

The Gypsy Moth

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State Entomologist

The Connecticut Agricultural Experiment Station



CAES

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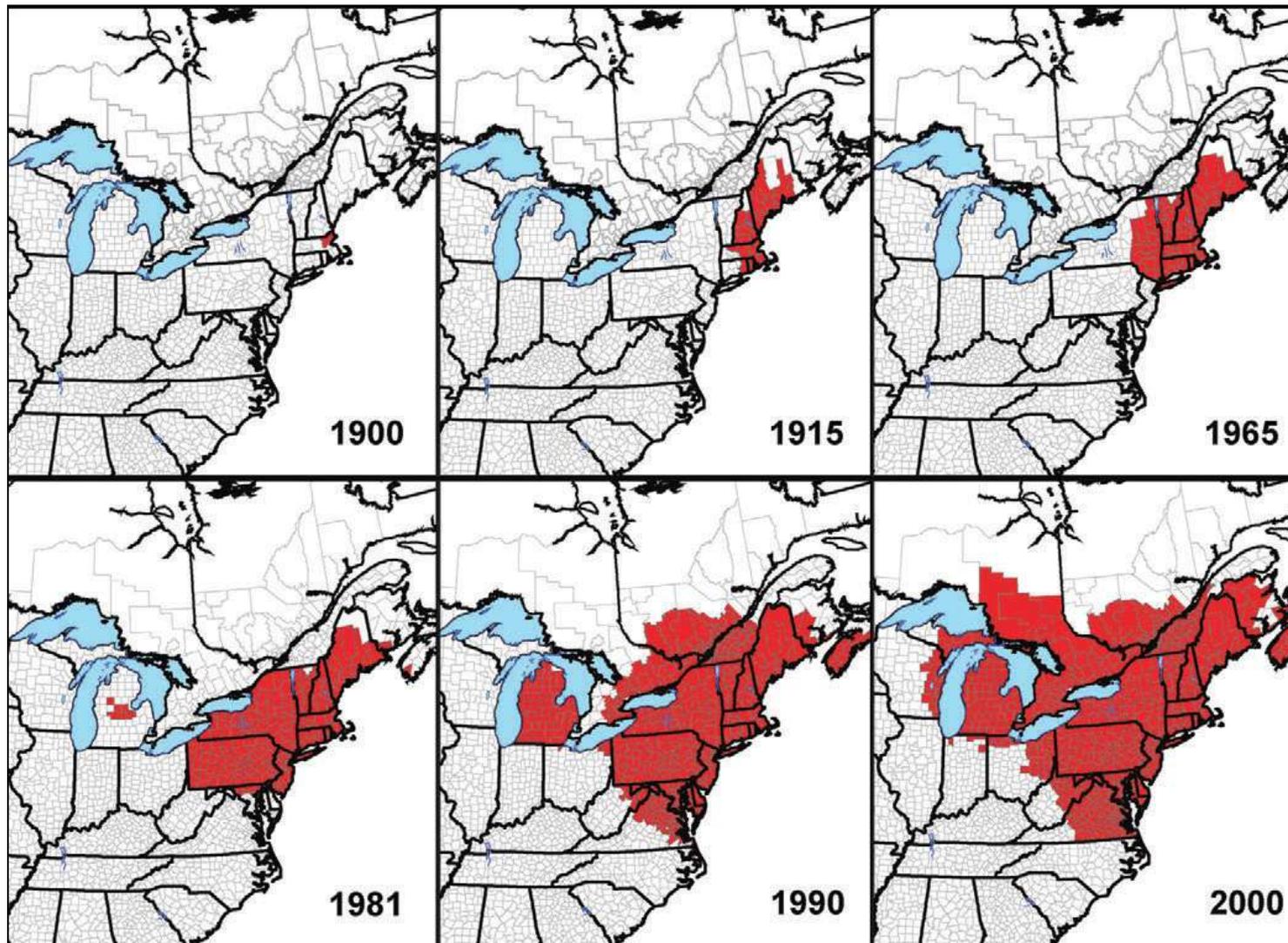
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Gypsy Moth Arrival in Connecticut

- Gypsy moth, *Lymantria dispar*, was first brought into the US (Medford, MA) from France around 1869 by Etienne Leopold Trouvelot. He was interested in silk production.
- In 1882, larvae escaped and spread on Medford Street and the infestation grew in size.
- In 1889, the Massachusetts State Board of Agriculture began a campaign to eradicate the gypsy moth.
- Gypsy moth was first discovered in CT in Stonington in July, 1905.
- By 1923, it had spread to 100 towns.
- By 1952, it was present in all 169 Connecticut towns.



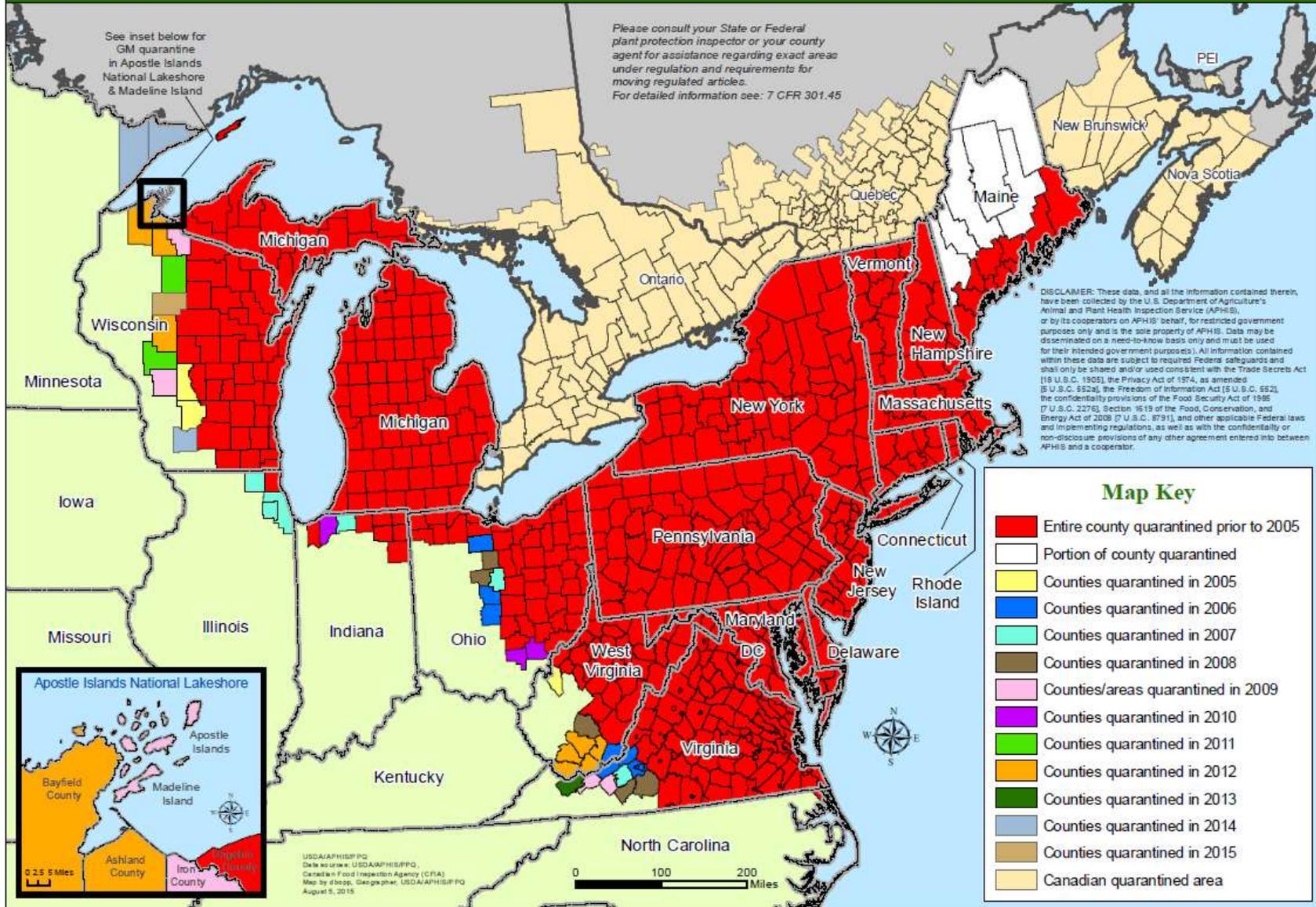
Spread of the Gypsy Moth



From: Slow the Spread: A National Program to Manage the Gypsy Moth, USDA Tech Report NRS-6, April 2007



European Gypsy Moth (*Lymantria dispar*) North America quarantine



Gypsy Moth Quarantine

- Gypsy moth egg masses are most common hitchhikers .
- Nursery stock shipped out of a quarantine by a nursery or dealer must be treated or visually inspected and certified pest-free. Shippers must be operating under a compliance agreement with state or federal agriculture agencies prior to moving stock.
- Shippers of logs, posts, bark, operating under a compliance agreement must document all loads leaving the quarantine and specify the destination.
- For homeowners, self-inspection (checklist available) is allowable while packing up household goods to move. Those using a moving company or portable storage must include the completed checklist with the shipment. Qualified Certified Applicators or state/federal agriculture agencies may provide inspection. **There have been detections on shipping pods.**
- RVs, Campers, Mobile Homes: Inspection and documentation are required prior to moving outside of the quarantine. Qualified Certified Applicators or state/federal agriculture agencies may provide inspection assistance. Treat or remove any life stages found upon inspection.

Gypsy Moth Life History

- Egg clusters laid in the summer hatch the following spring. (Approx. May 1)
- There can be from 100 to 600 eggs per cluster.
- After hatching the caterpillars begin feeding.



