# Biological Control of Hemlock Woolly Adelgid and Mile-a-Minute Weed



Carole Cheah

Department of Entomology

The Connecticut Agricultural Experiment Station

# Biological control

- “The actions of parasites, predators and pathogens in maintaining another organism’s density at a lower average than would be in their absence” (DeBach)
- Classical biological control is the introduction of a native natural enemy of the pest /weed from area of origin
- Other techniques include augmentation and conservation of natural enemies

# Challenge of landscape structure

Hemlock Woolly Adelgid

- Forest ecosystem with complex structure and higher diversity
- Relatively stable, long-lived, spatially expansive
- Variable tree age and class leading to a high degree of vertical structure
- Cryptic tiny predators

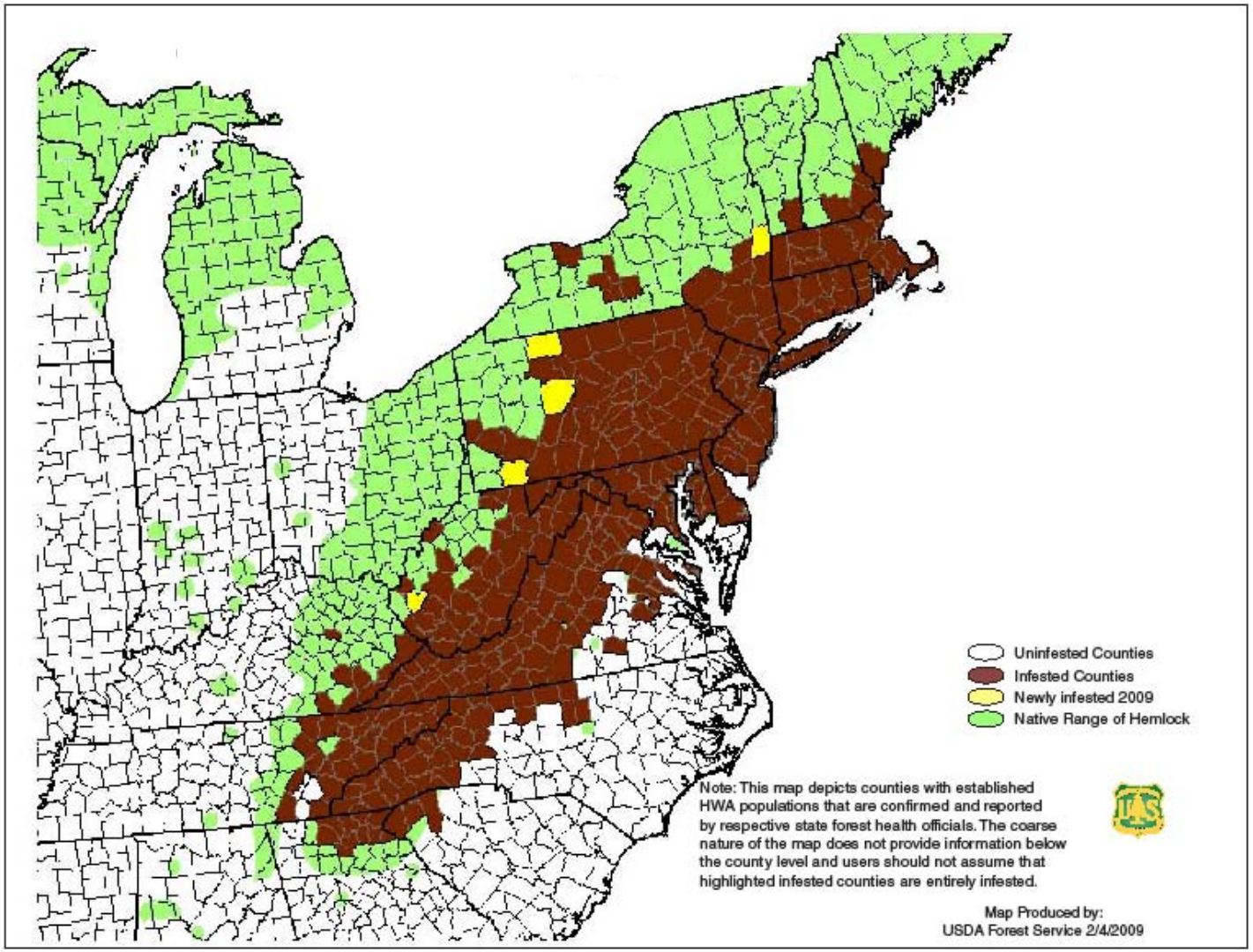
Mile-a-Minute

- Ecosystems disturbed by human activity e.g. deforestation, grazing cultivation, erosion
- Also invades undisturbed wetlands, natural openings in forests
- Damage by insect agent more easily observed
- Cryptic herbivorous insects

