percent of the population uses private domestic groundwater wells that draw primarily from bedrock aquifers. Small-scale farm irrigation often uses surface water or groundwater from bedrock aquifers. Geologic-source arsenic is common in bedrock-aquifer groundwater, but groundwater in shallow glacial-deposit aquifers that overlie bedrock has little or no arsenic. Glacial-deposit aquifers have been under-used for decades because they are perceived to be low-yield and susceptible to bacteriological and chemical contamination.

A new U.S. Geological Survey (USGS) shallow well design could mitigate concerns about using glacial-deposit aquifers and provide safe, reliable irrigation and drinking water across New England. The well design incorporates drought resiliency through the combined effects of a large inflow area and in-well storage. The well has a vertical riser with slotted horizontal collectors that extend outward from the bottom of the riser, all within an excavation backfilled with crushed stone. A geotextile fabric and native fill material overlie the crushed stone to filter out potential contamination from vertical recharge. In 2018, the USGS completed sampling for a study using the new well design at two sites in northern New England—one for a maple sugar producer and one for domestic supply. Both wells were monitored continuously for water level and sampled bi-monthly for a total of six sampling rounds for water quality, including major ions, trace metals, nutrients, and bacteria. Results clearly indicated that properly sited and installed wells, using the novel design, performed well. Potential applications for farm irrigation and domestic supply will be presented.

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About Joseph Ayotte

Joe Ayotte is a supervisory hydrologist with the U.S. Geological Survey New England Water Science Center and Chief of the Groundwater Quality Assessment Section in New England, where he oversees multidisciplinary studies involving groundwater quality. Most recently, he has worked on national and regional studies of trace elements (primarily arsenic) in groundwater and has worked closely with the National Institutes of Health, National Cancer Institute and the Centers for Disease Control and Prevention on arsenic in drinking water supplies. He received his B.S. in Hydrology from the University of New Hampshire. He joined the USGS in 1987 and has been involved in many studies of groundwater and surface water resources in New England and the U.S.

The largest fresh waterbody in Rhode Island, the Scituate Reservoir is the source of Providence Water's supply. Photo by USDA Northeast Climate Hub.

Using soil moisture sensors to inform irrigation decisions

by Jeremy DeLisle | University of New Hampshire Cooperative Extension

This presentation provided an overview of the New Hampshire-based soil moisture monitoring project on several farms during the 2018-2019 growing seasons. Lessons learned, grower feedback, and future research needs were discussed.

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About Jeremy DeLisle

Jeremy DeLisle is a Field Specialist for UNH Cooperative Extension on the Fruit and Vegetable Team. His primary responsibilities are to coordinate and deliver educational programming and provide individual consultations for commercial fruit and vegetable producers in New Hampshire. He is also a member of the Pesticide Safety Education Program team. Prior to joining UNH Extension, Jeremy worked as a County Agricultural Agent for the NC Cooperative Extension Service from 2004 to 2014. His programs there focused primarily on fruit and vegetable production, food safety and the development of local food distribution systems. He attended North Carolina State University, where he earned degrees in Horticulture and Agricultural Education.

VIEW MY SLIDES

Whole Farm Revenue Protection as a climate risk management tool

by Jeff Schahczenski | National Center for Appropriate Technology

This panel explored how crop insurance can or cannot help with protecting against the likely adverse impact of climate disruption in the Northeast. Participants also learned about the role of federally-subsidized insurance in promoting climate-friendly practices and the opportunities and barriers for Northeast farmers. In particular, the Whole Farm Revenue Protection (WFRP) policy was discussed. WFRP is intended to provide revenue protection and also support more resilient diverse crop and livestock systems. Panel presenters discussed what has been the good, bad and ugly in terms of the federal subsidized crop insurance program in encouraging conservation practices for adaptation to climate disruption and mitigating climate risks.

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About Jeff Schahczenski

Jeff Schahczenski is an agricultural and natural resource economist with the National Center for Appropriate Technology (NCAT). He has worked on the whole farm revenue approach to crop for 14 years. He is the lead author of NCAT publications on climate disruption and sustainable agriculture. He helped develop and implement a National Institute for Food and Agriculture (NIFA), Organic Research and Extension Initiative project entitled, Is Organic Farming Risky?: Overcoming and Understanding Crop Insurance Barriers to Expanding Organic Food Production and Markets. A free copy of the **2019 final report** is available.