Peter Trenchard, CAES



John Triana, SCRWA

GM Hatching April 27, 2016

Gypsy Moth Life History

- They feed on a large variety of trees and shrubs. Oak is their favorite food.
- If populations are heavy enough, they will feed on conifers.
- After about 40 days (Late June) the larva are fully grown and go to protected places to pupate.



Peter Trenchard, CAES



Peter Trenchard, CAES



Peter Trenchard, CAES

Gypsy Moth Life History

- Adults emerge in 10-14 days.
- The female is a large bodied white moth.
- Females cannot fly.
- The male is smaller and darker in color (brownish) and can fly.
- They begin mating shortly after emerging.
- Adults do not take food and live a short time.



Peter Trenchard, CAES



Peter Trenchard, CAES

Gypsy Moth Life History



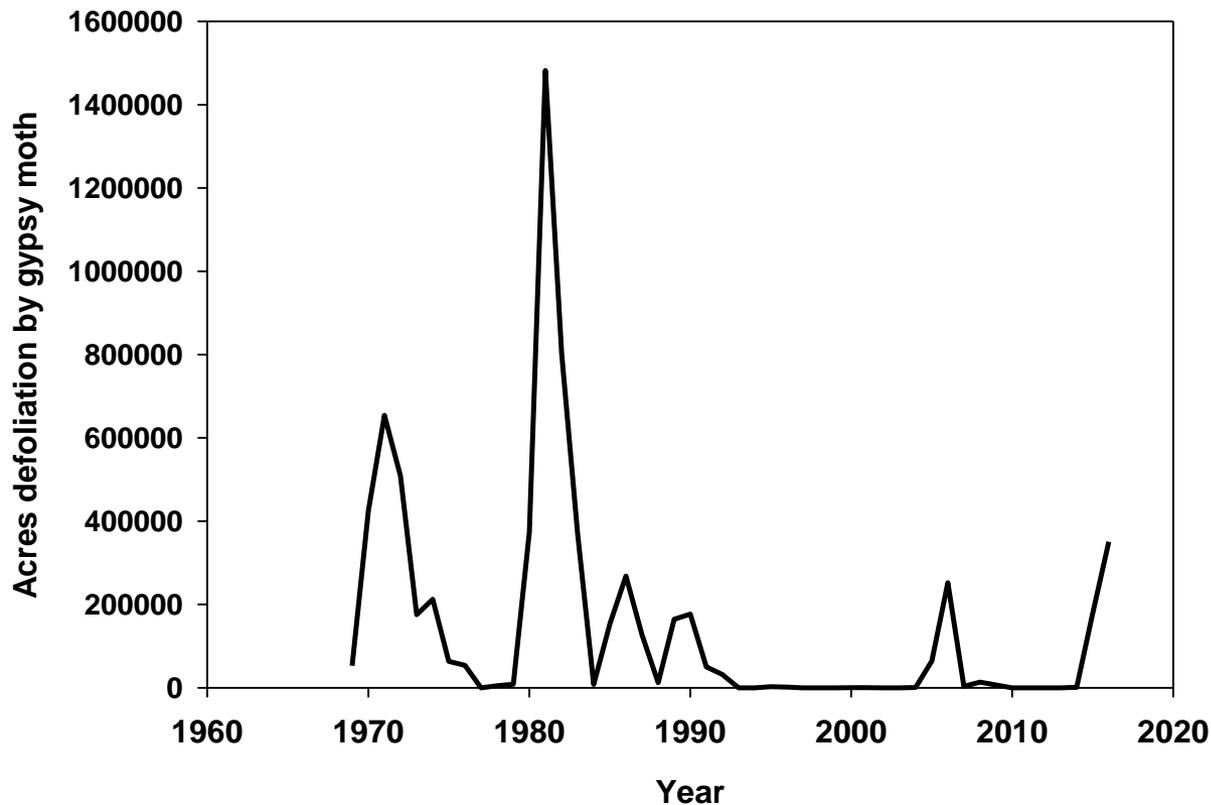
Peter Trenchard, CAES



Peter Trenchard, CAES

Gypsy moth will lay eggs on anything, trees, fence posts, cars, rocks, firewood, cars.

Gypsy Moth Defoliation, CT 1969-2016* (acres)



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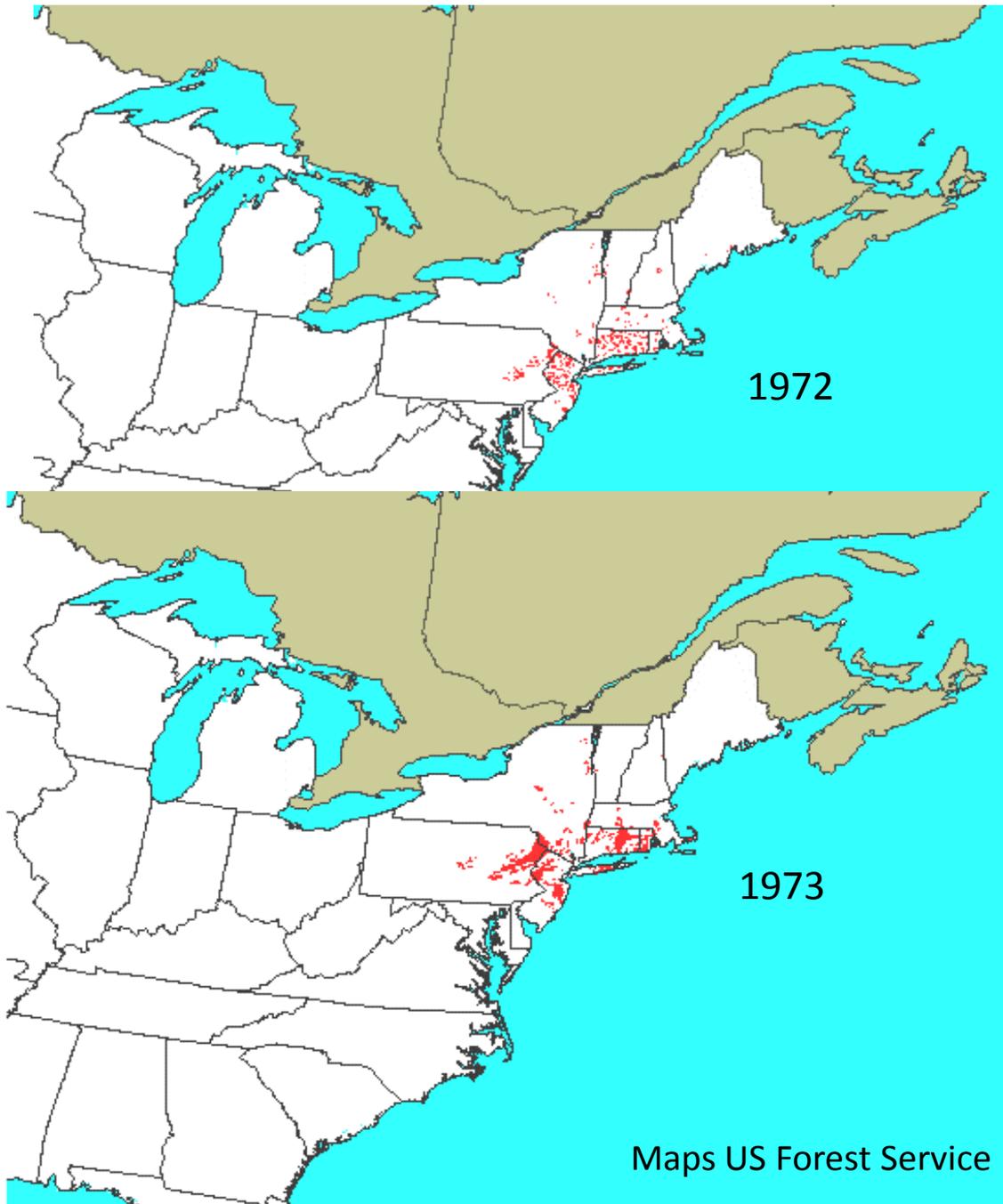
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1st Large Recorded Outbreak

From 1970-1973, gypsy moth defoliated several hundred thousand acres of Connecticut forest each year.