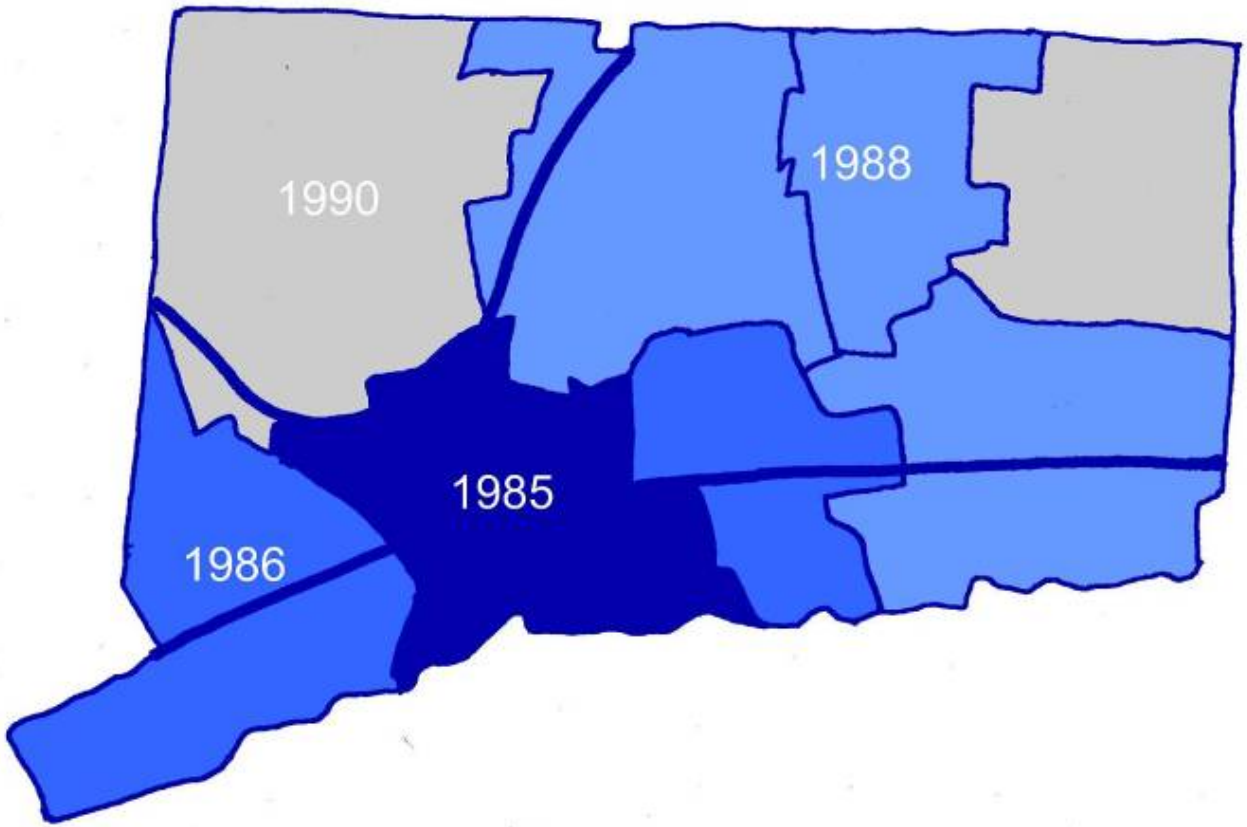
# Hemlock Woolly Adelgid

## *Adelges tsugae* (Homoptera:Adelgidae)

# Counties with established HWA populations 2009



# Progression of HWA in CT



# Hemlock Decline & Mortality

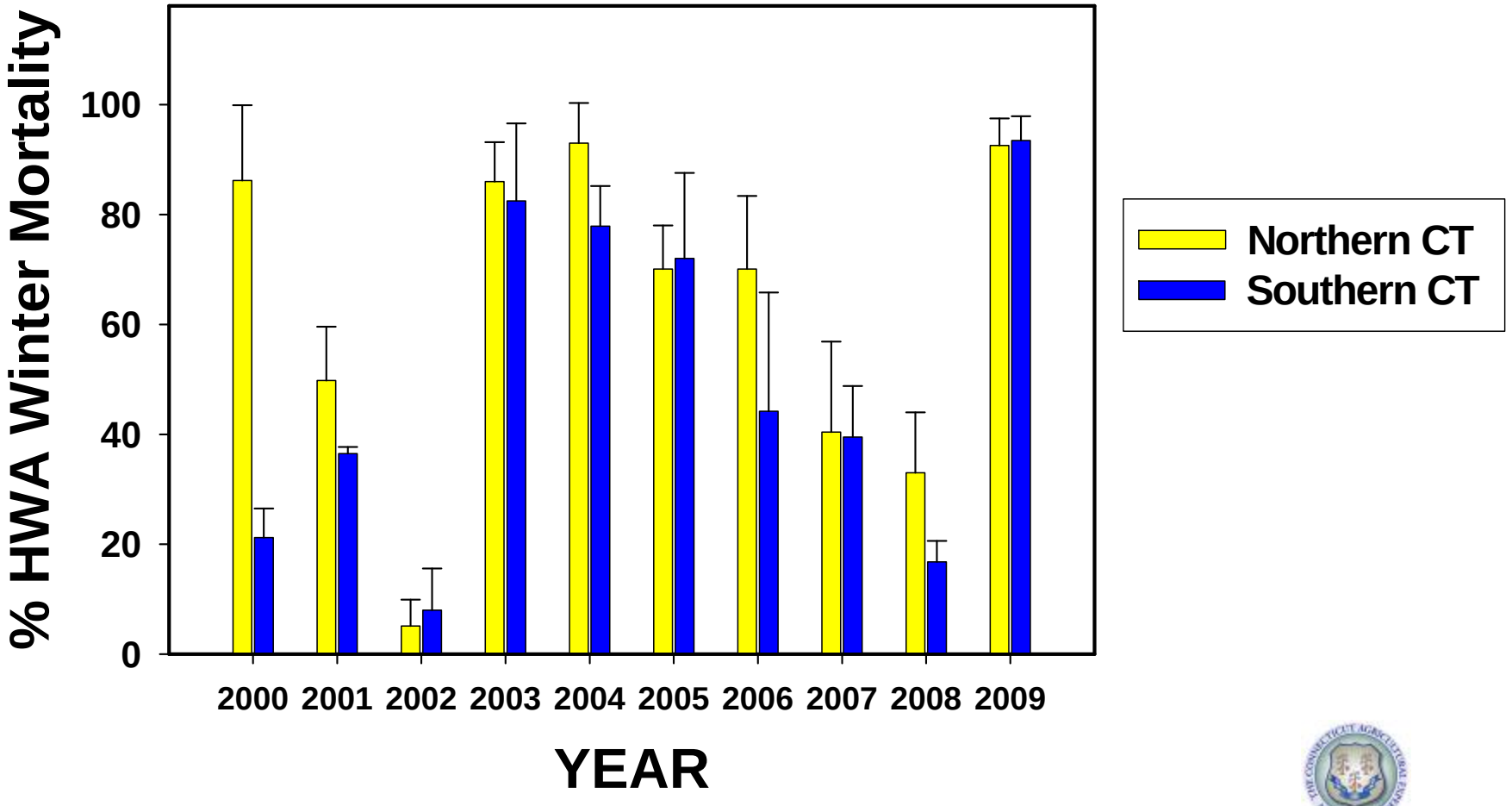




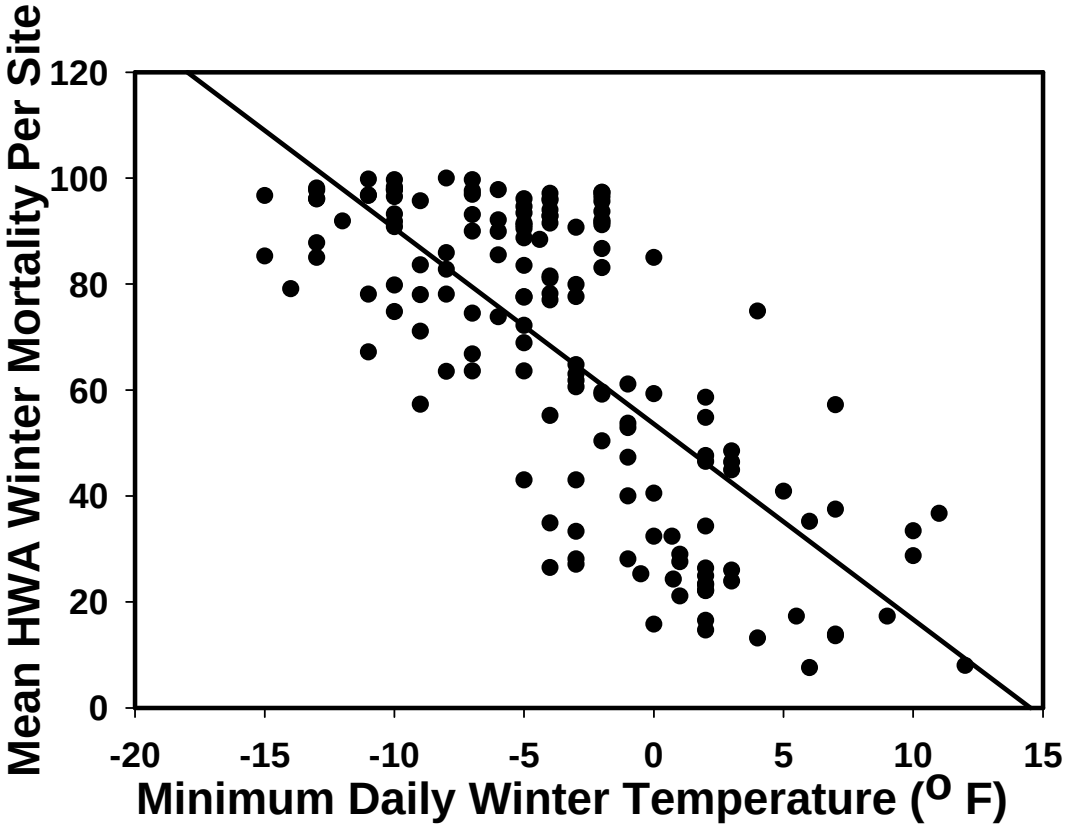

# Biology of HWA

- First described in Oregon by Annand in 1924
- Native to China, Japan, Taiwan & India
- Discovered in early 1950's in central Virginia, now recorded in 18 eastern states
- 2 all female generations completed/year: Sistens (winter) & Progrediens (summer)
- Unique development by sistens during fall & winter
- Mouthparts insert into parenchyma cells, not directly in sap
- Feeding drains tree's reserves, retarding growth

