# Long-term Environmental Changes and Emerging Threats in CT

**Jason C. White, PhD**

Director, The Connecticut Agricultural Experiment Station

Presented at the 50th Anniversary meeting of Connecticut Association of The Conservation and Inland Wetlands Commissions (CACIWC), November 16, 2024

# The Connecticut Agricultural Experiment Station

- Established 1875
  - 1st Agricultural Experiment Station in the US
- Separate State-supported agency
  - Annual budget - $14,186,772
  - $8,441,287– State Funds
  - $3,075,915– Federal Grants (NIH, NSF, USDA, NIFA, FDA)
  - $1,358,923– Hatch, Multi-State, and McIntire-Stennis
  - $1,310,647– Industry Grants
- Governed by an 8-member Board of Control
  - Governor
  - Commissioner of Agriculture
  - Appointees from Yale, UCONN and Wesleyan University
  - 2 Governor Appointees
  - CAES Director



Judd Hall, Wesleyan University 1875


Sheffield Hall, Yale University 1877


Chemistry Laboratory, New Haven 1882

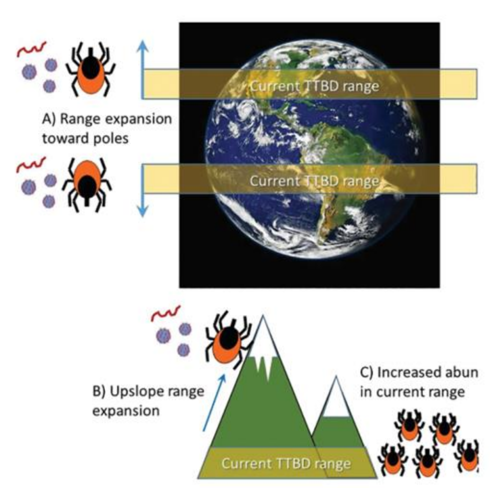
# The Connecticut Agricultural Experiment Station

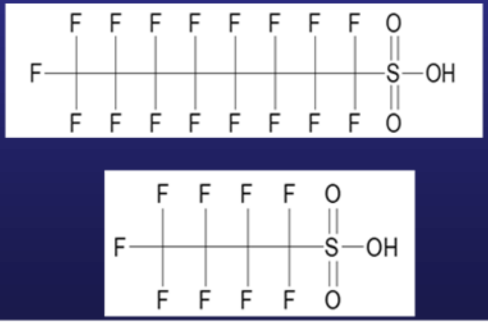
- Primary Mission is **Research** – 4 core areas
  - Agriculture
  - Environment
  - Food Safety
  - Public Heath
- Statutory Responsibilities
  - Inspect nurseries for pests and plant disease
  - Analyze food products and fertilizers
  - Inspect apiaries and certify beekeepers
  - Survey towns for insect pests of forests
  - Conduct state-wide surveillance for mosquito-borne disease
- 6 Departments
  - Analytical Chemistry
  - Entomology
  - Environmental Sciences
  - Forestry & Horticulture
  - Plant Pathology & Ecology
  - The Valley Laboratory
- Current Staff – 110
  - 46 PhD Scientists
  - 28 Research Technicians
  - 19 Postdoctoral Scientists
  - 6 Administrative staff
  - 5 Farm staff
  - 6 Maintenance staff

# Relevant Research Topics at CAES

## The impact of climate change impacts on threats from…

- ➢Vector-borne diseases (mosquitoes, ticks)
- ➢Terrestrial invasive species
- ➢Aquatic invasive species
- ➢Emerging contaminant exposure (PFAS, micro-nanoplastics, toxic elements)
- ➢Food security



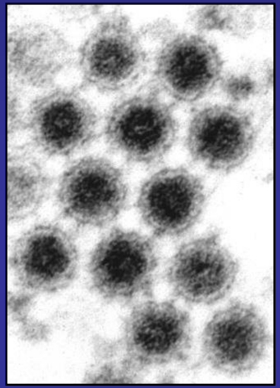
# Vector-Borne Disease

Climate change may influence the incidence of vector-borne diseases through its effect on four principal characteristics of vector populations that relate to pathogen transmission.

- Geographic and Temporal Distribution: Range shifts in vector distribution that bring vectors into contact with new human populations.
- Population Density: Changes in the population density of the vectors would result in increased frequency of contact with humans.
- Prevalence of Infection: Changes in the prevalence of pathogen infection in the reservoir host or vector populations would increase the frequency of human contact with infected vectors.
- Pathogen Load: Changes in pathogen load brought about by changes in the rates of pathogen reproduction, replication, or development in the vector populations.

# Vector-Borne Disease

- Mosquitoes and Ticks transmit many disease-causing pathogens that affect hundreds of millions of humans/animals worldwide.
  - West Nile virus
  - Eastern Equine Encephalitis virus
  - Zika
  - Yellow Fever
  - Malaria
  - Filariasis



- Lyme disease
- Anaplasmosis
- Babesiosis
- Powassan virus
- Filariasis

- These diseases are directly impacted by changes in weather and climate.
  - Vector-borne pathogens/ parasites spend a part of their life cycle in cold-blooded arthropods and are subject to many environmental factors.
  - Marginal changes in temperature, humidity and rainfall can have potentially large biological effects on disease transmission.

# Temperature and Vector-Borne Disease

- Can extend season when mosquitoes and ticks are active and transmit pathogens for longer period of time
- Increase overwintering survival
- Shorten mosquito larval/ nymphal development time
- Adult female mosquitoes digest blood more quickly and feed more frequently
- Increase survival at higher latitudes




- Increase capacity to produce more offspring
- Increase frequency of contact with humans or other hosts

- Can extend distribution range of more tropical vector species
  - *Aedes aegypti*
  - *Aedes albopictus*
  - *Amblyomma* spp.
  - *Hyalomma* spp.