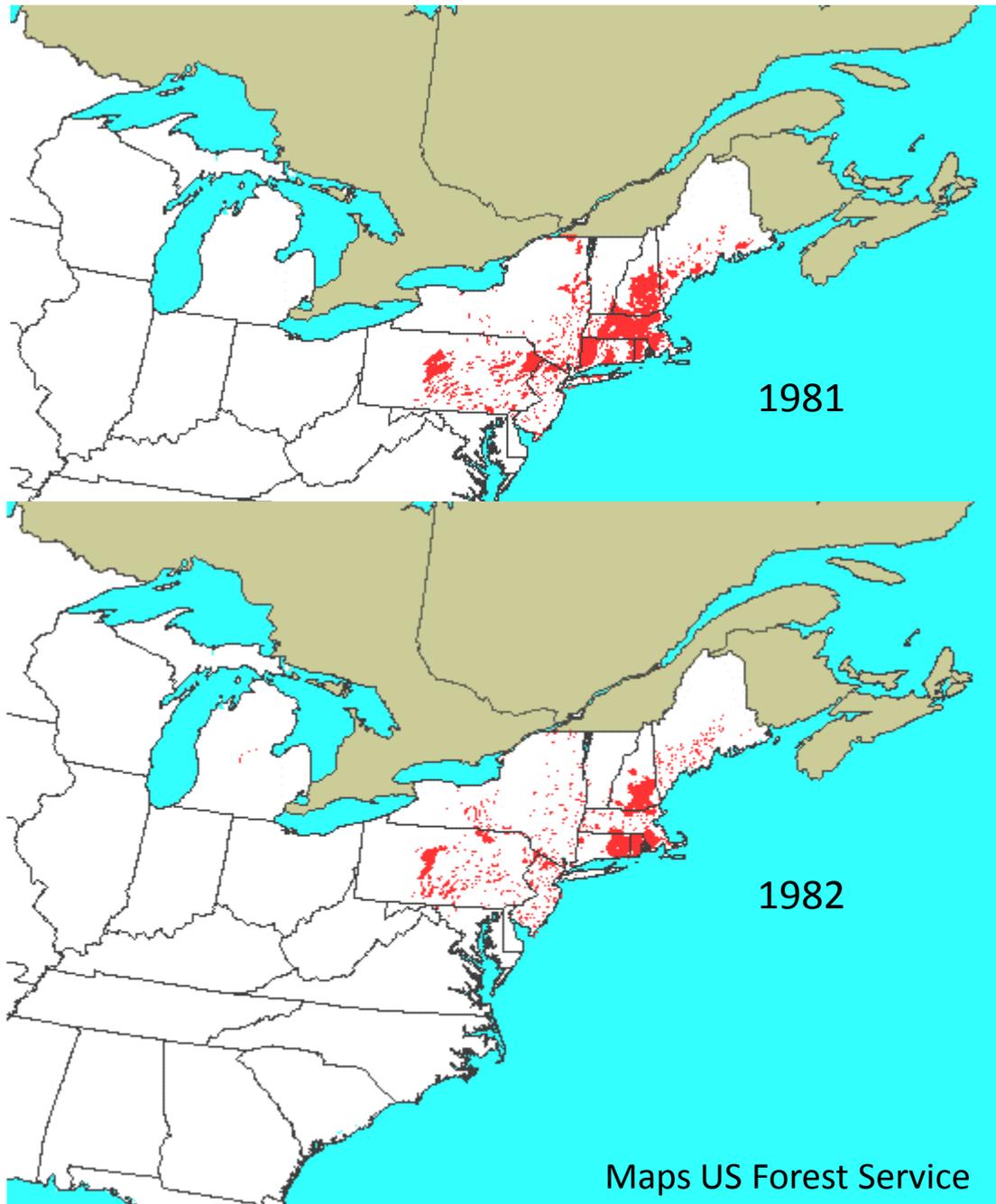
1970 – 425,039 acres
1971 – 654,102 acres
1972 – 508,460 acres
1973 – 333,215 acres
1974 – 212,315 acres



2nd Large Recorded Outbreak

Through 1980s, gypsy moth defoliated several hundred thousand to over a million acres of Connecticut forest each year.

1980 – 381,868 acres
1981 – 1,482,216 acres
1982 – 803,802 acres
1983 – 369,267 acres

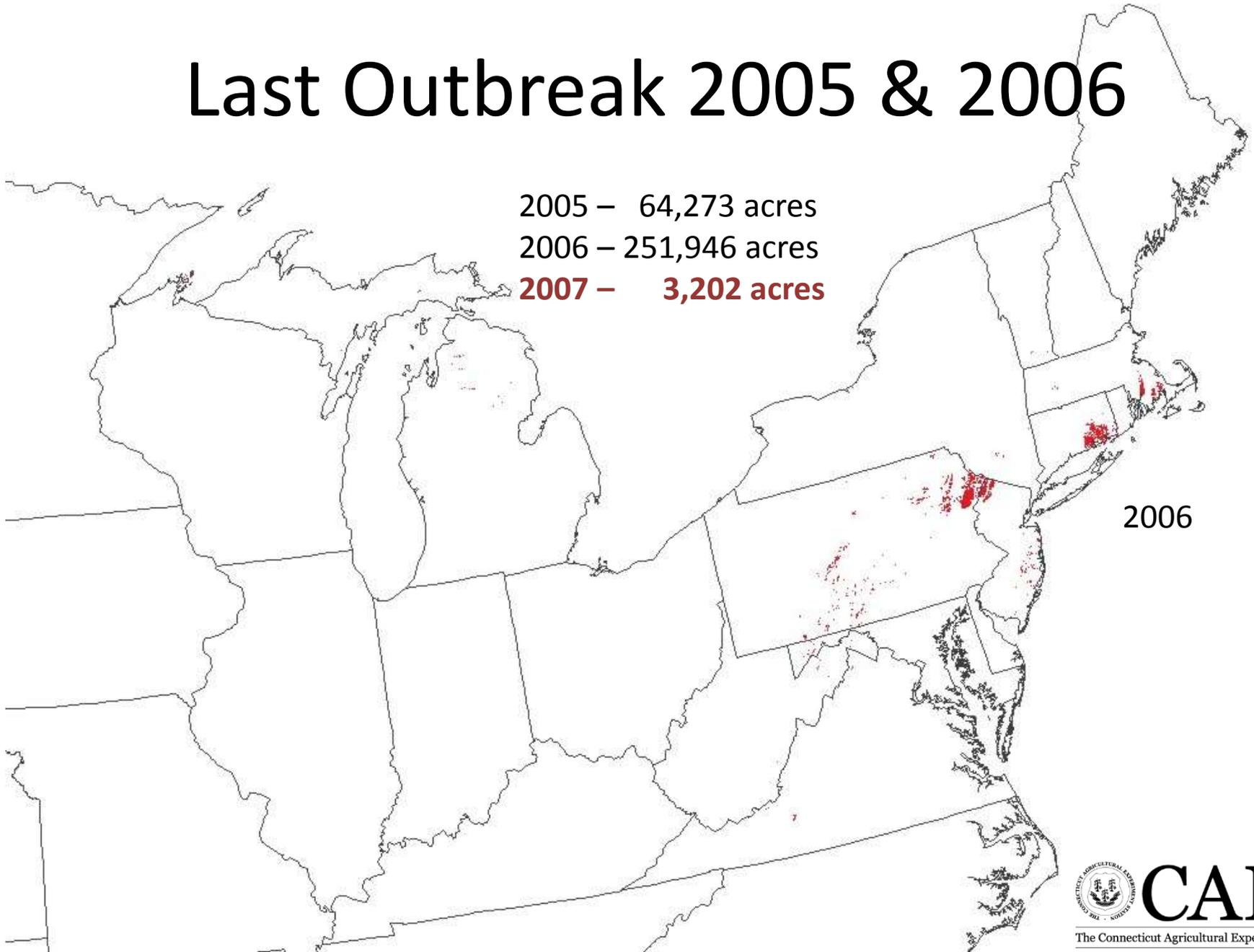


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Last Outbreak 2005 & 2006

2005 – 64,273 acres
2006 – 251,946 acres
2007 – 3,202 acres



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Connecticut's Forest Aerial Survey

- Connecticut's forest health assessment is conducted each year from late June to early August or as events and weather dictate (need clear skies, no haze).
- This aerial survey has been conducted since the late 1960's. Funded by the U.S. Forest Service.
- The survey originally focused on Gypsy Moth defoliation, but with increased use of technology, (Digital Aerial Sketch mapping) it has expanded to include all types of forest damage.
- Now includes forest defoliation (Gypsy Moth, Winter moth, Emerald Ash borer, Orange striped oak worm), discoloration (Anthracnose, Hemlock Woolly Adelgid), storm related damage and fire.



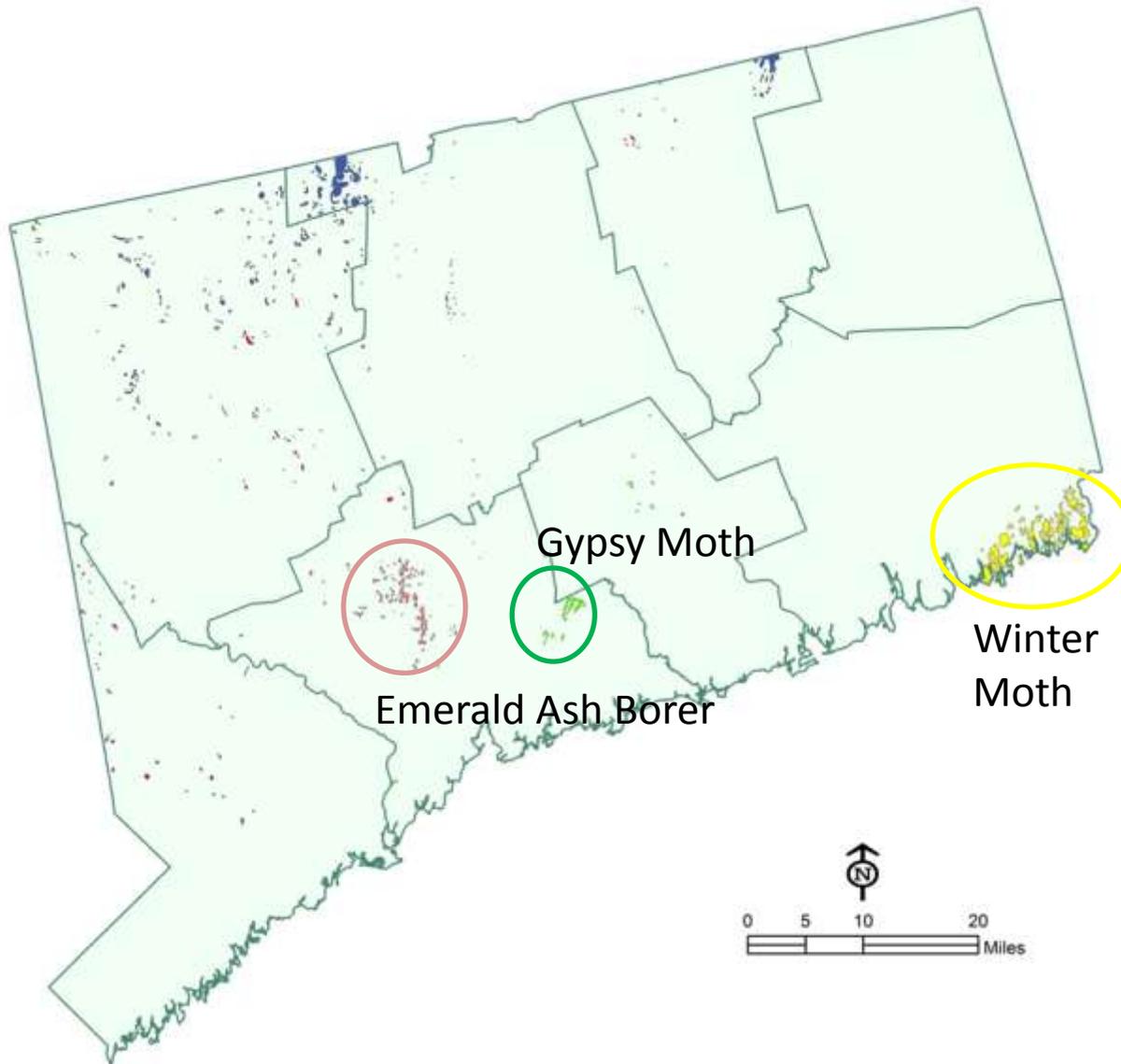
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Deputy State Entomologist Victoria Smith and Inspector Peter Trenchard conducted previous forest health surveys. 2016 aerial survey conducted by Victoria Smith and Tia Blevins



