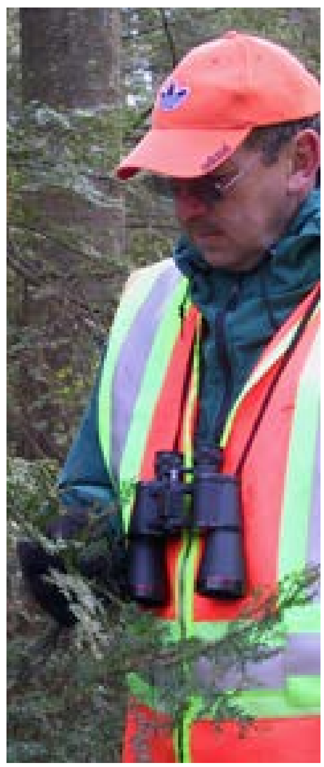
CAES

The Connecticut Agricultural Experiment Station

Putting Science to Work for Society since 1875

DIRECTOR’S REPORT



The Connecticut Agricultural Experiment Station

Putting Science to Work for Society since 1875

The Connecticut Agricultural Experiment Station

First in the Nation, Founded 1875
Putting Science to Work for Society
Protecting Agriculture, Public Health, and the Environment

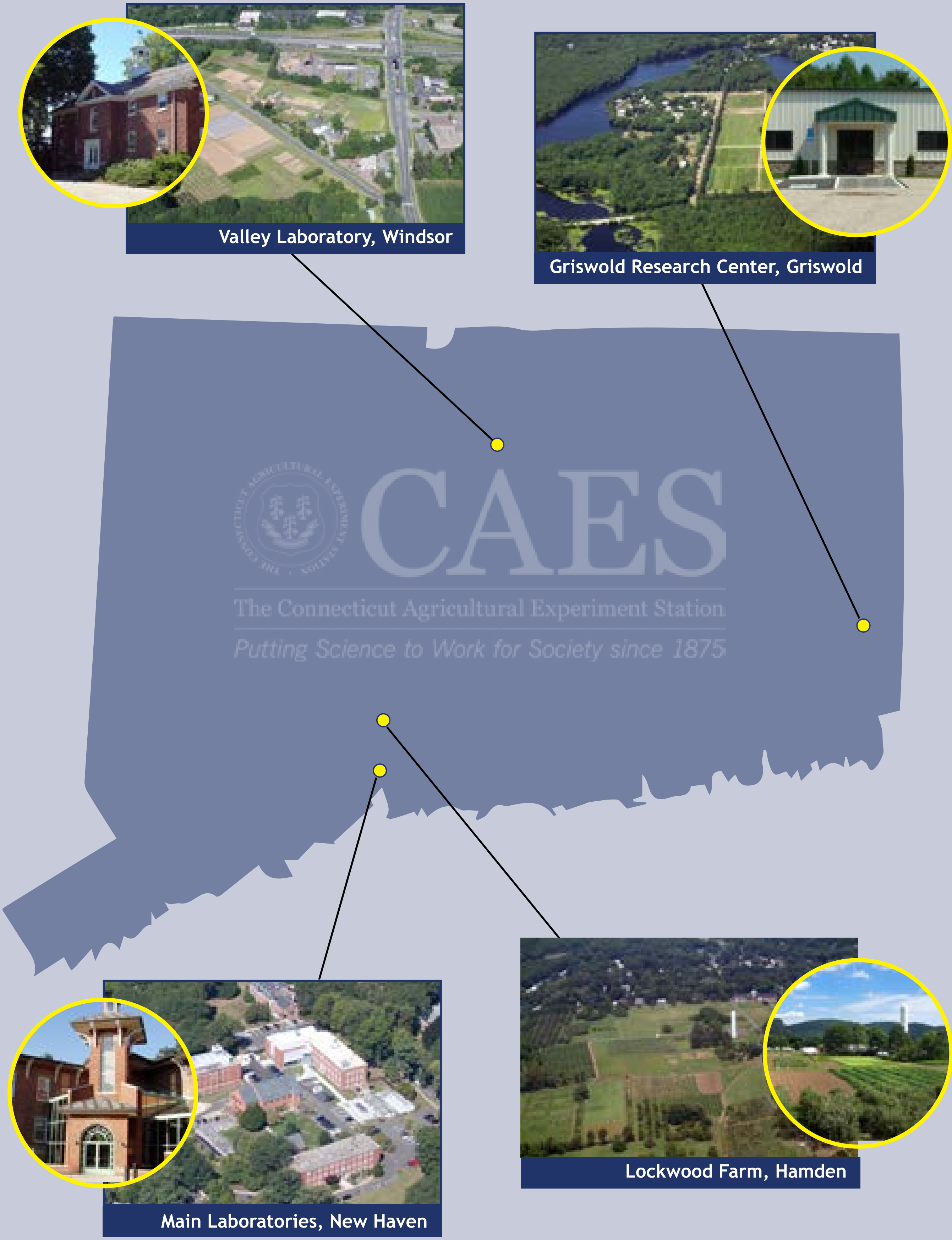
Welcome to The Connecticut Agricultural Experiment Station, a state-supported research institute that has been serving the needs of state residents and the nation since its founding in 1875. Now in its second century, our tradition of excellence continues as we advance the frontiers of knowledge to solve the region's most challenging problems in our four core areas: agriculture, food safety, the environment and public health.

True to our beginnings, we aspire to achieve ground-breaking discoveries with a commitment to public service through the combined application of basic and applied investigations. Our scientists perform innovative research with multidisciplinary programs that utilize the latest advances in biotechnology, turning discovery into solutions that "Put Science to Work for Society," a mission that embodies all we do.

I hope you enjoy the information presented in this report as you discover more about this esteemed institution. It highlights the many notable accomplishments of Station scientists through the years, and provides a brief sampling of research projects we are conducting today. This report also includes a description of our public service and regulatory programs that improve the quality of life for citizens across the state and beyond.

Sincerely,

Dr. Theodore G. Andreadis
Director


Valley Laboratory, Windsor
Griswold Research Center, Griswold
CAES
The Connecticut Agricultural Experiment Station
Putting Science to Work for Society since 1875
Main Laboratories, New Haven
Lockwood Farm, Hamden

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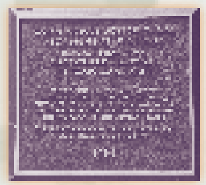
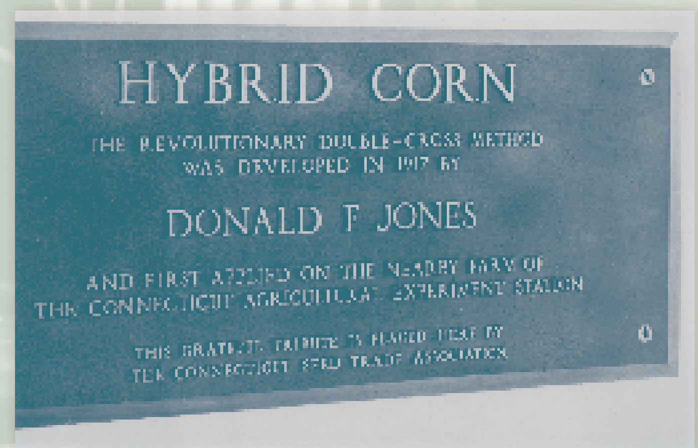
Historical Perspective





OPEN

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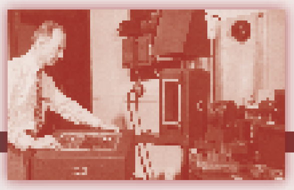
HISTORICAL PERSPECTIVE
KEY EVENTS AND SCIENTIFIC ACCOMPLISHMENTS



1875 Samuel Johnson's proposal to support agricultural research comes to fruition with establishment of the Nation's first agricultural experiment station, "for the purpose of promoting agriculture by scientific investigation and experiments".

1875 The Station begins work in the area of consumer protection with the analysis of agricultural feeds and fertilizers.

1877 The Station moves from Wesleyan University to the Sheffield Scientific School at Yale University.

1882 The Station buys five acres of land from the estate of Eli Whitney, Jr. and moves to its current location on Huntington Street (formally Suburban Street) in New Haven.

1888 The Mycology Department is established to provide diagnosis and information for control of plant diseases and the fungal pathogen causing potato scab is identified.

1888 Biochemistry research on plant proteins begins leading to the discovery of vitamin A in 1913 by Thomas Osborne.

1900 The tobacco shade tent is introduced for the first time in Connecticut, revolutionizing the tobacco industry.

1901 Office of the State Entomologist is formed leading to state regulation of plant pests and diseases. Wilton Britton appointed.

1901 Forestry research begins, Walter Mumford becomes the first Station and "State Forester".

1903 The first "spray calendar" guide is published to help Connecticut farmers minimize pesticide use.

1903 The Station initiates investigations on mosquitoes and mosquito control in the State.

1903 The Station purchases the first parcel of land that will become the 170,000 acre state forest system.

1910 Lockwood Farm in Mt. Carmel is purchased with income from the Lockwood Fund, the first "Field Day" is held.

1915 The Experiment Station is authorized by law to make rules and orders regarding the elimination of mosquitoes and to survey and eliminate mosquito breeding areas.

1919 Geneticist Donald Jones invents a double cross pollination method leading to commercial production of hybrid corn revolutionizing global agriculture.

1921 The Tobacco Substation is established in Windsor and research on tobacco diseases begins.

1926 The oldest research plots in the United States to monitor unmanaged forest change and succession over time are established.

1927 Research on the use of "insect parasitoids" for biological control of insect pests is initiated as an alternative to chemical pesticides.

1933 X-disease of peaches is discovered.

1934 M. Francis Morgan develops the world's first test for rapid analysis of soil fertility.

1940 The first organic fungicides to protect crops are discovered.

1940 A new laboratory is constructed in Windsor and renamed the Valley Laboratory (1964) to reflect more diversified agriculture in the Connecticut Valley.