VIEW MY SLIDES

The use of crop insurance for climate resilience on vegetable and fruit farms in the Northeast: Insights from the New England Adaptation Survey

by Alissa White | University of Vermont

Results of the **New England Adaptation Survey** indicate a very low level of crop insurance use among diversified vegetable and fruit producers in the Northeast. In our listening tour, farmers described financial safety nets like crop insurance as a part of a holistic approach to financial resilience. Farmers described relying on other assets, social networks and emergency funds to help them recover from large climate impacts. Primary barriers to enrollment cited by farmers include burdensome paperwork, the complexity of their farm system, cost, and perceived eligibility requirements.

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About Alissa White

Alissa White is a researcher and PhD student in the Department of Plant and Soil Science at the University of Vermont. Alissa works closely with extension and applied research projects to engage farmers in research on climate resilience and ecosystem services in Vermont and the northeastern US. Her research integrates social, economic and ecological data, and highlights the role of peer learning in supporting innovation and adaptation in agricultural communities. Alissa brings fifteen years of experience working on program development, grassroots fundraising, education and horticulture to her work for UVM.

VIEW MY SLIDES

Micro-irrigation system design using NRCS methods

by Les Wright | USDA Natural Resources Conservation Service

In 2008, Vermont NRCS began providing technical assistance in the design, installation, and management of micro-irrigation systems. Local staff had limited experience in the field. As we learned more about the subject, we realized that the design methods used nationally were complicated and inadequate for the way crops are managed in Vermont. We needed to develop our own procedure to evaluate a farm, estimate the water requirements, and determine if an irrigation system would be feasible. We needed to expedite the design process and make it simple for smaller scale portable systems. We needed to create a template for writing an irrigation water management plan that would provide straightforward guidance on the operation of the system. This presentation will show the procedure we developed and highlight some considerations originally overlooked in the design of micro-irrigation systems.

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About Les Wright

Les Wright, PE is a civil engineer with the Natural Resources Conservation Service in Rutland, Vermont where he works with agricultural producers to design and install various conservation practices ranging from animal waste management systems to streambank stabilization projects. Since 2012, Les has led Vermont NRCS's efforts to assist with irrigation and has developed the implementation procedures. Les has worked for NRCS in Rutland since 2005. Prior to that he worked for NRCS in Highland, NY beginning in 2003. Les graduated from Texas A&M University with a bachelor's degree in agricultural engineering in 2003.

VIEW MY SLIDES

Dealing with saltwater intrusion: A growing problem

by Chris Miller | USDA Natural Resources Conservation Service

The issue of saltwater intrusion on the East Coast due to rising sea levels and coastal flooding has become increasingly problematic for some agricultural producers. Managing the impact of saltwater intrusion into groundwater (affecting both irrigation water quality and crop fields from overland flooding) will require producers to use more adaptive agricultural practices. This presentation shared how saltwater changes soil chemistry and what amendments and field management techniques may be used to mitigate the problem for the short-term, and what adaptive management practices may be employed to address the saltwater problem for the longer term. This may involve altering crop selection, changing cropping rotations, and/or establishing various conservation practices and best management practices to provide a buffer for additional crop field protection.

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About Chris Miller

Chris has been the Manager of the NRCS Cape May Plant Materials Center for 12 years. In 2019, he was the NRCS Project Liaison to the USDA Northeast and Southeast Climate Hubs. Prior to that, he served for 18 years as an NRCS Plant Materials Specialist for the Northeastern and Mid-Atlantic states. He has provided guidance to State technical specialists and field office/Conservation District staff on techniques and plant selection for many NRCS conservation practices, including conservation cover, riparian buffers, wetland restoration and native grass plantings. In addition, he has worked with many agencies on stabilizing disturbed and eroding areas such as dunes, tidal shorelines, streambanks, and mined areas. Chris has a B.S Degree in Agronomy from Pennsylvania State University and a M.S. in Plant Science from the South Dakota State University.

VIEW MY SLIDES

The Dry Farming Collaborative: Participatory climate adaptation research

by Amy Garrett | Oregon State University Extension

Farmers in the Western United States are becoming increasingly impacted by climate change through reduced snowmelt, increased temperatures, drought, and reductions in summer irrigation availability. It is becoming critical for the viability of farms in our region and the security of our food system, to increase our knowledge and awareness of drought mitigation tools and develop strategies for farming with little or no irrigation.

The OSU Dry Farming Project began in 2013 with case studies, demonstrations, and field days in Western Oregon. Interest in dry farming vegetables has grown significantly since the drought in 2015. For example, since 2016 more than 45 growers in the Dry Farming Collaborative (DFC) throughout Western Oregon and Washington have experimented with dry farming, hosted trials on their farm, and shared information with one another about their methods, experience, and results.