- Bring mosquito/ tick vectors into contact with new human populations

- Decrease survival of some species

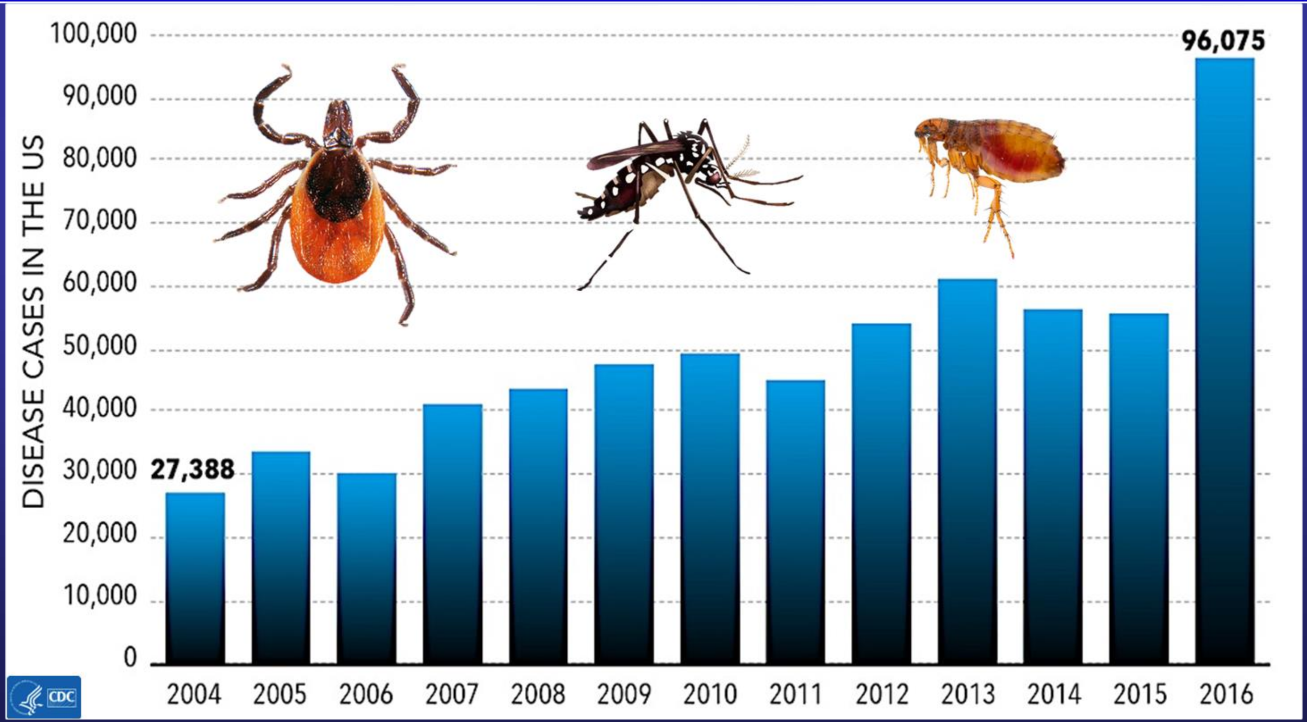
# Precipitation and Vector-Borne Disease

## Increased Precipitation

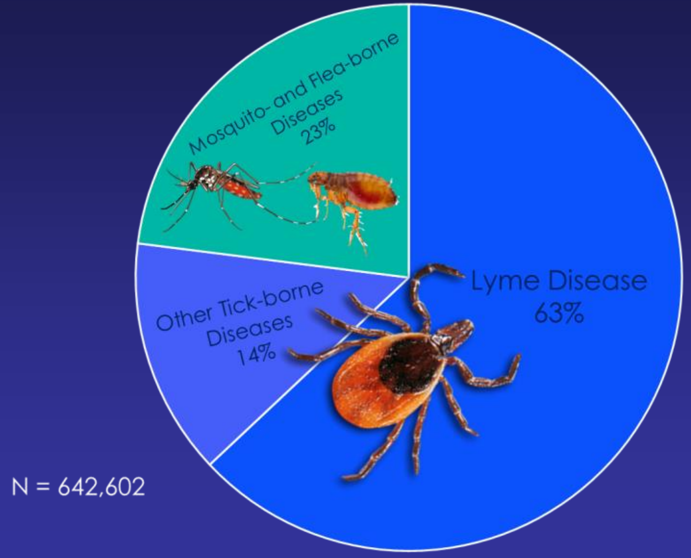
- Negative Impacts
  - Will increase the number and quality of larval breeding sites.
  - Epic rainfall events can synchronize mosquito host seeking and pathogen transmission.
  - Associated increase in humidity will increase mosquito and tick  survival.
- Positive Impact
  - Excess rainfall or snowpack can eliminate larval habitat by flooding thus reducing the mosquito population.