1945 The Horsfall/Barratt scale for assessing plant disease severity is published.

1946 The usefulness of composted sewage sludge for soil improvement is demonstrated for the first time.

1948 Activated charcoal is used for the first time to adsorb a toxic organic pesticide from contaminated potato fields.

1948 Phosphorus generated from upstream factories is shown to enhance growth of algae in Connecticut lakes.

1949 The technique for "chemotherapy-by-injection" is developed for control of Dutch Elm Disease.

1951 The tobacco cyst nematode is discovered.

1955 The use of Ion exchange chromatography is developed for analysis of organic acids.

1957 State Entomologist, Neely Turner prevents the USDA's proposal to spray the entire state of Connecticut with DDT from the air to "eradicate" the gypsy moth. Rachel Carson publishes Silent Spring" four years later.

1963 CAES scientists develop a gas chromatography technique to detect pesticide residues on agricultural produce.

1964 The Connecticut Agricultural Experiment Station is designated as a National Historical Landmark by the US Department of the Interior.

1966 A new system is invented to describe the biochemistry of enzymatic reactions that is widely used in biochemistry research today.

1967 Nutrient budgets and phosphorous recycling from sediment that affect lake eutrophication are described helping to establish priorities in providing clean water.

1967 Pioneering methods of pest control based on insect behavior are developed.

1968-69 Computer models are developed showing the impact of leaf area on temperature and evaporation in the forest canopy. The first computer model of a plant disease epidemic is published.

1970 A rapid method for detecting lead in urine of children suspected of eating lead paint is developed.

1970 An extensive survey of Connecticut coastal wetlands is published.

1972 A parasitic wasp credited with helping to control an outbreak of the elm span worm is discovered.

1973 A European "hypovirulence" technique is developed and implemented to control chestnut blight and increase survival of American chestnut trees.

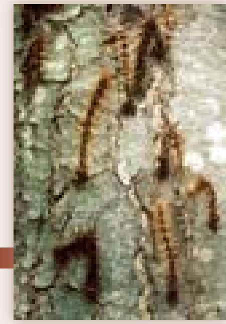
1973 An artificial soil composed of sand, peat, and vermiculite is developed for the nursery industry.

1974 Tree mortality in Connecticut forests is shown to be significantly increased by insect defoliation.

1975 Research on ticks and tick-borne diseases in Connecticut is initiated. A serology laboratory is established and an isolation facility is built on the New Haven campus.

1980 In a statewide survey, 15 different species of ticks are discovered in the State.








1982 Conducted the first aerial spray trial with the biological insecticide, *Bacillus thuringiensis* for control of gypsy moth infestations in Connecticut forests.

1982 A computer model for long-distance, aerial transport of spores causing plant disease is published.

1983 The first isolations of the Lyme disease agent, *Borrelia burgdorferi* are made from ticks, mice and raccoons.

1984 Antibody tests for laboratory diagnosis of Lyme disease are developed.

1987 Studies on the ecology and control of the black-legged tick, *Ixodes scapularis* are initiated leading to the development of novel integrated pest management techniques to reduce risk of exposure to ticks and tick-borne diseases in and around the home.

1987 Studies reveal that some pollutant molecules in soil become trapped in micropores of soil particles and therefore are highly immobile and biologically inaccessible.

1989 A fungal pathogen, *Entomophaga maimaiga*, that causes the collapse of the gypsy moth is discovered.

1990 A Tick Testing Program for the Lyme disease agent, *Borrelia burgdorferi*, that is free to Connecticut residents is established.

1991 The first of several new cultivars of broadleaf cigar wrapper tobacco that are resistant to wilt and tobacco mosaic virus are developed and licensed saving millions of dollars for local growers.

1992 Novel methods for decontaminating organic pollutants from water and soil using chemical reagents are developed.

1993 Station scientists introduce the concept of "dispersive epidemic waves" which accelerate as they move away from a focus of disease, a major advance in understanding the ecology of plant disease.

1997 A comprehensive statewide Mosquito/Arbovirus Surveillance Program is launched following an outbreak of eastern equine encephalitis activity in southeastern Connecticut.

1997 Scientists initiate a series of reports identifying several novel chemical bonding mechanisms of pollutants to carbonaceous particles found in soil.

1999 Station scientists make the first isolations of West Nile virus in North America from mosquitoes and crows. Findings are published in *Science*.

2000 Station scientists discover that specific plants accumulate persistent organic pollutants from soils.

2001 The principal mosquito species that transmit West Nile virus to birds and humans are identified.

2001 A new exotic, invasive, mosquito native to Japan, *Aedes japonicus* is discovered in Connecticut.

2002 Systematic studies on invasive aquatic plants in Connecticut lakes and ponds are initiated that find 60 percent of the water bodies contain one or more invasive species, and that identify two new invasive species originating from southern states.

2004 A new Biosafety Level 3 Containment Facility begins operation in the newly renovated and constructed Johnson-Horsfall Laboratory.

2005 The Analytical Chemistry Laboratory is selected by the US FDA's Food Emergency Response Network (FERN) to help protect the nation's food.

2005 Two mosquito-borne viruses, Lacrosse and Potosi are isolated and described from mosquitoes in New England and the northeastern US for the first time.

2006 Station scientists discover that the American Robin is the chief reservoir and amplification host for West Nile virus in the region.

2009 The Griswold Research Center is established and a new laboratory is constructed (2012).

2009 The Center for Vector Biology & Zoonotic Diseases is established to advance knowledge of the epidemiology and ecology of vector-borne disease organisms and to develop novel methods and more effective strategies for their surveillance and control.

2009 Invasive shrubs are shown to create habitats that increase the density of blacklegged ticks carrying Lyme disease.

2010 The Analytical Chemistry Department becomes one of three laboratories in the country to test seafood from waters of states impacted by the Deepwater Horizon oil spill.

2011 The spotted wing Drosophila is discovered in Connecticut, the first record for New England, by a Station scientist.

2011 A pathogenic fungus called *Fusarium palustre* is described and found to be associated with massive diebacks of salt marsh grasses along Connecticut's coastlines.

2012 - 2015 The Department of Analytical Chemistry is awarded grants from US FDA to accredit methods testing the safety of the state's food supply (2012) and pet and livestock foods (2015).

2012 The exotic and destructive emerald ash borer is discovered in Connecticut for the first time by Station scientists.

2012 A new cyst nematode-resistant broadleaf tobacco cultivar is registered and licensed that results in more effective nematode control than soil fumigation.

2013 A new strawberry cultivar is developed and licensed that is more resistant to insect damage and fungal infection.

2015 New "Plant and Insect Information Offices" are opened in the newly renovated and constructed Jenkins-Waggoner Laboratory.

2015 Scientists in the Departments of Analytical Chemistry and Plant Pathology & Ecology are awarded USDA funding to investigate how nanotechnology can be used to suppress crop disease and increase food production levels.

Agriculture

INTRODUCTION

Agriculture has been important in Connecticut since colonial times and is still a significant part of the state's economy, producing up to $4.6 billion in economic output annually and accounting for nearly 30,000 jobs. Connecticut ranks first in New England in value of sales per farm and nearly half of all agricultural sales are from the nursery, greenhouse, turf, and ornamentals industry. Livestock, including dairy and poultry, account for about 24% of commodity sales, and forestry and logging, tobacco, fruit and vegetables are important components of agriculture, followed by a wide variety of crops and agricultural commodities from Christmas trees to maple syrup.

The numbers of farms in Connecticut are increasing, associated with increasing numbers of farmer's markets, CSA (community-supported agriculture) farms and other direct sales to consumers. Increasing the quality of products grown is one of the primary reasons consumers are excited about increasing purchases of locally produced food and ornamentals.

The Connecticut Agricultural Experiment Station has a major role in supporting agriculture in the state, identifying and developing new specialty crops for local production as well as increasing the health and quality of the plants and produce grown and sold in Connecticut. This involves research to develop integrated pest management tactics to reduce pesticide inputs, modeling and forecasting pest and pathogen outbreaks to best time control tactics, increasing soil quality to improve plant health and productivity, and maintaining the health of important honey bee and native pollinator populations, to name just a few.

Potentially devastating diseases and pest outbreaks in the state are addressed quickly and the Experiment Station's unique combination of research to develop control tactics, outreach to inform growers of new developments, and regulatory certification of healthy exports to ensure that Connecticut produces and exports the healthiest plants and products possible.

NEW CROPS FOR CT

Hops were once widely grown in the Northeast but susceptibility to downy and powdery mildews eventually limited production. With the recent introduction of resistant cultivars, hop cultivation has returned to the Northeast. Hop production would increase economic options for local growers in CT and add value to other local crops such as malt grains. With funding from the CT Dept. of Agriculture, Dr. James LaMondia and Dr. Victor Triolo of Southern Connecticut State University have initiated research on optimization of hop cultivation in CT.

Since 1983, CAES scientists have been investigating specialty crops to provide new opportunities for Connecticut's farmers. Over 40 fruits and vegetables have been studied in the New Crops Program including beach plums, Japanese plums, globe artichoke, heirloom tomatoes, radicchio, vegetable amaranth, sweet potato, okra, and tomatillo. In addition, variety trials of more common vegetables, such as broccoli, corn, and lettuce have been conducted to determine those best suited for Connecticut's soil and climate.

Dr. James LaMondia
Dr. Abigail Maynard
Dr. Katja Maurer
Mr. Nathaniel Child
Ms. Michelle Salvas

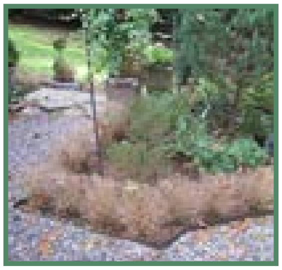
SOIL HEALTH AND SOIL-BORNE DISEASE

Practices that improve soil health ultimately enhance plant micronutrient availability. Micronutrients function in host defense reactions, but become less available in slightly acid to neutral (pH 6-7) soils. We found that adequate nutrition with chloride or specific N-forms increased rhizosphere microbes that, in turn, increased micronutrient uptake by roots, which led to less root rot and wilt diseases. One approach to increase micronutrient levels in roots was to apply nanoparticles (NP) of CuO to leaves. Plants sprayed with NP of CuO and grown in infested soils had less disease, more yield and more Cu in the roots than plants treated with the same amount of the bulked CuO. Other approaches we are taking include fertilizing with Si, a beneficial element, to suppress diseases on cucurbits, grasses, poinsettias, and zinnias; earthworms to increase fertility, beneficial microbes, and yield; and biochar (pyrolyzed plant material) to increase beneficial mycorrhizae and bacteria. Research focused on promoting soil health holds promise for improved methods for managing plant diseases in the future.