# HWA Winter Mortality in CT



# The Relationship between HWA Winter Mortality and Minimum Daily Temperatures in CT




***From nearest weather station; $r^2 = 0.5391$ $p < 0.00001$**

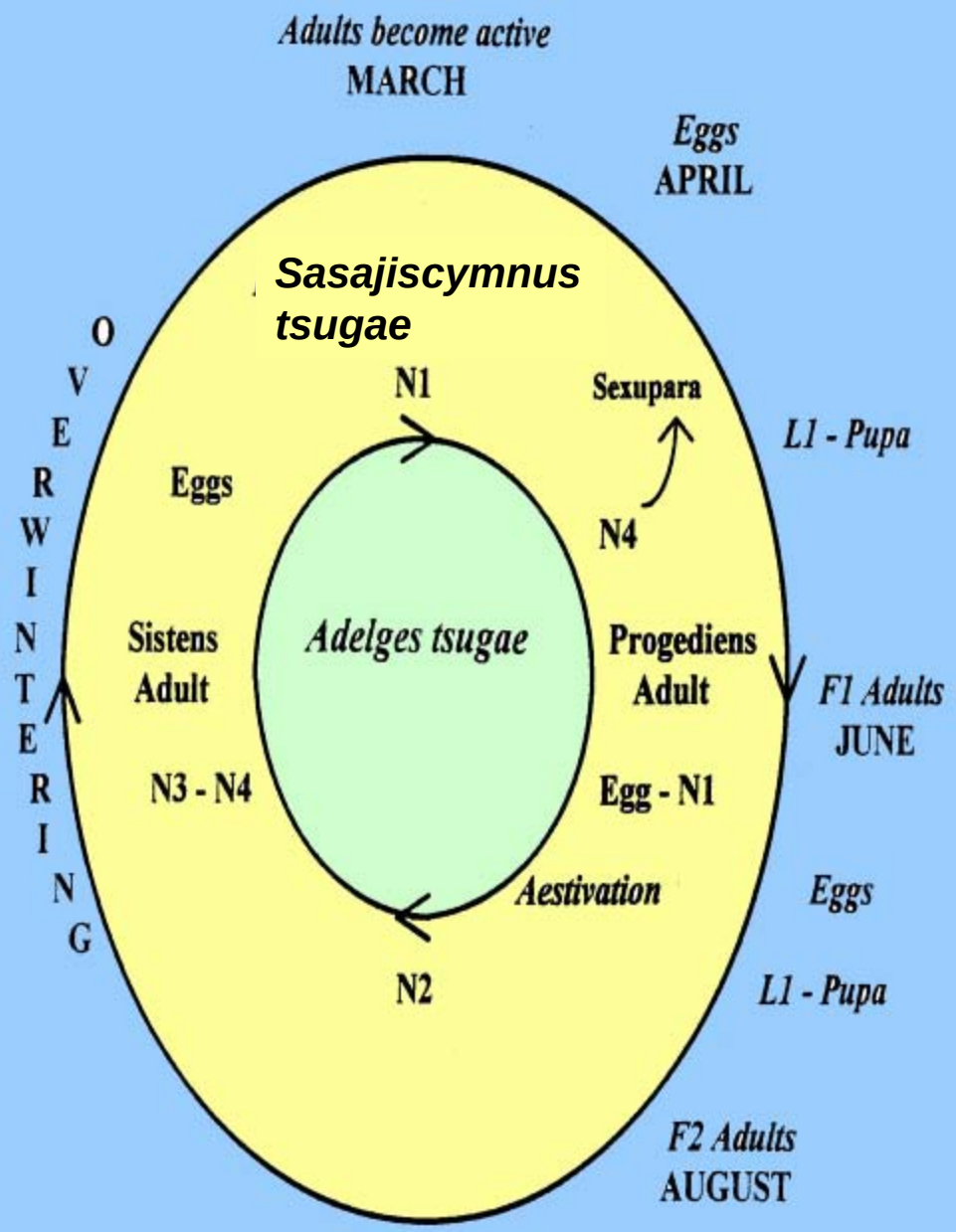
# Stages in Biological Control Implementation

- Foreign exploration for natural enemies
- Quarantine rearing & screening for non-target impacts
- Permit for release following USDA-APHIS FONSI (Finding of No Significant Impact)
- Continued research into attributes, host range, mass rearing, experimental releases
- Assessment of impact on pest/weed following release

- Host specificity is critical to avoid non-target impacts
- Objective is to reduce pest/weed populations to non-injurious levels and obtain an equilibrium
- Biological control of HWA first implemented in USA by CAES in Connecticut in 1995

