THE SPONGY MOTH IN OUR YARDS AND FORESTS

CLIVE JONES

CHARLES CANHAM

www.caryinstitute.org

THE SPONGY MOTH IN OUR YARDS AND FORESTS

Clive G. Jones & Charles D. Canham

Cary Institute of Ecosystem Studies, Millbrook

US Forest Service, https://www.fs.usda.gov/Internet/FSE_MEDIA/fseprd1091839.jpg
Bill McNee, Wisconsin Dept of Natural Resources, Bugwood.org, https://www.forestryimages.org, image 5502826
Dhalusa, https://commons.wikimedia.org/wiki/File:Gypsy_Moth_Defoliation_Snow_Shoe_PA.jpg

- Where does the Spongy Moth come from?
- When was it introduced to North America & what happened next?

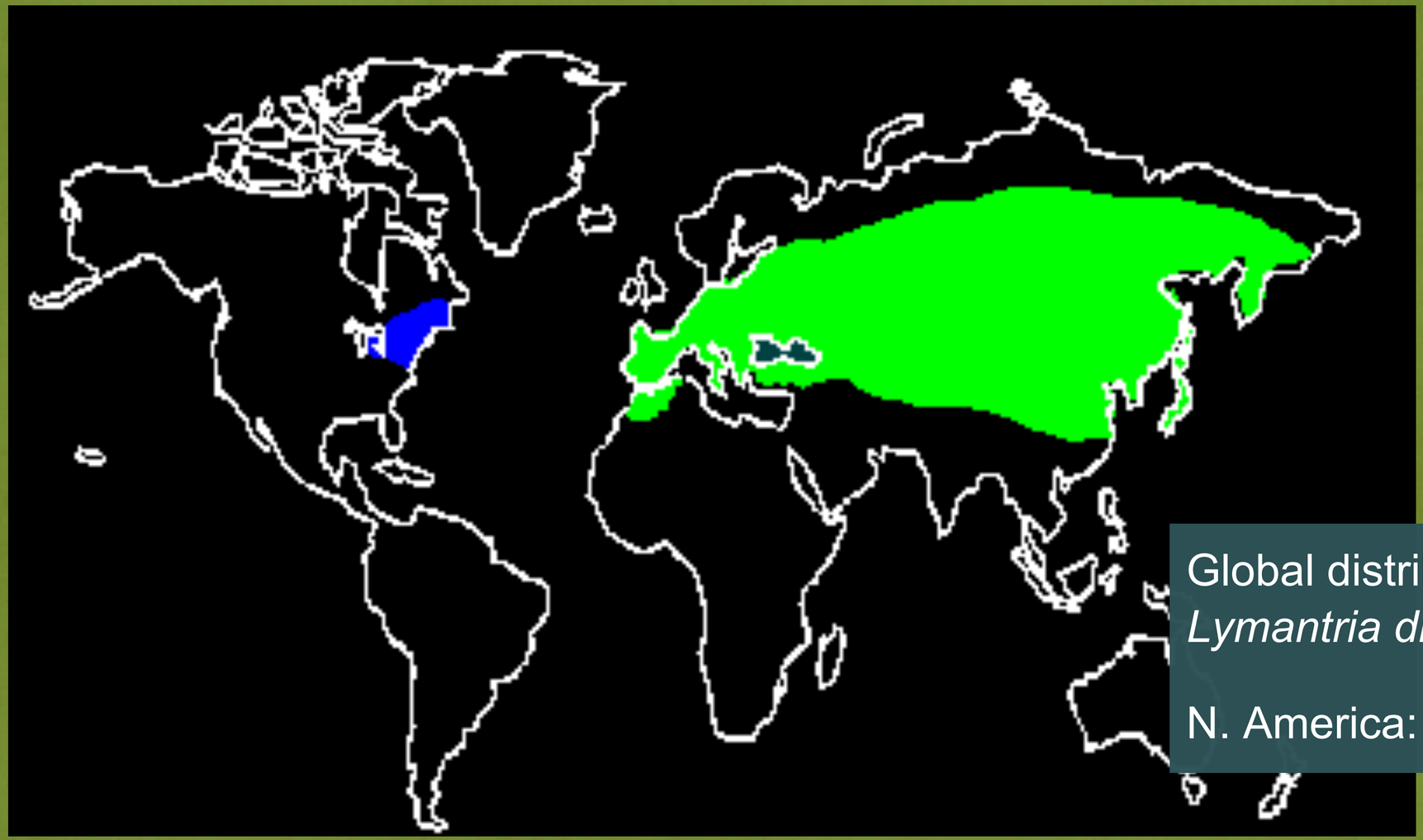
- Relevant life history & ecology
- What causes Spongy Moth outbreaks?
- And what causes outbreaks to collapse?

- Why the current outbreak?
- What can you expect next and in the future?

- What can you do about the moth?

- What will happen to the trees and the forest?

WHERE DOES THE SPONGY MOTH COME FROM?



Global distribution of the Spongy Moth, *Lymantria dispar*

N. America: *Lymantria dispar dispar*

US Forest Service, https://www.forestpests.org/vd/images/maps/165.gif

WHEN WAS IT INTRODUCED TO NORTH AMERICA & WHAT HAPPENED NEXT?

MEDFORD MA, 1868/69

Étienne Léopold Trouvelot

27 Myrtle St, Medford MA

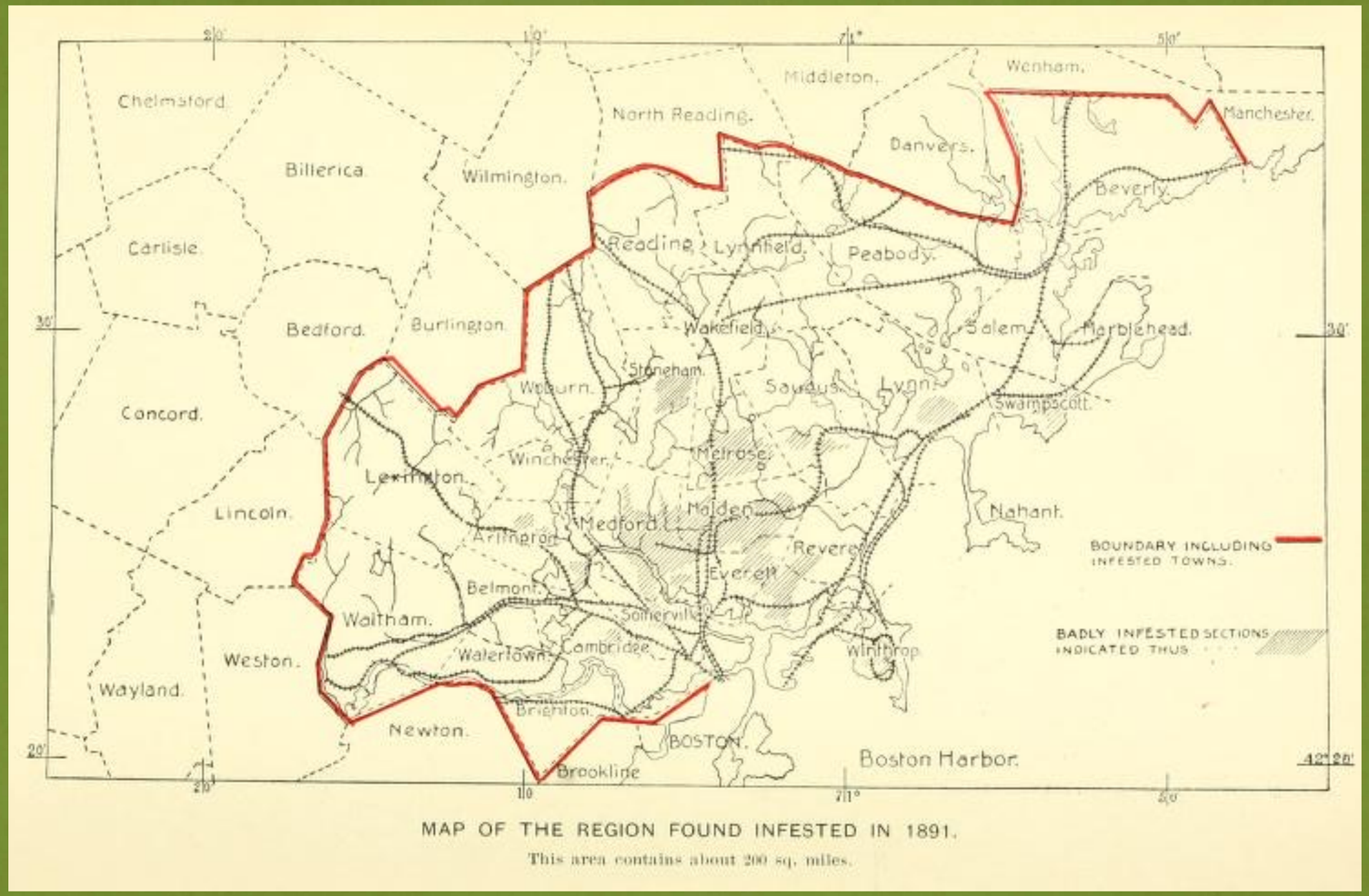
“I was informed that Mr. Trouvelot brought a cluster of gypsy moth eggs from Europe, and, having opened the box, took out the eggs and laid them on the sill of an open window, when the wind blew them out and he was not able to find them.”