# Vector-Borne Disease

## *Disease Cases from Infected Ticks, Mosquitoes, and Fleas Have Tripled in 13 Years!*

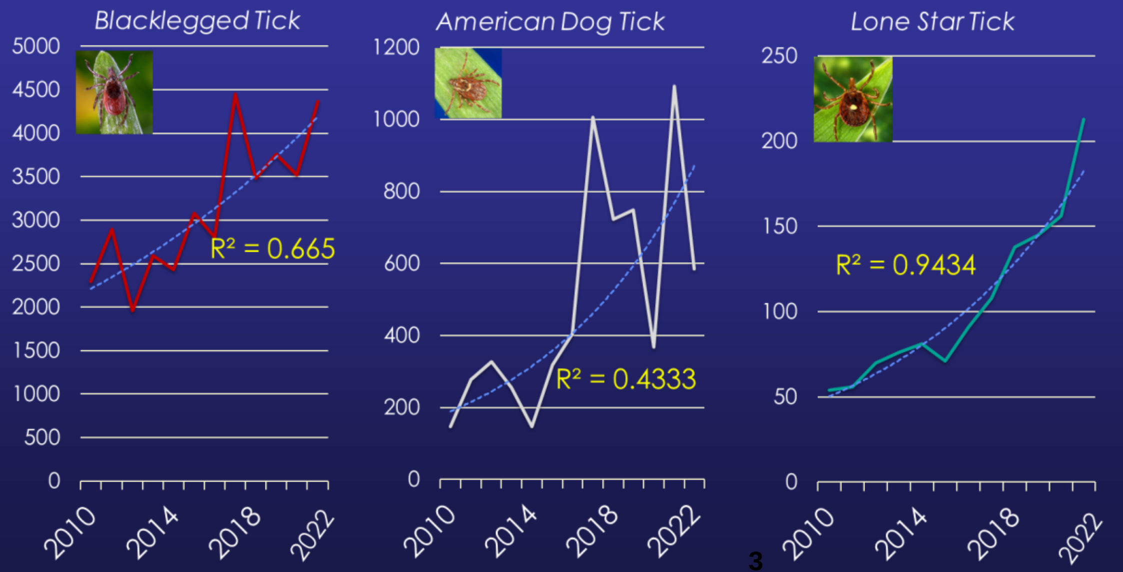



## *Cases of Nationally Notifiable Vector-borne Diseases Reported in the U.S.*




www.ct.gov/caes

## *Populations of Tick Species are on the Rise*



# Managing Vector-Borne Disease

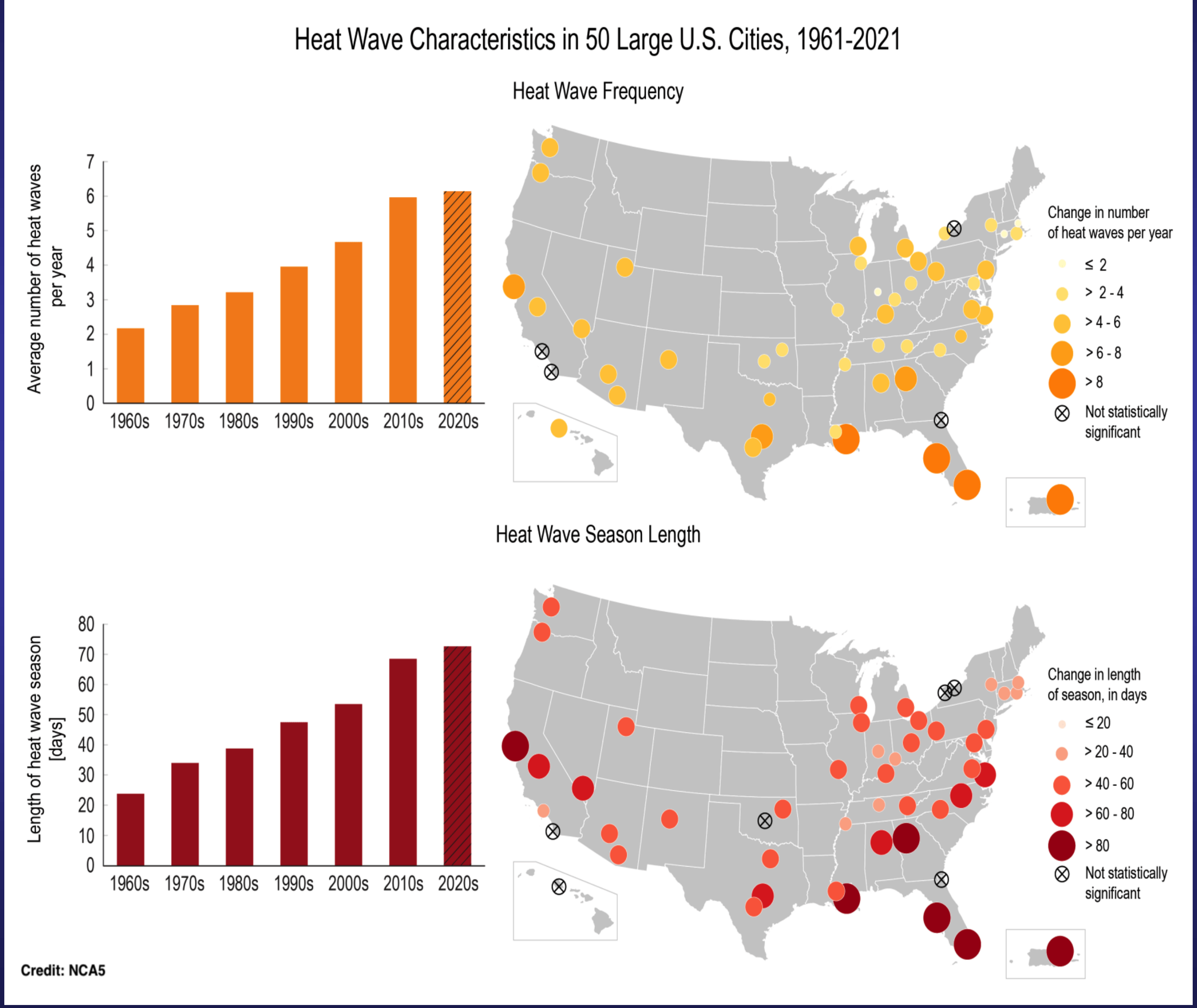
- Repellants, clothing, checking, and timing of outdoor activity!

1. **Manage water resources.** Eliminating standing water in neighborhoods, particularly urban neighborhoods, and biological control of mosquitoes reduces mosquito egg and larval development.
2. **Reduce social and economic disparities.** In both urban and rural settings, social and environmental drivers such as inequality, poverty, and differential effects of climate change increase the risk of vector-borne diseases.
3. **Promote health of migrant populations.** Quite often, migrant populations have limited access to healthcare and public health resources, are frequently exposed to vector-borne diseases as occupational health hazards, and lack adequate resources for proper housing.
4. **Enhance vector surveillance and risk-mapping in vulnerable neighborhoods.** Risk mapping will be enhanced by sustained systematic vector surveillance in vulnerable urban and rural communities. Integrating risk mapping into vector control programs will make vector-borne disease control more targeted and sustainable.
5. **Reduce environmental risk factors for vector-borne diseases.** Environmental risk factors can be reduced by measures such as landscaping to minimize tick encounters around the home, or eliminating artificial sources of stagnant water to reduce mosquito breeding.
6. **Plan for vector-borne diseases following natural disasters.**
   - Monitoring priority endemic and emerging diseases
   - Training health-care workers to detect vector-borne diseases and report to lead health agencies
   - Incorporating vector control measure into natural disaster planning

3

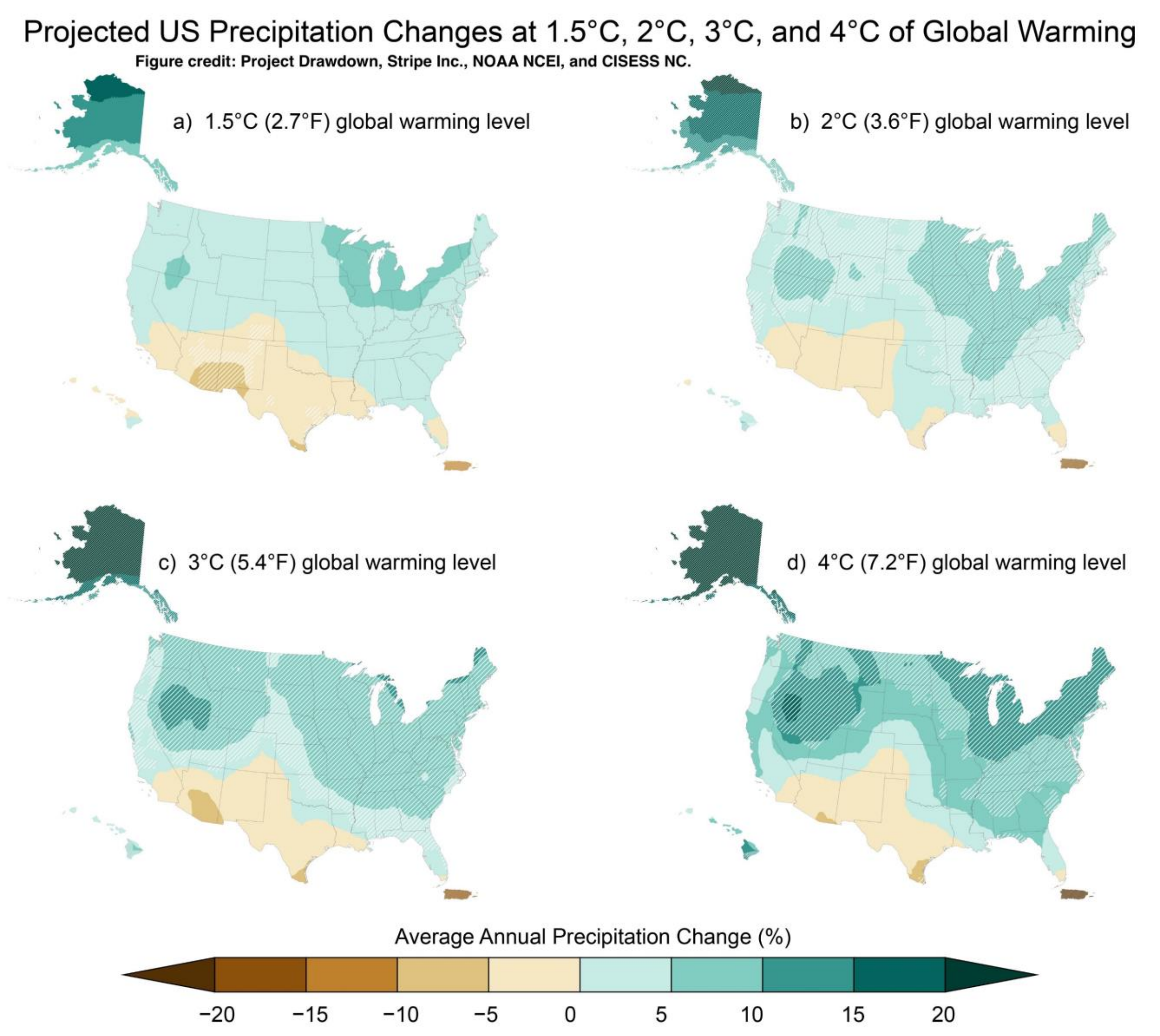
# Climate and terrestrial invasive plants in CT