# Connecticut: A Biological Control Case Study for *Sasajiscymnus tsugae*

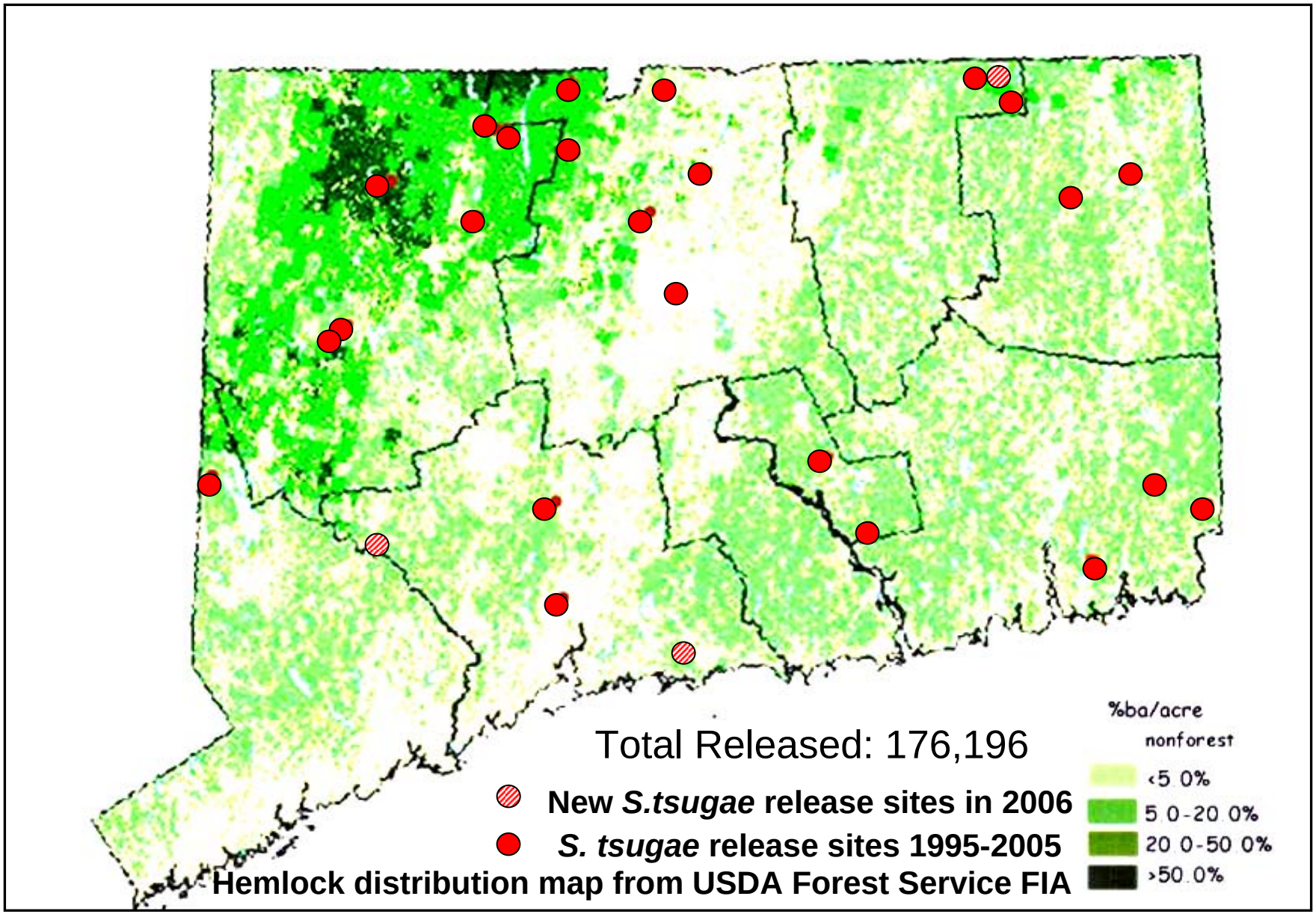
Origin: Southern Japan,
Order Coccinellidae (ladybeetles)


Adults become active
MARCH
Eggs
APRIL
Sasajiscymnus tsugae
OVERWINTERING
N1
Sexupara
L1 - Pupa
Eggs
N4
Sistens Adult
Adelges tsugae
Progediens Adult
F1 Adults
JUNE
N3 - N4
Egg - N1
Aestivation
Eggs
N2
L1 - Pupa
F2 Adults
AUGUST
OCTOBER - DECEMBER
F1 and F2 adults seek overwintering sites