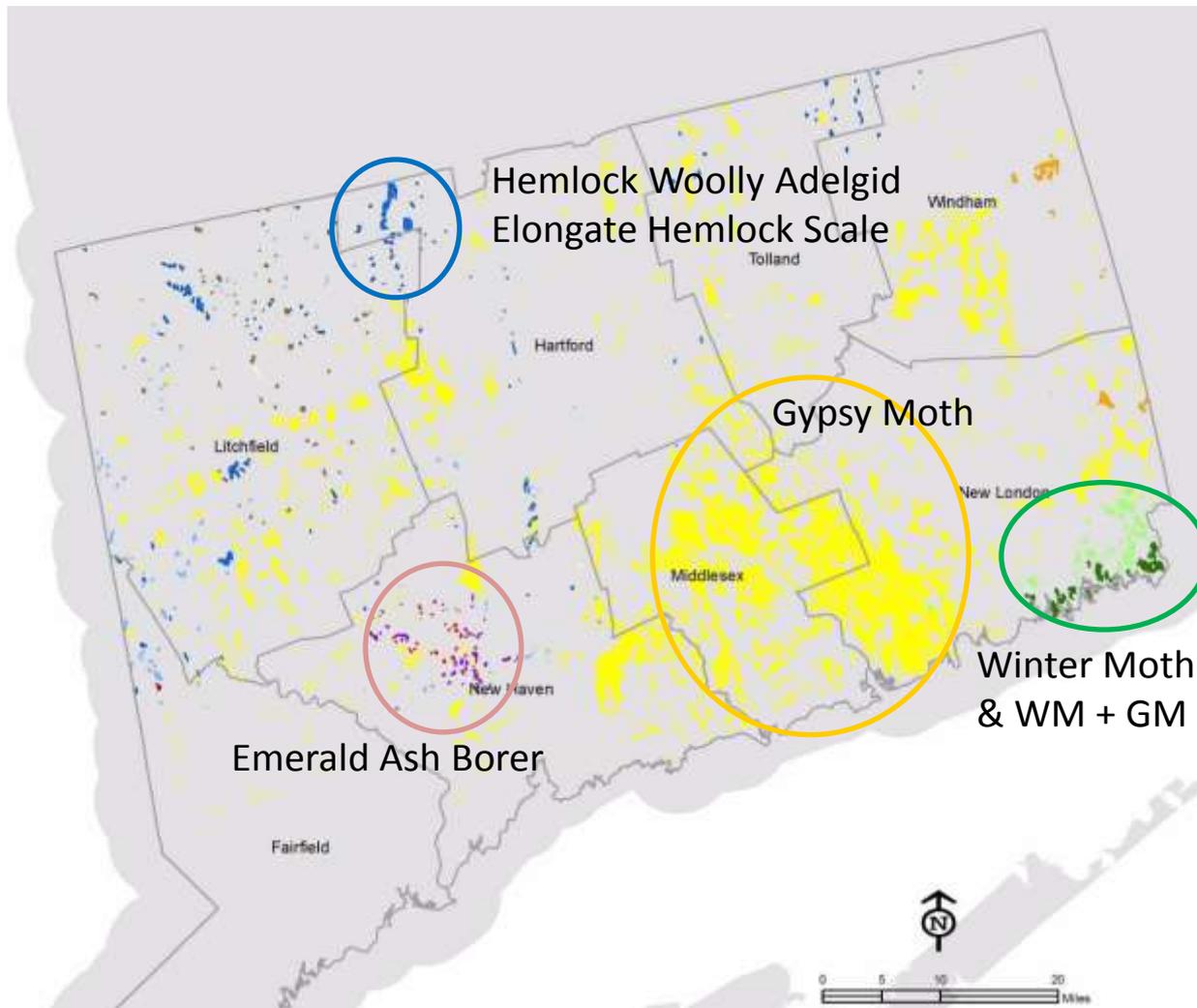
Aerial Survey Map for 2014



- Gypsy Moth
- Locust Leafminer
- Winter Moth
- Hemlock Woolly Adelgid
- Elongate Hemlock Scale
- Red Pine Scale
- Emerald Ash Borer
- Ash Decline/Yellows
- Hail Damage
- Wind Damage

1,337 acres
defoliated by
gypsy moth in New
Haven County

Aerial Survey Map for 2015



Winter Moth & WM + GM

Emerald Ash Borer

Hemlock Woolly Adelgid
Elongate Hemlock Scale

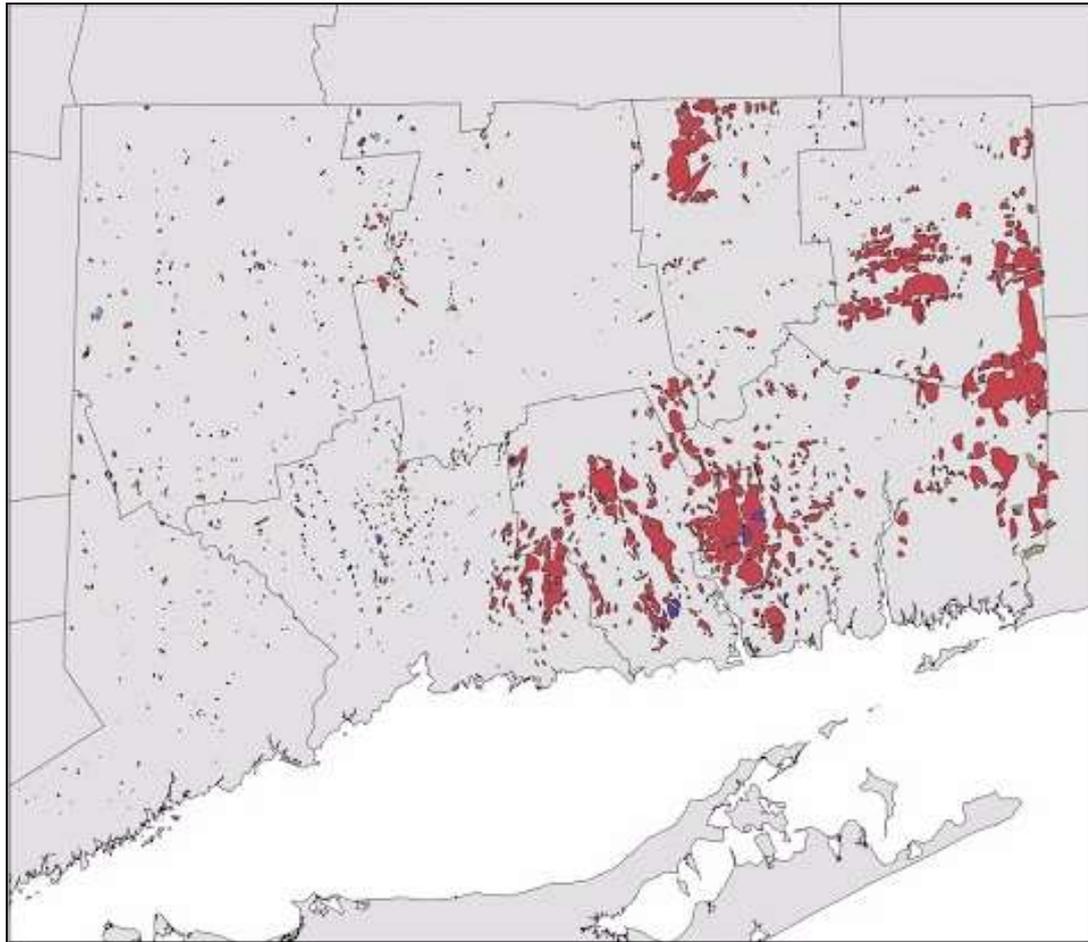
Gypsy Moth

Gypsy Moth Defoliation
175,273 acres

Aerial Survey Map for 2016

The area defoliated in 2016 was 204,167 acres.

It was also more intense, with greater proportion of trees with >50% defoliation. Conifers (e.g., spruce, pine, hemlock), were also heavily attacked in many areas.