- Some Northeastern areas are > 2°F warmer than in the first half of the 20th century.
- Heatwaves in the northeast have increased from 2 per year in 1960s to 6 per year in 2020s.
- Heat waves are becoming more intense and lasting longer.
    - 1960s ~ 20 days.
    - 2020s ~ 70 days.



# Climate and terrestrial invasive plants in CT

- The Northeast is getting wetter
- The Northeast has seen a roughly 60% increase in the number of days with extreme precipitation, the largest increase of all the U.S. regions.
- This trend, along with an increased risk of flooding, will continue in the future.
- There will be an estimated 5% to 25% increase in annual precipitation with further 2.7°F to 7.2°F rise in global temperature.

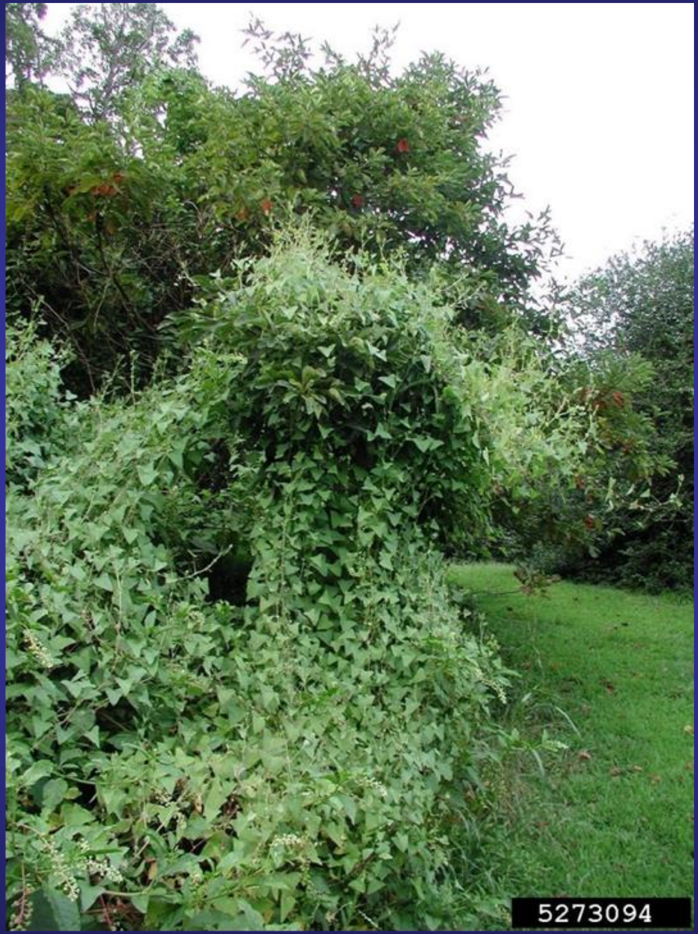


# Climate and terrestrial invasive plants in CT

- Invasive plants require unique opportunities such as habitat disturbance and ecosystem stress to invade new areas.
- Drought, rainstorms, and flooding will create new niches for the spread of invasive plants like oriental bittersweet, porcelain-berry, mile-a minute, etc.

Oriental bittersweet

Porcelain-berry



Mile-a-minute

# Climate and terrestrial invasive plants in CT

- Excess rain and ensuing flooding will aggravate the stream bank invaders like Japanese knotweed and phragmites by promoting stream bank erosion leading to their detachment and downstream spread into new areas.
- Root fragments (1-inch) can produce new plants.

Japanese knotweed

Japanese knotweed plant from a root fragment.

Phragmites

Phragmites rhizomes

# Climate and terrestrial invasive plants in CT

- The Northeast will likely become home to the new invasive plants.
- The invasive plants of the southeast and mid-Atlantic regions such as Chinese tallow tree, cogongrass, kudzu, Johnsongrass, trifoliate orange will likely invade and become established in the northeast.