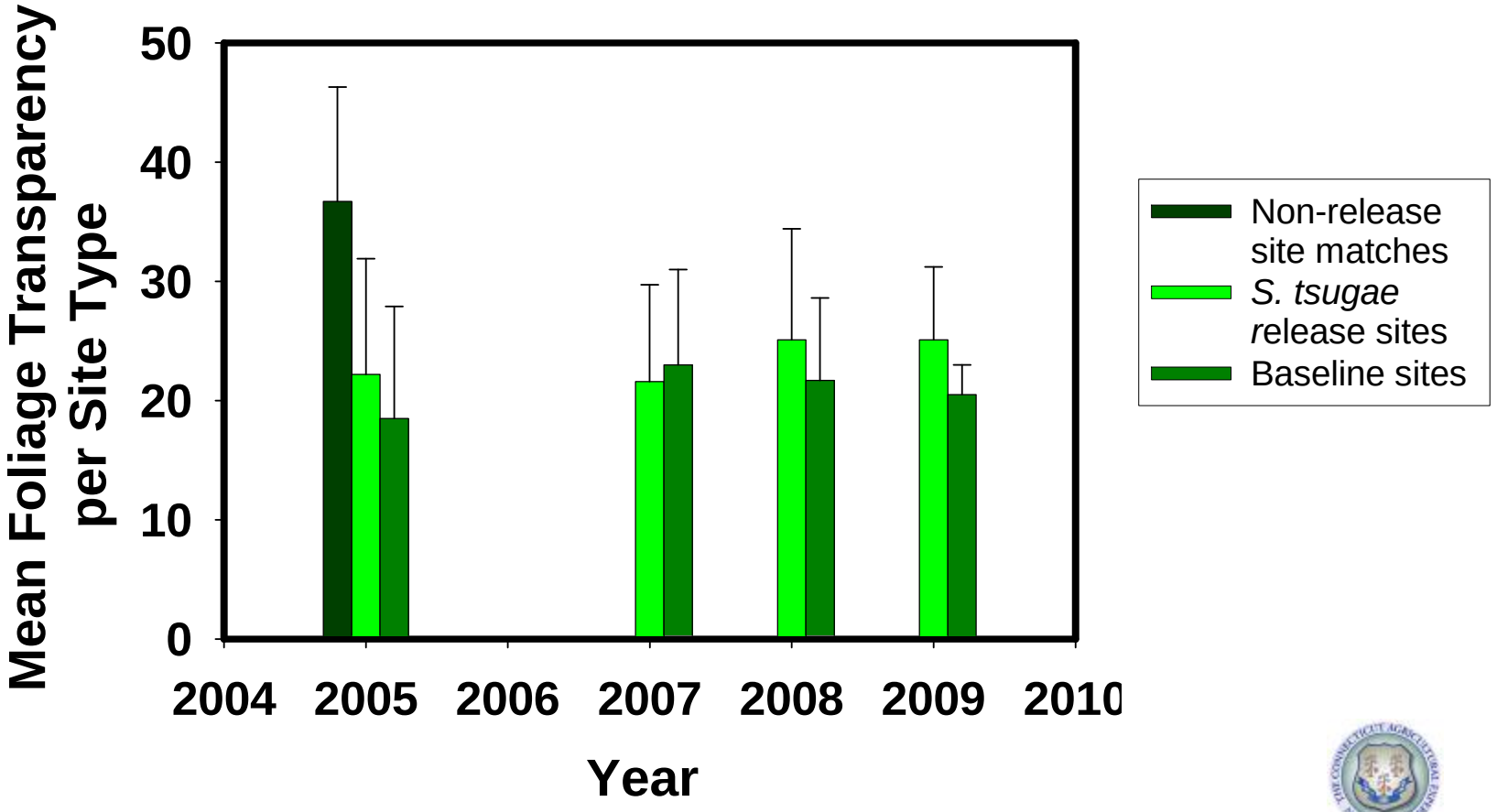
# Predator Sampling Challenges

*S. tsugae* found 50-60ft in tree canopy by bucket truck sampling

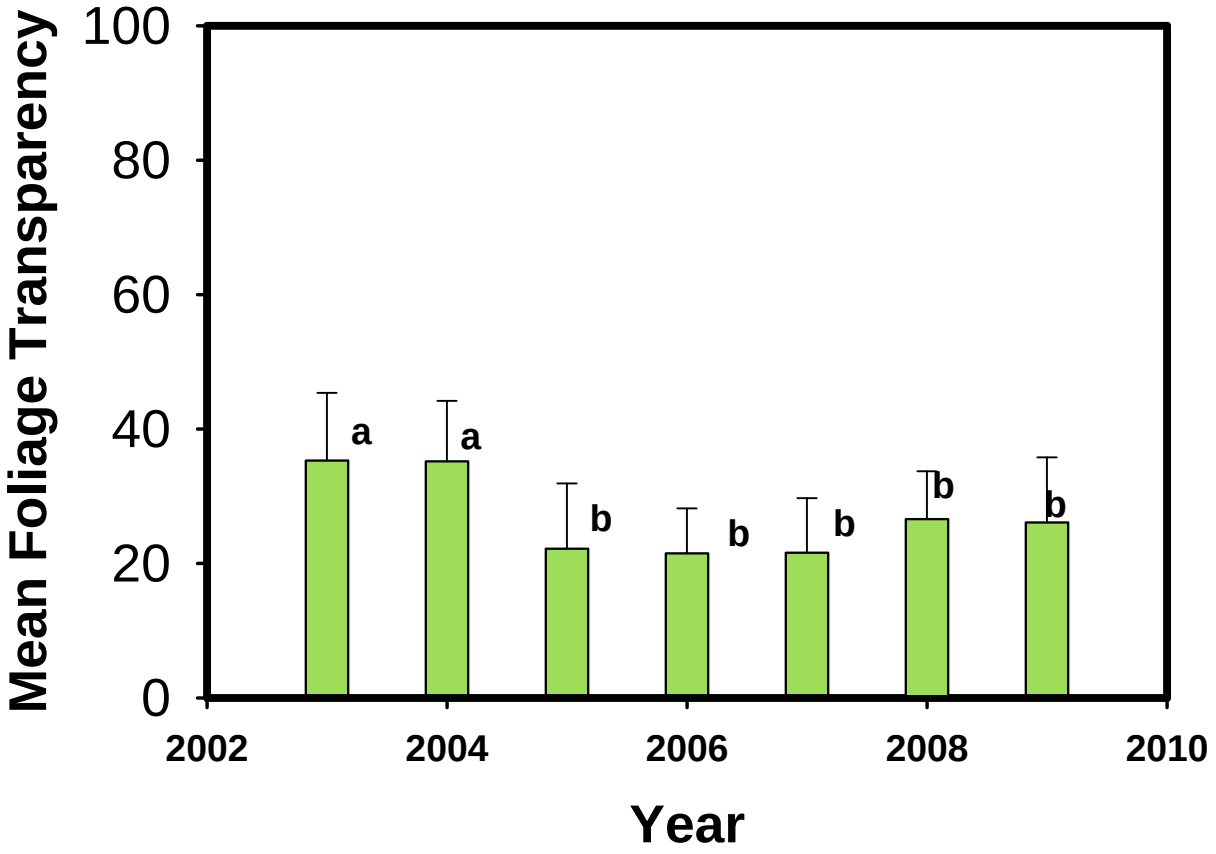
# *S. tsugae* release sites 1995-2007



# Comparison between *S. tsugae* release, non-release and uninfested baseline hemlock forest sites



# Hemlock crown health in release sites




Crown monitoring compounded by elongate hemlock scale infestations

# Current Status in Connecticut

- After HWA first detected in southern CT in 1985, period of initial heavy damage, decline and mortality of eastern hemlocks
- 1995: first release of non-native ladybeetle predator of HWA from Japan by CT Agricultural Experiment Station; > 176,000 released 1995-2007; *S. tsugae* establishment recorded between 1996-2005
- 2010: HWA is now at low or negligible densities with little hemlock mortality
- Severe winters and cold snaps have helped reduce HWA populations; hemlocks are resilient and have recovered
- Wet growing seasons and drought-free years have aided hemlock recovery

# *S. tsugae* Release Sites in 2009







# Special Thanks to HWA Cooperators

- Jody Bronson, Russell Russ, Star Childs
  Great Mountain Forest Corp., Norfolk, CT
- CT DEP : Bureau of Natural Resources:
  Forestry Division & Bureau of Outdoor Recreation State Parks & State Forests
- Carol Youell, Lisa Smith & Scott Rogers
  MDC Natural Resources Division
- Curtis Rand, Mt. Riga Corporation
- John Lepper & Town of Wethersfield
- John Rodgers, Leyden, MA
- Charlie Burnham, MA DCR
- Mark Mayer & Jenni DeSio, PABIL, NJDA

