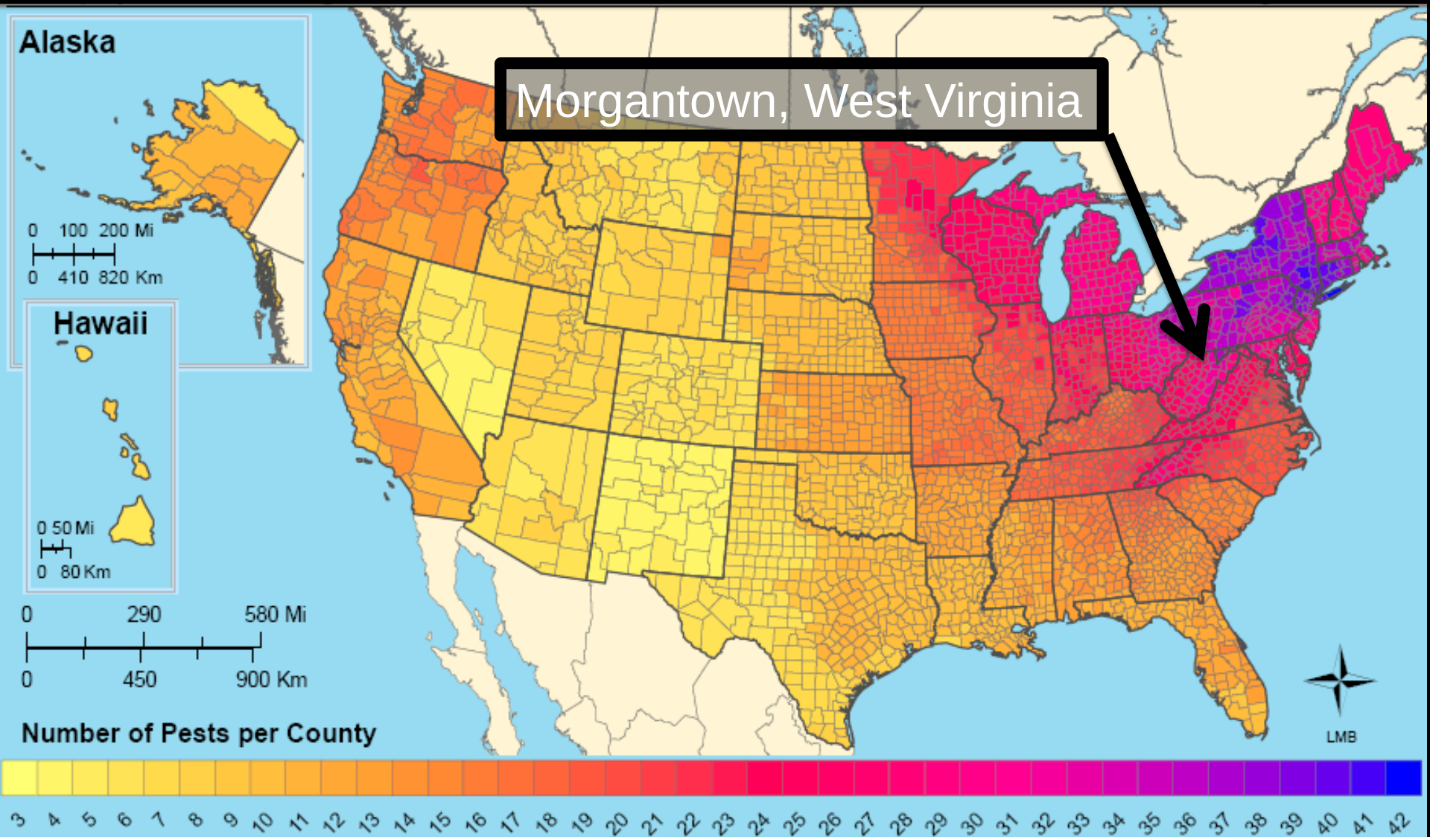
Area-Wide Management of Invading Gypsy Moth (*Lymantria dispar*) Populations in the USA

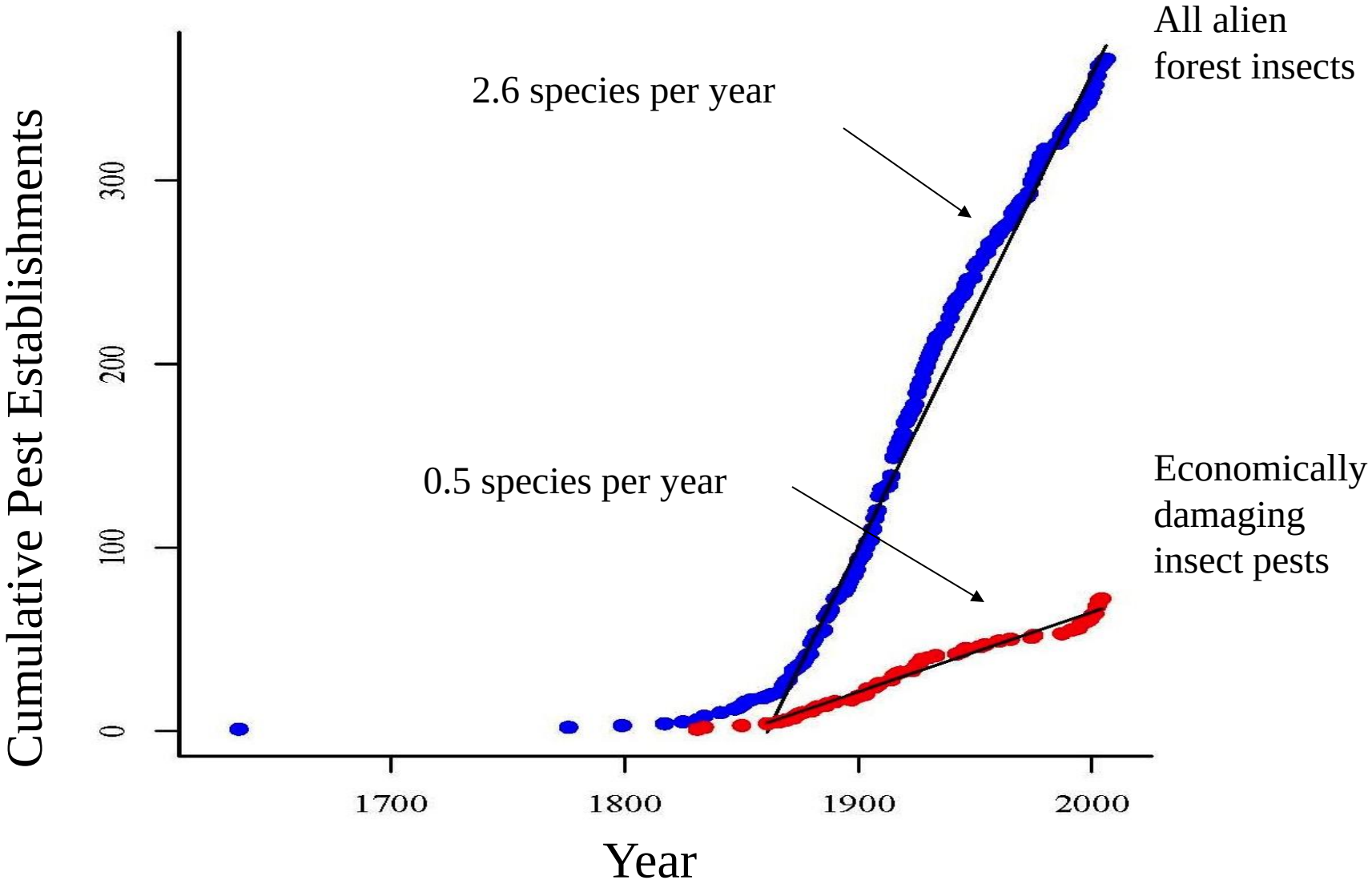
Andrew Liebhold, USDA Forest Service Northern Research Station, Morgantown, WV USA