The DFC is a group of farmers, extension educators, plant breeders, and agricultural professionals partnering to increase knowledge and awareness of dry farming management practices with a hands-on participatory approach. The Oregon State University Extension Service Dry Farming Project is supporting the DFC by:

1. Facilitating networking and communication via the DFC Facebook Group (800+ members), email list (200+ subscribers), and annual meeting.
2. Coordinating and hosting trials, demonstrations, and field days at multiple DFC sites.
3. Developing educational materials (extension publications, videos, resource hub on OSU Small Farms website) to help growers new to the project understand the basics of dry farming.
4. Developing tools and resources for participatory climate adaptation research.

Sharing models and examples of participatory climate adaptation research could help inspire other projects out of the planning phase and into action. A working template of the collaborative approach and tools developed for this project could be used and modified for other projects in our region and beyond.

Please see **page 16** for Amy Garrett's bio.

VIEW MY SLIDES

Weather data for water use optimization for crop water needs

by Glen Koehler | University of Maine Cooperative Extension

Recent developments have improved the spatial and temporal resolution of the real-time, gridded weather databases produced by the National Oceanic and Atmospheric Association (NOAA). The AgEye Weather system delivers weather forecast and observation measurements with spatial resolution at 1.5 miles, with hourly time steps, twice a day. Four times a day updates are technically possible, but not currently operational. AgEye reports contain the latest forecast along with observations updated through the previous day. These data files can be viewed as text files, and also ingested into Excel or other software for analysis and translation into decision support model output. Near real-time monitoring and prediction of air and soil temperature, precipitation, relative humidity, solar energy, evapotranspiration and other variables allows for planning to meet upcoming agricultural water needs and to estimate current soil moisture status for sites without direct monitoring.

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About Glen Koehler

Glen Koehler has directed the University of Maine Cooperative Extension Tree Fruit Integrated Pest Management (IPM) Program since 1988. He served for 10 years as coordinating editor of the New England Tree Fruit Management Guide. Recognizing the critical impact of weather on orchard management decisions, for the past 23 years he has developed and operated Ag-Radar, an automated online system that translates observed and forecast hourly weather into apple pest and horticultural risk assessments and management advisories. Recently he became co-founder of AgEye Weather, a provider of high-resolution, real-time hourly weather data from the NOAA forecast and observation gridded weather databases used as the foundation for weather reports in the United States. Koehler added climate change coverage to his Extension work in 2012, developing presentations for tree fruit growers and the public. In 2015, he helped establish the UMaine Climate and Agriculture Network.

Apple orchard in Fall.
Photo by Dr. Terence Bradshaw..

Day 1 | December 18, 2019

SETTING THE STAGE: AGRICULTURAL WATER MANAGEMENT IN THE NORTHEAST

8:30-10:15 PM	Water water everywhere and not a drop to drink: Trends, impacts and adaptation tools for Northeast Specialty Crops	Dr. Art DeGaetano	P. 9
	Drought in the Northeast: Planning towards Early Warning with the NIDIS Program	Ellen Mecray	P. 10
	Overview of agricultural water resources in the Northeast	Cheryl Dieter	P. 11
	Environmental and regulatory concerns related to water use in the Northeast	Dr. Meredith Niles	P. 13

STATE OF SPECIALTY CROPS AND RELATED WATER RESOURCES ACROSS THE U.S.

10:30-12:00 PM	Reports from the Midwest	Dr. Dennis Todey	P. 14
	State of specialty crops and related water resources from the Southwest and California	Dr. Doug Parker	P. 15
	Reports from the Southeast	Dr. Sandra Guzman	N/A
	Reports from the Northwest	Amy Garrett	P. 16
	Synthesis	Dr. Terence Bradshaw	N/A

KEYNOTE SPEAKER - WORKING LUNCH

	The California water system	Dr. Doug Parker	P. 6

BREAK-OUT SESSION 1

VEGETABLES - FACILITATED BY DR. VERN GRUBINGER

1:00-2:00 PM	A whirlwind tour of vegetable irrigation systems on Northeast farms	Dr. Vern Grubinger	P. 18
	The Intervale Community Farm's approach to irrigation management	Silas Branson	P. 20
	An economic case study of irrigation on the Intervale Community Farm	Lynn G. Knight Suzy Hodgson	P. 22
	On-farm irrigation monitoring and initial results from a controlled irrigation trial in Burlington, Vermont	Dr. Rachel E. Schattman	P. 25