US Forest Service, https://commons.wikimedia.org/wiki/File:Trouvelot.jpg

Forbush & Fernald, 1896, USDA APHIS Archives | Forbush, E. H., & Fernald, C. H. 1896. The gypsy moth: Porthetria dispar (Linn.). A report of the work of destroying the insect in the commonwealth of Massachusetts, together with an account of its history and habits both in Massachusetts and Europe. Wright & Potter Printing Co.

WHEN WAS IT INTRODUCED TO NORTH AMERICA & WHAT HAPPENED NEXT?

MEDFORD AREA, MA, 1891



MAP OF THE REGION FOUND INFESTED IN 1891.

This area contains about 200 sq. miles.

Forbush & Fernald, 1896, https://commons.wikimedia.org/wiki/File:Bulletin_(1888)_(14598329900).jpg

WHEN WAS IT INTRODUCED TO NORTH AMERICA & WHAT HAPPENED NEXT?

HOW THE MOTH SPREADS

Flightless female laying eggs

Larva ‘ballooning’

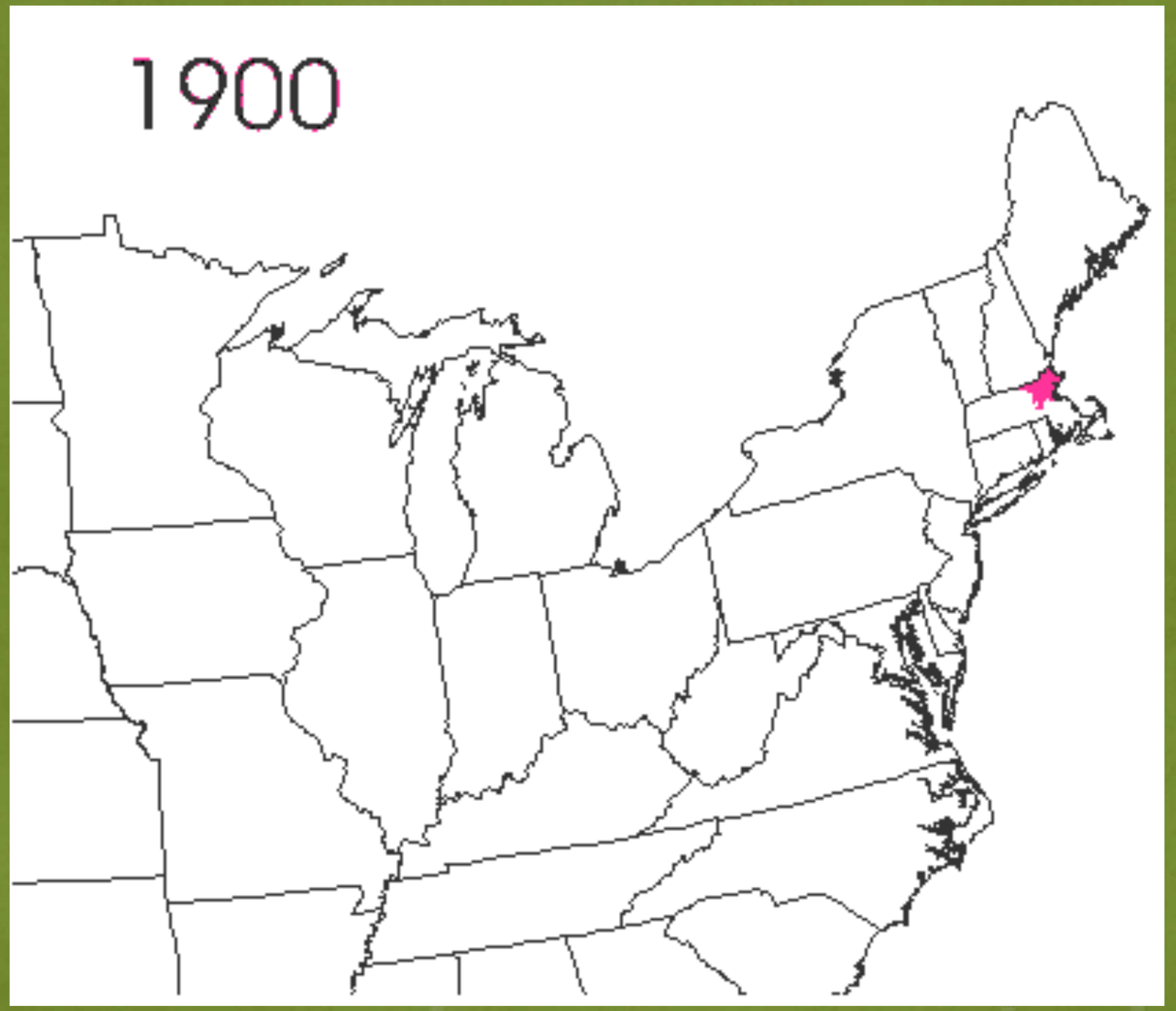
Egg masses on dead tree

Egg masses on picnic table

USDA Forest Service, http://www.angelfire.com/pikefederation/fedpics/Gypsy_Moth6.jpg
Rick Koval/Pocono Record, https://www.poconorecord.com/story/news/2015/05/31/forests-fate-hangs-by-thread/34440228007/
Carl Strang, https://natureinquiries.files.wordpress.com/2009/03/mayslake-gm-eggs-b.jpg?w=477
Bob Queen, WI DNR, https://fyi.extension.wisc.edu/spongymothinwisconsin/files/2011/03/Picnic-Table-Egg-Masses.jpg

WHEN WAS IT INTRODUCED TO NORTH AMERICA & WHAT HAPPENED NEXT?

SPREAD: 1900-2007



File
https://www.caryinstitute.org/sites/default/files/public/2024-01/spongy_moth_spread_1900-2007.gif

USDA Forest Service, https://commons.wikimedia.org/wiki/File:Gypsy_moth_spread_1900-2007.gif

WHEN WAS IT INTRODUCED TO NORTH AMERICA & WHAT HAPPENED NEXT?

PERIODIC OUTBREAKS, DEFOLIATION & COLLAPSE

Rapid increases in moth density from low to very high then back to low

Defoliation of oak-dominated forests

Allegheny region PA, July 2007

Outbreaks in the native range

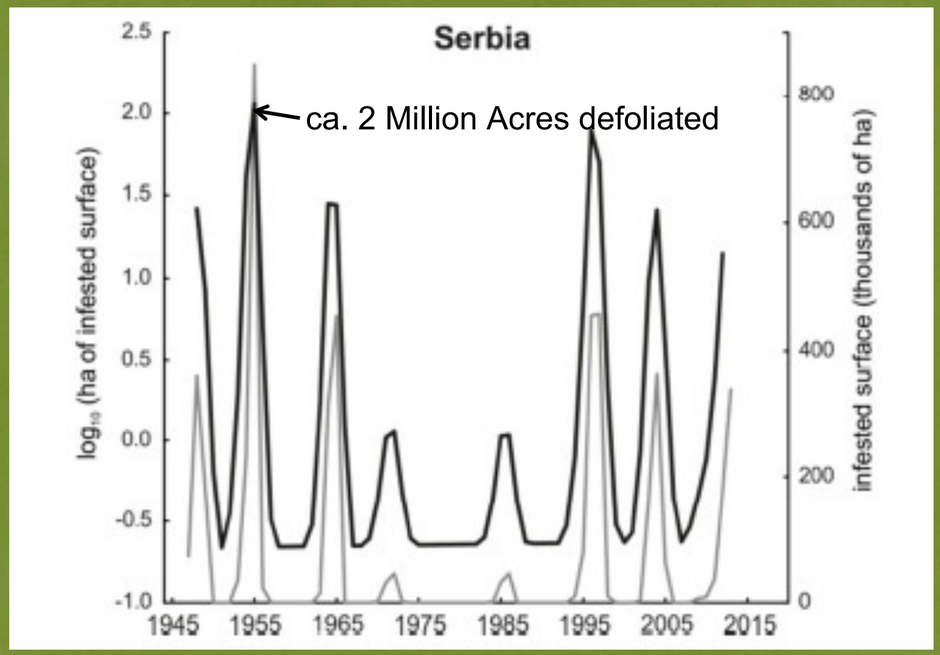
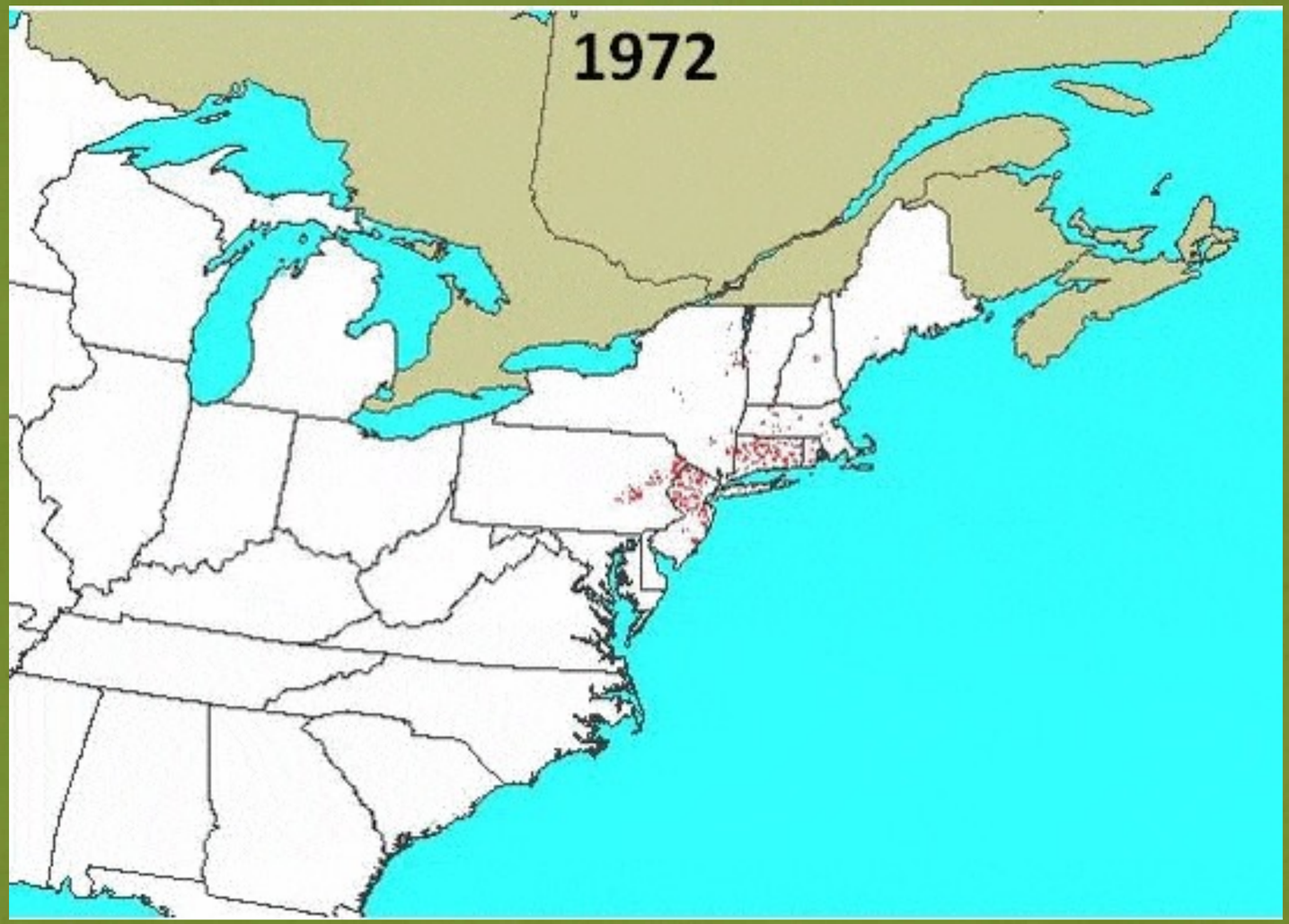