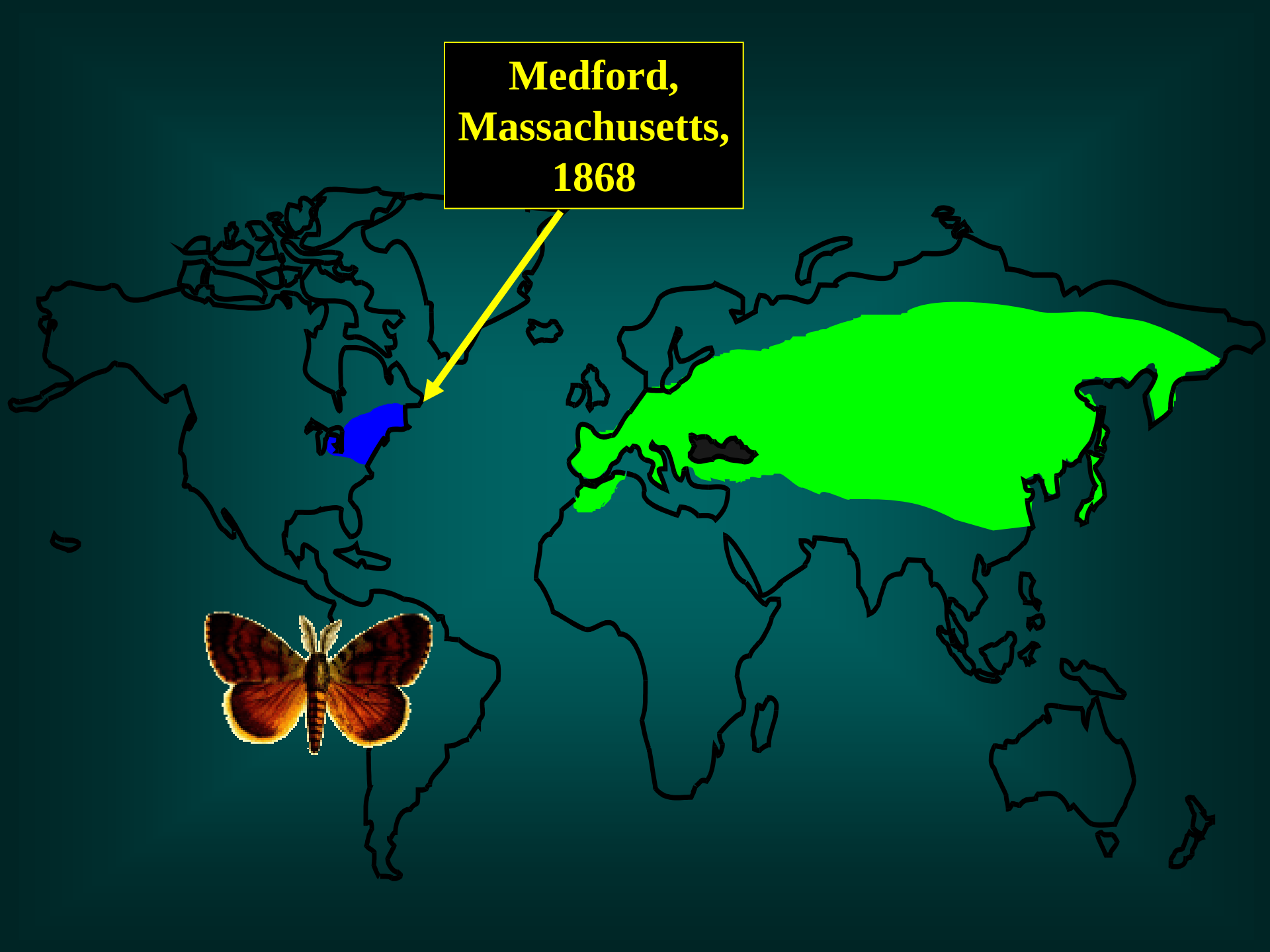
Numbers of Damaging Non-native Forest Insect & Pathogen species



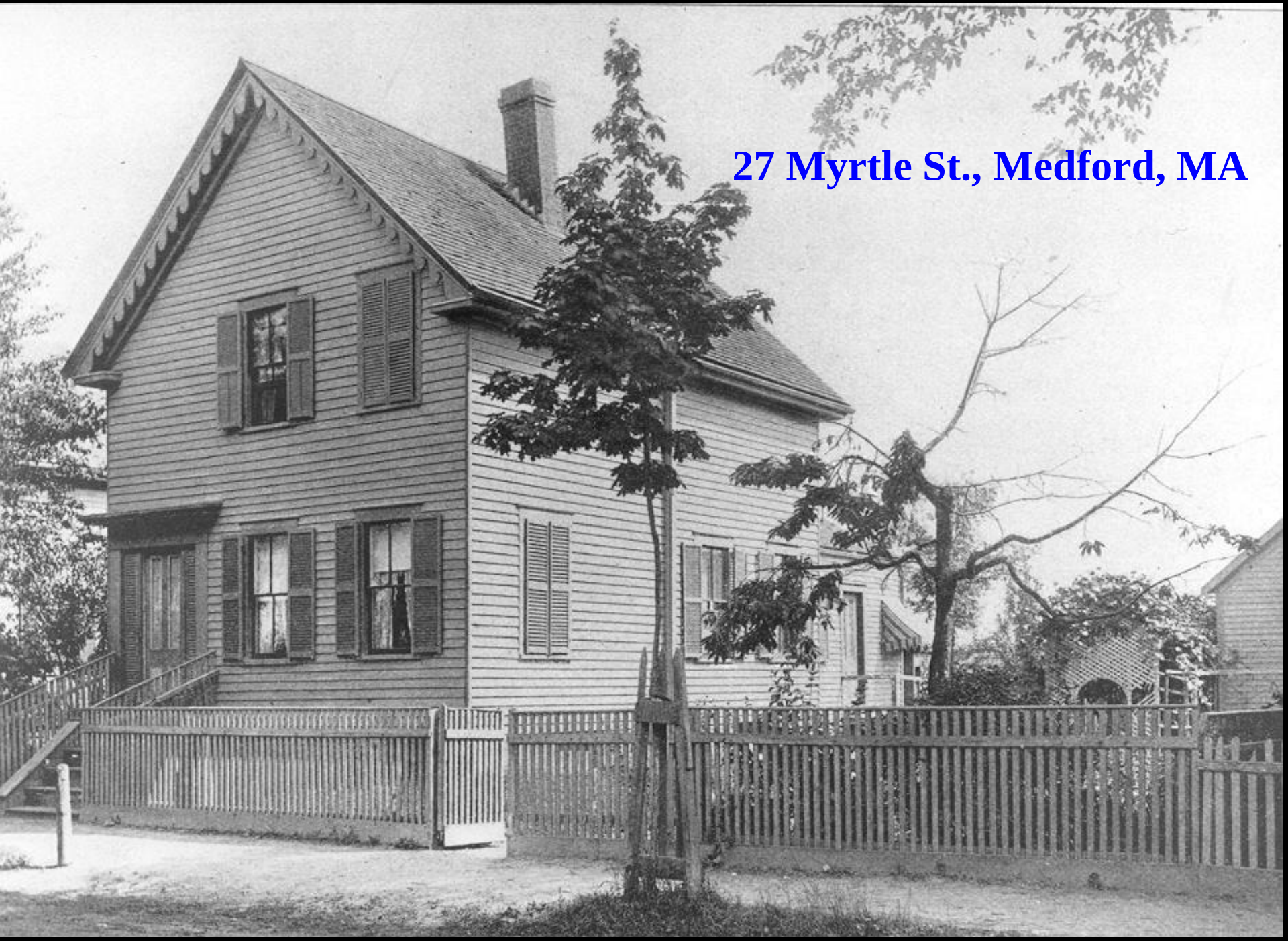
Liebhold, A.M., D.G. McCullough, L.M. Blackburn, S.J. Frankel, B. Von Holle and J.E. Aukema. 2013. A highly aggregated geographical distribution of forest pest invasions in the USA. Diversity and Distributions 19, 1208-1216.