Gypsy Moth Control

- Physical controls (barriers, remove egg masses)
- Quarantines
- *Bacillus thuringiensis* kurstaki (B.T.k.)
- Nucleopolyhedrovirus (NPV) product - Gypchek
- Insecticides like Spinosad, Sevin, and several pyrethroids and growth regulators.
- Application made after bud-break or leaf-out depending on whether treatment is for apple trees or landscape trees to prevent continued feeding and defoliation.
- Oils (soybean, canola, mineral) to suffocate egg masses (e.g., 50% soybean oil and 50% water)



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Biological Control

Nuclear Polyhedrosis Virus (NPV)



Photo John Ghent, Bugwood.org

Gypsy moth killed by NPV

- NPV (Nuclear polyhedrosis virus) was accidentally introduced from Europe. Was first observed in Connecticut in 1907.
- NPV was studied extensively in the 1960s at the Experiment Station.
- NPV was one of the main causes for collapse of large populations of gypsy moths until the gypsy moth fungus was discovered in 1989.
- NPV (Gypchek) applied by Forest Service for control in areas edge GM population (STS) and by government entities.

Entomophaga maimaiga



Gale Ridge, CAES

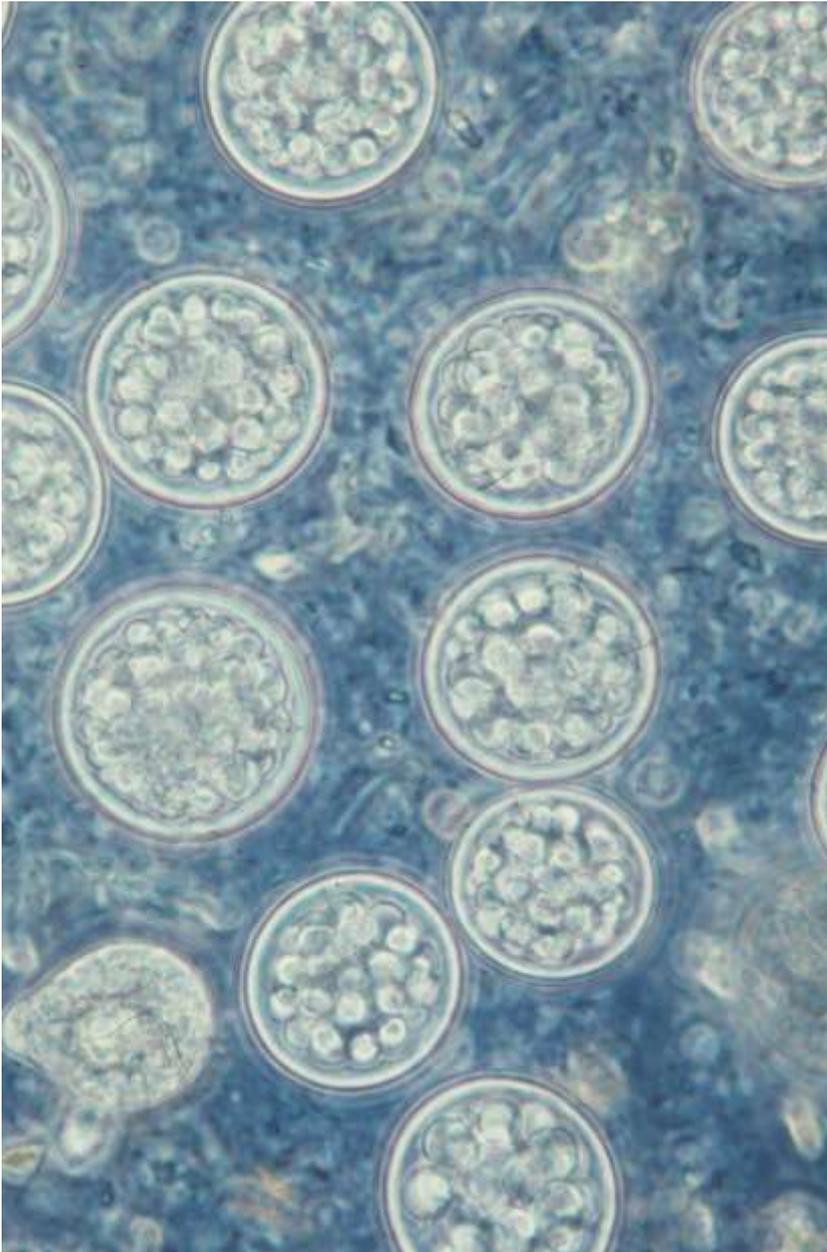
Larvae killed by *Entomophaga maimaiga* in 2015
Bethany and Hamden, CT

- In June 1989, several Experiment Station personnel noticed that dead and dying gypsy moth larvae were clinging to the sides of trees.
- The cause of the death of larvae was determined to be *Entomophaga maimaiga*, a fungus.
- *Entomophaga maimaiga* had been introduced from Japan into the Boston area in around 1910.
- It failed to establish because of an outbreak of NPV, which caused the collapse of the gypsy moth population.
- The fungus was never recovered despite numerous surveys until 1989.
- Some fungal activity in western CT in 2015 and observed few locations in 2016

Gypsy Moth Fungus

Entomophaga maimaiga

- Resting spores survive over 10 years
- Specific to gypsy moth
- Largely responsible for controlling gypsy moth from year to year
- The fungus is weather dependent, requires rain (moisture) for infection of caterpillars and propagation of the spores.



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Gale Ridge, CAES



Larvae killed by *E. maimaigi*, 2015

Oak Defoliated & Dying Caterpillars, Hadlyme, CT 2016

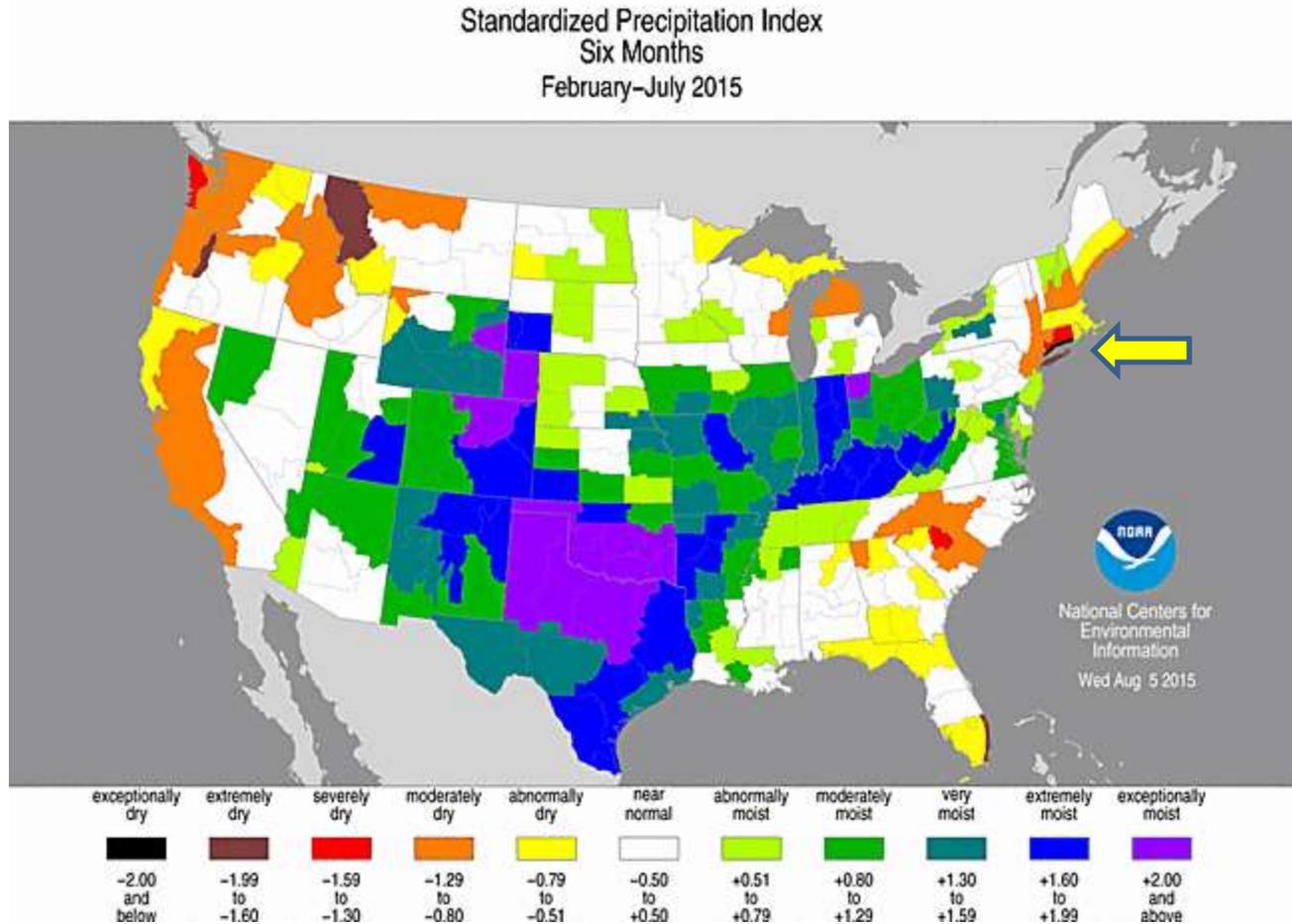


Caterpillars were killed by *Entomophaga maimaiga*
There was very limited fungal activity in 2016