Chinese tallow tree


Kudzu

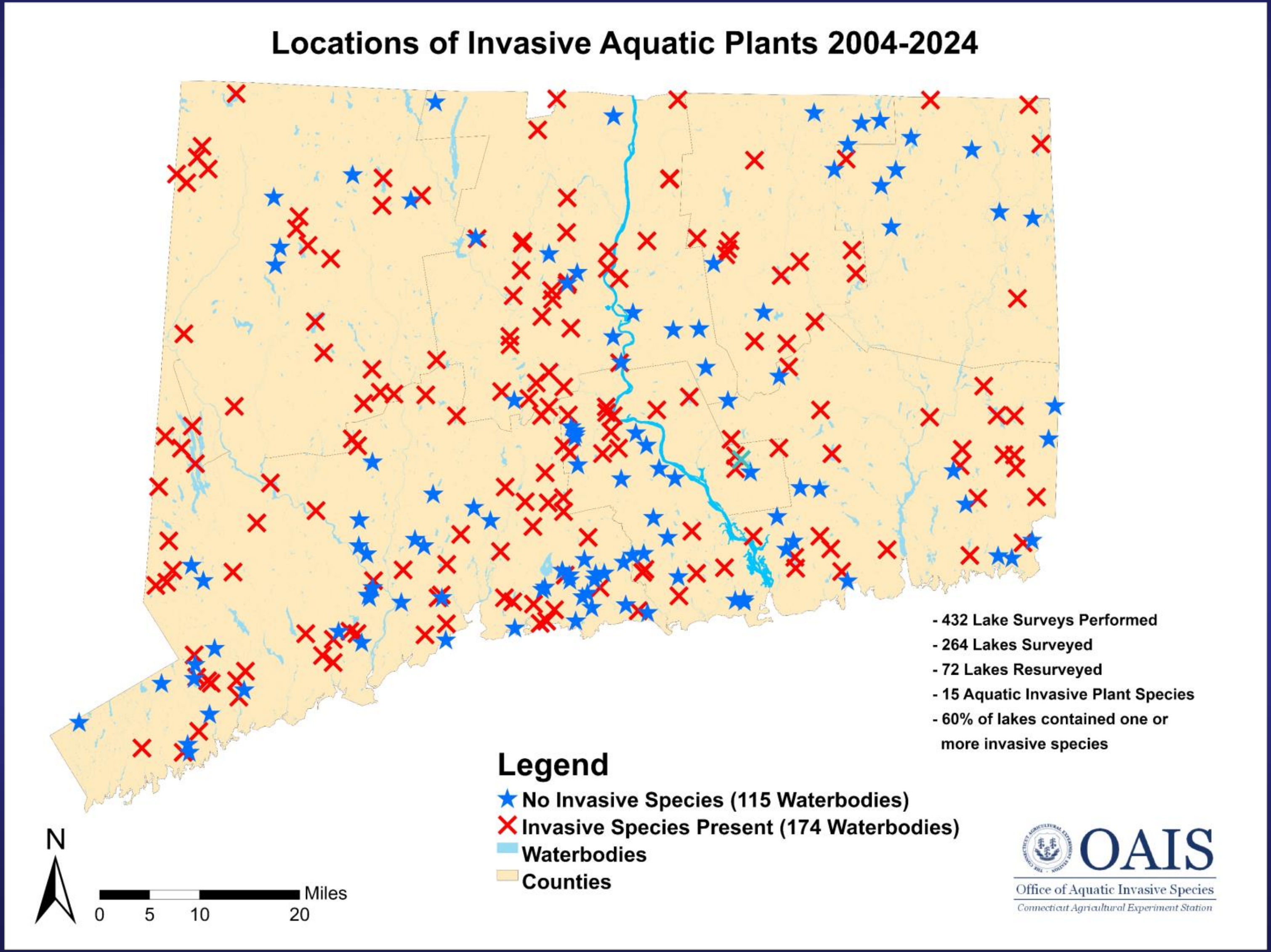

Johnsongrass


Cogongrass

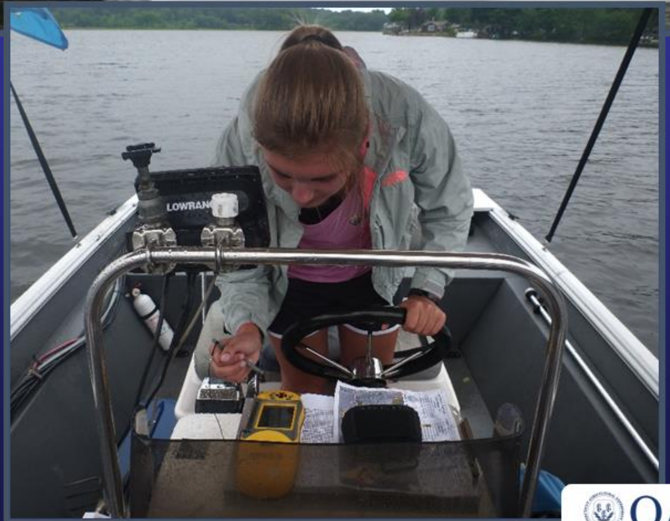
# Climate and aquatic invasive plants in CT

- **Ecosystem Impacts**
  - Displace native species
  - Alter native ecosystems
- **Economic Impacts**
  - Reduce recreation
  - Lower property values and tax revenue
  - Interfere with navigation
  - Economic damage and management costs of approximately $15 billion per year in the United States

# Climate and aquatic invasive plants in CT




CAES OAIS Aquatic Vegetation Surveys

# Climate and aquatic invasive plants in CT

**OAIS**
Office of Aquatic Invasive Species
*Connecticut Agricultural Experiment Station*

Established
July 2022

**What do we do?**

- Research and survey aquatic plant species
- Serve as a repository for statewide aquatic invasive species data
- Educate the public on aquatic invasive species issues and identification
- Coordinate with the Invasive Plants Council
- Advise municipalities on aquatic invasive species management
- Act as a liaison among organizations and state agencies for AIS control and eradication issues

Gregory Bugbee | Jeremiah Foley | Summer Stebbins | Riley Doherty

# CAES OAIS Discovers Novel Strain of Hydrilla in the Connecticut River

(This is the Mattabesset River, which is a tributary of the Connecticut River)

# Climate and aquatic invasive plants in CT

## Aquatic invasive species are increasing

| Connecticut River | | | |
|---|---|---|---|
| **Invasive Aquatic Plant** | **Presence** | | |
| **Common Name** | **1947*** | **1994-1995**** | **2019***** |
| Curlyleaf pondweed | ✓ | ✓ | ✓ |
| Fanwort | | ✓ | ✓ |
| Eurasian watermilfoil | | ✓ | ✓ |
| Hydrilla | | | ✓ |
| Variable-leaf watermilfoil | | | ✓ |
| Water chestnut | | | ✓ |

*Hotchkiss, 1947
**Barrett *et al.*, 1997
***CAES OAIS, 2019

OAIS
Office of Aquatic Invasive Species
*Connecticut Agricultural Experiment Station*

Federal funding put in the defense budget for USACE in cooperation with CAES OAIS to implement demonstration projects to study methods for controlling hydrilla in the Connecticut River watershed.

# Climate and invasive plants in CT

**Prevention**:

- Collaboration at the local, regional, and national level to stop invasive plants and their propagules spread into the new areas.
- Educating the public and various state and private stakeholders.