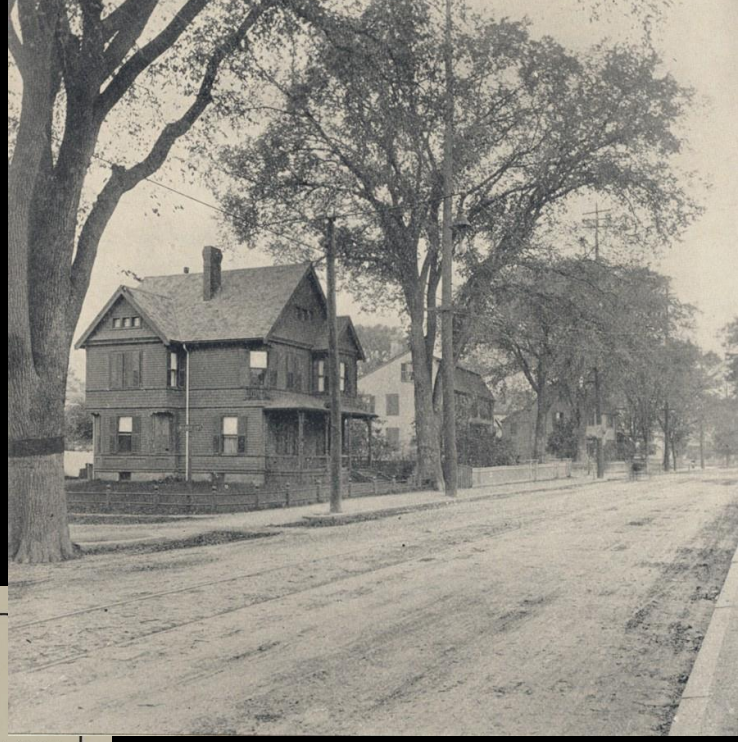
Alien Forest Insect Establishments in US Over Time