Figure A1. Hlásny, T., et al., 2015. *Journal of Pest Science*, 1-13.

- Outbreaks every ca. 10y on average
- Can be relatively synchronous over large areas
- Extensive defoliation at peak, e.g., > 9 million acres, 1981

WHEN WAS IT INTRODUCED TO NORTH AMERICA & WHAT HAPPENED NEXT?

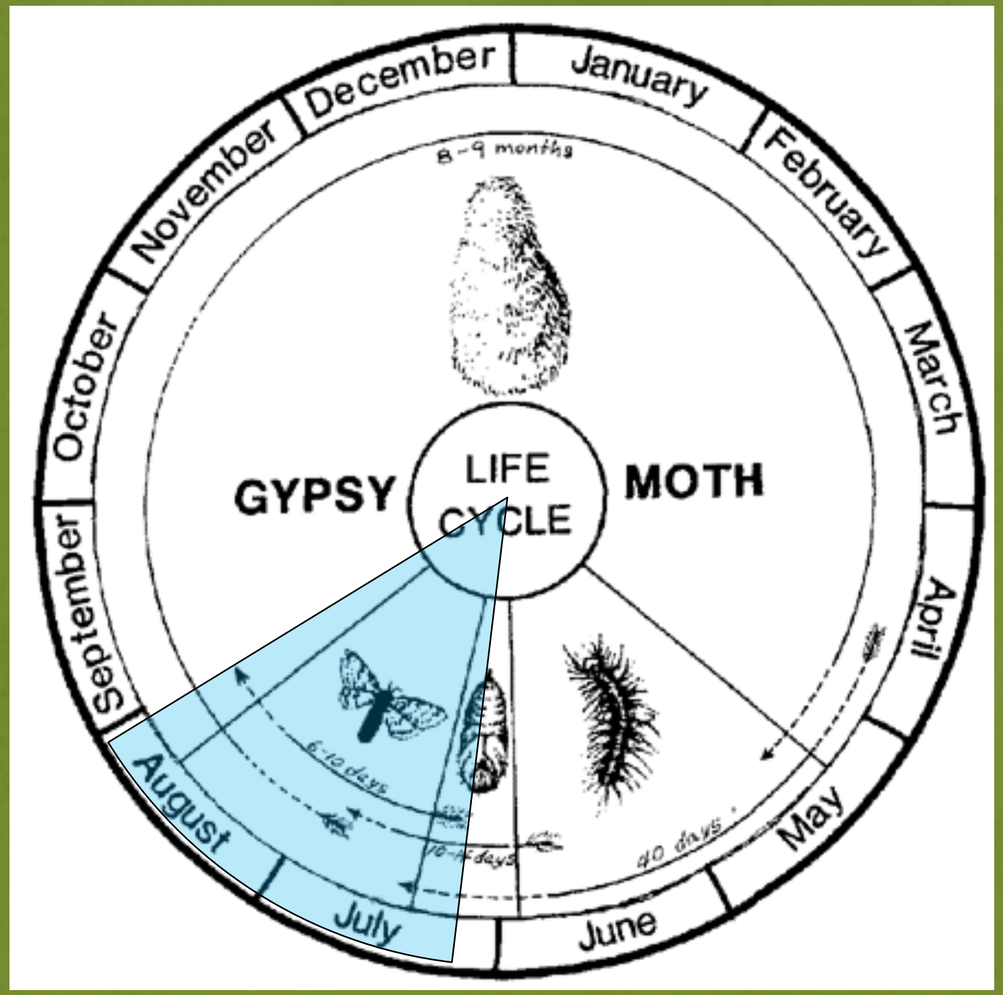
DEFOLIATION 1972-2007

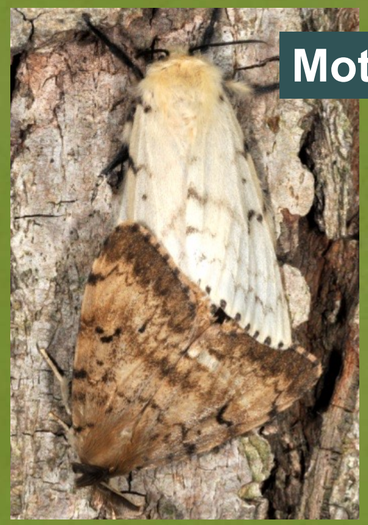


File
https://www.caryinstitute.org/sites/default/files/public/2024-01/spongy_moth_defoliation.gif

Compiled from US Forest Service Data,1972-1994 & 1995-2007, courtesy A. M. Liebhold et al.