**Early detection and eradication**:

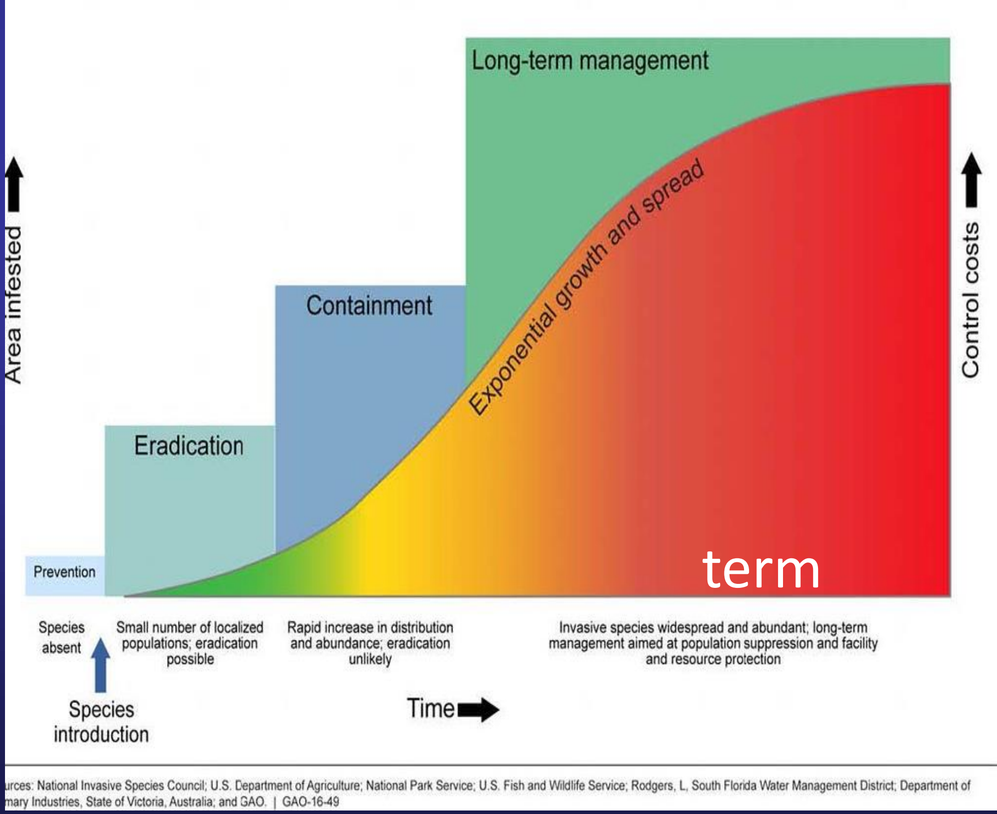
- New invaders (small scale infestations)

**Management**:

- Integrated management involving biological, chemical and cultural control tactics.

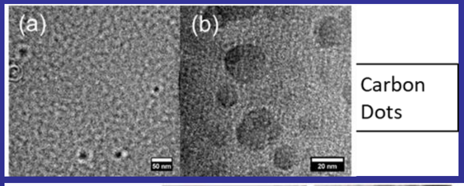
**Future research topics**:

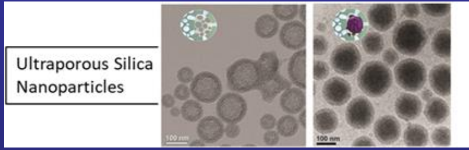
- Integration of chemical and cultural control tactics for eradication/management
- Discovery and evaluation of biocontrol for long-term management.
- This will be possible only with increased federal/ state support for research.

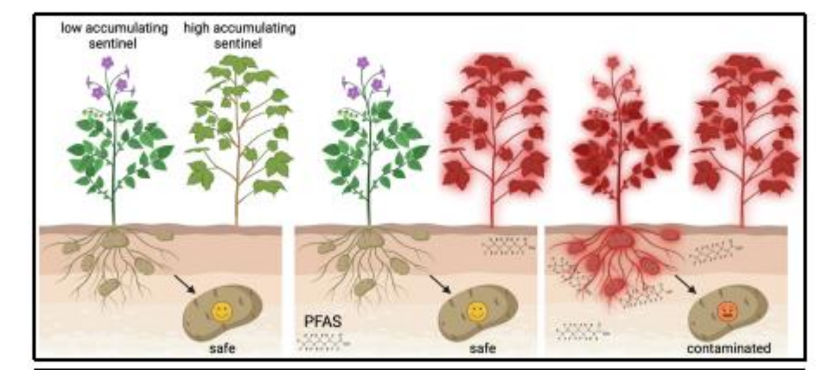


# PFAS, micro-nanoplastics and toxic metals, oh my

- CAES has several state and federally funded projects focused on understanding, reducing the exposure, and remediating emerging contaminants
- PFAS NIEHS SRP- Nano-enabled PFAS Phytoremediation
- PFAS EPA- Novel, bio-enabled strategies to prevent PFAS accum-ulation in crops and food webs)
- PFAS CT- Farm Soil Testing Program