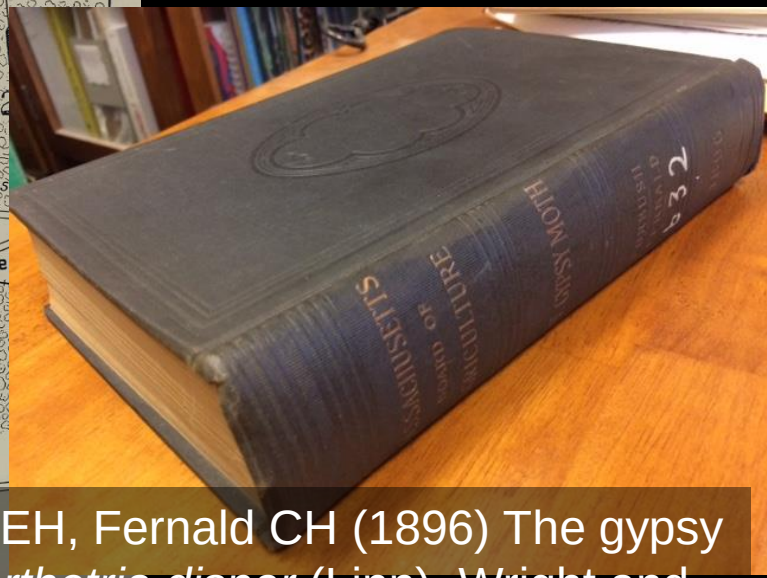



Medford,
Massachusetts,
1868

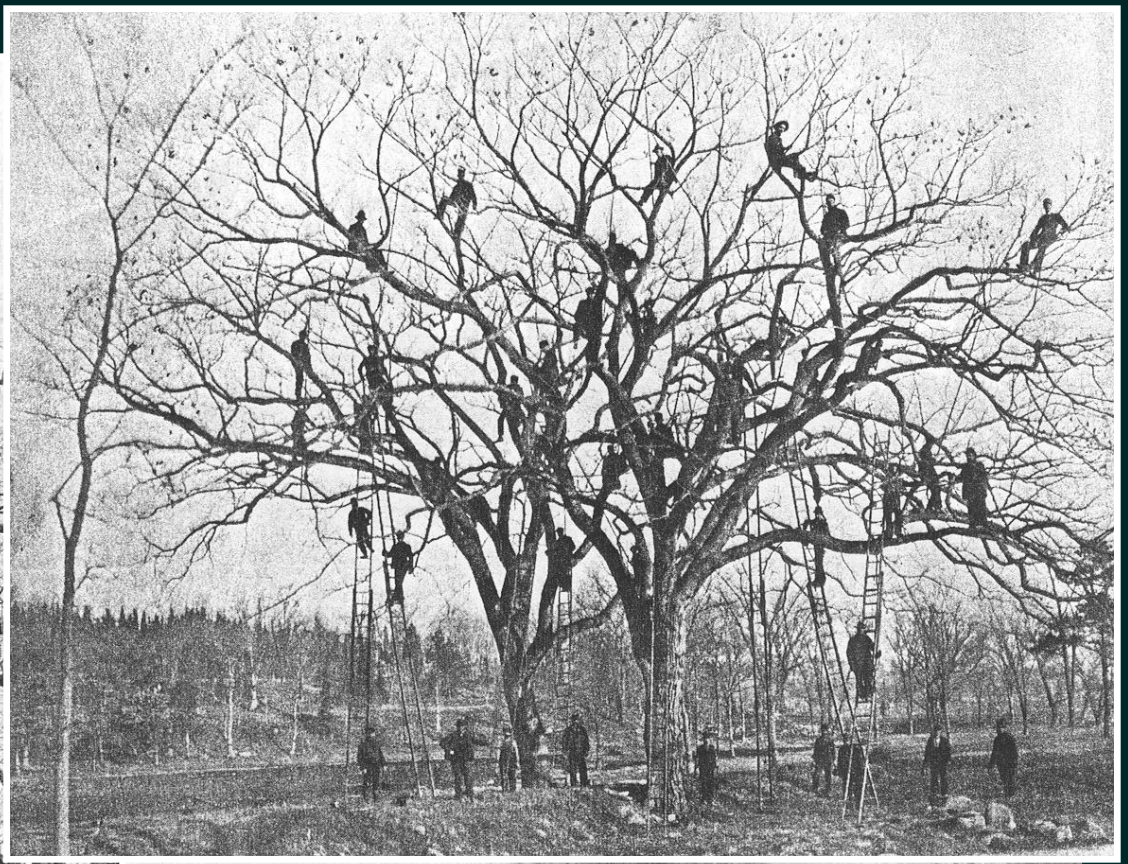
Étienne Léopold Trouvelot, 1827 - 1895


27 Myrtle St., Medford, MA

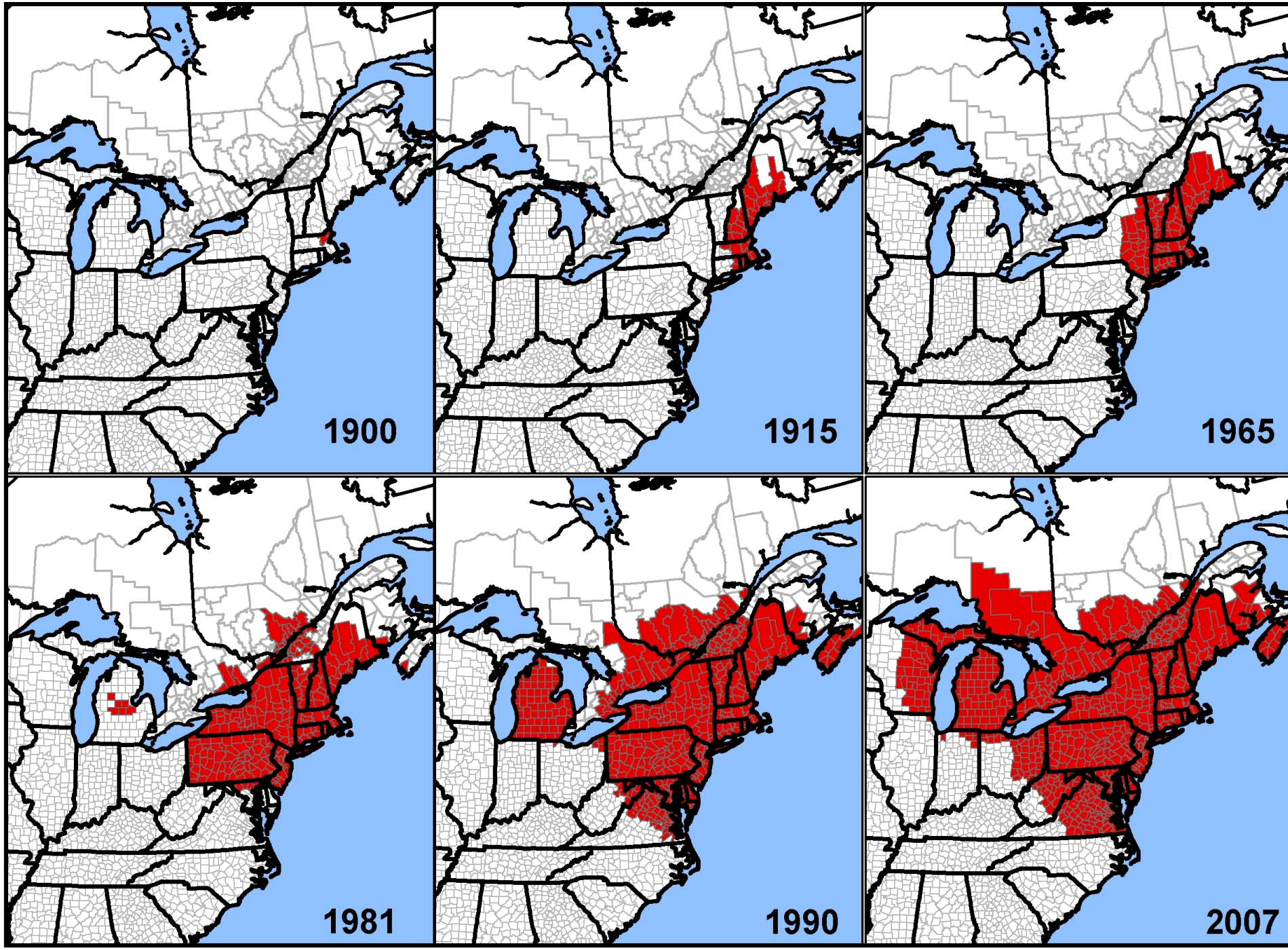


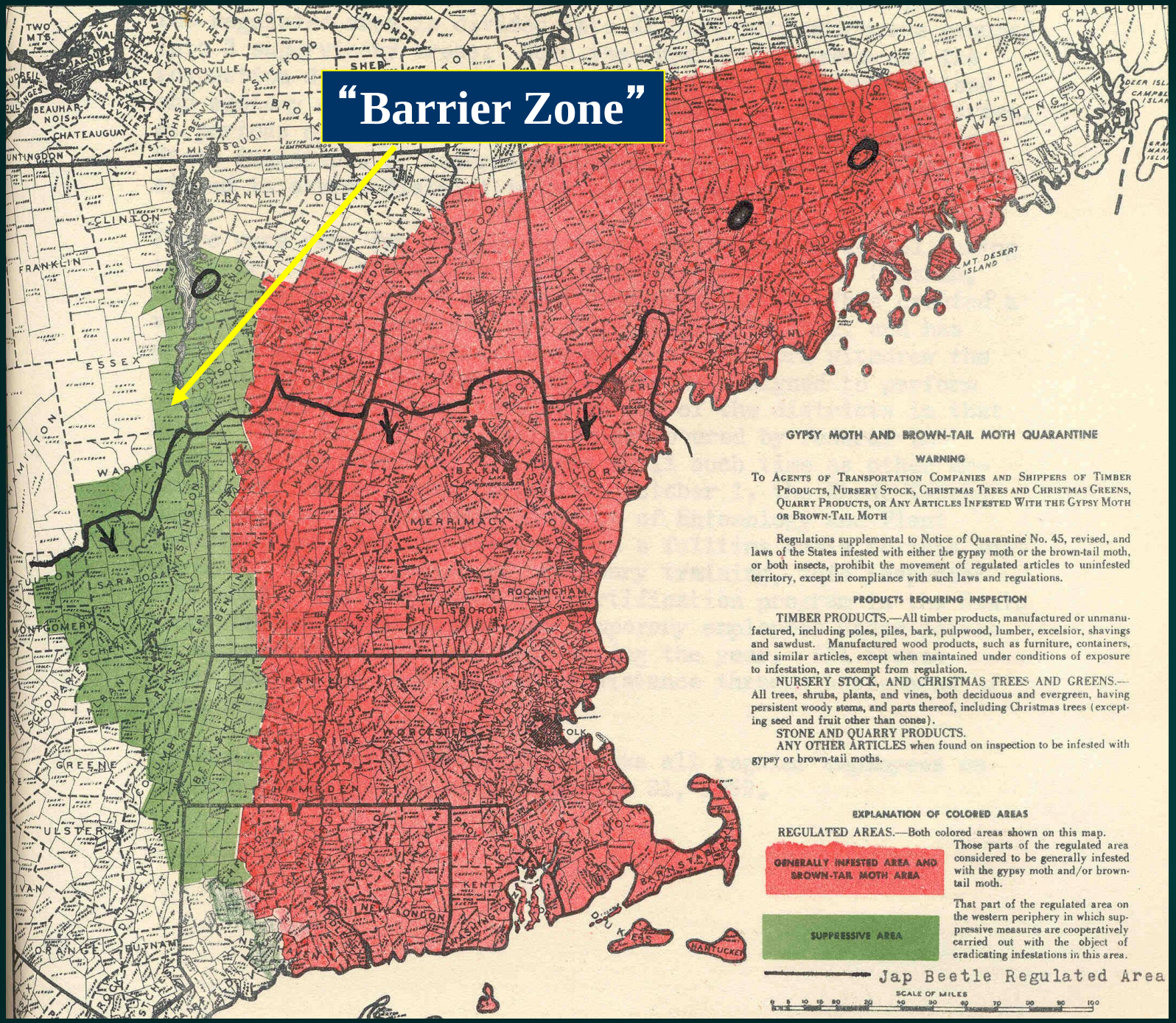


Forbush EH, Fernald CH (1896) The gypsy moth, *Porthetria dispar* (Linn). Wright and Potter, Boston