Dr. Wade Elmer
Mr. Peter Thiel

BOXWOOD BLIGHT DIAGNOSTICS AND MANAGEMENT

Boxwood blight, caused by the fungus *Calonectria pseudonaviculata (C.ps.)*, is new to North America and first reported in October 2011 in Connecticut and North Carolina. This devastating disease caused over $5.5 million in losses in CT alone. CAES scientists have been conducting research to improve understanding, detection, and development of Best Management Practices (BMPs) for this disease. We developed real-time PCR and other nucleic acid-based assays for early, accurate detection of C.ps. Investigations have identified effective disinfectants to sanitize tools and equipment. *In vitro* and *in planta* studies identified efficacious systemic and protectant fungicides. Research also reported *Pachysandra* species as new hosts of *C.ps* and differences in susceptibility of cultivars. Experiments have been initiated to determine the potential for development of fungicide resistance in *C.ps* and rapid molecular assays for early detection of these genes. CAES has a pivotal role in research focused on mitigating the impact of this destructive disease, minimizing further spread of the pathogen, and eliminating new introductions from outside the U.S.



Dr. James LaMondia
Dr. Robert Marra
Dr. Katja Maurer
Mr. Michael Ammirata
Mr. Nathaniel Child
Ms. Michelle Salvas

MODELING PLANT DISEASE EPIDEMICS

Plant disease epidemics are governed by the disease triangle comprised of the weather, the pathogen, and the host plant. Using physics, meteorology, mathematics, and statistics, CAES scientists develop models to describe and predict the spatial spread and temporal increase of plant disease epidemics. To this end, remote access weather stations have been installed at the three CAES research farms and at three commercial Connecticut vineyards to continuously monitor various components of weather, which directly influence plant phenology, growth, and productivity, as well as the development of plant disease. To construct a detailed mathematical model for spore dispersal, one must first determine the dispersal function, which gives the probability that a spore released from an infected leaf lands on a healthy leaf some distance away. This can be accomplished using Lagrangian stochastic simulation models founded on a thorough knowledge of the nature of the turbulent wind. For this reason, wind speed is currently being intensively measured in and above a vineyard canopy.

Dr. Francis Ferrandino

FIRE BLIGHT—DISEASE MECHANISMS AND MANAGEMENT

Fire blight, caused by the bacterial pathogen *Erwinia amylovora*, is one of the most devastating diseases currently limiting apple and pear production in Connecticut and the United States. Most apple and pear varieties preferred by consumers are either susceptible or highly-susceptible to fire blight. Application of the antibiotic streptomycin during bloom is by far the only management option available that provides a high level of control efficacy. The intensive, long-term use of streptomycin, however, has resulted in the evolution of streptomycin resistance in *E. amylovora*. The goal of this research is to advance our understanding of the disease mechanism of fire blight, and to develop novel disease control approaches. Using fluorescence imaging and transcriptomic analysis approaches, we are trying to understand how each individual cell in a bacterial population responds to signals from plants and coordinate virulence gene expression during disease progression. In addition, we aim to develop effective fire blight control alternatives using RNA silencing technology.

Dr. Quan Zeng
Ms. Regan Huntley

DIVERSITY AND VIRULENCE MECHANISMS IN PLANT PATHOGENS

Bacterial species in the *Xanthomonas* group cause diseases on a wide variety of crop and ornamental plants. Control options are limited, but understanding the bacterial virulence mechanisms can help identify targets for resistance. *Xanthomonas* species inject virulence proteins into plant cells, changing the plant environment to allow bacterial growth and infection. We are using biochemical and genetic methods to understand how some of the secreted proteins contribute to disease development. By studying the changes in plant cells after exposure to the pathogen virulence protein, we can identify the critical host pathways affected. Understanding the effects of secreted proteins could help identify future strategies for chemical control and breeding for disease resistance. By analyzing the genetic makeup of similar *Xanthomonas* strains isolated from different crops around the US, we will determine how common those virulence genes are, and how they may be changing. The genetic sequence we analyze can also be used to generate specific diagnostic tools for future disease tracking.

Dr. Lindsay Triplett
Dr. Teja Shidore

SPOTTED WING DROSOPHILA

Spotted wing drosophila (SWD) is a small fruit fly that attacks raspberry, strawberry, and late varieties of blueberry, adding to the costs of growing these crops due to heavier use of insecticides. SWD has a 14-day generation time, leading to explosive population outbreaks and sudden loss of susceptible crops. This requires continuous application of insecticides from the start of fruit ripening up through harvest, reversing decades of progress toward reduction of pesticide use on fruit crops. Dr. Cowles has been investigating the use of attractant traps, combined with insecticides applied only to the outside of the traps, in an attract-and-kill approach that is an alternative to direct spraying of ripening fruits. Dr. Cowles is conducting research to improve attractant baits, improve trap design and increase efficacy of insecticides. His experiments are focused on attractants such as fermented and volatile baits, trap headspace and trap design and color, resulting in improved trap function and SWD knockdown. Results will provide a practical method for fruit production with reduced pesticide use.

Dr. Richard Cowles

MANAGING NEMATODE POPULATIONS

Nematodes are microscopic roundworm animals that infect plants and cause disease. There are many different genera of plant parasitic nematodes that attack most vegetables, fruits, many ornamentals, and even weeds. Most nematodes attack roots and exist in soil, making them very difficult to manage. Ongoing research to control these pathogens includes the identification of plant resistance genes that reduce nematode feeding, damage, reproduction and population increase and the use of these genes in plant breeding; the identification of rotation or cover crops that are non-hosts of specific nematodes; or the production of nematode-antagonistic plants. Antagonistic plants can produce chemicals that kill plant parasitic nematodes when incorporated into soil, a process termed biofumigation. An example is the use of mustards or other Brassica species to produce glucosinolates that break down to compounds that kill different nematode pathogens. Dr. LaMondia has determined that not all Brassicas are equally effective, some glucosinolates are more effective than others at killing different nematode species.

Dr. James LaMondia
Ms. Jane Canepa-Morrison

HONEY BEE HEALTH

As part of a Northeast regional project studying pollination of various fruit and vegetable crops, Dr. Kimberly Stoner has studied pollination of pumpkins and winter squash on 20 commercial fields and on all three Experiment Station research farms in Connecticut. She has found that bumble bees are the primary pollinators, responsible for 66% of the bee visits, with squash bees and honey bees secondary in importance. Detailed studies of bee behavior, followed by measurement of the amount of pollen deposited on the female flower parts, will give farmers a better understanding of how to evaluate bee numbers and activity to determine if they are getting enough pollination to get good yield of marketable pumpkins and squash. In collaboration with Dr. Brian Eitzer and colleagues at the University of Massachusetts and the University of Maine, Dr. Stoner is studying factors that could affect bee health and pollination in the future, including movement of pesticides into the nectar and pollen of flowers and availability of pollen and nectar in the landscape surrounding the pumpkin and squash fields.

Dr. Brian Eitzer
Dr. Kimberly Stoner
Ms. Tracy Zarrillo
Ms. Morgan Lowry

NATIVE POLLINATORS

Native bees are important pollinators for fruit, vegetable and nut crops, and also for native New England plants. Recent research has shown that bumble bee diversity is in severe decline in Connecticut and across North America. The status of many other species of bees is unknown. Dr. Kimberly Stoner, with assistance from Tracy Zarrillo, Morgan Lowry, and seasonal research assistants, systematically surveyed bees on flowering plants such as cut flowers, herbs, cover crops, and wildflowers on 10 diversified vegetable farms in central and western Connecticut. Dr. Stoner collected and Ms. Zarrillo identified 106 species of bees from 25 genera in this two-year study, and Dr. Stoner has published a fact sheet rating flowering plants for their attractiveness to honey bees, bumble bees and other bees. Ms. Zarrillo, Dr. Stoner, and colleagues are preparing a scientific paper that will add 14 new state records to the 326 species of bees known to occur in Connecticut.

Dr. Kimberly Stoner
Ms. Tracy Zarrillo
Ms. Morgan Lowry

WINEGRAPE CULTIVAR TRIALS

In the past 15 years, the number of wineries in Connecticut has doubled (32 extant), while the number of vineyards (42) and the total acreage planted to winegrapes has tripled (450 A). This industry brings economic benefits to the rural communities in which most are located. Grapevine survival is determined by the minimum winter temperature, which can vary from 0˚F near the coast to -15˚F in the Litchfield hills. Since it is of paramount importance to choose the "right" cultivar when planting a new vineyard due to high cost (~$5,500 per acre) and delayed salable harvest (3 years), research at CAES has focused on monitoring winegrape survival of cultivars. CAES is also participating in national, multi-state research projects on production. The three CAES research farms are planted to 32 cultivars of grapes whose performance (yield and quality), survival, and suitability for wine making is being evaluated. The ultimate goal is to divine which cultivars are best suited to Connecticut.

Dr. Francis Ferrandino
Ms. Joan Bravo

PROTECTING HONEY BEE HIVES FROM AMERICAN FOULBROOD

Honey bees form an important cornerstone in agricultural production. Because honey bees are prone to many diseases, agricultural production is directly impacted. One of the most serious diseases to honey bees is the highly contagious disease American foulbrood (AFB). AFB is caused by the spore-forming bacterium *Paenibacillus* larvae, and is currently controlled in apiaries by antibiotic treatment (suppression of disease) or, when a colony shows disease symptoms, by destruction of the hive. Economic loss to a beekeeper can be in excess of $1000 per hive. Previous studies have shown that approximately half of the beehives in Connecticut carry spores of this bacterium. Approximately 10% of Connecticut beehives were also shown to exhibit disease symptoms. Since only these controls for AFB are available, alternative methods are needed. Research at CAES to understand the mechanisms used by this bacterium to cause disease, and how these mechanisms are regulated within the bacterium, represents a powerful way to develop alternative methods of control.