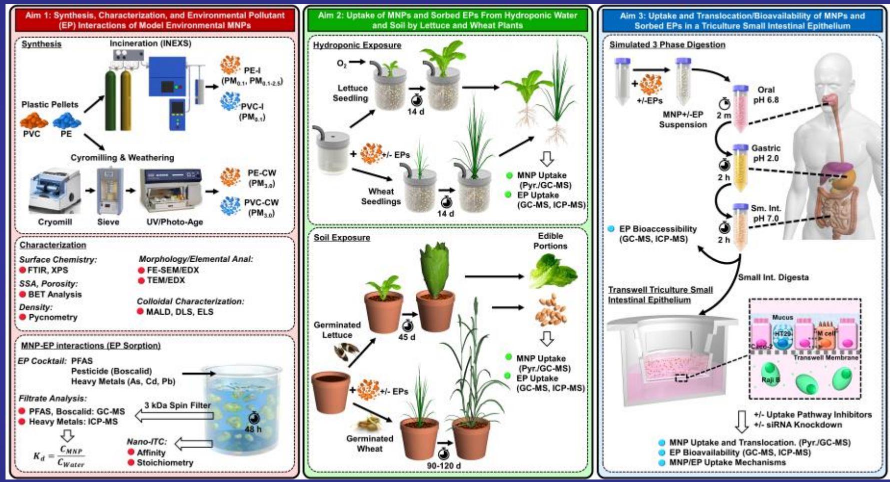


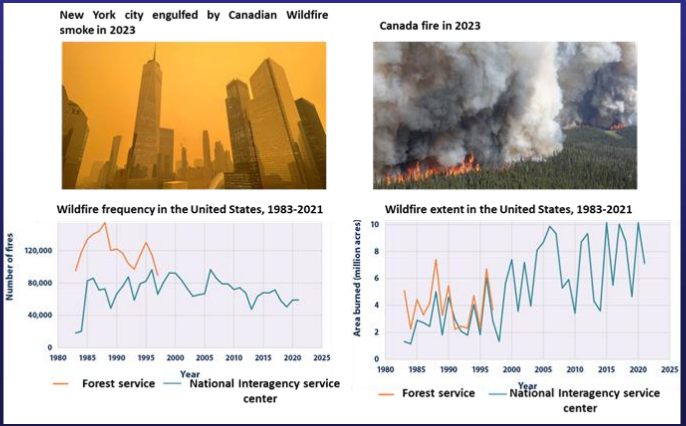



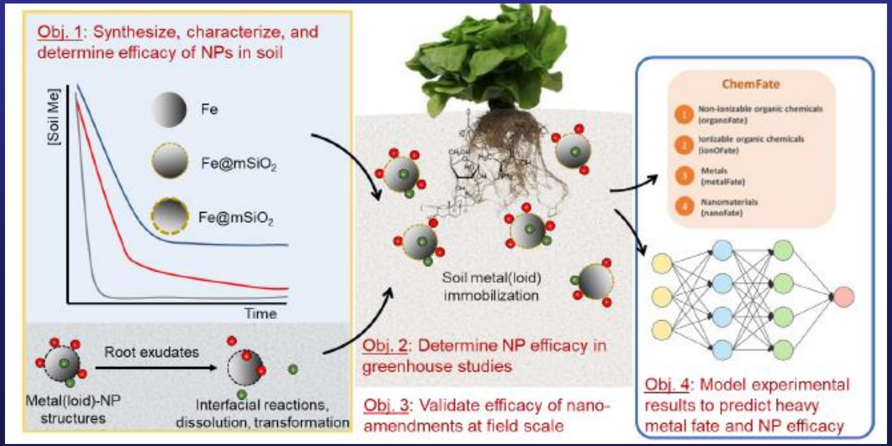



# PFAS, micro-nanoplastics and toxic metals, oh my

- Micro-nanoplastics USDA- Crop exposure to micro-nanoplastics and potential impact on human nutrition and health (NIH Center?)
- Toxic elements USDA- Nanoparticulate soil amendments for achieving “Closer To Zero” via metal(loid) encapsulation
- Toxic elements NIEHS- A novel strategy for arsenic phytoremediation
- Wildfire Particulate Exposure USDA (under review)- “Unraveling the wildfire emitted particles on plants metabolism and human health”



# Nano-enabled agriculture: A path to global food security in a changing climate


**Jason C. White et al…**

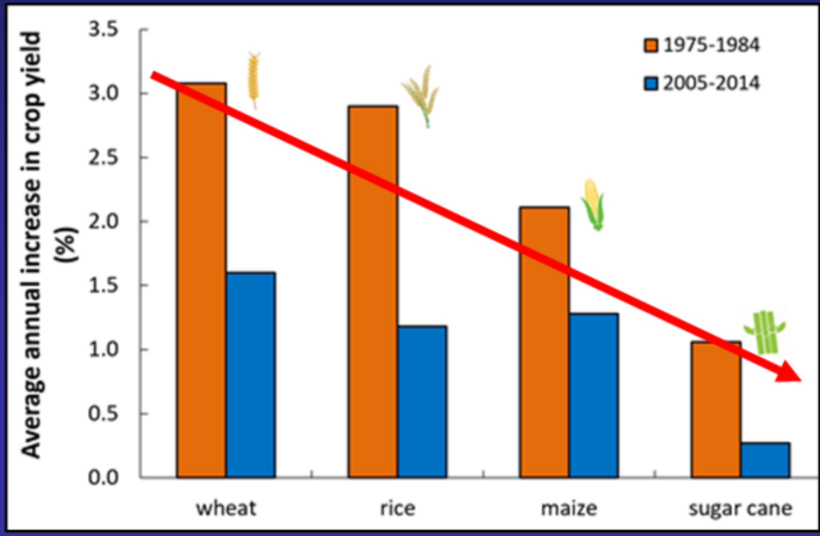
The Connecticut Agricultural Experiment Station, 123 Huntington Street, New Haven CT 06511 USA

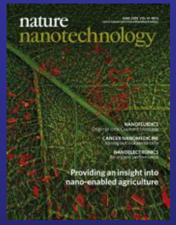


Presented at the National Academies of Sciences, Engineering, and Medicine's Committee on the Quadrennial Review of the National Nanotechnology Initiative; June 6, 2024

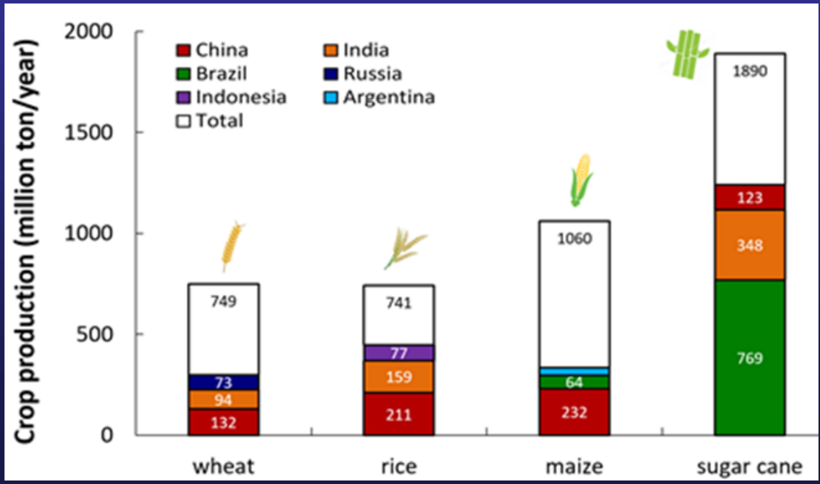
# <u>Conventional Agriculture: Current Perspective</u>

- Agricultural productivity has increased dramatically in the last 70 years (Green Revolution…irrigation, agrichemicals). However, there are many significant shortcomings
- 70% of all freshwater use on the planet goes to agriculture.
- The rate of crop yield increase has <u>declined</u> since the 1980s.
- We still have 800 million chronically hungry every day; 2 billion suffer micronutrient deficiencies.
- Agricultural systems in the much of the world have plateaued at 20-80% of yield potential
- 20-40% of crops are lost to disease/pests
- Agrichemical delivery efficiency is often only 1-25% (**<u>Nanotechnology!</u>**)