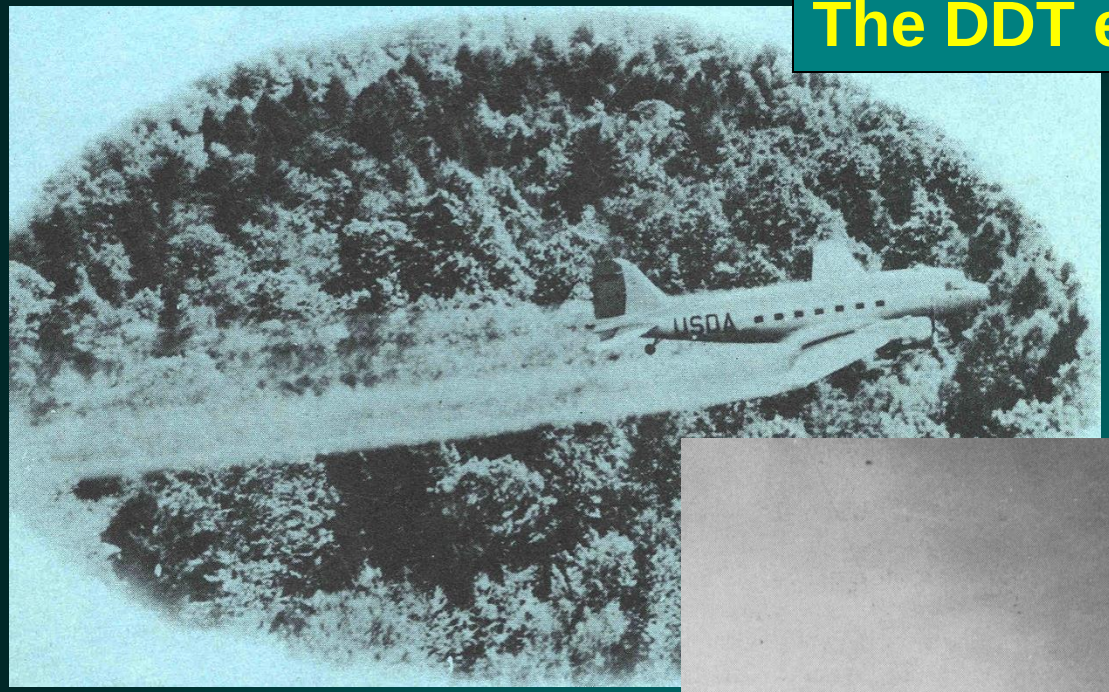


Eradication is attempted, 1880-1900

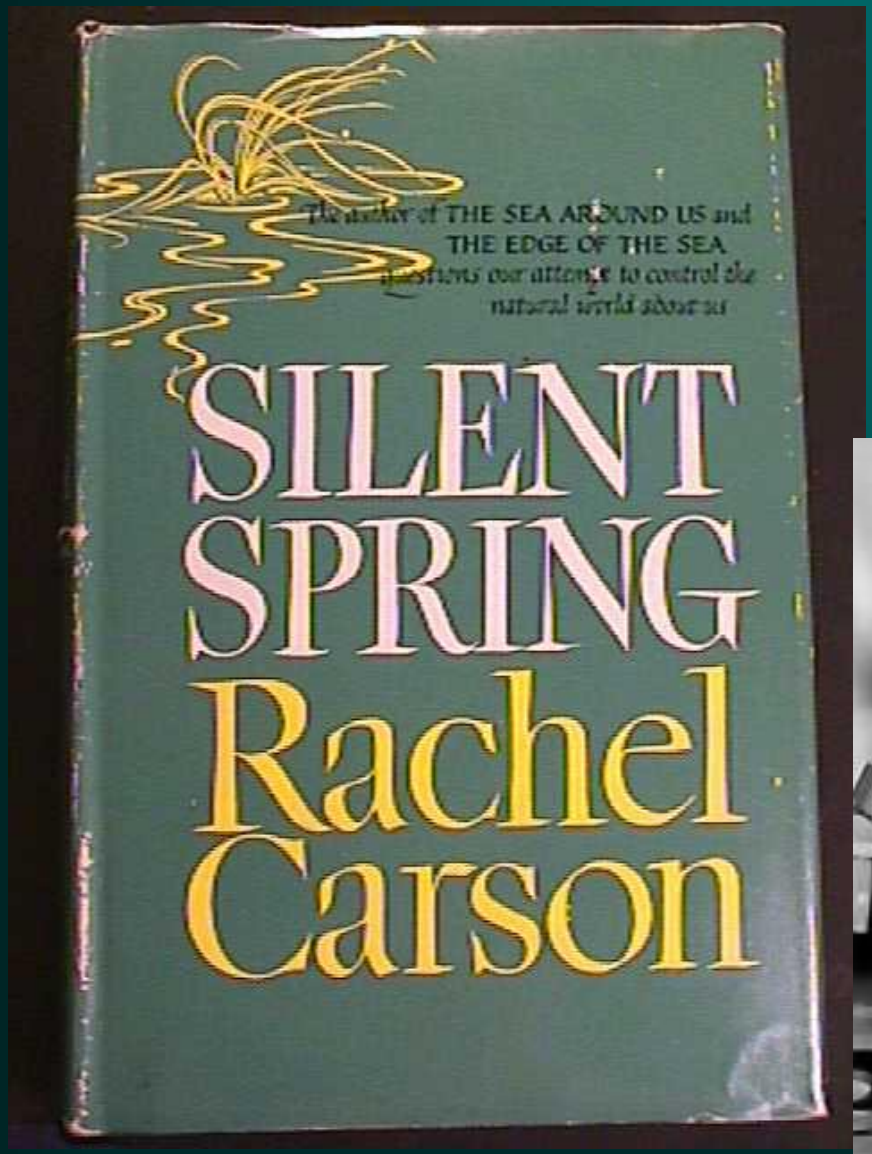

1900
1915
1965
1981
1990
2007

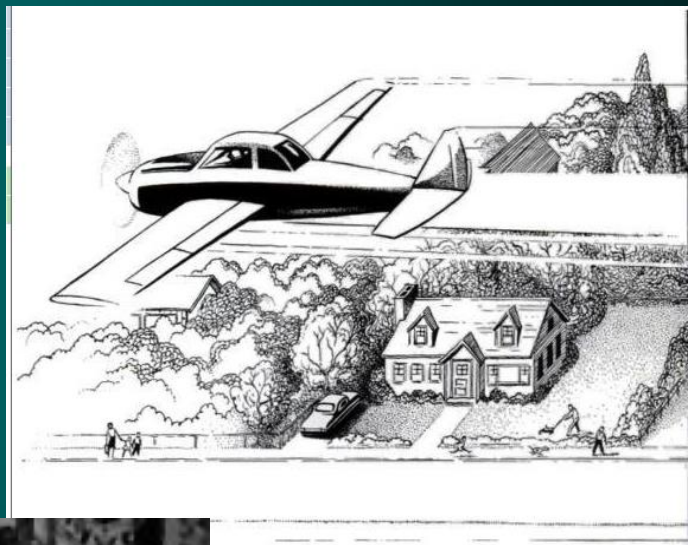

"Barrier Zone"
GYPSY MOTH AND BROWN-TAIL MOTH QUARANTINE
WARNING
To Agents of Transportation Companies and Shippers of Timber Products, Nursery Stock, Christmas Trees and Christmas Greens, Quarry Products, or Any Articles Infested With the Gypsy Moth or Brown-Tail Moth
Regulations supplemental to Notice of Quarantine No. 45, revised, and laws of the States infested with either the gypsy moth or the brown-tail moth, or both insects, prohibit the movement of regulated articles to uninfested territory, except in compliance with such laws and regulations.
PRODUCTS REQUIRING INSPECTION
TIMBER PRODUCTS.—All timber products, manufactured or unmanufactured, including poles, piles, bark, pulpwood, lumber, excelsior, shavings and sawdust. Manufactured wood products, such as furniture, containers, and similar articles, except when maintained under conditions of exposure to infestation, are exempt from regulation.
NURSERY STOCK, AND CHRISTMAS TREES AND GREENS.—All trees, shrubs, plants, and vines, both deciduous and evergreen, having persistent woody stems, and parts thereof, including Christmas trees (excepting seed and fruit other than cones).
STONE AND QUARRY PRODUCTS.
ANY OTHER ARTICLES when found on inspection to be infested with gypsy or brown-tail moths.
EXPLANATION OF COLORED AREAS
REGULATED AREAS.—Both colored areas shown on this map.
GENERALLY INFESTED AREA AND BROWN-TAIL MOTH AREA
Those parts of the regulated area considered to be generally infested with the gypsy moth and/or brown-tail moth.
SUPPRESSIVE AREA
That part of the regulated area on the western periphery in which suppressive measures are cooperatively carried out with the object of eradicating infestations in this area.
Jap Beetle Regulated Area
SCALE OF MILES
0 5 10 15 20 30 40 50 60 70 80 90 100

The DDT era



Application of DDT over Scanton, PA (1948)