Photos courtesy Bob Standish

Moisture and Drought Indices

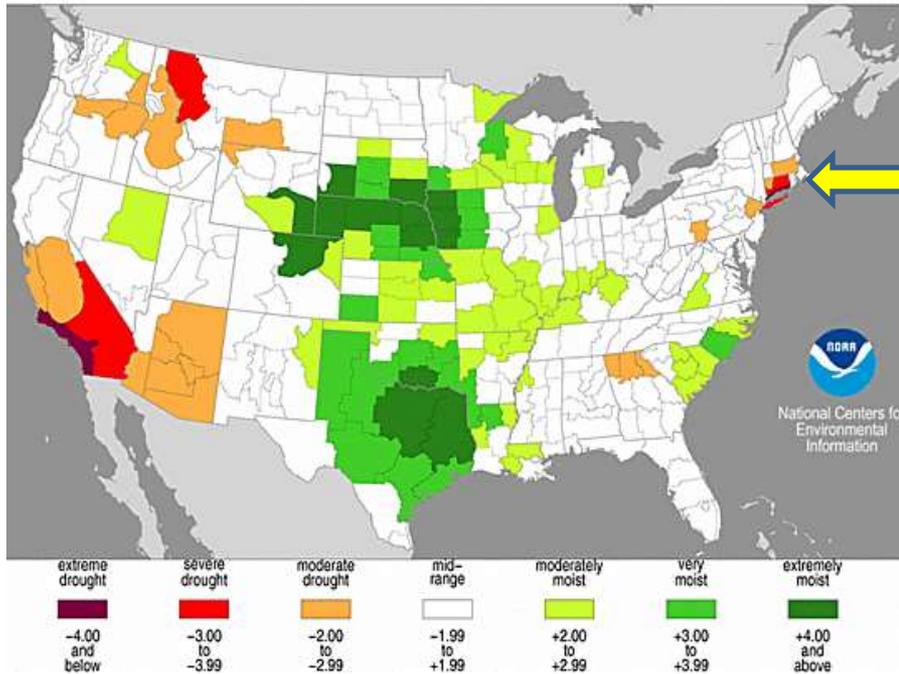
Lack of Precipitation is Reason for No or Little Fungus Activity



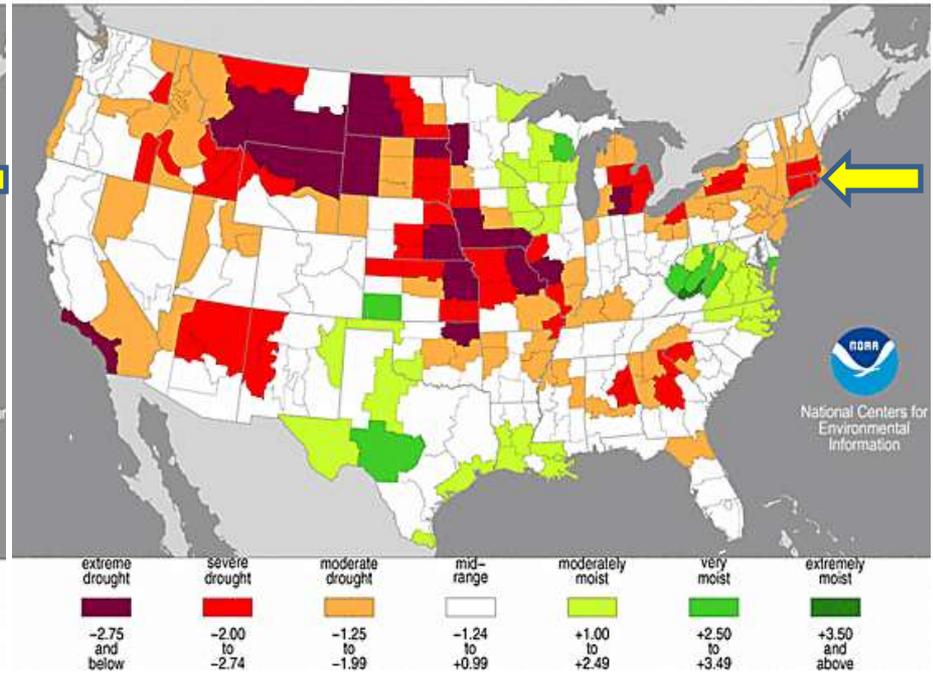
The Standardized Precipitation Index (SPI) measures moisture supply.

Moisture and Drought Indices

Palmer Hydrological Drought Index
May, 2016



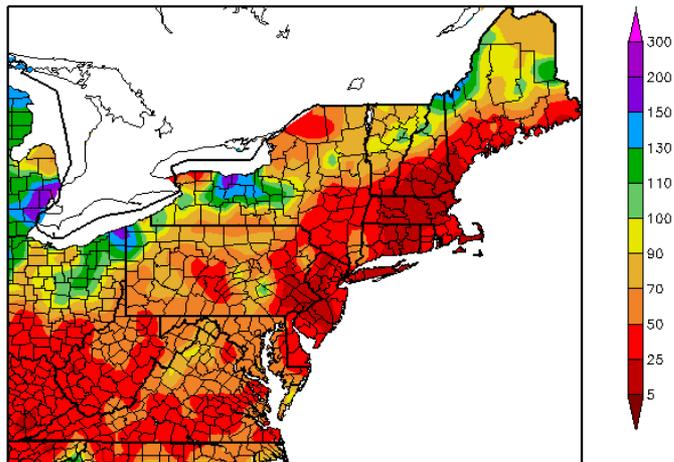
Palmer Z-Index
June, 2016



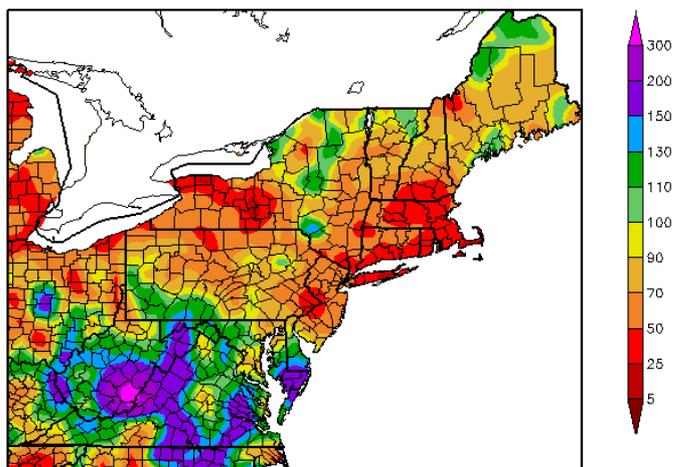
The [Palmer Z Index](#) depicts moisture conditions for the current month, while the [Palmer Hydrological Drought Index](#) (PHDI) and [Palmer Drought Severity Index](#) (PDSI) depict the current month's cumulative moisture conditions integrated over the last several months.

Gypsy Moth Outbreak 2015 & 2016

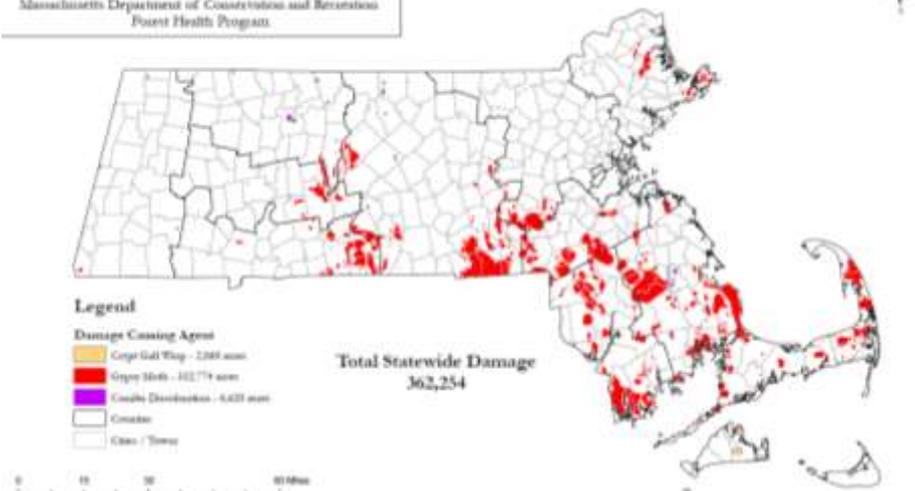
Percent of Normal Precipitation (%)
5/1/2015 – 5/31/2015



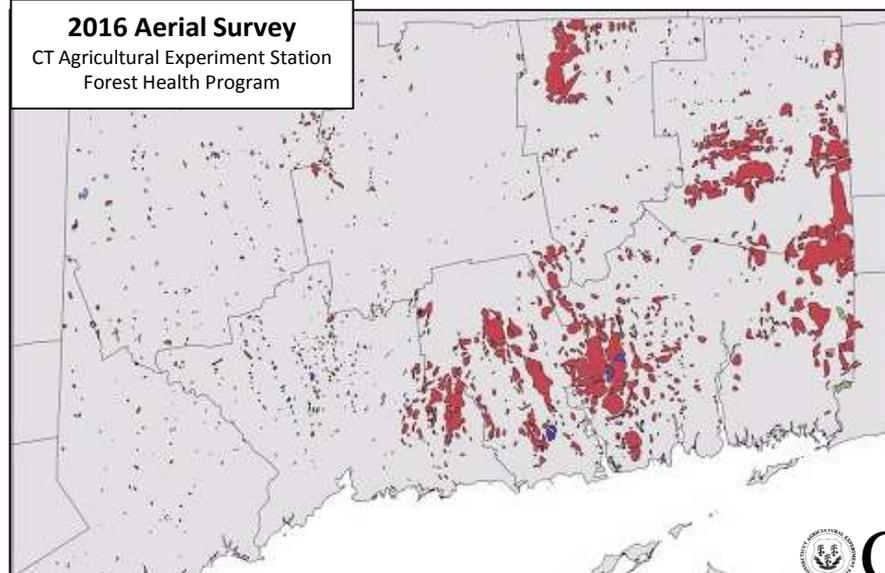
Percent of Normal Precipitation (%)
6/1/2016 – 6/30/2016