Dr. Douglas Dingman

MANAGEMENT OF MUGWORT AND WEEDS OF ORNAMENTAL PLANTS

Increasing invasion of non-native, invasive plants is a serious threat to the biodiversity and stability of natural ecosystems in Connecticut. Mugwort (*Artemisia vulgaris* L.) is a non-native invasive plant which is commonly found growing along roadsides, ornamental plant nurseries, pasture and rangeland, rights-of-way, and in various agronomic, turf and landscape settings. Research is being conducted on the integrated management of mugwort using low herbicide rates, mowing, and over-seeding native perennial grasses. This research will provide land managers and growers with an economical, environmental-friendly, and sustainable approach to manage mugwort in various crop and non-crop situations. Several weeds compete with Christmas trees and ornamental plants for nutrients, water, light, and space. Recently, some new herbicides have been/are being commercialized for pre-emergence weed control in ornamental plants and Christmas trees. These herbicides include indaziflam (Alion and Marengo) and flumioxazin (Sureguard). As both weeds and ornamental plants vary in their tolerance to herbicides, information is needed on the safe, economical and environmentally sound use of herbicides. Dose response relationships for weed management and crop plant sensitivity involving different herbicide rates, ornamental plants, and weed species will generate valuable information for making sound and ecofriendly weed management decisions. In addition, various cover crops such as cereal rye, crimson clover, spring oats, and Sudan sorghum are being evaluated for weed management in organic production systems.

Dr. Jatinder Aulakh

Environment

INTRODUCTION

Connecticut, like the rest of the country, faces a number of environmental challenges: contamination of air, water and soil; invasive insect and plant species; climate change impacts; and stresses associated with urban development. Improving the quality of natural and affected environments through research is a primary mission of The Connecticut Agricultural Experiment Station. Improving environmental quality requires a deep understanding of how natural processes work. Economic losses and environmental degradation are an unintended consequence of introduced plants, insects, and pathogens. CAES scientists are developing novel management tools to control exotic terrestrial and aquatic invaders, monitoring the State for new threats and investigating methods of rehabilitating degraded woodlands and returning them to healthy forests. The following pages summarize our research activities in these areas.

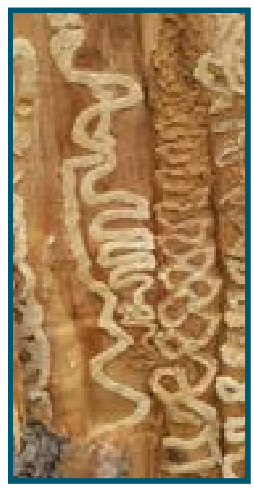
INVASIVE EXOTIC INSECTS

Exotic insects can injure crops, transmit pathogenic microorganisms, alter ecosystem processes, and reduce biological diversity. Surveys are being conducted in Connecticut to detect new alien insects and to determine the distribution and hosts of both new and established ones. We are also developing new sampling methods that have led to an improved understanding of the biology of invasive insects, such as the European barberry fly, the Eurasian spruce needle miner, and introduced longhorn beetles. One important study aims to reveal the host range and impact of the Eurasian lily leaf beetle, an insect that has spread from flower gardens into wild stands of native lilies and other plants. Experiments performed in sunlit gaps in forests of northwestern Connecticut demonstrated that feeding by this beetle negatively affected the growth of wild Canada lilies. Early detection and an improved understanding of the biology of invasive insects will reduce their detrimental impact on the economy and the environment.

Dr. Chris Maier
Ms. Tracy Zarrillo
Ms. Morgan Lowry

WOOD BORING INSECTS

The emerald ash borer (EAB), is the most destructive and costly invasive forest pest in U.S. history. Discovered in Detroit MI in 2002, EAB attacks and kills healthy ash trees (*Fraxinus* sp.). To detect new infestations of EAB, we are using *Cerceris fumipennis*, a native ground-nesting solitary wasp that provisions her nest with adult jewel beetles, including EAB. We first detected EAB in Connecticut in 2012 by monitoring *C. fumipennis*, and we continue to track the spread of EAB in this way. We are assisted by 'The Wasp Watchers', a group of over 60 citizen-scientists who monitor wasp colonies. The monitoring has created an extensive collection of native jewel beetles: 12,000 specimens comprising 70 species, including 15 species not previously known to occur in Connecticut. We are also participating in the USDA APHIS biological control program for EAB which deploys two species of parasitic wasp. Releases in 2012 and 2013 totaled 30,000 wasps, and releases will continue next year. Also integral to the program is educational outreach to communities on EAB management practices.

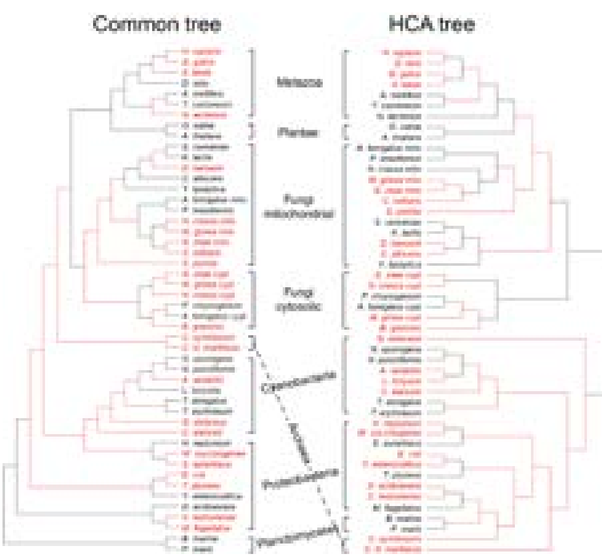


Dr. Claire Rutledge

CONVERGENT EVOLUTION OF PROTEINS

Convergent evolution is the independent evolution of ecological adaptations in species of different taxa. There are numerous examples of convergent evolution in nature. An obvious one is flight, which has evolved independently in birds, insects, bats and reptiles. Others include loss of limbs in vertebrates, pesticide resistance, adaptation to a parasitic way of life, etc. We find that proteins—specifically, enzymes—also undergo convergent evolution. Manganese Superoxide Dismutase (MnSOD) is an enzyme that plays a crucial role in protecting cells from oxidative stress. Through phylogenetic and structural analysis we are comparing protein amino acid sequences of MnSOD from a wide variety of life forms including plants, animals, fungi and bacteria. We have developed a method to visualize and understand convergent evolution in protein structures and can see that when separate organisms experience the same environmental stress they can evolve proteins with similar structure and function.

Dr. Charles Vossbrinck



INVASIVE AQUATIC PLANTS

Connecticut lakes are being threatened by the spread of non-native plants. These invaders come from other parts of the world and—absent natural enemies—disrupt native ecosystems, interfere with recreational uses of lakes, and reduce property values. From 2004 - 2013, we mapped the invasive and native plants in over 200 Connecticut lakes and ponds to determine the extent and causes of the problem. Sixty percent of the water bodies were found to contain one or more invasive species. In 2013 we began a detailed survey of 23 lakes to quantify long-term changes. We developed models to predict at-risk lakes based on their water chemistry. We are also testing control measures, for example, winter drawdown in Candlewood Lake and fall herbicide treatments in Bashan Lake. We offer advice to communities in managing unwanted aquatic vegetation, and we often visit water bodies to help solve imminent problems. Results from our survey program are posted on our website and updated regularly.

Mr. Gregory Bugbee
Ms. Jennifer Fanzutti

CHEMICAL CONTAMINANTS IN SOIL, WATER AND AIR

Pollution affects human safety and health and threatens the vitality of the natural environment. This research program addresses broad issues related to understanding the fate and biological accessibility of pollutants in the environment, and the development of novel methods for removing pollutants from waste streams and decontaminating

water and soil. The program covers both fundamental and applied aspects, and deals with many different types of pollutants, including pesticides, volatile organic compounds, dyes, hormones and hormone-mimicking compounds, pharmaceuticals, petroleum hydrocarbons, munitions chemicals, and engineered nanomaterials. A special emphasis has been on the chemistry of pollutants at the soil-water interface. We have also studied the chemistry of natural processes. Current projects include: the bonding forces controlling adsorption of charged compounds on surfaces of natural organic matter and charred particles; the aggregation of engineered nanoparticles in soil; sunlight-driven reactions of organic compounds and dissolved natural organic matter in marine waters; bioavailability of pollutants in environmental particles in models simulating the human digestive tract; sunlight-driven detoxification of contaminants in waste waters; the potential use of biochar (a charcoal-like product of biomass waste) in environmental remediation and soil fertilization; removal of commodity fumigants in vent streams; remediation of crude oil spills on land and sea; and emission of climate-warming gases from soil.

Dr. Joseph Pignatello
Dr. Hsin-se Hsieh

SOIL MICROBIAL ECOLOGY

Microbial communities are extremely sensitive to small perturbations in the environment. The ability to predict how microbes respond and contribute to important climate and biogeochemical cycles is required for accurate ecosystem models. We are using molecular and microbial techniques to characterize complex microbial systems in soil. One example is the microbial systems that exist in Connecticut wetlands, particularly those experiencing Sudden Vegetative Dieback, or SVD. In SVD, plants rapidly die off within a single season and plants lose the ability to regrow. Understanding the microbial role in SVD will lead to a better understanding of its causes. We are also interested in the development of algal blooms in freshwater lakes, particularly blooms of cyanobacteria that cause blight and often produce toxins which can affect both animal and human health.

Characterizing the factors associated with algal bloom development will lead to better prediction of their occurrence and, consequently, better management of Connecticut's freshwater resources.

Dr. Blaire Steven

REDUCING DAMAGE FROM ANIMAL HERBIVORES

Browsing by white-tailed deer and eastern cottontail rabbits can cause significant agricultural, nursery, and managed landscape damage in Connecticut. Physical exclusion such as fencing works well to prevent animal damage to plants; however, fences can be costly and unsightly, particularly in a residential setting. Commercially available repellents for deterring both deer and rabbit browse may provide a reasonable alternative to fencing, but their relative effectiveness has not been tested. Therefore, over the past several years we have compared the effectiveness of various repellents with fencing for reducing both deer and rabbit browse damage. Our results indicate that fencing is the most effective and would be the best alternative for nurseries. For homeowners, the choice of which repellent to use depends on whether the damage is caused by rabbits or deer.