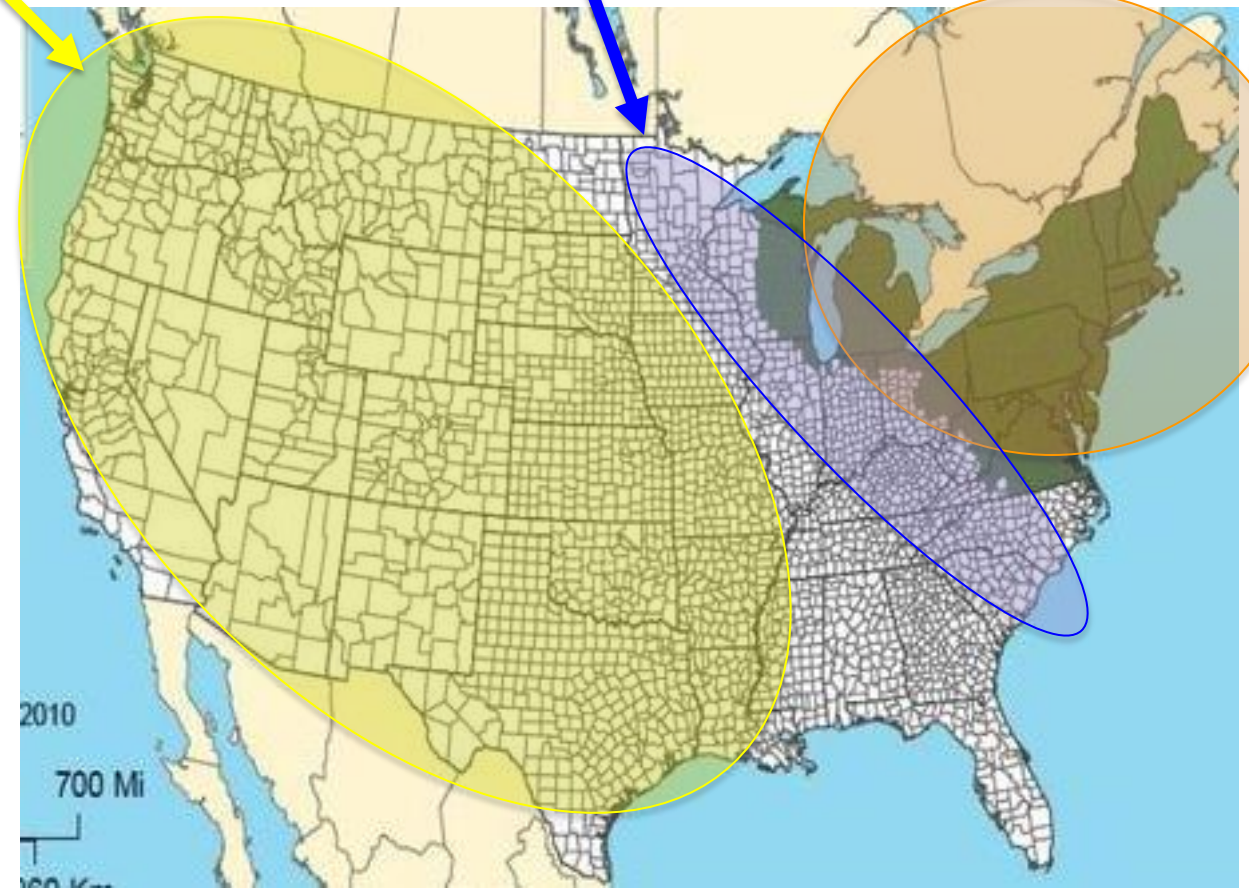
10. Indiscriminately
from the Skies

Gypsy Moth Management

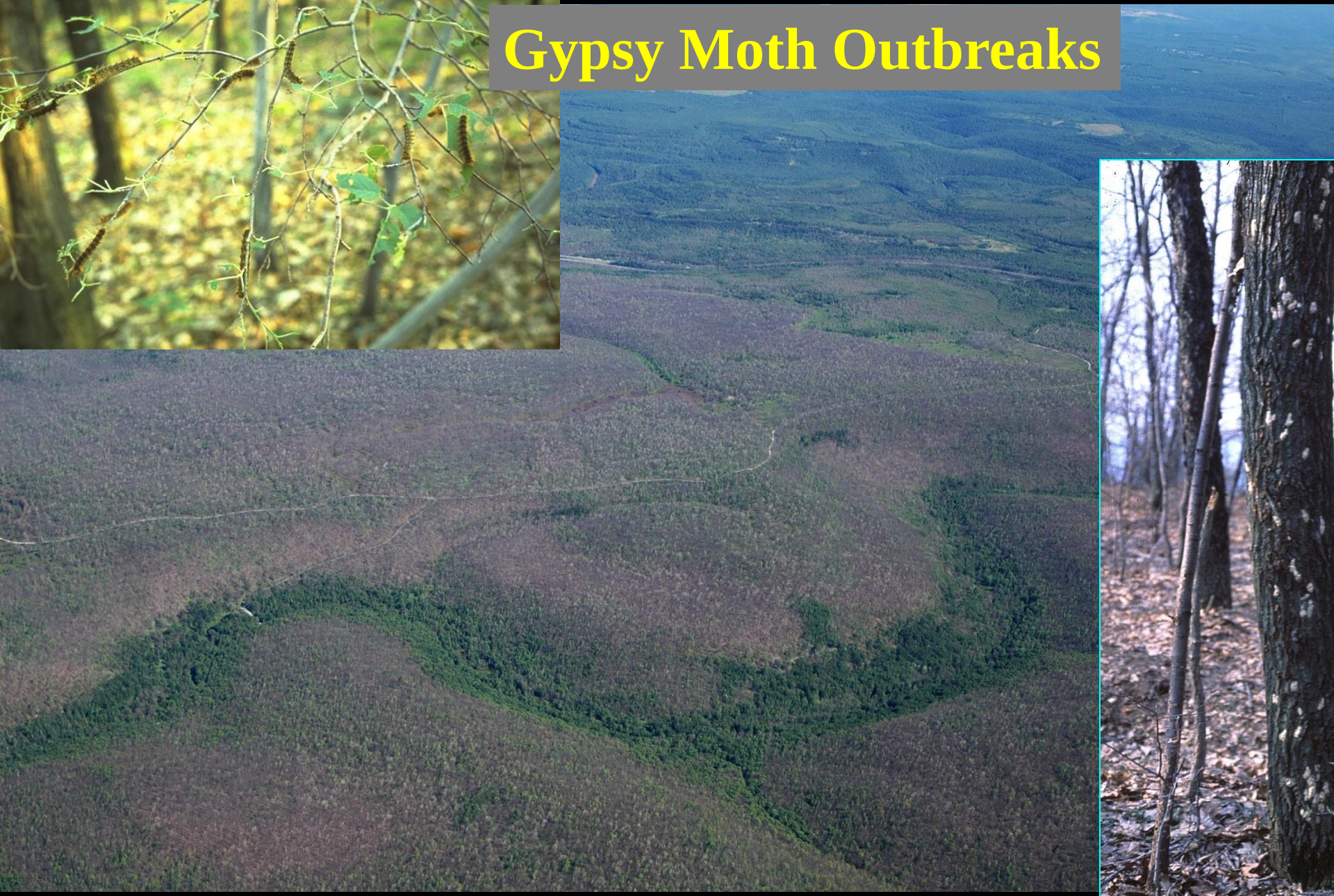
Detection / Eradication

Slow the Spread

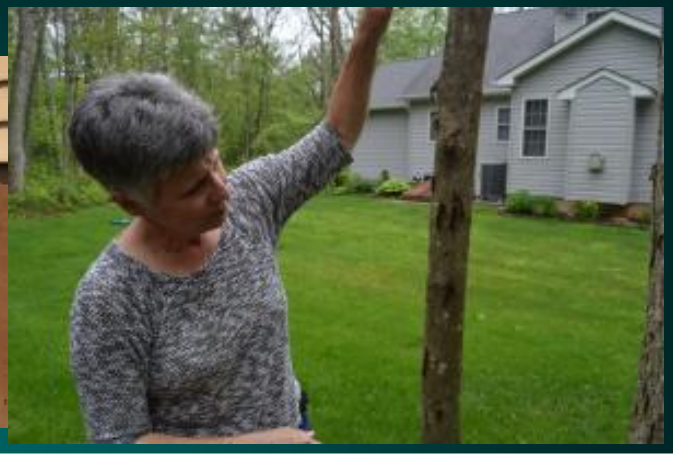
Suppression



Gypsy Moth Outbreaks



Nuisance and aesthetic impacts on homeowners

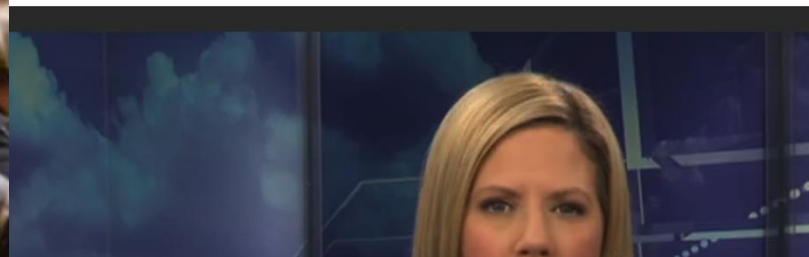


Gypsy Moth Spraying Costs Ange Luzerne County Property Owners

Property owners are being billed for much more land they own

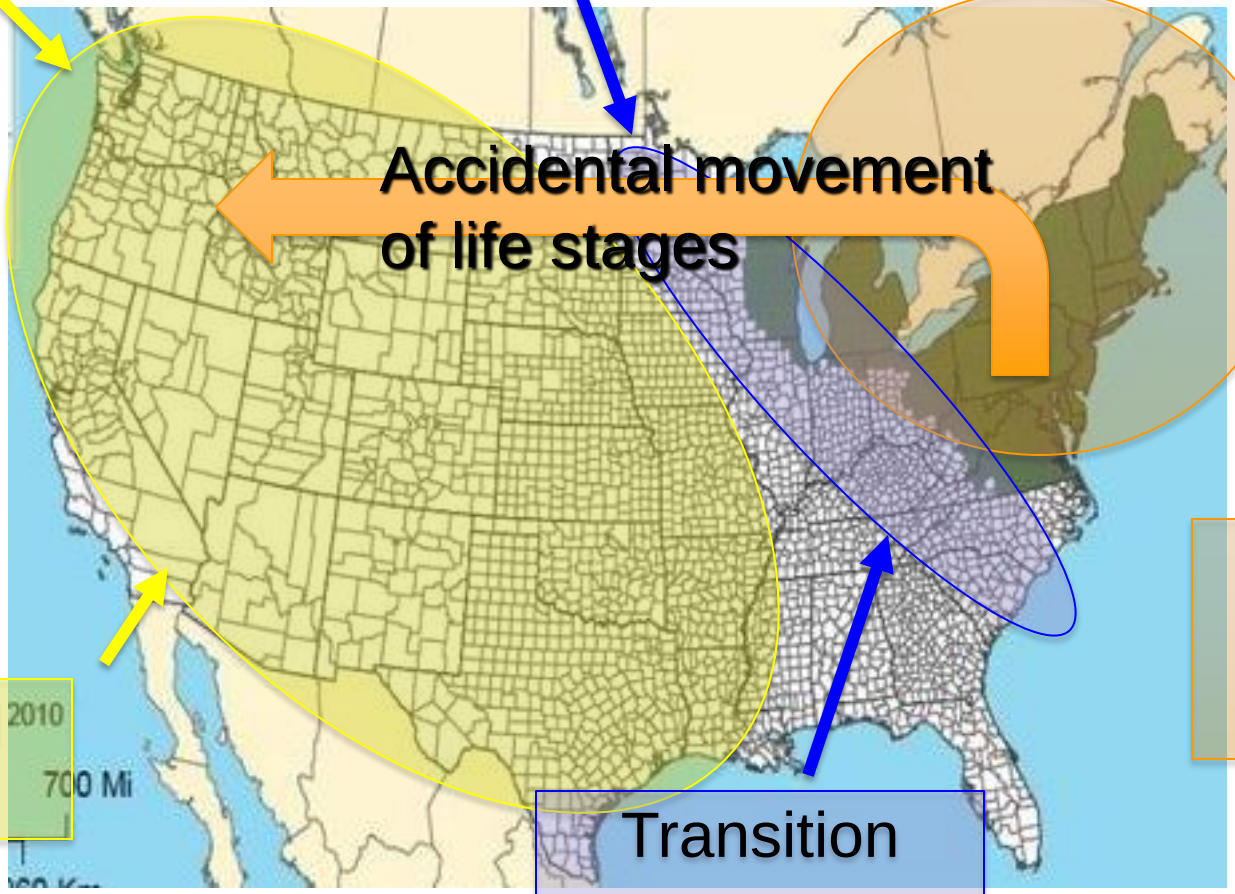
By Mark Hiller | mhiller@pahomepage.com

Published 11/04 2015 05:42PM Updated 11/04 2015 07:57PM



Defoliation Suppression