2016 Aerial Survey
Massachusetts Department of Conservation and Recreation
Forest Health Program



2016 Aerial Survey
CT Agricultural Experiment Station
Forest Health Program



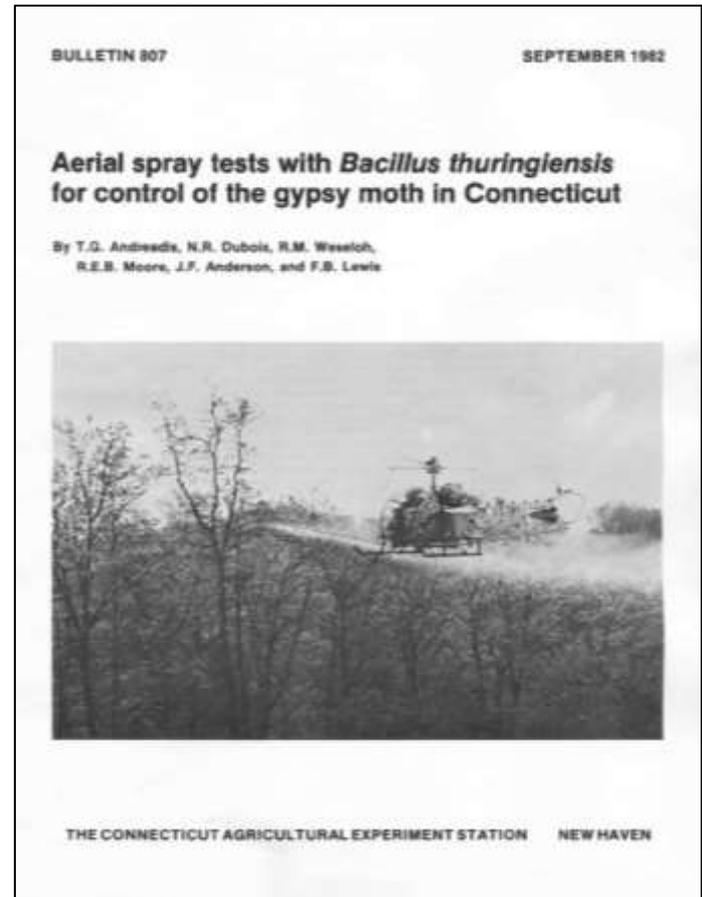
Chemical Control

- *Homeowner and Arborist Applications*
- *Roadside Applications*
- *Aerial Applications*
- Labeled options for aerial application include Btk (DiPel[®] 8L, Foray[®] 48F, Foray[®] 48B, Foray[®] 76B), and IGRs tebufenozide (Mimic[®] 2LV) and diflubenzuron (Dimilin[™] 25W).
- However, only Btk (e.g., DiPel[®] & Foray[®]) is approved for residential gypsy moth control in Connecticut.
- DiPel is a paraffinic oil-based formulation
Foray is an aqueous flowable formulation

Bacillus thuringiensis kurstaki (Btk)

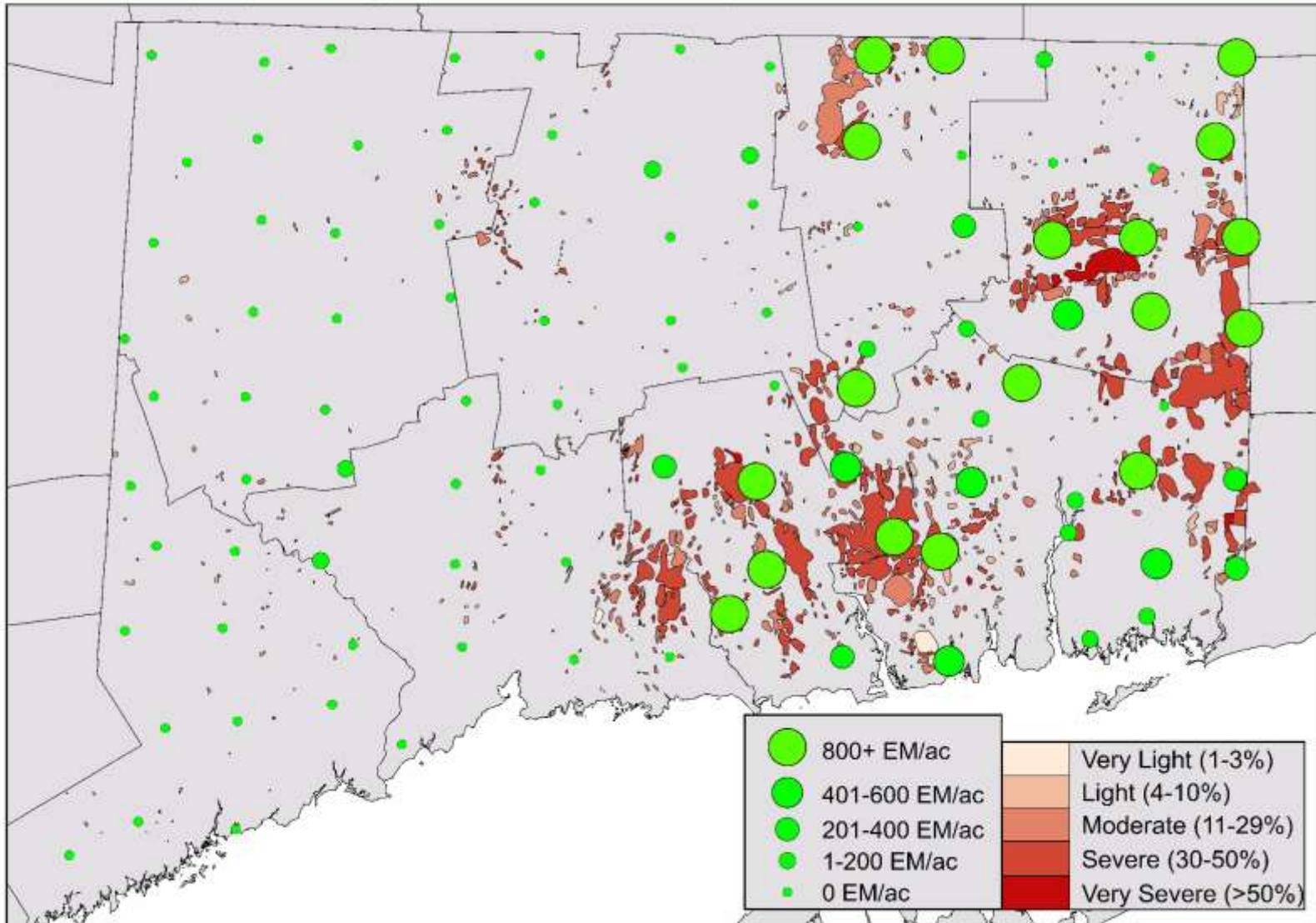


- Study CAES in Harwinton, CT with 3 strains BT (incl. DiPel® 4L)
- Applied May 21, 1981 for 1st & 2nd instars; second app on May 28th with 2nd and 3rd instars equally present
- Significant larval reductions with one application, but better foliage protection with two applications
- Most effective for 1st and 2nd instars, around 30-40% leaf expansion.
- Btk kills gypsy moth as well as other selected non-target lepidopteran larvae



2016 Defoliation with Egg Mass Survey

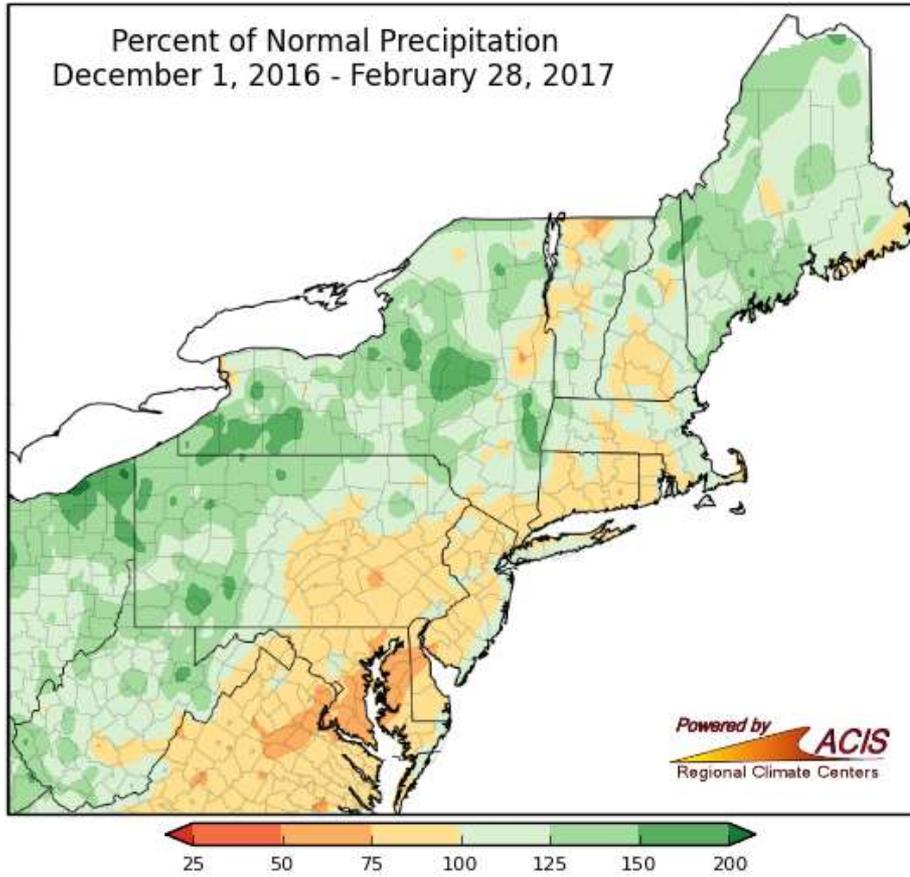
2016-2017 Gypsy Moth Egg Mass 7-Mile Grid Survey Results