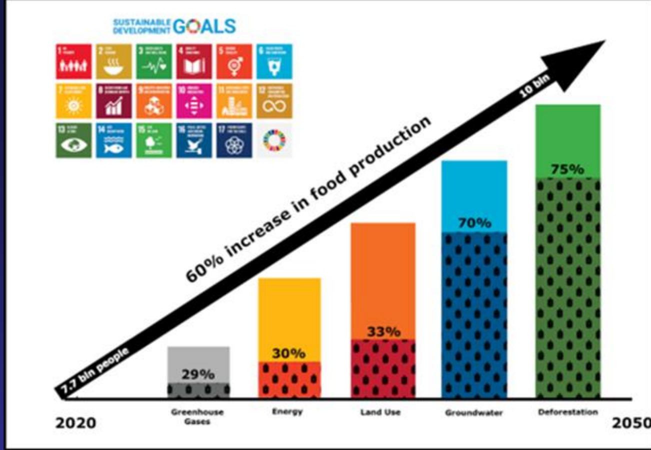



Kah et al. 2019 *Nature Nano.* 14, 532-540.
Ma et al. 2020 *Nature Nano.* 15, 1033–1042
Deng et al. 2022 *Nature Nano.* 17, 347–360

# Why Nano-Agriculture? Declining Global Food/Nutrition Security!!!

- Food production needs to increase by 60-100% by 2050
- Negative pressure from a **changing climate** and a loss of arable soil
- And COVID, conflicts in Ukraine and the Middle East, …
- Novel strategies/technologies are needed from "farm to fork" (and beyond) to solve the grand challenge of global food insecurity
- Nano-enabled strategies include… more precise nano-enabled micro/macronutrient/pesticide delivery platforms, nanoscale micronutrients to enhance abiotic and biotic stress tolerance and promote photosynthesis/N fixation, induction of RNA interference, nutrient fortification, sensing environmental conditions/pathogens, extending shelf life, reduce food waste,…




*PNAS* January 2019

Decline in climate resilience of European wheat

Helena Kahiluoto, Janne Kaseva, Jan Balek, Jorgen E. Olesen, Margarita Ruiz-Ramos, Anne Gobin, Kurt Christian Kersebaum, Jozef Takáč, Francoise Ruget, Roberto Ferrise, Pavol Bezak, Gemma Capellades, Camilla Dibari, Hanna Mäkinen, Claas Nendel, Domenico Ventrella, Alfredo Rodríguez, Marco Bindi, and Mirek Trnka

CLIMATE CHANGE — Science Aug. 2018

Increase in crop losses to insect pests in a warming climate

Curtis A. Deutsch, Joshua J. Tewksbury, Michelle Tigchelaar, David S. Battisti, Scott C. Merrill, Raymond B. Huey, Rosamond L. Naylor

ACS NANO — EDITORIAL

At the Nexus of Food Security and Safety: Opportunities for Nanoscience and Nanotechnology

PNAS

Opinion: To feed the world in 2050 will require a global revolution

Paul R. Ehrlich and John Harte

Nanoscale chemistry in plants plays a significant role in achieving SDGs

ACS Campaign for a Sustainable Future ZERO HUNGER SUMMIT

The role of chemistry in addressing hunger and food security Free Virtual Event | December 5 – 8, 2022

White House Science and Technology Advisor Says Chemistry is Fundamental to Solving Global Food Security Crises

INSIGHTS

Science July 2020

COVID-19 risks to global food security

THE LANCET Planetary Health

REVIEW | ONLINE FIRST

Mechanisms underlying food insecurity in the aftermath of climate-related shocks: a systematic review

Kristie Hadley, MD • Stefan Wheat, MD • Heidi Honegger Rogers, DNP • Arjun Balakumar, MD • Diana Gonzales-Pacheco, DCN • Sarah Shrum Davis, MPH • et al. Show all authors

Open Access • Published: February 09, 2023 • DOI: https://doi.org/10.1016/S2542-5196(23)00003-7 •

# “Nano” Research at the CAES

## Applications: Nano-enabled agriculture

- Nano-enabled micro/macronutrient and pesticide delivery platforms
- Nanoscale micronutrients to modulate crop nutrition for disease suppression
- Nanoscale materials to enhance stress tolerance, photosynthesis, nitrogen fixation and induce RNA interference

ROS ROS ROS ROS ROS ROS

USDA National Institute of Food and Agriculture

The Center for Sustainable Nanotechnology

Nanyang Technological University – Harvard T.H. Chan School of Public Health Initiative for Sustainable Nanotechnology

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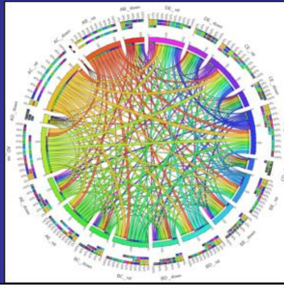
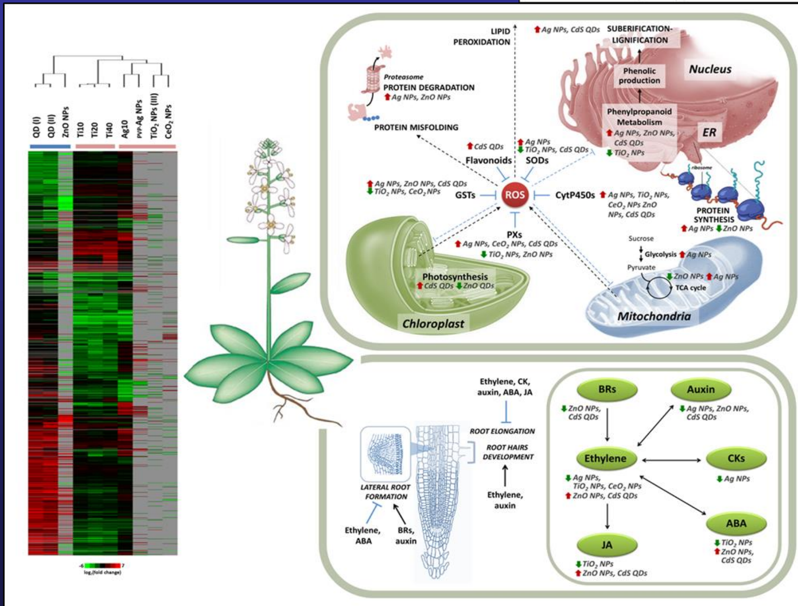


Ruotolo et al. 2018. *Environ. Sci. Technol.* 52, 2451-2467.




## Implications: Nanotoxicology

- Nanomaterials (NM) fate/effects on plants and related biota.
- Investigating the molecular basis of plant response; needed to ensure accurate risk assessment and safe use.
- NM trophic transfer and transgenerational impacts in the food chain
- NM co-contaminant interactions

# Conclusions and Acknowledgments

- The CAES is well positioned to conduct research and find solutions for a broad range of emerging threats in CT as a function of long-term environmental changes

- We acknowledge funding and support from the state of CT, USDA, NSF, EPA, FDA, NIH, NIEHS, CDC, DoD

- I specifically acknowledge the expertise, productivity, and spirit of the CAES staff whole are tirelessly "Putting Science to Work for Society"

www.ct.gov/caes