Gypsy Moth Management



Gypsy Moth Egg Masses Accidentally Transported During Household Moves

delta trap

Use of pheromone traps to locate and delimit isolated colonies

base grid

delimitation grid

treatment

Year 1

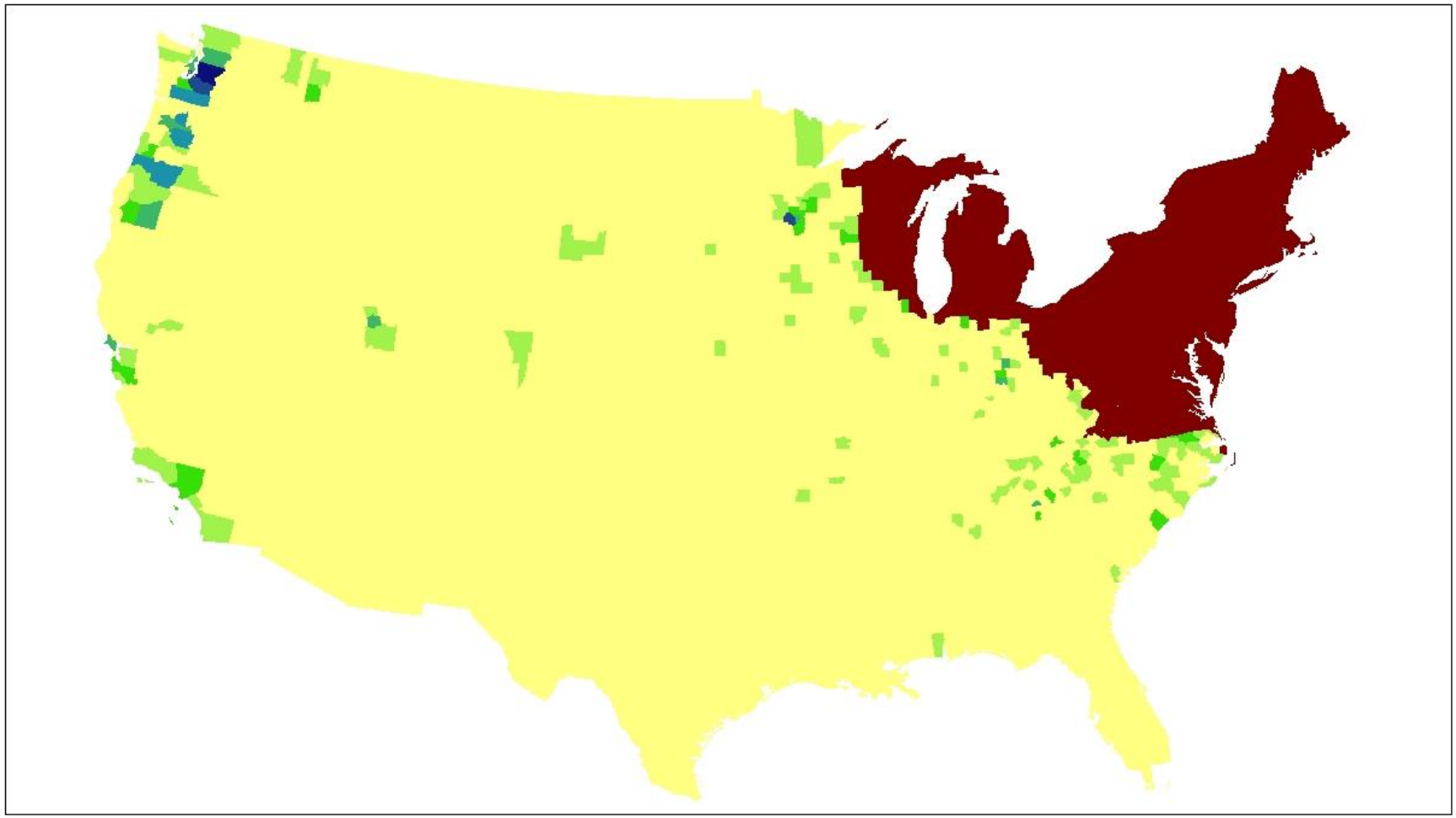
Year 2

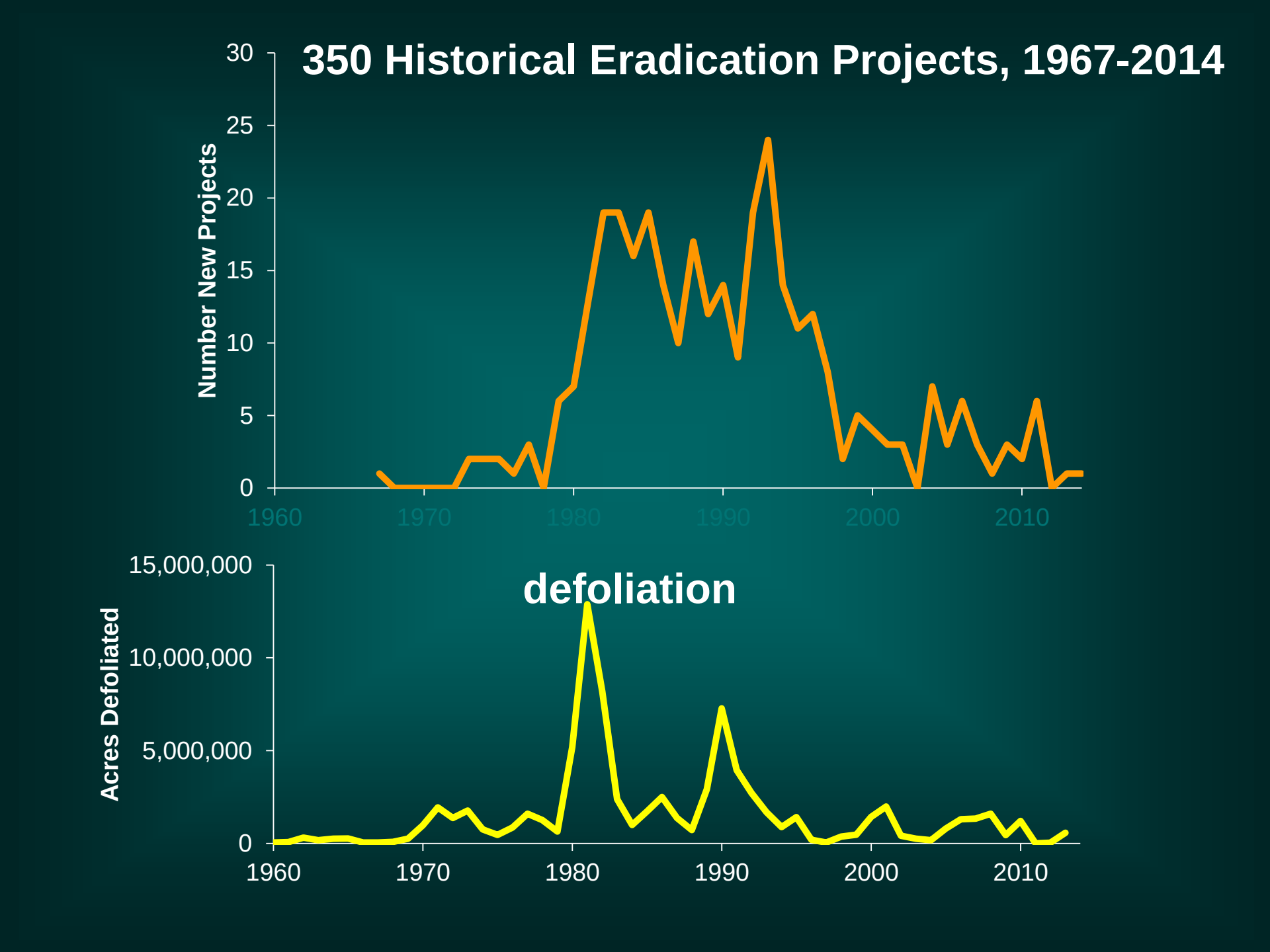
Year 3

- 0 moths/trap
- >0 moths/trap

treatment

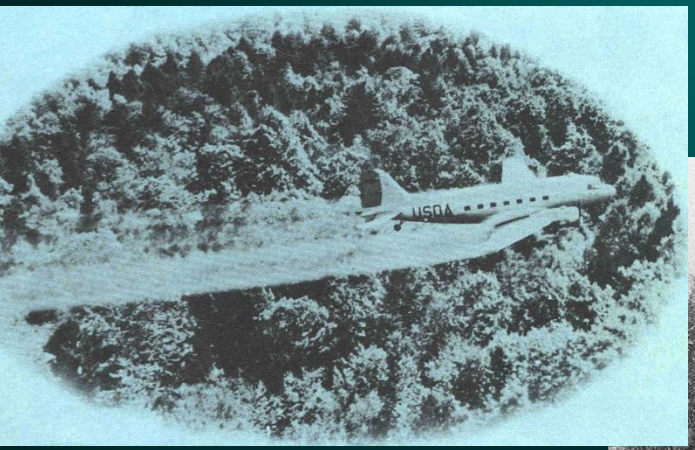
350 European Gypsy Moth Eradication Projects, 1967-2014

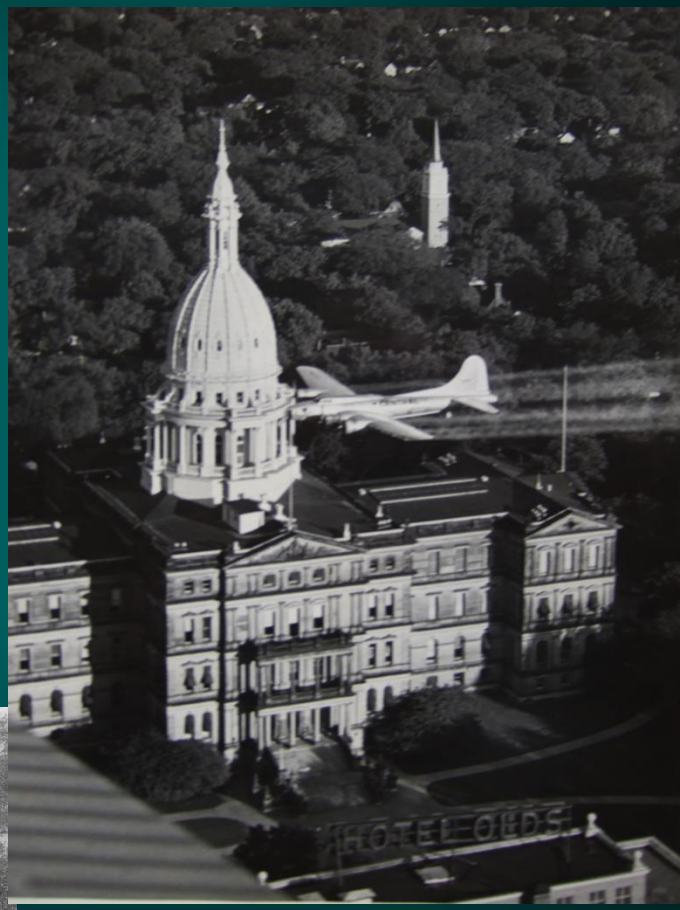



350 Historical Eradication Projects, 1967-2014
Number New Projects
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
2010
defoliation
Acres Defoliated