# Acknowledgments
# HWA Funding


USDA Forest Service

Northeastern Area

Forest Health Protection

State & Private Forestry

Forest Health Technology Enterprise Team

# Pros and Cons of Biological Control of Noxious Weeds

*USDA FOREST SERVICE*

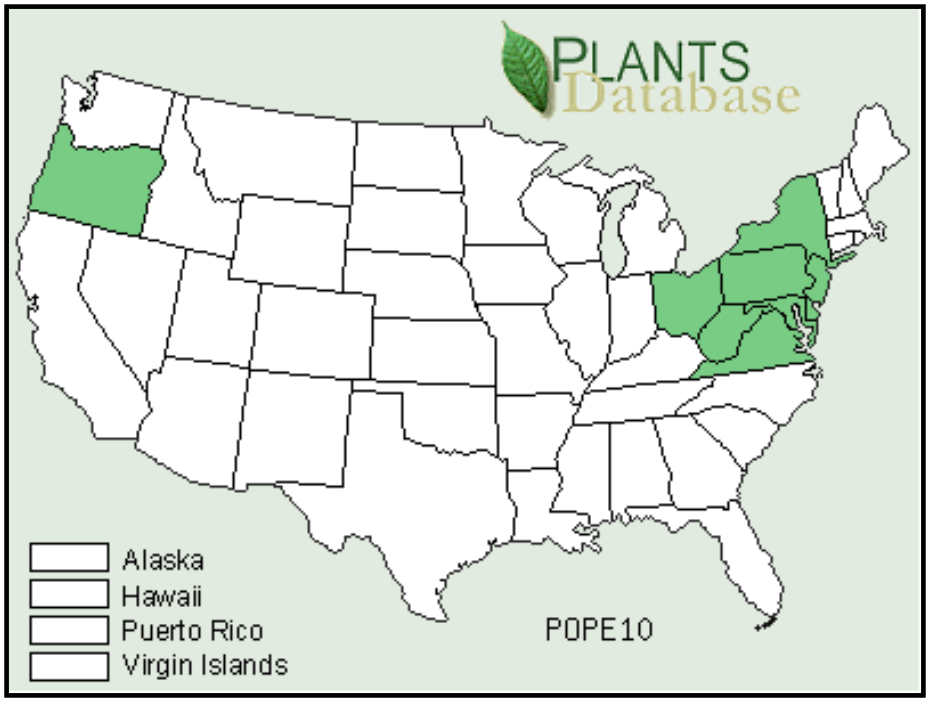
## *Advantages*

- Selective agents can control a specific weed or closely related group of weeds
- Control is long term and agent can disperse and attack inaccessible infested areas
- Agents are self-perpetuating and long term cost is minimal

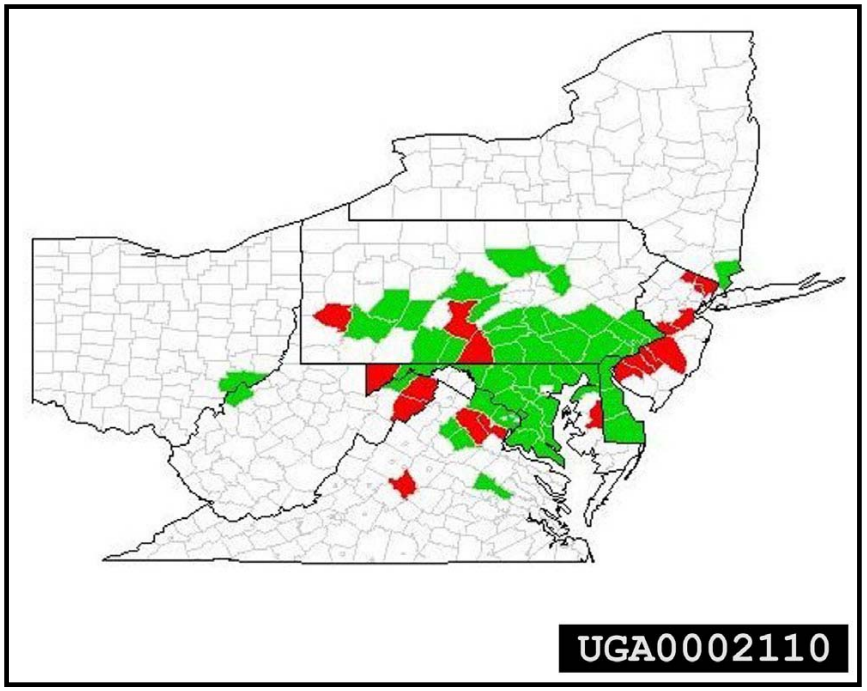
## *Disadvantages*

- Initial costs for foreign exploration and testing are high
- No guarantee of success
- Risk of non-target impacts on other plant species
- Impacts, even if successful, may not be observed for 5-10 years

# Distribution of MAM

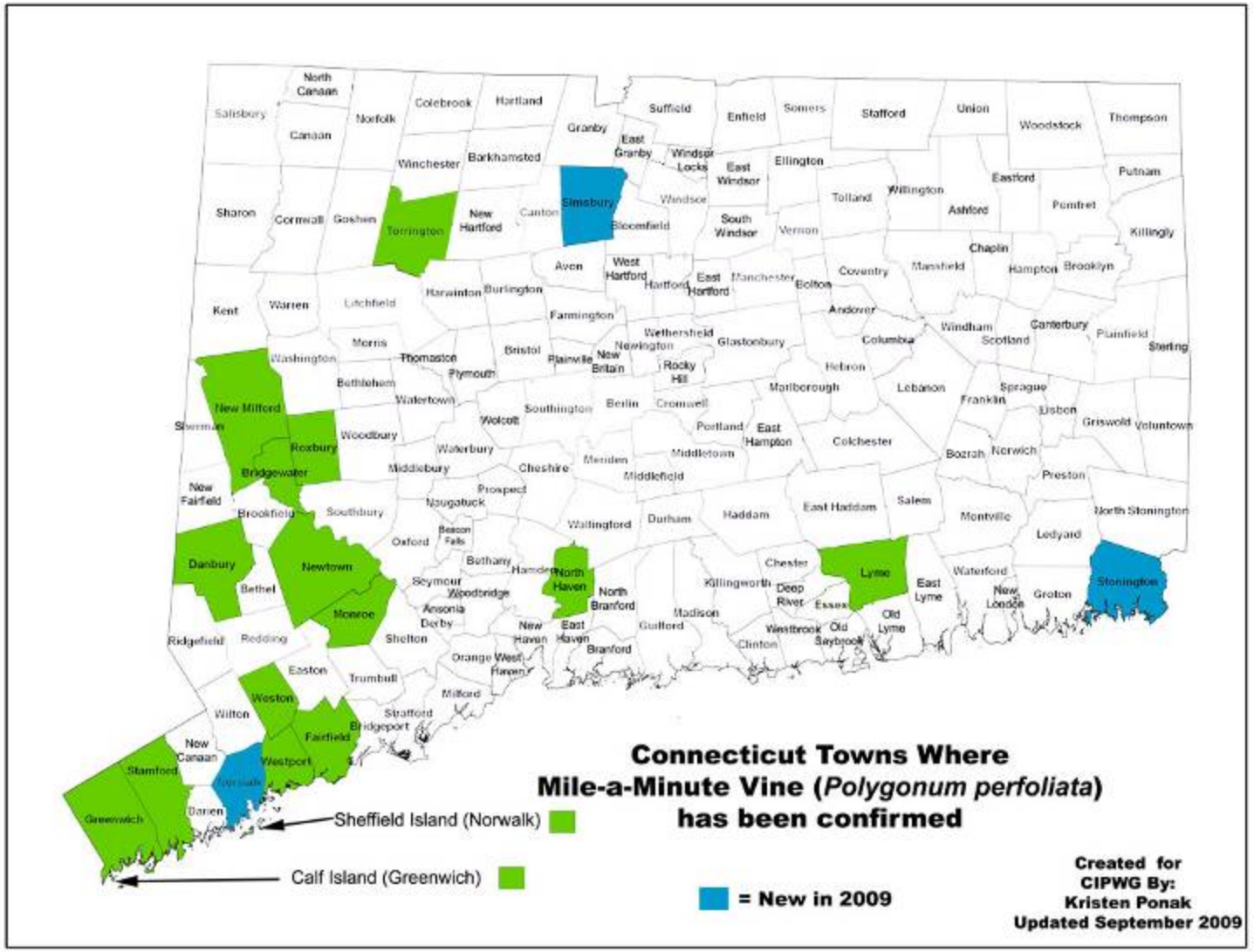



USDA NRCS 2003




USDA Forest Service

# Mile-A-Minute in CT




http://www.hort.uconn.edu/mam/index.html


Ripening fruit


Shoot tips

# Identifying characters for MAM

- Triangulate leaves
- Recurving barbs
- Blue fruit when ripe
- Saucer-shaped leaves encircling stem