Dr. Scott Williams
Dr. Jeffrey Ward
Mr. Michael Short

INVASIVE TERRESTRIAL PLANT CONTROL

While most non-native plants stay put in our gardens and landscapes, a few have escaped and become aggressive invaders of our woodlands. Invasive species are a greater problem in areas of high deer populations because they are usually more tolerant of heavy deer browsing than native species. Invasive species can form dense thickets (Japanese barberry, multiflora rose) or suffocating groundcovers (Japanese stiltgrass) that impede native tree regeneration and growth of wildflowers. Oriental bittersweet often strangles entire trees. We led a multi-institutional, collaborative research program that examined 56 treatment/timing combinations to determine the most effective method of controlling Japanese barberry. The guidelines for site-specific treatment resulting from our study are summarized in a Station Bulletin that is now used throughout the Northeast and mid-Atlantic regions. Controlling Japanese barberry can reduce the risk of exposure to Lyme disease by 50% or more. Our research has also found that reducing invasive cover and deer browse damage will increase the density of native wildflowers and growth of native tree seedlings.

Dr. Scott Williams
Dr. Jeffrey Ward
Dr. Carole Cheah
Dr. Jatinder Aulakh
Mr. J.P. Barsky
Mr. Michael Short

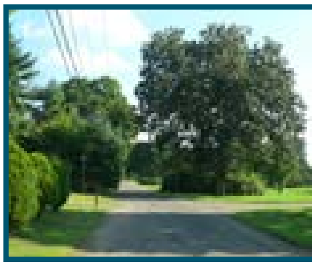
FOREST MANAGEMENT

Connecticut is the fifth most forested state in the nation and has the highest forest cover in urban areas of any state. Responsible stewardship of our forests will provide future generations with healthy, sustainable forests. Challenges to sustainable forest management include the small size of many properties and the tendency to value forests for privacy and wildlife. Since the early 1980s, we have been investigating a range of alternative forest practices that, on the one hand, will provide a periodic source of products such as timber and firewood, while on the other hand enhance the aesthetic appeal of the woods by maintaining charismatic large trees, as well as favor the development of multi-layered communities with abundant shrubs and herbaceous plants that attract birds and other wildlife. These alternative forest practices include crop tree management, cultivation of multi-aged stands, and rehabilitation. For example, we found that crop-tree release increased diameter growth of black birch and sawtimber red oak by 40% or more.

Dr. Jeffrey Ward
Mr. J.P. Barksy

ECO-PHYSIOLOGY OF URBAN TREES IN A CHANGING ENVIRONMENT

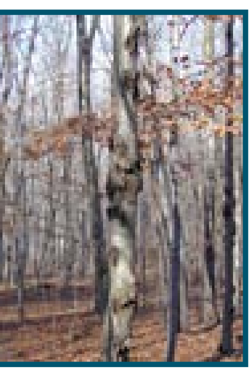
Historically, trees have proven to be extremely resilient to biological and physical pressures. However, climate change models predict future changes in the amplitude and variation of temperature and precipitation that could affect urban trees due to their longevity and the special microclimatic conditions under which they live. Tree adaptation to novel conditions is crucial for survival in the urban environment, where the urban heat island effect magnifies temperature changes, where tree root growth is restricted by soil compaction and limited growing space, and where roadside trees are exposed to the deleterious effects of de-icing salts. We have initiated a research program to answer basic scientific questions like "What are the most important physiological variables to consider in tree adaptation studies?" and to answer practical questions like "Which tree species should be planted, given predicted climatic changes?" Specifically, the objectives are to determine the adaptive mechanisms of trees to survive under different stresses such as water limitation, salt toxicity and insect pest attacks.



Dr. Adriana Arango Velez
Mr. J.P. Barksy

POPULATION DYNAMICS IN PLANT PATHOGENIC FUNGI

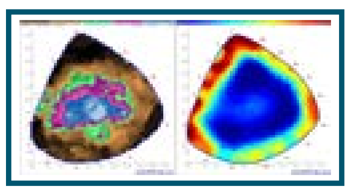
The ways in which plant pathogen populations are genetically structured in natural environments are subject to complex interactions among factors such as environmental variation, host densities, and the characteristics of pathogen dispersal, with profound impacts on disease severity and the development of management strategies. We are investigating different plant pathogens in their natural environments using genetic markers. Sudden Vegetation Dieback, or SVD, is a disease syndrome of saltmarsh cordgrass, *Spartina alterniflora*. Focusing on the fungal species associated with SVD, we have identified at least two new species of *Fusarium*, which appear to be genetically quite distinct. We are now focusing on their reproduction and dispersal. *Neonectria ditissima* is an endemic fungal pathogen of eastern North America that causes perennial cankers on a wide range of broad-leaved trees of forests and orchards. It is particularly disfiguring to black and yellow birch, drastically reducing their log quality and value. We have shown that *N. ditissima* has unexpectedly high levels of genetic diversity despite high rates of self-fertilization, suggesting complex spatial patterns of dispersal and distribution.



Dr. Robert Marra
Mr. Michael Ammirata

INTERNAL DECAY IN LIVING TREES OF THE FOREST

Trees play a critically important role in mitigating climate change by storing carbon in the form of wood through photosynthesis and growth. Counteracting this process is wood decay, wherein bacteria, fungi, and other microorganisms metabolize wood, releasing CO_2 and other greenhouse gases back into the atmosphere. Internal wood decay occurs in most trees, which live with this process for decades. Nondestructively imaging the internal condition of living trees has been an elusive goal of forest pathologists, arborists, and scientists who study forest carbon cycles. The advent of tomography, analogous to the CAT scan in medicine, has made this goal attainable. We are using tomography to quantify internal decay and carbon loss in the northern hardwood forest. This research will be the first to investigate the role of internal decay in carbon cycling, and will contribute to a more thorough understanding of the importance of forests in mitigating global warming and climate change.



Dr. Robert Marra
Mr. Michael Ammirata

MANAGING HEMLOCK WOOLLY ADELGID

The hemlock woolly adelgid (HWA) has been a serious forest, nursery and landscape pest of eastern hemlock since its first detection in Connecticut in 1985. The Experiment Station, with support from the US Department of Agriculture Forest Service, discovered, reared and released over 176,000 Japanese ladybeetle HWA predators in Connecticut. This was the first biological control agent for the management of HWA. Releases occurred between 1995 and 2007 in Connecticut forests, and from 2005-2011 there was widespread recovery of hemlocks. The recent warm winters of 2012 and 2013, however, have revived threats of HWA and another pest known as elongate hemlock scale (*Fiorinia externa*), and hemlocks are again declining in parts of the state. We are evaluating the factors needed to improve biological control of HWA. We are also investigating the use of a weevil imported from China and released for biological control of mile-a-minute weed, an invasive vine whose exponential growth and prolific seeding threatens native vegetation in Connecticut.

Dr. Carole Cheah
Dr. Richard Cowles

REMEDIATION OF COASTAL MARSHES

Salt marshes are the most productive ecosystems on the planet. They provide shelter for birds and animals, absorb excess nitrogen and phosphorous, detoxify contaminants, and protect property against storm surges. Sudden Vegetation Dieback, or SVD, is a rapid loss of marsh grass, *Spartina alterniflora*. Recovery from SVD can take ten years or longer. We discovered a new pathogen of *S. alterniflora* called *Fusarium palustre* that is associated with SVD along the East Coast, as well as diebacks of native marsh grass *Phragmites australis* in China. However, SVD is not caused by *Fusarium palustre* alone. Herbivory by the purple marsh crab (*Sesarma reticulatum*) also exacerbates SVD. We showed that crabs favored stressed, diseased plants over healthy plants. This supports our hypothesis that SVD is initiated by stress factors, such as poor nutrition and rising sea levels. Inadequate or excessive supplies of the nutrient silicon may also make plants more susceptible to SVD and alter their production of stress metabolites, like dimethylsulfoniopropionate. Understanding how nutrition may affect the yields of such stress metabolites may help decipher the causes of SVD.

Dr. Wade Elmer
Mr. Peter Thiel

Food Safety

INTRODUCTION

The Department of Analytical Chemistry at The Connecticut Agricultural Experiment Station (CAES) has a 120-year history of work in Food Safety. In 1895, the CT General Assembly passed "An Act Regulating the Manufacture and Sale of Food Products" which mandated that "The Connecticut Agricultural Experiment Station shall make analysis of food products on sale in Connecticut suspected of being adulterated, at such times and places and to such extent…may take from any person…any article suspected of being adulterated."

Since then, the Department of Analytical Chemistry has become the state's primary analytical laboratory, testing over 2000 samples each year from a variety of entities. The Department analyzes animal feeds and fertilizers for the CT Department of Agriculture so as to determine label accuracy and purity, as well as cultivated seaweed for human consumption for contaminants such as heavy metals, pesticides, and polychlorinated biphenyls (PCBs). As part of a Market Basket program with the CT Department of Consumer Protection (DCP) and the US Food and Drug Administration (FDA), we analyze foods for pesticide residues and adulteration. In addition, we conduct analysis on food-related consumer complaints submitted to DCP. We provide analysis for pesticide misapplication investigations on food and non-food crops for the CT Department of Energy and Environmental Protection (DEEP). We provide food-based chemical analysis as needed for the CT Department of Public Health (DPH), as well as for local and municipal health agencies. Last, we work directly with the CT DPH Bioterrorism Coordinator, CT Poison Control Center, 14th Civil Support Team, CT State Police Emergency Services Unit (ESU), and US Federal Bureau of Investigation (FBI) Weapons of Mass Destruction Directorate (WMDD) on programs related to chemical terrorism and the food supply.

The Department of Analytical Chemistry is also part of the US FDA Food Emergency Response Network (FERN). The FERN was established to respond to terrorist events involving the food supply and the Department of Analytical Chemistry was one of the eight original laboratories selected to participate. The FERN chemistry network has been activated for national food safety issues such as melamine contamination of pet/human food, seafood contamination as part of the 2010 Deepwater Horizon oil spill, and the analysis of arsenic in juice and rice. Last, scientific staff within the Department conduct federally and state funded research on the analysis and detection of emerging chemical contaminants in food, including engineered nanomaterials, mycotoxins, and antibiotics/chemotherapeutics.