RELEVANT LIFE HISTORY & ECOLOGY





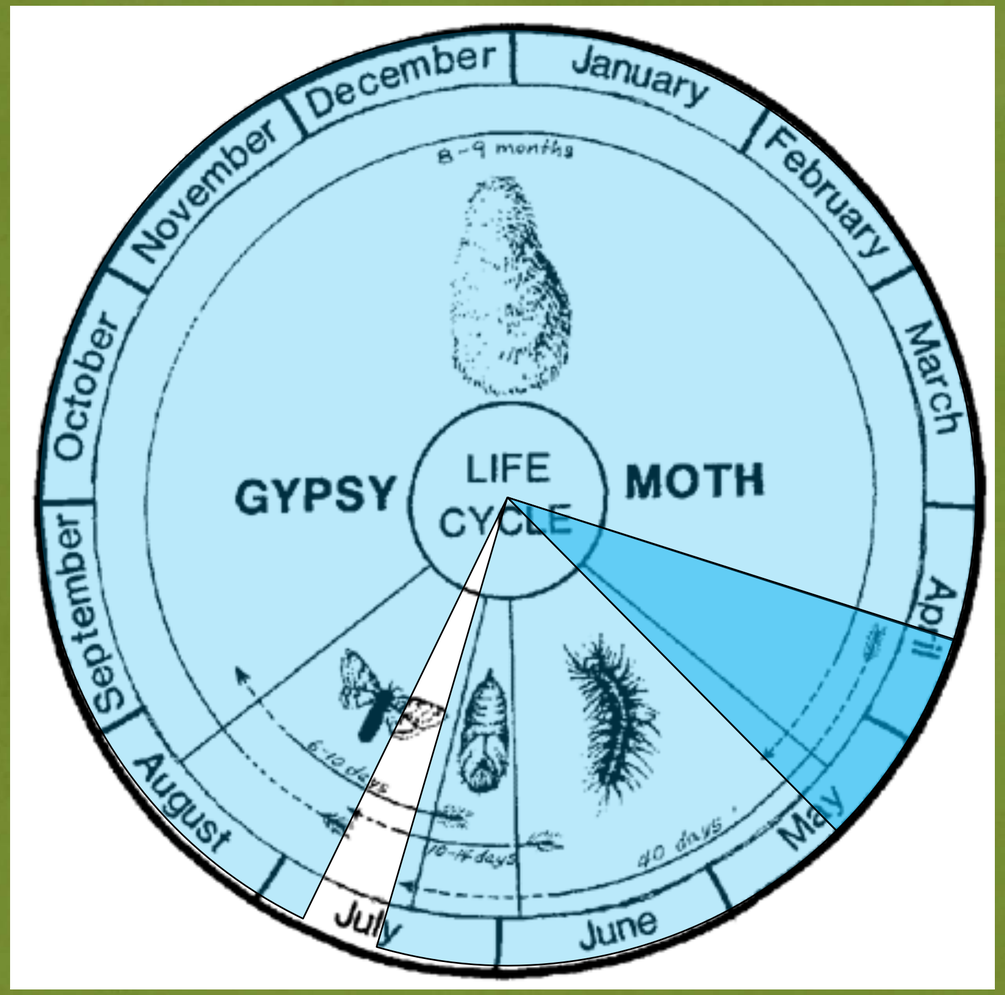
Moths mating

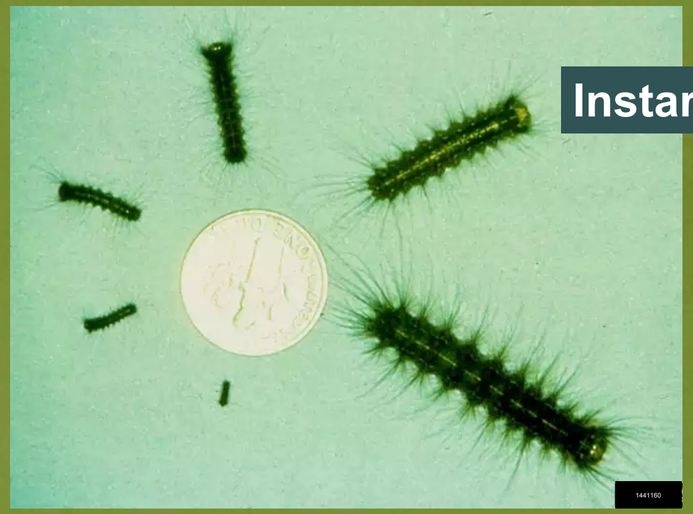
Egg mass

Females & egg masses

John Obermeyer, Perdue Univ. Extension, https://extension.entm.purdue.edu/publications/GM-5/graphics/Gypsy%20MothsMating2.jpg
MN Dept. Agriculture, https://www.mda.state.mn.us/sites/default/files/inline-images/gm-eggmass.jpg
T. Simisky, UMass Extension, https://ag.umass.edu/sites/ag.umass.edu/files/styles/150x150/public/fact-sheets/images/figure_2_0.jpg

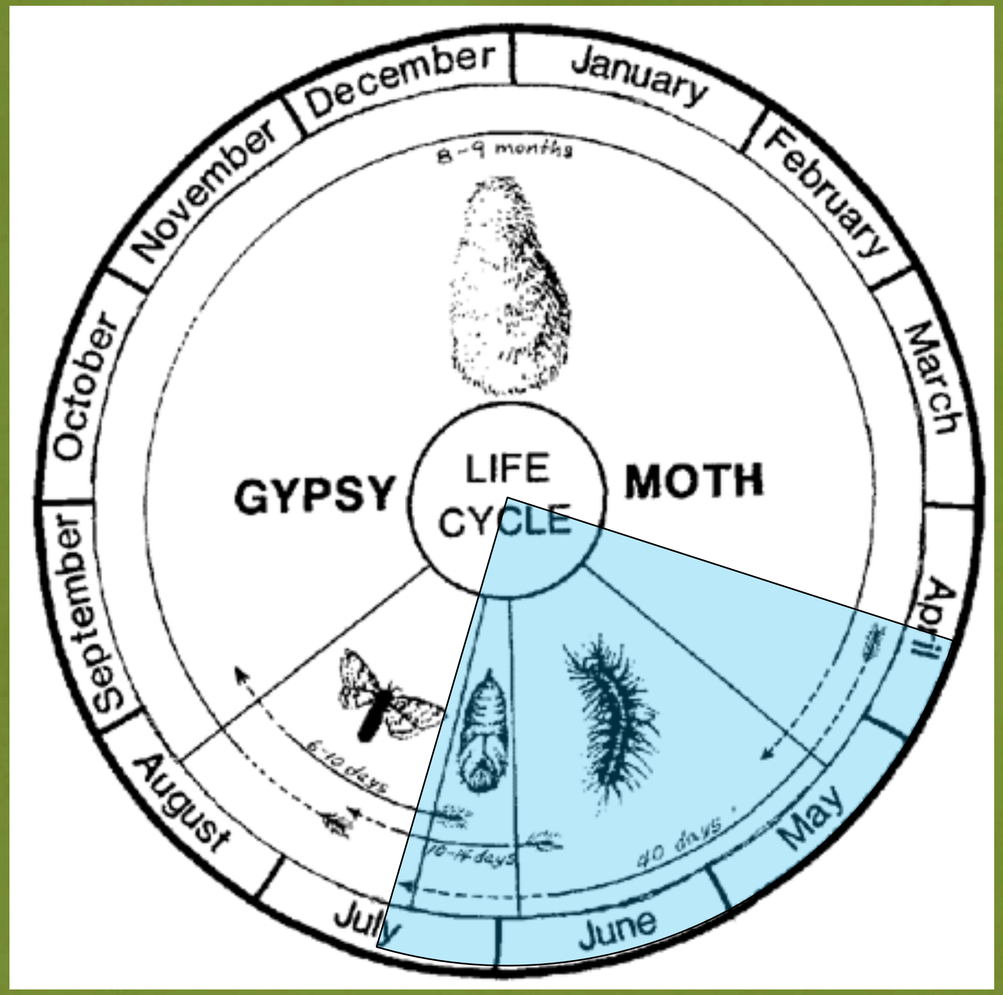
RELEVANT LIFE HISTORY & ECOLOGY





USDA Forest Service - Region 8 - Southern , USDA Forest Service, Bugwood.org, https://www.forestryimages.org, image 1507053
USDA Forest Service - Region 2 - Rocky Mountain Region , USDA Forest Service, Bugwood.org, https://www.forestryimages.org, image 1441160

RELEVANT LIFE HISTORY & ECOLOGY



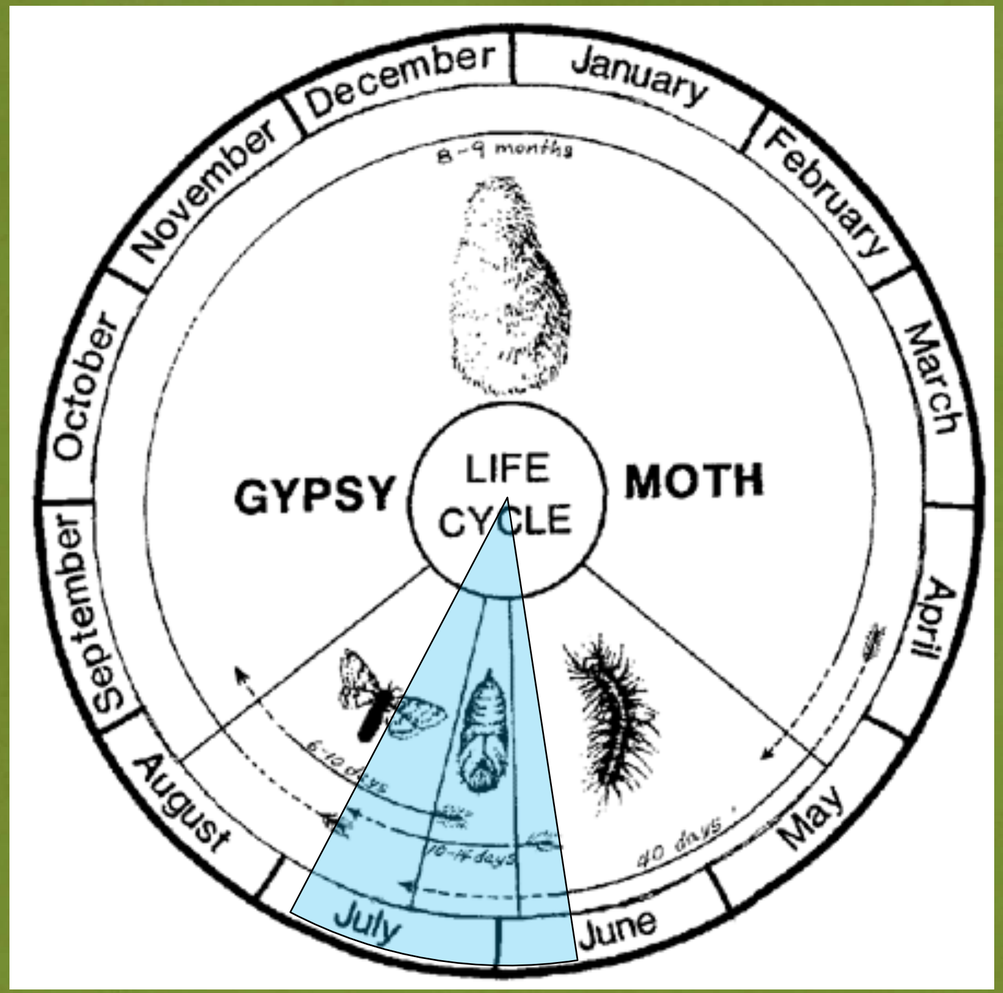
‘Ballooning’

Resting

Feeding

Bill McNee, Wisconsin Dept of Natural Resources, Bugwood.org, https://www.forestryimages.org, image 5625247

RELEVANT LIFE HISTORY & ECOLOGY



Male &
Female Pupae

Ferenc Lakatos, University of Sopron, Bugwood.org, https://www.forestryimages.org, image 5081045

RELEVANT LIFE HISTORY & ECOLOGY

NATURAL ENEMIES THAT DON'T MAKE A BIG DIFFERENCE

THEY DO KILL SPONGY MOTH …

Native & introduced species

Predators, parasitic insects, pathogens

Collectively attack all life stages

BUT …

Their 'failure' to kill does not cause outbreaks

At best, help an outbreak collapse, but not the primary causes

WHY?