# Biological Control of MAM in CT

Carole Cheah[1], Donna Ellis[2] & Todd Mervosh[1]
[1]CT Agricultural Experiment Station; [2]University of Connecticut

Lots of help from Logan Senack, UCONN/DEP; Kathleen Nelson, “Mad Gardeners” and many others…

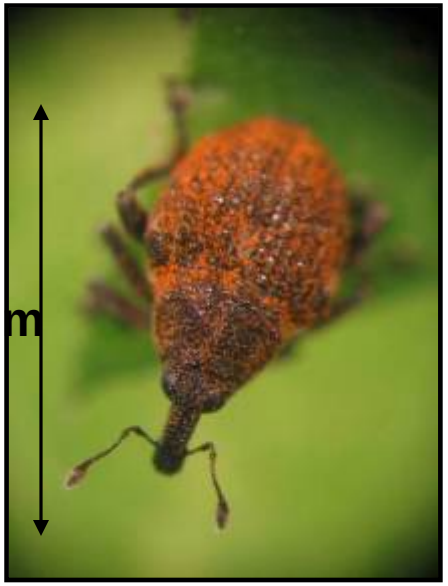
# Development of the Biological Control Program for MAM

- Initiated by Richard Reardon, USDA Forest Service with the Chinese Academy of Sciences and the University of Delaware in 1996
- Out of 11 potential candidate species from China and 6 from Japan, *Rhinoncomimus latipes* emerged as the safest and best candidate for introductions in eastern USA
- Careful assessments of risks to non-targets such as native *Persicaria* spp and other related species were performed in USA and China
- Final Environmental Assessment permitting field release of *R. latipes* in 2004 in DE and NJ

# Native Persicaria spp.

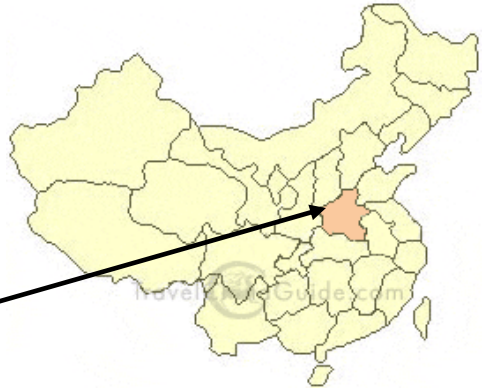
Adult weevils will not lay eggs on other species and larvae can only survive on MAM


# *Rhinoncomimus latipes*
## *(Coleoptera:Curculionidae)*






# Source for *R. latipes* US introductions:Henan Province, China

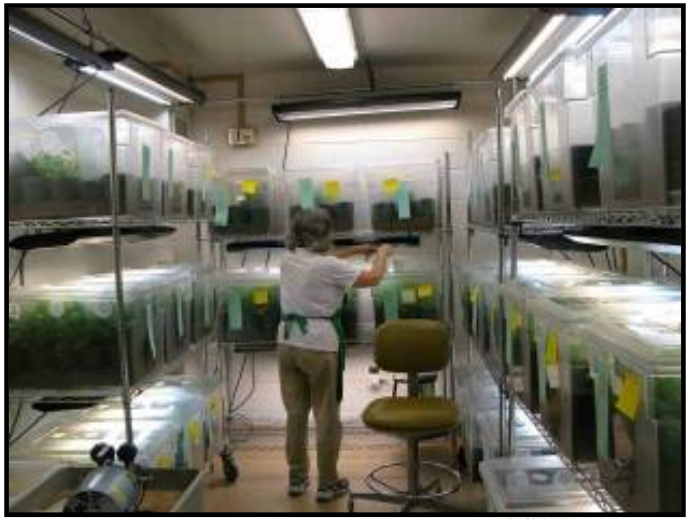
MAM is widely distributed in China; weevils collected by Ding Jianqing were sent to USDA Newark quarantine lab. in 1999 -2000

USDA Forest Service in partnership with the Institute of Biological Control, Chinese Academy of Sciences, Beijing.

# Biology & life cycle of *R. latipes*

- Adults feed on youngest leaves, flowers and buds of MAM and are very host specific
- Eggs are laid on undersides of leaves and on the stem, preferentially on plant capitula of MAM
- Larvae hatch, bore into first node in stem and enter stem to feed and develop; cannot develop on other related species
- Mature larvae leave the stem and drop to soil to pupate
- New adults emerge from the soil: generation time is approx. 26 days; >2 generations in China
- Adults overwinter and can live about a year