PESTICIDE CONTAMINATION OF FOODS

The Department of Analytical Chemistry has conducted an annual Market Basket survey of Connecticut food for pesticide residues. Run with the CT Department of Consumer Protection (DCP), the findings are published each year online and in hard copy. The program ensures 1) that pesticides on food are used in accordance with their label and 2) that the public is protected from the deliberate or accidental misuse of pesticides. The program includes both domestic and imported food. Samples are collected from a range of establishments and are delivered to the laboratory for analysis. Violations, which include over-tolerance residues and the presence of residues where no tolerance exists, are reported to CT DCP for regulatory response on CT-grown/produced foods and to FDA for out-of-state or international products. Regulatory responses from our findings have included warnings, increased inspections, fines, product recalls, and cancellation of USDA Organic Certification. Other aspects of the food safety program include the analysis of food-related consumer complaints and the analysis of alcohol-containing beverages for authenticity and adulteration.

Dr. Brian Eitzer
Dr. Walter Krol
Ms. Terri Arsenault
Mr. Michael Cavadini
Ms. Kitty Prapayotin-Riveros

FDA FOOD EMERGENCY RESPONSE NETWORK

In 2005, the Department of Analytical Chemistry was selected by the US Food and Drug Administration (FDA) for inclusion in the Food Emergency Response Network (FERN). The FERN was established to respond to terrorism involving the food supply and has laboratories addressing chemical, microbiological, and radiological threats. There are 14 state laboratories in the chemistry program, with leadership at the FDA Forensic Chemistry Center and FDA National Program Office. In addition to annual funding to support technical staff, FDA purchased equipment in the Department laboratories exceeding $2 million. The FERN chemistry program was activated for the detection of melamine in pet/human food and for the 2010 Deepwater Horizon oil spill response. In addition, CAES staff received Group

Recognition Awards from the FDA Commissioner for the Deepwater Horizon response. In 2012, we tested food from both the Democratic and Republican National Political Conventions. Current programs include the speciation of arsenic in food, the evaluation of new analytical platforms, and the development of more sensitive methods for ricin and abrin detection in food.

Dr. Jason White
Dr. Brian Eitzer
Dr. Walter Krol
Dr. Christina Robb
Dr. Arnab Mukherjee
Dr. Sanghamitra Majumdar
Mr. Joseph Hawthorne
Mr. Craig Musante
Ms. Terri Arsenault

NANOPARTICLE CONTAMINATION OF AGRICULTURAL PLANTS

Nanotechnology is the science of the nanoscale (1-100 nanometers) and will be a $3 trillion market by 2020. Nearly every industry has been impacted by nanotechnology, including disease treatment, electronics, water treatment, textiles, and cosmetics. Importantly, agriculture has also benefited from nanotechnology; nano-fertilizers, nano-pesticides, and nano-sensors for food packaging are examples where performance is improved at the nanoscale. However, this exponential increase of nanomaterials application has raised concerns over adverse environmental and health effects. With funding from two USDA grants, Department of Analytical Chemistry scientists are investigating the fate and effects of engineered nanomaterials in agricultural systems. Investigations include a high throughput screening assay where plant health and particle accumulation within food is measured by a range of sensitive analytical techniques. Additional research is focusing on how interactions between nanomaterials and co-contaminant pesticides influence food quality, as well as the potential trophic transfer of nanoparticles through food chains. In four years, this project has generated 22 peer-reviewed manuscripts and collaborators include 7 domestic universities and 5 international institutions.

Dr. Jason White
Dr. Alia Servin
Dr. Roberto De La Torre-Roche
Mr. Joseph Hawthorne
Mr. Craig Musante

photo credit:
Christopher Riley,
Providence Water

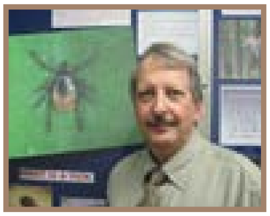
Public Health

INTRODUCTION

Mosquito-transmitted diseases, such as West Nile virus (WNV) and eastern equine encephalitis (EEE), and tick-borne diseases, such as Lyme disease, babesiosis, granulocytic anaplasmosis, a new relapsing fever *Borrelia*, and Powassan virus encephalitis, are significant public health concerns in Connecticut. A resurgence of bed bug activity, although they are not known to transmit any human pathogens, and indoor toxic mold are other public health issues. Public health research on human and animal disease vectors and the pathogens they carry has a long tradition at CAES. Research on mosquitoes and mosquito-borne diseases began back in 1903 and that on ticks in the 1970s. The Station's disease vector research, surveillance, and testing programs within the Departments of Entomology, Forestry and Horticulture, and Environmental Sciences are coordinated through the Center for Vector Biology and Zoonotic Diseases. Past accomplishments include the first isolation of the Lyme disease bacteria from wildlife, development of some of the first Lyme disease laboratory diagnostic tests, the first isolation of West Nile virus from mosquitoes in North America, and the discovery of exotic invasive mosquitoes and new mosquito-borne viruses in the state. Our multifaceted program currently focuses on the biology, behavior, and ecology of mosquito and tick vectors and their hosts; studies on WNV, EEE, Lyme disease, babesiosis, and Powassan virus; the statewide mosquito arbovirus surveillance program; studies on bed bug behavior, monitoring and control; tick pathogen testing; and tick control and management. Public outreach and education is another major component of the public health program. Three major educational publications include (1) *Tick Management Handbook: An Integrated Guide for Homeowners, Pest Control Operators, and Public Health Officials for the Prevention of Tick-Associated Disease*, (2) *Identification Guide to Mosquitoes of Connecticut, and* (3) *History of Public Health Entomology at The Connecticut Agricultural Experiment Station.*

INTEGRATED TICK MANAGEMENT AND TICK CONTROL

Lyme disease is the major vector-borne disease in Connecticut and the United States. Our research examines the biological, cultural, and integrated control of the blacklegged tick, *Ixodes scapularis*, to reduce the risk of Lyme disease and other tick-borne illnesses including human granulocytic anaplasmosis, and babesiosis. Research



has included the evaluation of least-toxic pesticides for tick control, deer exclusion, biological control, landscape modifications, and host-targeted acaricide applications to the white-footed mouse (*Peromyscus leucopus*), the main reservoir host and deer. Ecological studies have included habitat distribution, the role of birds as hosts and mice as a reservoir for anaplasmosis, impact of climate on tick abundance, and the relationship between tick abundance, reservoir host infection, the increase in human cases of Lyme disease and babesiosis. Based in part on our field trials, a naturally occurring entomopathogenic fungus, *Metarhizium anisopliae*, is now available commercially. An integrated tick

management study is evaluating the use of *M. anisopliae* with host-targeted methods to reduce tick abundance with a new program to evaluate a rodent-targeted Lyme disease vaccine to reduce tick infection rates in the residential setting. These investigations would help in evaluating the effectiveness of control measures on disease prevalence and serve as a valuable model in other Lyme disease endemic regions.

Dr. Kirby Stafford
Dr. Scott Williams
Dr. Goudarz Molaei
Mr. Michael Short
Ms. Heidi Stuber
Ms. Megan Linske
Ms. Saryn Kunajukr

MANAGING VEGETATION TO REDUCE LYME DISEASE RISK

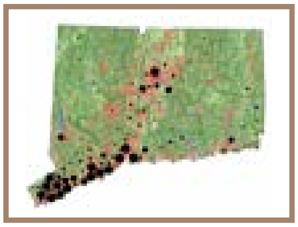
Japanese barberry is an invasive shrub found on 20% of forests in southern New England. It can form dense thickets that limit tree regeneration and native herbaceous plants. Japanese barberry was controlled at six Connecticut study areas. At each, we examined areas where dense barberry infestations were eliminated, areas where barberry infestations remained intact, and areas where barberry was minimal. Adult ticks and white-footed mice have been sampled annually since 2007. At two study areas, temperature and relative humidity during the growing season have been recorded annually since 2008. Intact barberry stands had 140 ± 21 *B. burgdorferi*-infected adult ticks/acre, which was significantly higher than for managed (73 ± 26/acre) and no barberry (38 ± 17/acre) areas. Microclimatic conditions where Japanese barberry was controlled were similar to those areas without barberry. Japanese barberry infestations provide a buffered microclimate that limits desiccation-induced tick mortality. Control of Japanese barberry reduced the number of ticks infected by nearly 50%.

photo credit: Christopher Riley, Providence Water

Dr. Scott Williams
Dr. Jeffrey Ward
Mr. Michael Short
Mr. J.P. Barsky

MOSQUITO AND ARBOVIRUS SURVEILLANCE

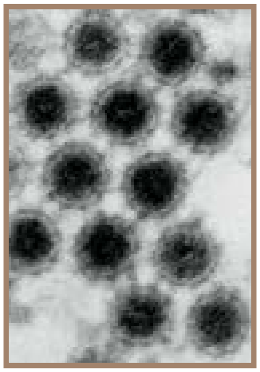
Mosquito-borne viral diseases constitute an annual threat to human health in Connecticut. A comprehensive surveillance program complemented by science-based controls and timely public outreach are the most effective ways of protecting the public and reducing the risk of human disease. Our group monitors eastern equine encephalitis (EEE) and West Nile virus activity each year by trapping and testing mosquitoes statewide. Mosquitoes are collected at 91 locations from June-October, sorted into pools by species, and then tested for viral infection by cell culture and molecular assays. This information is used to assess environmental risk of human infection and guide mosquito control and other disease prevention efforts as needed. Although virus activity varies annually, some regional trends have emerged that can help focus the public health response. We find that West Nile virus is most frequently detected in densely-populated areas of Fairfield, Hartford, and New Haven counties. Seasonal transmission of EEE virus occurs sporadically and the focal areas are located primarily in southeastern Connecticut.



Dr. Philip Armstrong
Dr. Theodore Andreadis
Ms. Angela Bransfield
Mr. John Shepard
Mr. Michael Thomas
Mr. Michael Misencik

MOLECULAR EVOLUTION OF MOSQUITO-BORNE VIRUSES

Mosquito-borne viruses, like other RNA viruses, have high mutation rates that allow them to rapidly diversify, acquire new biological properties, and adapt to new environments. Our group is interested in following viral genetic changes in West Nile virus and other mosquito-borne viruses over time. We have sequenced and analyzed numerous viruses sampled in Connecticut during 18 years of continuous statewide surveillance to track the origin, spread, and long-term persistence of strains involved in disease outbreaks. From this work, we found that eastern equine encephalitis (EEE) virus strains overwinter in the northeastern US for up to 5 years before disappearing. Northeastern populations of EEE virus also share recent common ancestry with strains circulating in the southern United States suggesting long-range viral dispersal among these locations. Our group has also described the patterns of viral lineage turnover and protein evolution for West Nile virus strains circulating in Connecticut since its introduction in 1999.