ORNAMENTAL HORTICULTURE AND TURF - FACILITATED BY DR. JOSHUA FAULKNER

1:00-2:00 PM	Overview of the session	Dr. Joshua Faulkner	N/A
	Landscape management for improved water conservation	Dr. Mandy Bayer	P. 27
	Evaluating wood-based biochar in field production of woody ornamentals in Long Island nurseries	Mina Vescera	P. 28
	Using alternative irrigation water sources in ornamental crops and urban landscapes	Dr. Raul Cabrera	P. 30

TREE FRUIT AND VINEYARDS - FACILITATED BY DR. TERENCE BRADSHAW			
1:00-2:00 PM	Overview of the tree fruit and vineyards session	Dr. Terence Bradshaw	P. 32
	Seasonal water use needs of apples and grapes	Dr. Alan Lakso	P. 33
	The network for environment and weather applications (NEWA) apple irrigation (ET) model	Jon Clements	P. 34
SMALL FRUIT - FACILITATED BY DR. LILY CALDERWOOD			
1:00-2:00 PM	Can we predict wild blueberry plant stress using drones?	Dr. Lily Calderwood	P. 36
	Water and soil management for strawberry production	Nate Nourse	P. 38
	Automated irrigation based on soil moisture monitoring in blueberry production	Ben Waterman	P. 40
	The impact of water on disease pressure	Dr. Alicyn Smart	P. 41
FOCUS ON IMPROVED WATER USE EFFICIENCY PRACTICES AND TECHNOLOGY			
2:45-4:00 PM	Grapes and apples: Factors affecting water use, performance and quality	Dr. Alan Lakso	P. 42
	Modifying microclimates using trees and shrubs: Enhancing specialty crop water use through agroforestry applications	Kate MacFarland	P. 43
	Improving water use efficiency practices and technology in vegetable systems	Dr. Joshua Faulkner	P. 45
	Technology for improved water use efficiency	Dr. Mandy Bayer	P. 47
	Q&A	All Panelists	N/A
TRADE SHOW AND POSTER SESSION			
Day 2 | December 19, 2019			
REGIONAL ISSUES IN SPECIALTY CROP WATER MANAGEMENT			
8:30-10:15 AM	Welcome	Tom Berry - Office of U.S. Senator Patrick Leahy	N/A
	Water management in the Northeast - Perspectives over 40 year and a look forward	Dr. Alan Lakso	P. 48
	FSMA: Irrigation and produce safety update	Chris Callahan	P. 49
	Low cost data logger system for on-farm research	Dr. Harry Schomberg Scott Anderson	P. 51
BREAK-OUT SESSION 2			

INNOVATIONS IN WATER MANAGEMENT			
10:30-12:00 PM	IoT-based precision irrigation systems for specialty crops	Dr. Long He	P. 54
	A novel shallow well technology to provide sustainable and economical water supply for agricultural and domestic use	Joseph Ayotte	P. 55
	Using soil moisture sensors to inform irrigation decisions	Jeremy DeLisle	P. 57
	Q&A and Discussion	All	N/A
MITIGATING CLIMATE DISRUPTION WITH CROP INSURANCE: BUILDING RESILIENT SYSTEMS ['BUILDING RESILIENT SYSTEMS' IN DOCUMENT]			
10:30-12:00 PM	Overview of session	Jeff Schahczenski	N/A
	Whole Farm Revenue Protection as a climate risk management tool	Jeff Schahczenski	P. 58
	Automated irrigation based on soil moisture monitoring in blueberry production	Roger Noonan	N/A
	The use of crop insurance for climate resilience on vegetable and fruit farms in the Northeast: Insights from the New England Adaptation Survey	Alissa White	P. 59
	Q&A and Discussion	All	N/A
DEALING WITH WATER SUPPLY CHALLENGES IN DIVERSE CROPPING ENVIRONMENTS ['WATER SUPPLY CHALLENGES' IN DOCUMENT]			
10:30-12:00 PM	Micro-irrigation system design using NRCS methods	Les Wright	P. 60
	Dealing with saltwater intrusion: A growing problem	Chris Miller	P. 61
	The Dry Farming Collaborative: Participatory climate adaptation research	Amy Garrett	P. 62
	Weather data for water use optimization for crop water needs	Glen Koehler	P. 63
	Q&A and Discussion	All	N/A
KEYNOTE SPEAKER - WORKING LUNCH			
	Climate change in the Northeast: What history tells us about crop loss, drought and wet conditions	Dr. David Hollinger	P. 7
PROGRAM DEVELOPMENT STRATEGY SESSION			
1:00-4:30PM	All attendees are invited to join us for this facilitated session. We will plan 3-5 regional projects or programs to address water use in specialty crop Agricultural in the Northeast. Goal: to leave with ideas tied to funding opportunities, and to develop working groups and leadership teams for each idea.		