# Mass rearing at Phillip Alampi Beneficial Laboratory, NJDA



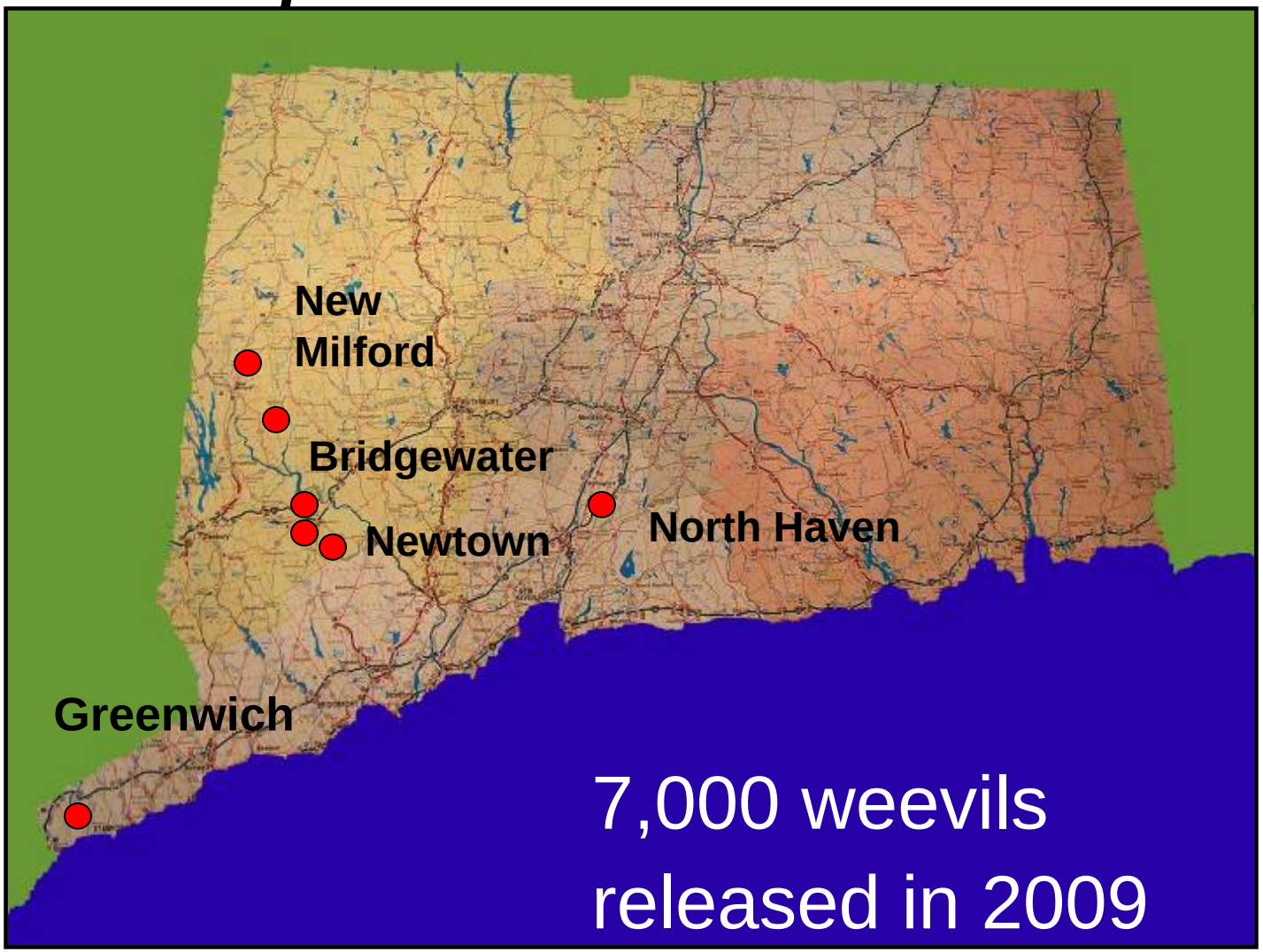
# Releases & impacts in other states

- In NJ, seedling counts were greatly reduced to <10% of original counts in 3 years; weevils dispersed >3 miles in 2 years, with overall overwintering recovery in 95% of release sites (Mark Mayer, NJDA, 2008)
- In WV, weevils dispersed > 5 miles and over 100+ acres in 3 years
- In PA, weevils dispersed 7-18 miles from nearest release area in 3 years, increased populations by 2-5x, significantly decreased MAM seed clusters, apical growth and seedling densities in 3 years (Ellen Lake, University of DE, 2008)


New Jersey *R. latipes* release site after three years; Mark Mayer NJDA

*Pictures from: Biology and Biological Control of Mile-Minute Weed; Hough-Goldstein, J., Lake, E., Reardon, R. and Yun-Wu; USDA FHTET 2008*

# *R. latipes* sites in CT 2009



# Quinnipiac River State Park, North Haven






First release site July 2, 2009

# Intensive monitoring at QRSP site

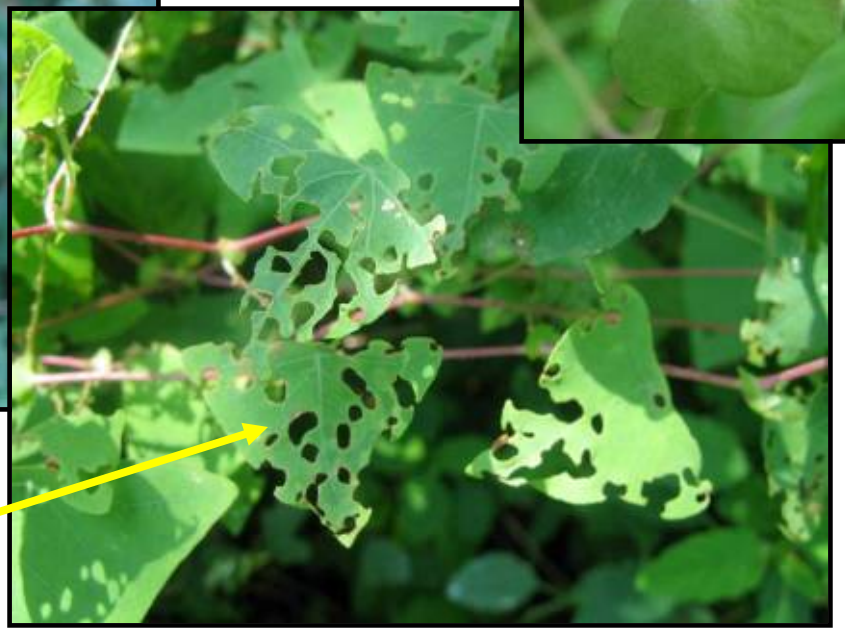


Using Dr. Judy Hough-Goldstein's (Univ. of DE) standardized monitoring protocol

# Weevil activity in August 2009

Weevil adult

Evidence of larval feeding



Adult feeding damage

# Other releases at Greenwich, Newtown and New Milford


# Signs of MAM suppression in 2009

Pre-Release June 28




Deep Brook Road, Newtown,

# Weevil activity Fall 2009






# Plans for MAM Biocontrol 2010

- Expand releases at new sites in SW CT
- Check for overwintering survival of the weevil at 2009 release sites
- Check for survival from spring flooding of sites
- Improve biomonitoring for dispersal and establishment

# Many thanks to MAM Cooperators

- Jenni Desio, Tom Dorsey, Mark Mayer; NJDA PABIL
- Kathleen Nelson;  Mad Gardeners
- Ann Astarita; Newtown Inland Wetlands Enforcement
- Aleksandra Moch; Greenwich Environmental Analyst
- Karen Dixon; Audubon Greenwich
- Rob Sibley; Town of Newtown
- Tim Currier & Annie Stiefel;  Sticks & Stones Farm
- Peter Picone & Lori Lindquist ; CT DEP
- Ken Ruel and Joe Adkins; Spectra Energy

# Acknowledgments
# MAM Funding


USDA Forest Service

Northeastern Area

State & Private Forestry

Forest Health Technology Enterprise Team

and USDA APHIS PPQ

Carole Cheah
Department of Entomology
Valley Laboratory
153 Cook Hill Road
Windsor, CT 06095

Phone: 860 683 4980
Email: Carole.Cheah@ct.gov
Website: www.ct.gov/caes