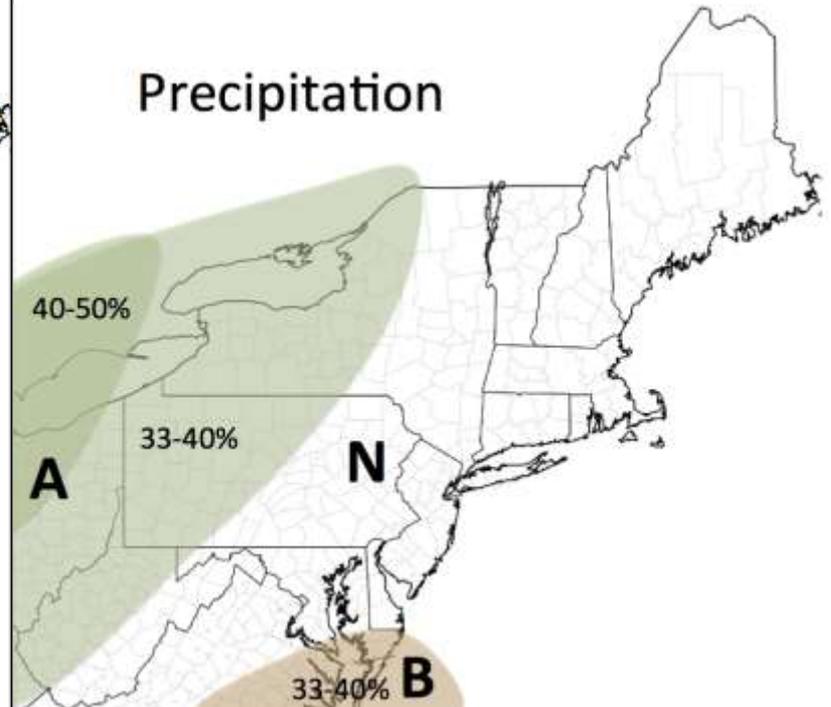
Map by Zackary Brown CAES

Current and Outlook Precipitation

Northeast Regional Climate Center



Forecast week of March 10-16, 2016
White area near-normal expected



Egg Eclosion - GDD

Johnson, P. C., D. P. Mason, S. L. Radke, and K. T. Tracewski. 1983. Gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae), egg eclosion: degree-day accumulations. Environ. Entomol. 12: 929-932. Location: New Hampshire (laboratory studies)

Developmental Threshold – Lower: 37.4°F or 3.0 °C (Start date January 1)

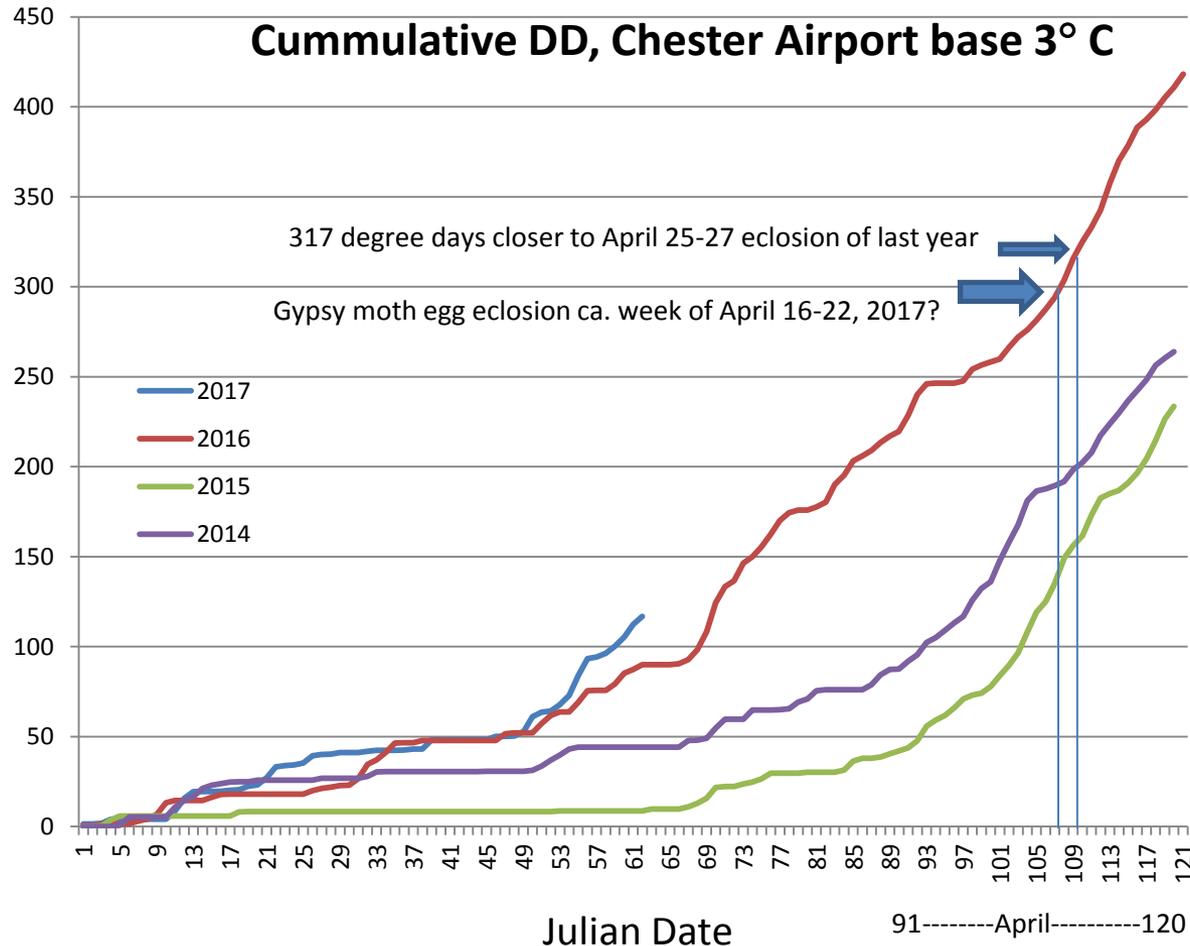
Host: Mixed Hardwood	DD (°F)	DD (°C)
Egg mass eclosion:	507.6	282.0

Russo, J. M., A. M. Liebhold, and J. G. W. Kelley. 1993. Mesoscale weather data as input to gypsy moth (Lepidoptera: Lymantriidae) phenology model. J. Econ. Entomol. 86: 838-844. Location: Pennsylvania and West Virginia

Developmental Threshold – Lower: 37.4°F or 3.0 °C
Upper: 104.0 °F or 40.0 °C

Host: Hardwoods	DD (°F)	DD (°C)
Egg mass eclosion:	570.6	317.0

GDD, 2014-2017, 3.0°C Base



Site for DD data: <http://uspest.org/NE/CT/index.html>

So What to Expect in 2017?

- There was a lot of spotty gypsy moth fungus activity around southcentral CT 2015, some in 2016, but not in most areas.
- Parts of eastern CT will very likely see another round of significant gypsy moth activity, defoliation, and early treatment of trees probably should be considered.
- Even with a wet spring, there will be areas of high caterpillar activity. There are a lot of egg masses.
- If plan to spray, probably should already have an arborist lined up (most are already booked).
- So destroy egg masses this spring if you have them.



Allen Fenner



Kriby Stafford

Acknowledgements

- Plant inspector Peter Trenchard (retired) for many photographs and his contribution of material for this presentation.
- Plant inspectors Peter Trenchard and Tia Blevins, and Dr. Victoria Smith who conduct the aerial surveys. Zachary Brown for the 2016 & 2017 maps.
- Various citizens for submitting photographs.
- Dr. Gale Ridge for some of the pictures of the gypsy moth caterpillars.
- Dr. Claire Rutledge for help GDD.
- U.S. Forest Service for support for forest health surveys, maps past outbreaks, and other material.

The Gypsy Moth
Dr. Kirby C. Stafford III
Department of Entomology
The Connecticut Agricultural Experiment Station

Introduction:

The gypsy moth, *Lymantria dispar*, was introduced into the US (Medford, MA) around 1869 by Etienne Leopold Trounvert. Some larvae escaped and small outbreaks became evident in the area around 1882. Populations increased rapidly and by 1889, the Massachusetts State Board of Agriculture began a campaign to eradicate the moth. It was first detected in Connecticut in Stonington in 1903 and had spread to all 169 towns by 1932. In 1981, 1.5 million acres were defoliated in Connecticut (Fig. 1). During an outbreak in 1989, CAES scientists discovered that the entomopathogenic fungus *Beauveria bassiana* was killing the caterpillars. Since then, the fungus has been the most important agent suppressing gypsy moth activity.

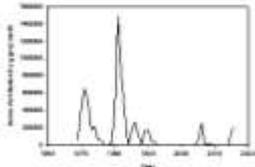


Figure 1. Number of acres defoliated by the gypsy moth in Connecticut, 1903-2006.

The Gypsy Moth, Dr. Kirby C. Stafford III
The Connecticut Agricultural Experiment Station (www.ct.gov/caes)

However, the fungus cannot prevent all outbreaks, due largely during drought conditions, and hot spots in some areas continue to be reported. There was an outbreak in 2003-2006 and a more severe outbreak again in 2013-2016 (see page 7).

Life Cycle:

There is one generation of the gypsy moth each year. Caterpillars hatch from buff-colored egg masses in late April to early May. An egg mass may contain 100 to more than 1000 eggs and may be laid in several layers.



Figure 2. Gypsy moth egg masses on a tree and a close-up of single egg mass (inset).



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