Dr. Philip Armstrong
Dr. Theodore Andreadis
Dr. Charles Vossbrinck
Ms. Angela Bransfield
Mr. Michael Misencik

VECTOR-HOST INTERACTIONS AND TRANSMISSION OF MOSQUITO-BORNE PATHOGENS

During the last few decades, we have witnessed an outbreak of West Nile virus (WNV), and resurgence and range expansion of eastern equine encephalitis virus (EEEV) activity with considerable impact on public health and economy in the U.S. As a main component of our research, we are investigating vector-host interactions and blood-feeding behavior of mosquitoes to assess: 1) the role of mosquitoes in transmission of WNV and EEEV to humans, and 2) the contribution of individual vertebrates as the source of blood meals for mosquitoes and reservoir hosts in maintenance and amplification of these viruses. We are also examining population genetic structure and underlying mechanisms for spatial and temporal variations in blood-feeding behavior of mosquitoes. These studies will identify factors that potentiate the risk of human infections in various localities, prove vital in better understanding of the ecology of virus transmission, and enable mosquito control agencies to more precisely target interventions at the most epidemiologically important populations.

Dr. Goudarz Molaei
Dr. Theodore Andreadis
Mr. John Shepard
Mr. Michael Thomas

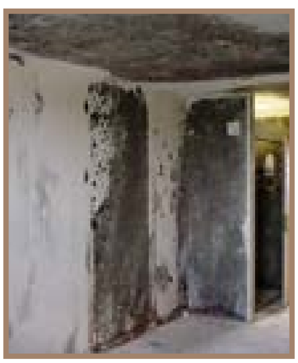
VECTOR-VIRUS INTERACTIONS

The North American West Nile virus epidemic and the recent introduction of Chikungunya virus into the Western hemisphere highlight the public health burden and continued threat of many arboviruses. It is therefore critical that novel approaches to controlling West Nile virus and other arboviruses be developed. Elucidating the mechanisms underlying virus-vector interactions is essential. The projects in our laboratory are focused on understanding the cellular and molecular mechanisms mediating virus-vector interactions using state-of-the-art techniques. The three principal areas of research include 1) elucidating key mosquito and viral factors responsible for mediating virus attachment and penetration of the mosquito midgut, 2) examining the role of autophagy during flavivirus and alphavirus infection of arthropod vectors, and 3) determine if and which host and vector factors influence the population structure of arboviruses.

Dr. Douglas Brackney
Ms. Angela Bransfield

CONTROLLING TOXIC INDOOR MOLDS

Molds develop in indoor environments following water damage and dampness. Exposure to certain molds can trigger allergies, cause infection, or aggravate existing medical conditions. Some common molds are allergens, such as species of *Cladosporium*, *Aspergillus*, *Penicillium*, and *Alternaria*. Others such as *Stachybotrys* are mycotoxin producers associated with mycotoxicosis and "sick building syndrome". Research is being conducted to determine the composition and concentrations of airborne molds in Connecticut, and to determine the incidence and distribution of indoor *Stachybotrys* species and their phylogenetic relationships. Several new species and records have been described from indoor environments. This research will provide a baseline fungal exposure and composition level for public health officials, medical-care providers, and indoor air quality (IAQ) professionals. The identification of mold species has assisted medical professionals in the diagnosis and evaluation of mold-related health risks in public school buildings and aided IAQ professionals in the mitigation of indoor mold problems.



Dr. De Wei Li

BED BUG MANAGEMENT AND OUTREACH

Bed bug infestations cause suffering from the irritation caused by feeding, and can be expensive and difficult to eliminate from buildings. Insecticide resistance to pyrethroids, the most common class of insecticide used for their control, is a major problem. We demonstrated that desiccant dusts, which remove surface waxes leading to desiccation and death, were as effective as the dust formulated with pyrethroids. A silica aerogel dust without an insecticide was recently registered for control of bed bugs. Desiccant dusts do not degrade over time, so placement in bed bug harborages can provide long-term protection against these pests. Other research includes using fungal pathogens, behavioral studies, and heat treatment for bed bug control. Numerous professional trainings, bed bug forums, fact sheets, including multilingual services, and legislative assistance have been provided through the Experiment Station and the Connecticut Coalition Against Bed Bugs (CCABB).

Dr. Richard Cowles
Dr. Gale Ridge

Public Service

INTRODUCTION

With the mission and motto of The Connecticut Agricultural Experiment Station in mind, staff are continually "Putting Science to Work for Society" with a broad spectrum of service and outreach efforts to educate and assist the public. These activities complement our basic and applied research programs and provide information on topics ranging from plant diseases to ticks to all Connecticut stakeholders. Beginning in 1875, scientists at CAES tested fertilizer for label compliance. This was the cornerstone for many of the service activities that continue to this day. CAES scientists test soil for fertility; ticks for the presence of tick-borne human and animal pathogens; seeds for compliance with federal seed law and truth in labeling; feed and fertilizers for compliance with state and national standards; and pesticides and PCBs in the environment. Other service activities include efforts to safeguard Connecticut's agriculture and forests through nursery, plant and apiary inspections, through assistance with plant health questions by employing traditional and molecular approaches to detect difficult-to-diagnose plant diseases and new or emerging pathogens, and assistance with insect questions.

CAES scientists are on the frontlines providing information to residents, with outreach efforts by educating the public during visits to the Station, by talks at meetings, by hosting workshops, by answering phone calls and emails, and by writing fact sheets, alerts, and bulletins for distribution to the public and for posting on the website.

FEEDS AND FERTILIZERS

The analysis of fertilizers and animal feeds is the program on which the Experiment Station was founded in 1875. The current program in the Department of Analytical Chemistry is conducted in collaboration with the CT Department of Agriculture (DoAg). CT DoAg inspectors deliver 100-300 samples annually and the analysis focuses on accuracy of the label with regard to nutrient and associated content. For fertilizers, products intended for both residential and commercial agricultural operations are included. For animal feeds, products for both household pets and commercial agriculture are included. Analytical results are reported to DoAg, who in turn report findings to the product dealer and/or manufacturer for a response.

Mr. John Ranciato

NURSERY, PLANT, AND APIARY INSPECTIONS

Working under the Station's Office of the State Entomologist, inspectors conduct surveys for pests and pathogens that threaten the vitality of CT agriculture, forests, and landscapes. Inspectors conduct surveillance programs for established and exotic plant pests, including some of national regulatory concern such as Chrysanthemum white rust, Ramorum blight, and Asian longhorned beetle. Responsibilities include ensuring that the nursery industry, valued at over 1 billion dollars, is free of plant pests and certify their products for shipment to other states and other nations. In 2014 for example, 305 nurseries were certified to conduct intra- and interstate commerce; 671 nursery inspections were conducted; and 157 firms were issued nursery dealer permits. In addition, inspectors oversee registration of beekeepers and inspection of apiaries to ensure that healthy hives are available to pollinate crops throughout the state. CAES inspectors also monitor the health of CT forests through yearly surveys of forest plots for signs of defoliation, disease, decline, and damage.

Dr. Kirby Stafford
Dr. Victoria Smith
Mr. Peter Trenchard
Mr. Stephen Sandrey
Mr. Jeffrey Fengler
Ms. Tia Blevins
Mr. Mark Creighton
Ms. Katherine Dugas

PESTICIDES IN THE ENVIRONMENT

In a program conducted in conjunction with the CT Department of Energy and Environmental Protection (DEEP) Pesticide Management Program, environmental samples are submitted to the Department of Analytical Chemistry for analysis of pesticide content. Sample

numbers collected by DEEP inspectors range from 150-250 per year, including determining pesticide concentrations associated with misapplication investigations or spray drift in support of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Additional samples are analyzed in support of DEEP surface and groundwater monitoring programs, as well as targeted analysis of synthetic pyrethroids in sediments collected from CT waterways.

Dr. Walter Krol

PCBS IN THE ENVIRONMENT

In a program conducted in conjunction with the CT Department of Energy and Environmental Protection (DEEP) Bureau of Waste Management, samples from regulated locations with polychlorinated biphenyl (PCB) contamination are submitted to the Department of Analytical Chemistry for analysis. DEEP inspectors deliver 25-50 samples per year, with common sample types including soils, water, oil, sediments, paint chips and surface wipes. Results are reported back to DEEP in support of ongoing monitoring efforts.

Dr. Brian Eitzer

SOIL TESTING

Plant health is governed to a large extent by soil fertility. Soil tests provide an intelligent guide to the use of fertilizers and other soil amendments. Testing soil for fertility and suggesting methods for growing better plants are a continuing service of CAES for the citizens of Connecticut. At laboratories in New Haven and Windsor, over 10,000 soil samples are tested annually from farms, lawns, home gardens, nurseries, golf courses and commercial grounds. The tests determine levels of nitrogen, phosphorus, potassium, calcium, and magnesium. These are the nutrients most likely to be deficient in Connecticut soils. Other tests performed are pH, organic matter, soil texture and soluble salts. In addition to improving plant growth and crop yields, CAES soil tests also help reduce the pollution of groundwater, lakes and Long Island Sound by preventing the overuse of fertilizer. Thousands of soil-related inquiries are also fielded annually by soil testing staff and dozens of onsite visits and talks are given.

Mr. Gregory Bugbee
Ms. Jennifer Fanzutti
Ms. Diane Riddle
Mr. Thomas Rathier

PLANT DISEASE INFORMATION OFFICES

Plant diseases represent ongoing threats to plants in Connecticut landscapes, farms, nurseries, woodlots, and forests. The Plant Disease Information Offices (PDIOs) in New Haven and Windsor diagnose plant health problems using traditional, serological, and molecular techniques for all Connecticut stakeholders. Accurate disease diagnoses and annual plant disease surveys ensure early detection, prevention, and eradication of potentially high risk pathogens. The PDIOs annually handle over 5,000 inquiries about plant health problems. We are a member of the National Plant Diagnostic Network created to enhance agricultural biosecurity in the U.S. The PDIOs maintain state and national plant disease databases to monitor recurring and emerging problems that threaten plants in Connecticut. Historical records on disease prevalence combined with fact sheets, outreach programs, and disease monitoring are used to educate and assist growers, plant professionals, and homeowners. These efforts lead to effective implementation of integrated strategies for disease management, which protect plants from epidemic diseases and reduce the amount of pesticides introduced into the environment and waters of Connecticut.