Kill too few – better food elsewhere &/or

Not very abundant, so do not kill many &/or

Do not increase in abundance as moth density rises &/or

Do increase, but do so too slowly to overtake the moth

RELEVANT LIFE HISTORY & ECOLOGY

NATURAL ENEMIES THAT DON'T MAKE A BIG DIFFERENCE

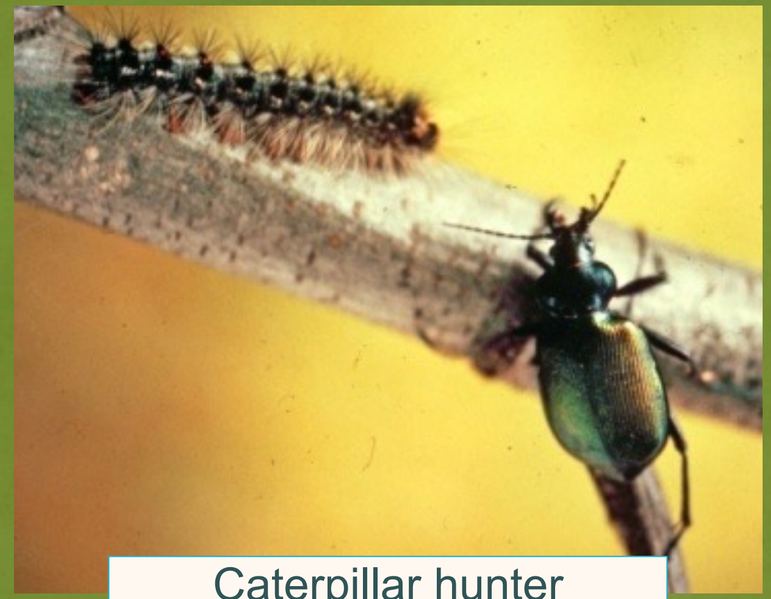
BIRDS

Black-billed cuckoo
Coccyzus erythropthalmus

MOST SMALL MAMMALS

Smoky shrew
Sorex fumeus

BEETLES, ANTS, SPIDERS



Caterpillar hunter
Calosoma scrutator

RELEVANT LIFE HISTORY & ECOLOGY

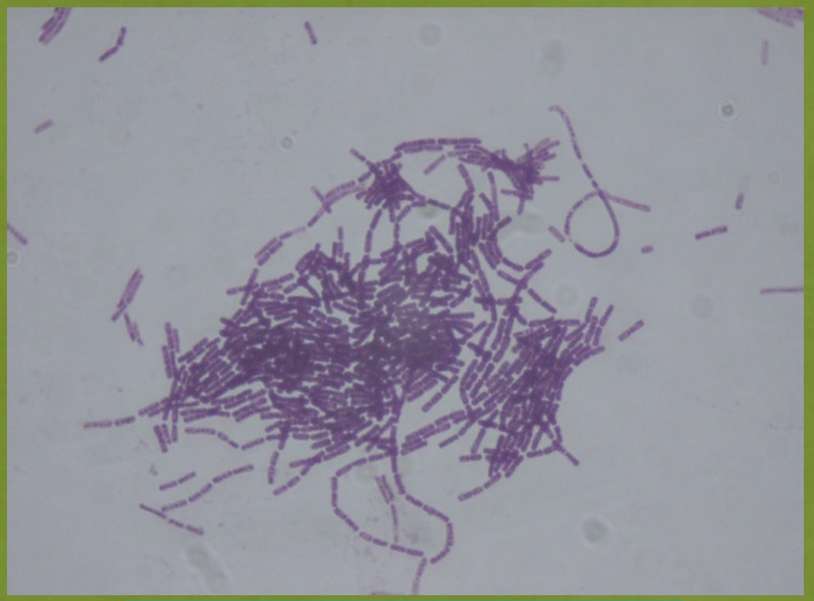
NATURAL ENEMIES THAT DON'T MAKE A BIG DIFFERENCE

INSECT PARASITOIDS

Encyrtid wasp
Ooencyrtus kuvanae

Braconid wasp
Aleiodes indiscretus

MOST PATHOGENS



Naturally occurring
Bacillus thuringiensis
BT

Scott Bauer, USDA ARS, https://commons.wikimedia.org/wiki/File:Aleiodes_indiscretus_wasp_parasitizing_gypsy_moth_caterpillar.jpg
Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org, https://www.forestryimages.org, image 5371176
Dr. Sahay, https://commons.wikimedia.org/w/index.php?curid=29339272

WHAT CAUSES SPONGY MOTH OUTBREAKS?

TWO CAUSES

1. High female fecundity

Imagine …
Every egg survives to adulthood
ca. 500 eggs per egg mass
ca. 50% females

= 1 x 500 x 0.5 = 250-fold increase each year

Maximum observed = 125-fold

Year	Maximum Egg Masses per Acre
1	1
2	125
3	15,625

Complete defoliation at ca. 2,000 + egg masses per acre

Maximum observed density ca. 6,000 masses per acre

Preventing outbreaks requires keeping moth density very low

WHAT CAUSES SPONGY MOTH OUTBREAKS?

TWO CAUSES

2. Mouse population collapse!

The white-footed mouse, *Peromyscus leucopus*

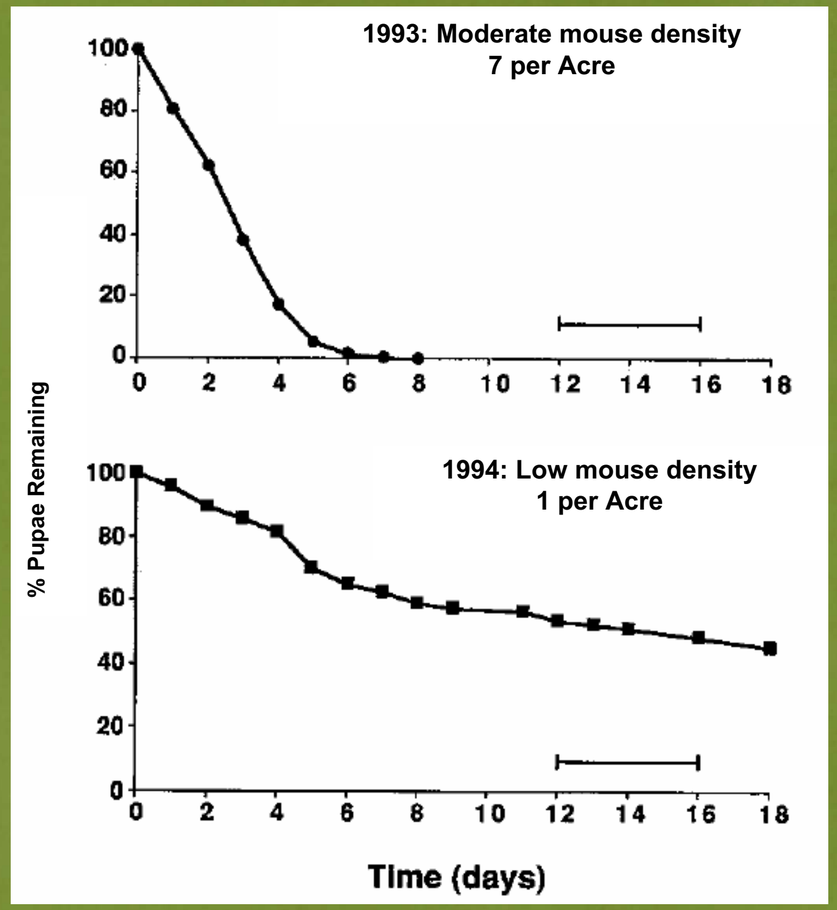
Most abundant small mammal in our forests

Voracious predator on moth pupae

Ostfeld Lab, Cary Institute of Ecosystem Studies
Sam Cillo, Cary Institute of Ecosystem Studies

WHAT CAUSES SPONGY MOTH OUTBREAKS?

2. Mouse population collapse!



Moderate > High mouse density
Keep moth populations low
Drive them to lower levels
Prevent them rising

Low > Very Low mouse density
Allow outbreaks to start

Fig. 7, Ostfeld, R.S., Jones, C.G. & Wolff., J. O. 1996. Of Mice and Mast: Ecological connections in eastern deciduous forests.*BioScience* **46** (5), 323-330.

WHAT CAUSES SPONGY MOTH OUTBREAKS?

2. Mouse population collapse!

Mice eat moth pupae, but …
The moth does not directly affect how many mice there are

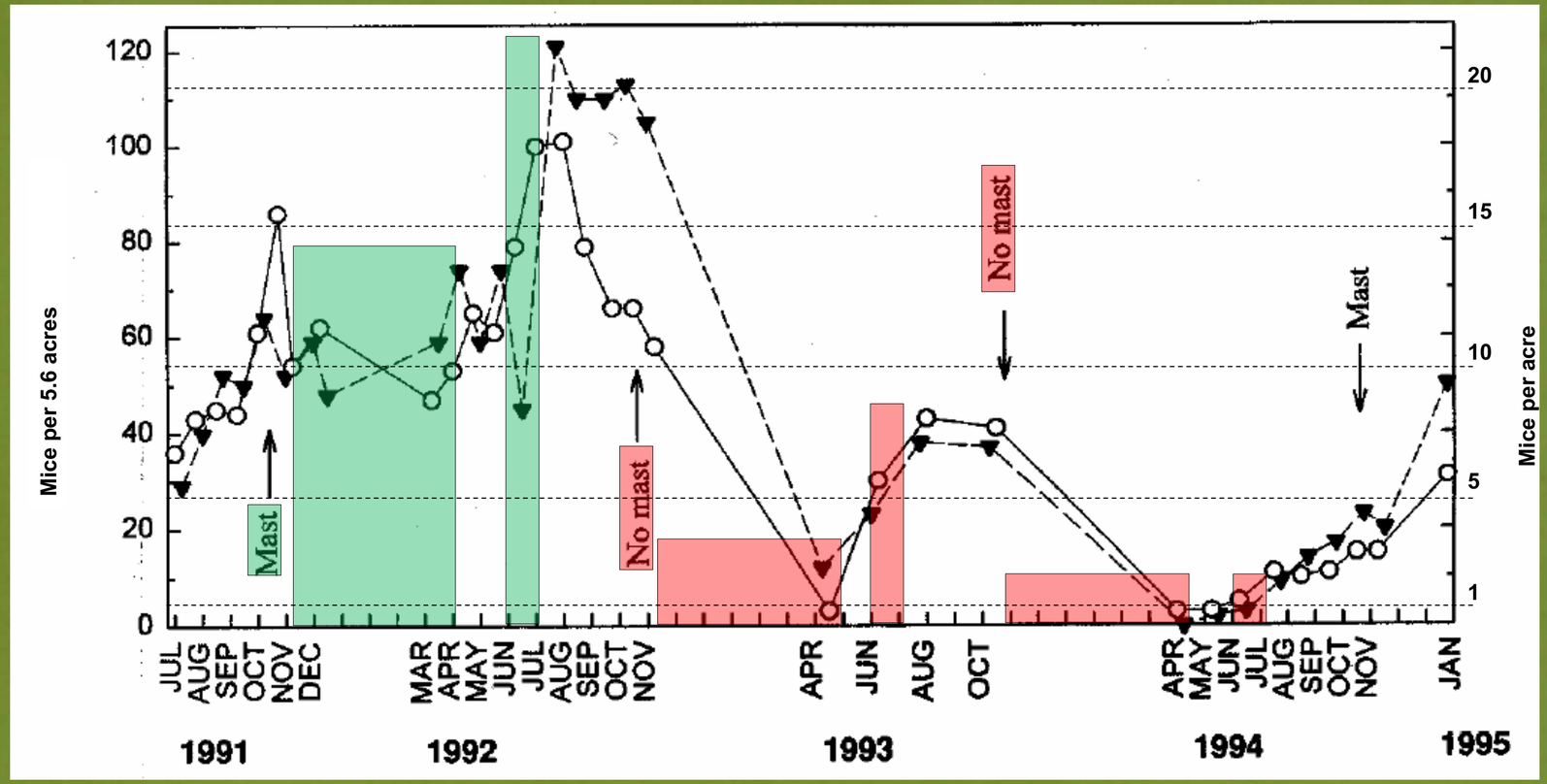
Mice are omnivores – Moth pupae are a minor part of their diet
A 2-week snack for mice with major moth consequence!

The number of mice is determined by acorns the previous fall

M. Ahearn, Cary Institute of Ecosystem Studies

WHAT CAUSES SPONGY MOTH OUTBREAKS?

2. Mouse population collapse!



Moderate to large acorn crops

Many mice survive the winter
Start reproducing late winter/early spring
An extra mouse generation
High mouse densities at moth pupation

No acorns or low acorn crop

Few mice survive the winter
Start reproducing later
Low mouse densities at moth pupation

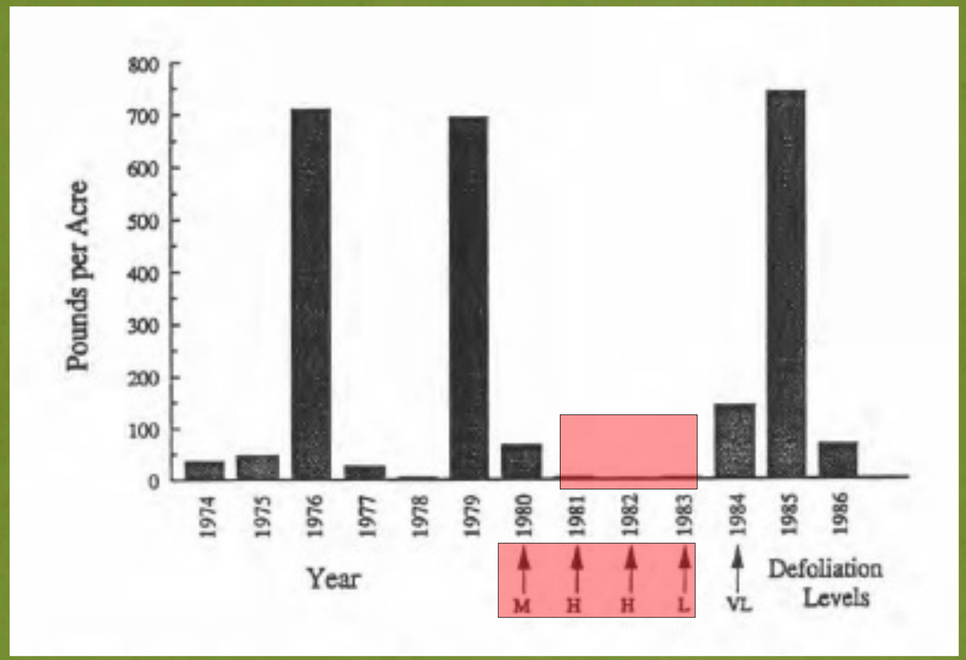
Fig. 3, Ostfeld, R.S., Jones, C.G. & Wolff., J. O. 1996. Of Mice and Mast: Ecological connections in eastern deciduous forests.*BioScience* **46** (5), 323-330.

WHAT CAUSES SPONGY MOTH OUTBREAKS?

2. Mouse population collapse!

The moth does not <u>directly</u> affect the number of mice, but …

Oak defoliation can reduce acorn production



Increasing the risk of another moth outbreak

McConnell, S. 1988. Effects of gypsy moth defoliation on acorn production and viability, litterfall, and litter layer depth and biomass in North—central Virginia and Western Maryland . MSc Thesis, Virginia Polytech Institute.

WHAT CAUSES OUTBREAKS TO COLLAPSE?

THREE CAUSES

1. The fungus *Entomophaga maimaga*

Introduced from Asia in 1910 – Never established
Re-introduced, late 1980's
Now quite widely distributed
Will persist once present

Kills some larvae each year at low moth density

Can kill many larvae within a year at moderate > high densities
Can curtail outbreaks > low/moderate defoliation > collapse

'Mass mortality' due to the fungus – Not yet well understood
More likely to occur when…
- Larval density is moderate or greater AND
- Spring is both wet and cool

Head-down desiccated cadaver

Steven Katovich, Bugwood.org, https://www.ipmimages.org, image 5443556

WHAT CAUSES OUTBREAKS TO COLLAPSE?

THREE CAUSES

2. Nuclear Polyhedrosis Virus, NPV

Naturally occurring
Always present

Mostly sub-lethal at low moth densities

Lethal at high moth densities
The primary cause of collapse of high density moth populations

Why sub-lethal to lethal?
- Increasing moth density ….
- Increases larval competition for food & resting space …
- Increases larval stress …
- Reduces larval immunity …
- Increases viral susceptibility & mortality

Soggy inverted **V**

John Ghent, Bugwood.org, https://www.ipmimages.org, image 5383248

WHAT CAUSES OUTBREAKS TO COLLAPSE?