Dr. Yonghao Li
Ms. Lindsay Patrick
Dr. James LaMondia
Ms. Rose Hiskes

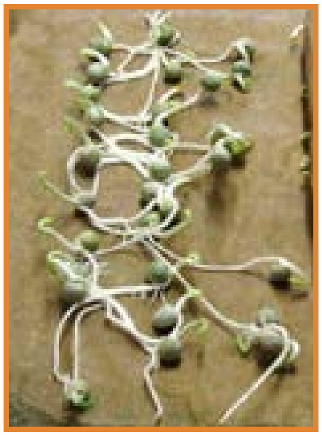
INSECT INQUIRY OFFICES

The report of The Connecticut Agricultural Experiment Station published in 1877 announced that it was offering to "identify useful or injurious insects… to give useful information on the various subjects of Agricultural Science for the use and advantage of the citizens of Connecticut". Insect Information Offices (IIOs) and diagnostic services are freely available at the New Haven campus and the Valley Laboratory in Windsor. The IIO in New Haven has a public reception center, a climate controlled collection room, and diagnostic laboratory with four research stations. The IIOs handle over 13,000 inquiries each year, covering insects, arachnids, and animals; use of pesticides, insect damage, general entomology, and horticultural issues. Bed bug identifications and information has been a dominant inquiry in recent years. Leading in public outreach, office staff provide numerous talks and factsheets to stakeholders and the public. We serve private citizens, pest management professionals, nurseries, land care and arborist industries, health professionals, charities, manufacturing, real estate and hospitality industries, housing authorities, municipalities, museums, libraries, state government, and the media.

Dr. Gale Ridge
Dr. James LaMondia
Ms. Rose Hiskes

SEED TESTING—GERMINATION AND PURITY ANALYSIS

As the official seed testing laboratory for the state of Connecticut, CAES works closely with the Connecticut Department of Agriculture Bureau of Regulation and Inspection who collect official samples of vegetable, crop, and lawn seeds for analysis every year. Samples are analyzed for germination and purity as required for compliance with the Connecticut Seed Law Regulations and the Federal Seed Act using protocols of the Association of Official Seed Analysts. Seedlings must meet label claims and appear "normal" (i.e., free from decay, have well-developed primary root systems, intact hypocotyls and/or epicotyls, and healthy cotyledons). Samples are also examined for the presence of noxious weeds. In 2014, 315 vegetable, 7 lawn, and 7 crop seed samples were tested. This program protects state residents from purchasing inferior seed and ensures that seeds sold in the state are in compliance. The program also minimizes unintentional introduction of noxious weed seeds that could potentially impact crops of economic importance and the state's ecosystem.



Dr. Yonghao Li
Ms. Pamela Sletten

TICK TESTING

Lyme disease (LD) is the most prevalent arthropod-associated disease in the U.S., with an estimate of 300,000 cases per year. In 2013, 95% of LD cases were reported from 14 states, among which Connecticut had the 4th highest incidence (confirmed cases per 100,000 persons) rate of 58.7. In Connecticut, the blacklegged tick, *Ixodes scapularis*, is the most important species in transmitting *Borrelia burgdorferi*, *Anaplasma phagocytophila*, and *Babesia microti*, the causative agents of LD, human granulocytic anaplasmosis, and babesiosis, respectively. The CAES Tick Testing Laboratory examines ticks submitted by health departments for evidence of infection with LD bacterium and other pathogens using molecular techniques. The tick testing service includes identification of the tick species, life stage, blood engorgement status, DNA extraction and PCR using diagnostic genes for identification of the pathogens that ticks carry. In 2014, a total of 2683 ticks were received for identification. Of these, 1380 were tested for the presence of LD bacterium, and 375 (27.2%) were positive.

Dr. Goudarz Molaei
Ms. Saryn Kunajukr

MOLECULAR PLANT DISEASE DIAGNOSTICS

The Molecular Plant Disease Diagnostics Laboratory (MPDDL) was established in 2006 to facilitate accreditation in a national program established by USDA-APHIS-PPQ for realtime PCR diagnostics of *Phytophthora ramorum*, the fungus-like pathogen responsible for Ramorum Blight (a.k.a. Sudden Oak Death). Connecticut, along with much of the rest of the eastern United States, is considered at high risk for *P. ramorum*, due to a conducive climate and the occurrence of many species of plants and trees—red oak, rhododendron, lilac, mountain laurel, and viburnum, to name a few—that are known or suspected hosts. The Department's MPDDL has become an increasingly important resource for rapid and early identification of other difficult-to-diagnose plant diseases. Recently, it is expanding its diagnostic capabilities to include phyoplasma diseases and some emerging virus diseases such as rose rosette disease. As new diseases emerge to threaten our nurseries, forests, and landscapes, the MPDDL will continue to enhance its disease diagnostics capabilities to address the needs of Connecticut's stakeholders.

Dr. Robert Marra

OUTREACH

Whether the concerns are focused on agriculture, environment, public health, or food safety, CAES scientists are on the frontlines providing information to Connecticut residents. Our goal is to educate and inform individuals, communities, and businesses on topics of interest and concern, utilizing the knowledge obtained through basic and applied research programs at the Station. Our premiere outreach event is Plant Science Day, an annual event held at the Station's Lockwood Farm on the first Wednesday of August every year, beginning in 1910. This one-day event features reports on research, field plots, barn exhibits, tours, and other opportunities for Connecticut residents and attendees to discuss many topics of plant science on an informal basis and interact with CAES scientists and staff. Many other types of outreach activities occur throughout the year, including workshops, lectures, town meetings, displays, and tours of research laboratories and research plots. Scientists also write fact sheets, maintain web-based information and weather records, mentor students, judge science fairs, and participate in numerous agricultural fairs throughout the state.

CENTER FOR VECTOR BIOLOGY & ZOONOTIC DISEASES

INTRODUCTION

The Center for Vector Biology & Zoonotic Diseases at The Connecticut Agricultural Experiment Station brings together the research, surveillance and diagnostic activities of our scientific and technical staff working on arthropods of public health and veterinary importance and the infectious disease organisms they transmit in Connecticut and the northeastern United States. The mission of the Center is to advance knowledge on the ecology and epidemiology of vector-borne disease organisms and to develop novel methods and more effective strategies for their surveillance and control.

The Center is responsible for conducting the statewide Mosquito and Arbovirus Surveillance Program for eastern equine encephalitis and West Nile viruses and testing of ticks for the Lyme disease and other infectious agents. Scientists at the Center are also engaged in full-time laboratory and field research on the biology and control of mosquitoes, ticks and bed bugs, and are investigating the epidemiology and ecology of a variety of mosquito- and tick-associated diseases that occur throughout the region including: eastern equine encephalitis, human babesiosis, ehrlichiosis, granulocytic anaplasmosis, Lyme disease, West Nile virus, Powassan virus and a related deer tick virus.

The Center maintains several microbiology, pathology, immunology, electron microscopy and molecular biology laboratories located at the main campus in New Haven and a Biosafety Level 3 containment facility where a worldwide reference collection of about 475 arboviruses are housed. The laboratory is one of the few in the northeast that is certified by the Centers for Disease Control and Prevention and the US Department of Agriculture to work with "select agents". Select agents are bio-agents which have been declared by the U.S. Department of Health and Human Services or by the U.S. Department of Agriculture to have the "potential to pose a severe threat to public health and safety". The Tick Identification, Testing and Information Laboratory and Insect Information Office are also located in New Haven, while insectary facilities for maintaining insect, tick, and vertebrate animal colonies are located at the Station's 75-acre research farm, Lockwood Farm in Hamden, CT. A 28-acre field station and laboratory for conducting additional studies is located at the Griswold Research Center in Griswold/Voluntown, CT.

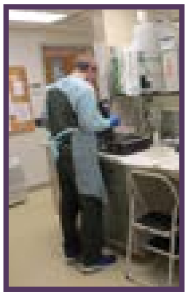
Core funding for the Center is provided from the State of Connecticut and federal Hatch funds administered by the U.S. Department of Agriculture. Research and surveillance activities on mosquitoes and mosquito-borne diseases are additionally supported in part by an "Epidemiology and Laboratory Capacity for Infectious Diseases (ELC)" grant from the Centers for Disease Control and Prevention administered through the Connecticut Department of Public Health. The Center has nine lead scientists, one support scientist and seven technicians, currently divided into three Research Groups investigating (1) Mosquitoes, (2) Ticks and (3) Bed bugs.

Lead Scientists:

- Dr. Theodore Andreadis, Director - Medical Entomology and Insect Pathology
- Dr. John Anderson, Distinguished Scientist Emeritus - Medical Entomology
- Dr. Philip Armstrong, Scientist - Virology
- Dr. Douglas Brackney, Assistant Scientist II – Microbiology
- Dr. Goudarz Molaei, Associate Scientist II - Insect Physiology
- Dr. Gale Ridge, Assistant Scientist II – Entomology
- Dr. Kirby Stafford III, Chief Scientist – Medical and Veterinary Entomology
- Dr. Charles Vossbrinck, Associate Scientist – Evolutionary Ecology
- Dr. Scott Williams, Associate Scientist – Wildlife Biology

Support Staff:

- Angela Bransfield, Technician II and Responsible Official
- Megan Linske, Technician I
- Michael Misencik, Technician II
- John Shepard, Assistant Scientist I
- Heidi Stuber, Technician II
- Michael Thomas, Technician II
- Michael Vasil, Technician II



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Secretary to the Director

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Brian Hart
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Ronald LaFrazier
Custodian

Miguel Roman
Custodian

Michael Scott
Custodian

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MISSION STATEMENT

The mission of The Connecticut Agricultural Experiment Station is to develop, advance, and disseminate scientific knowledge, improve agricultural productivity and environmental quality, protect plants, and enhance human health and well-being through research for the benefit of Connecticut residents and the nation. Seeking solutions across a variety of disciplines for the benefit of urban, suburban, and rural communities, Station scientists remain committed to "Putting Science to Work for Society," a motto as relevant today as it was at our founding in 1875.

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