THREE CAUSES

3. Food limitation

Run out of food & do not complete development

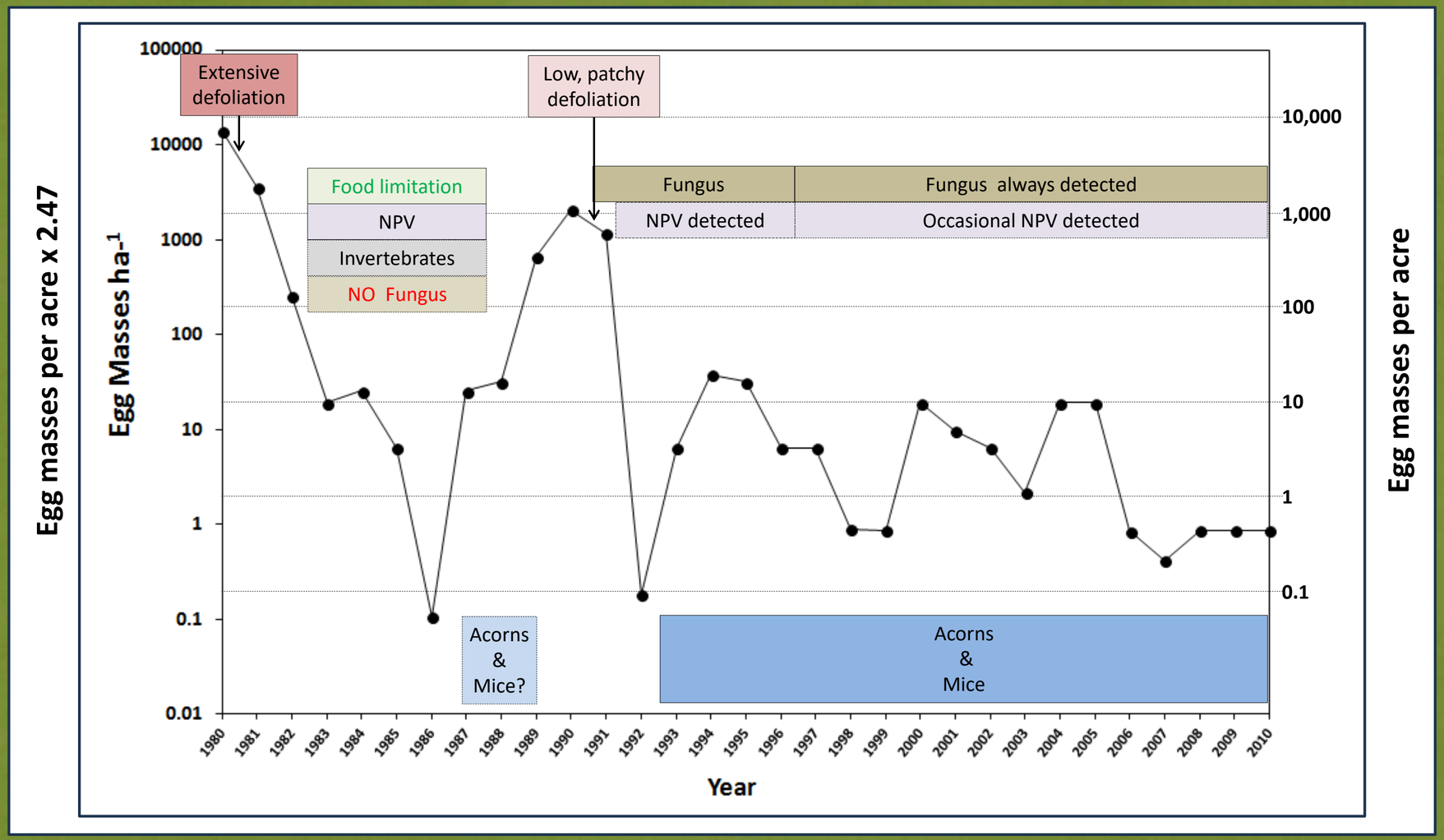
Later stage larvae do eat non-oaks, but …
Survival & fecundity is lower

Food limitation can bring about collapse, & …

Via caterpillar stress, boosts viral efficacy

WHAT CAUSES SPONGY MOTH OUTBREAKS & THEIR COLLAPSE?

All the players over 30 years at Cary



Data, C Jones. 2010 Updated version of Fig. 6, Ostfeld, R.S., Jones, C.G. & Wolff., J. O. 1996.

WHY THE CURRENT OUTBREAK?

Cary

	2019	2020	2021	2022	2023
Fall Acorns	Very High	**Low**	Moderate	Very Low	
Summer Mice		High	**Very Low**	High But Too Late?	Very Low
Fungus (Spring/ Summer)				Detected Low	Detected Low (Dry Spring)
NPV (Spring/ Summer)				Detected Low	Detected Low
Defoliation (Summer)					**ca. 50%**
Egg Masses (End Summer)			**Increase?**	**Increase**	**Increase**

Outbreak Started?

June 19, 2023. Defoliation

July 31, 2023. Re-flushed

Thanks : Michael Fargione, Vicky Kelly, Kelly Oggenfuss

Cary Institute of Ecosystem Studies, www.chronolog.io/site/CAR102

chronolog

WHAT CAN YOU EXPECT NEXT AND IN THE FUTURE?

Best guess for Cary

2024
NPV-induced collapse
+/- Fungal assistance, weather depending
A cool wet spring (mid-May through June) may help

Defoliation?
Depends on how fast the virus sweeps through the population (+/- Fungus)
Fast > Partial defoliation; Slow > Complete defoliation

If not, then **2025** has a very high probability of virus-induced collapse

Continued collapse to low density
A period of unknown duration when the moth will be rare due to the mice
But expect outbreaks in the future
With severity determined by efficacy of the fungus
More or less cool wet springs in the future?

WHAT CAN YOU DO ABOUT THE MOTH?

Interventions – When might they work?

4 GUIDELINES

1. Outbreak Stage as years after mouse failure!

Early (Yr 1, 2) – Low to Moderate density – Potentially feasible
- Egg masses – Accessible at base of trees
  - Removal/Dormant oil
- Larval immigration via dispersal – Relatively low
  - Sticky tape & burlap bands

Middle (Yr 2, 3, 4) – Moderate to very high density – Limited options
- Egg masses – All over trees
  - ~~Removal/Dormant oil~~
- Larval immigration via dispersal – High to very high
- Many larvae stay in the canopy
  - ~~Sticky tape & burlap bands~~
  - Btk – Not near water; timing 2 application; rain/sun (UV); lowest risk; non-target Lepidoptera effects limited by early season use
  - Acephate systemic tree injection – Girdling risk; non-bearing trees only; kills most leaf-eating insects; risk of non-target effects

Late (Yr 3, 4+) – Density falling/not rising – Fungus & NPV epizootics — Outbreak ending
Intervention worthwhile?

- Egg masses
  - Removal
  - Dormant oil/'Insecticidal' soap
    - Homeowner, 'spot application'
    - ~~Broadcast spraying NY~~
- Larvae
  - Sticky tape & burlap bands
  - Acephate systemic tree injection
  - Spraying
    - ~~Insecticides NY~~
    - Biological "insecticides", Btk (*Bacillus thuringiensis ssp. kurstaki*)
      - Homeowner
      - Registered Applicator
        - Ground to canopy
        - Drone
        - Plane
- Do nothing – Let nature take its course

WHAT CAN YOU DO ABOUT THE MOTH?

Interventions – When might they work?

4 GUIDELINES

2. Your Goal
A fully accessible tree/sapling, more viable than …
Many large trees, more viable than …
The forest

3. Area of Intervention
Small areas more viable than large areas
Surrounding areas can overwhelm local efforts
Larval immigration via dispersal

4. Location with respect to surrounding forest
Isolated trees more viable than …
Close to the forest more viable than …
In the forest

Egg masses
- Removal
- Dormant oil/'Insecticidal' soap
  - Homeowner, 'spot application'
  - ~~Broadcast spraying NY~~

Larvae
- Sticky tape & burlap bands
- Acephate systemic tree injection
- Spraying
  - ~~Insecticides NY~~
  - Biological "insecticides", Btk (*Bacillus thuringiensis ssp. kurstaki*)
    - Homeowner
    - Registered Applicator
      - Ground to canopy
      - Drone
      - Plane

Do nothing – Let nature take its course

USFS & NYS DEC no longer intervene except in some very special situations

WHAT CAN YOU DO ABOUT THE MOTH?

The Spongy Moth joins a long list of introduced forest pests and pathogens that we are unable to effectively control once they arrive

Asian longhorn beetle
Balsam wooly adelgid
Beech bark disease
Butternut canker
Chestnut blight
Dutch elm disease
Emerald ash borer
European wood wasp
Hemlock wooly adelgid

Phytophera dieback
Port Orford cedar root rot
Redbay ambrosia beetle & fungus
Shothole borer & *fusarium* fungus
Spongy moth
Sudden oak death
White pine blister rust
Winter moth

Gary M. Lovett et al., 2016. Nonnative forest insects and pathogens in the United States: Impacts and policy options. *Ecological Applications* **26**, 1437-1455.

WHAT WILL HAPPEN TO THE TREES AND THE FOREST?

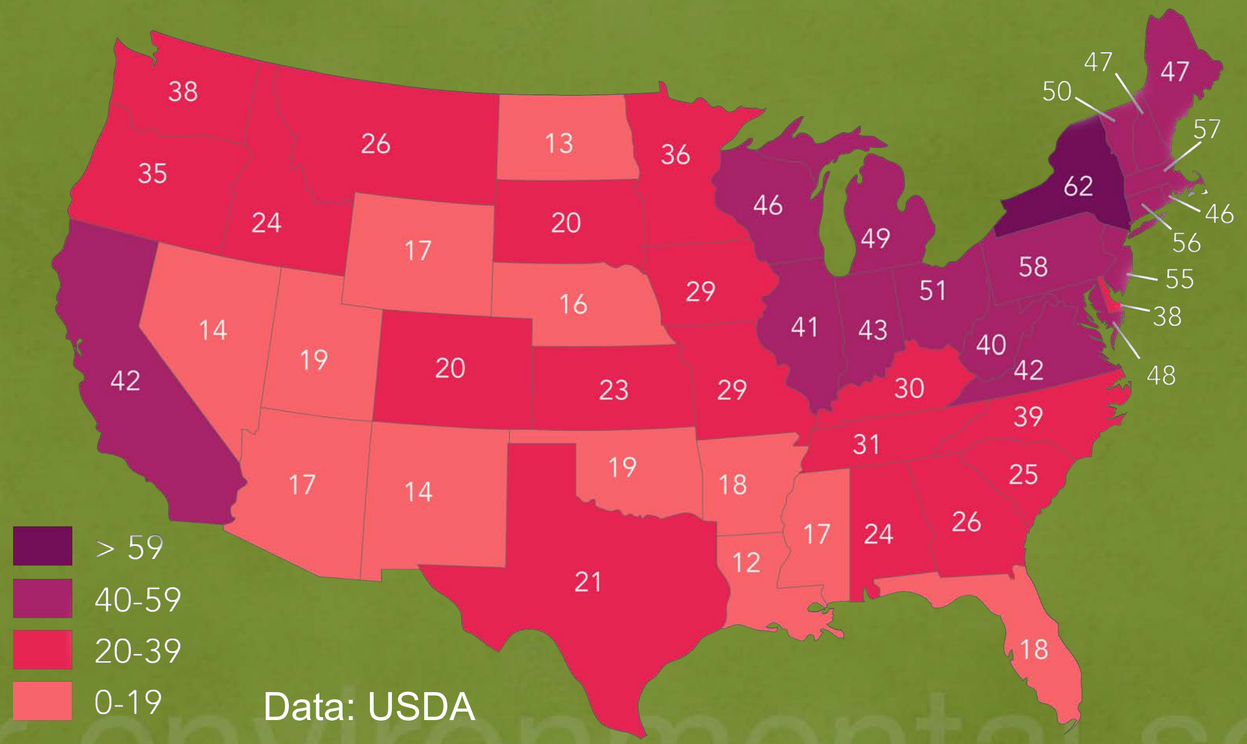
Lori Quillen, Cary Institute

LEGACIES OF GLOBAL TRADE: INTRODUCED PESTS AND PATHOGENS

Arguably the **most pervasive and persistent human impacts on eastern US forests** over the past century have been from the introduction of new pests and pathogens…

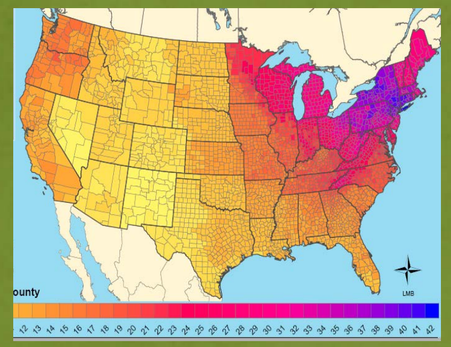
Chestnut blight
Dutch elm disease
Beech bark disease
Hemlock wooly adelgid
Emerald ash borer
Asian longhorned beetle
Spotted Lanternfly
Beech Leaf Disease
…?

NUMBER OF NON-NATIVE FOREST PESTS 2018



Data: USDA

2012

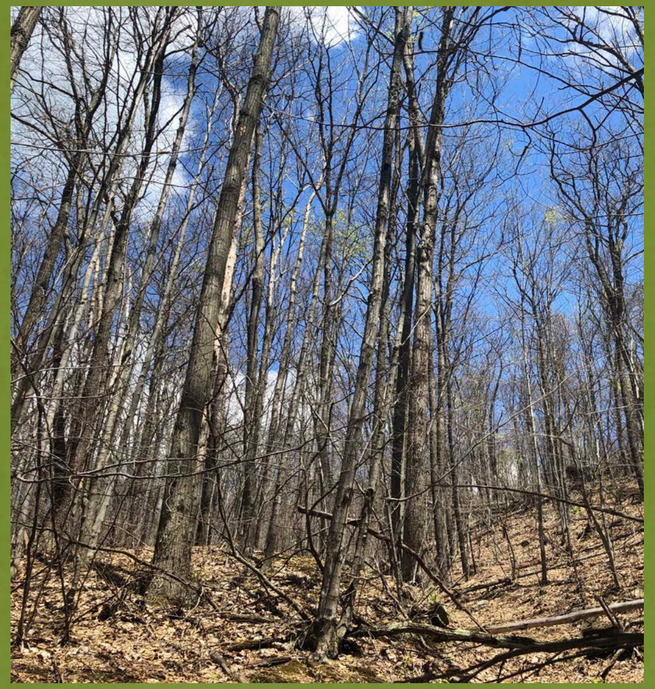


Liebhold et al. 2013

WHAT DID WE LEARN FROM THE OUTBREAK IN 1981-82?

Bottom line: **complete defoliation in early summer kills very few trees directly**

WHY NOT?



The role of carbohydrate reserves…

EXCEPTIONS

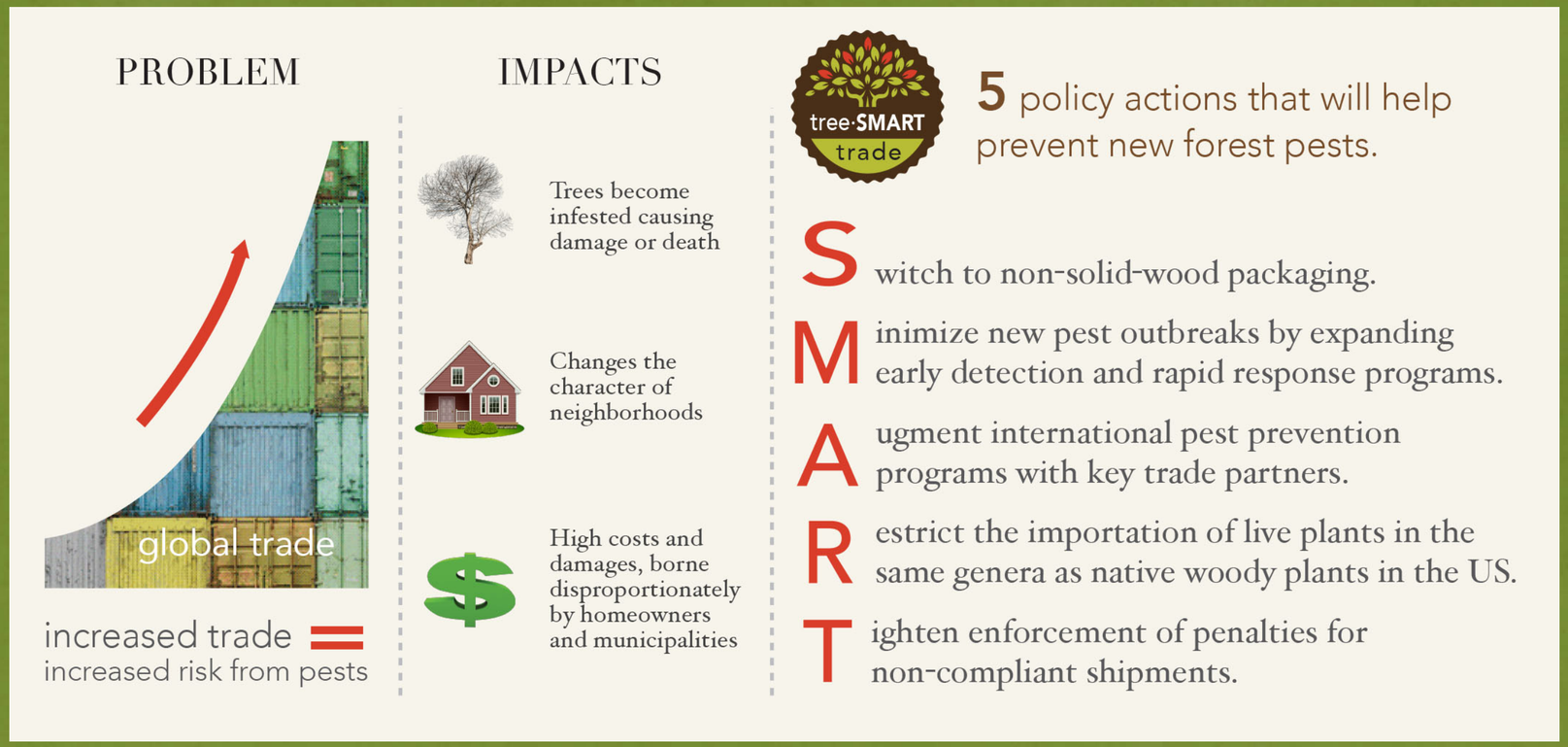
Hemlocks saplings in deep shade

LONG TERM RESIDUAL IMPACTS

THE TREE-SMART TRADE INITIATIVE

Invasive Forest Pests in the United States

COMMUNITY IMPACTS AND OPPORTUNITIES FOR TREE-SMART TRADE



Gary Lovett, Cary Institute

Treesmarttrade.org