15,000,000
10,000,000
5,000,000
0
1960
1970
1980
1990
2000
2010

Gypsy Moth Eradication Failures

- Medford, MA 1889-1900
- Luzerne Co., PA 1932-1943
- Midland, MI 1954-1976

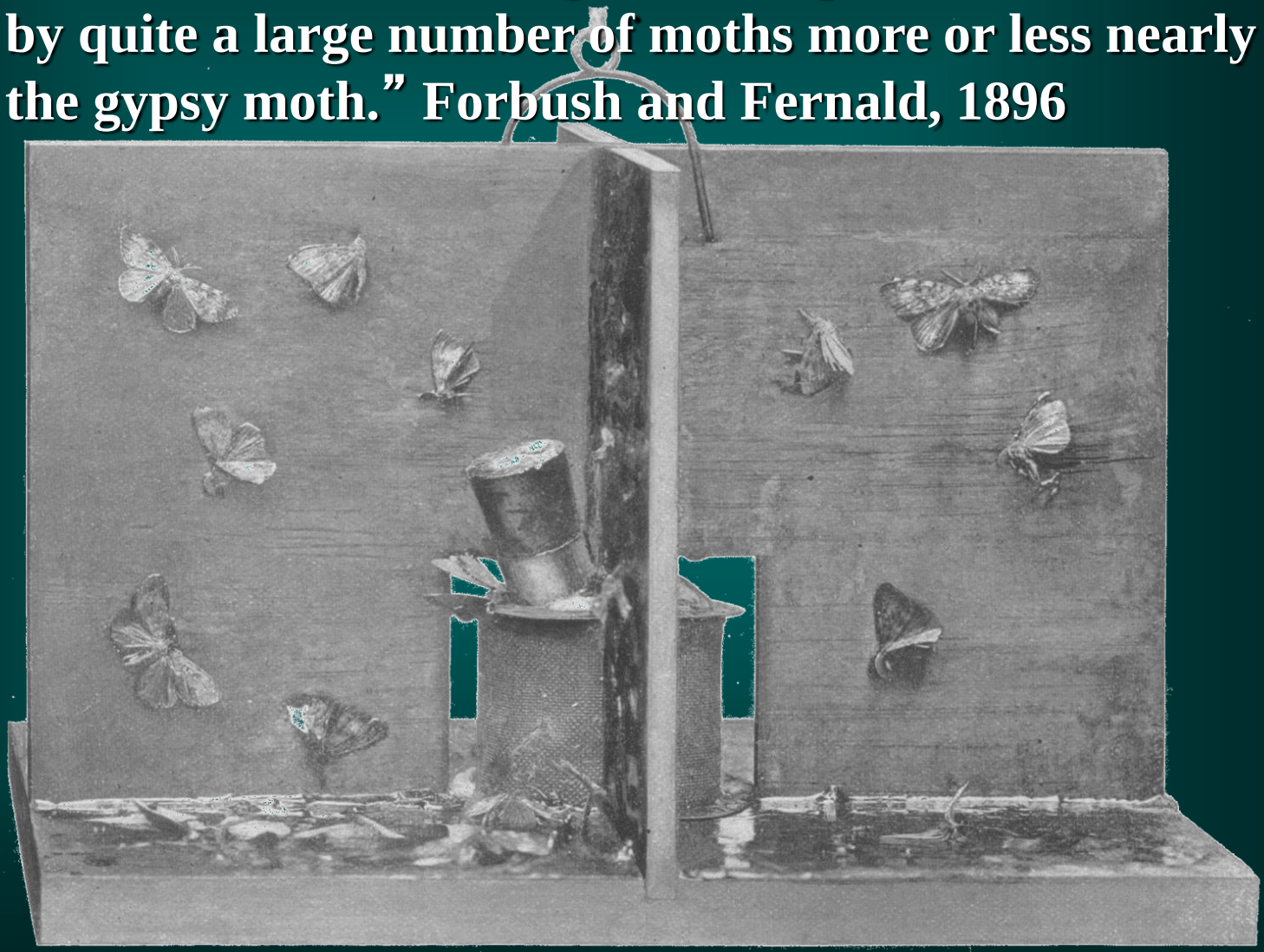




104,000 acres sprayed with DDT 1954, Ingham Co., MI, Photo: Ron Priest

Gypsy Moth Traps are Very Sensitive

“It is a well-known fact that unfertilized females of the gypsy moth are able to attract the males to them from a greater or less distance. This is called assembling, and this power to assemble is possessed by quite a large number of moths more or less nearly related to the gypsy moth.” Forbush and Fernald, 1896

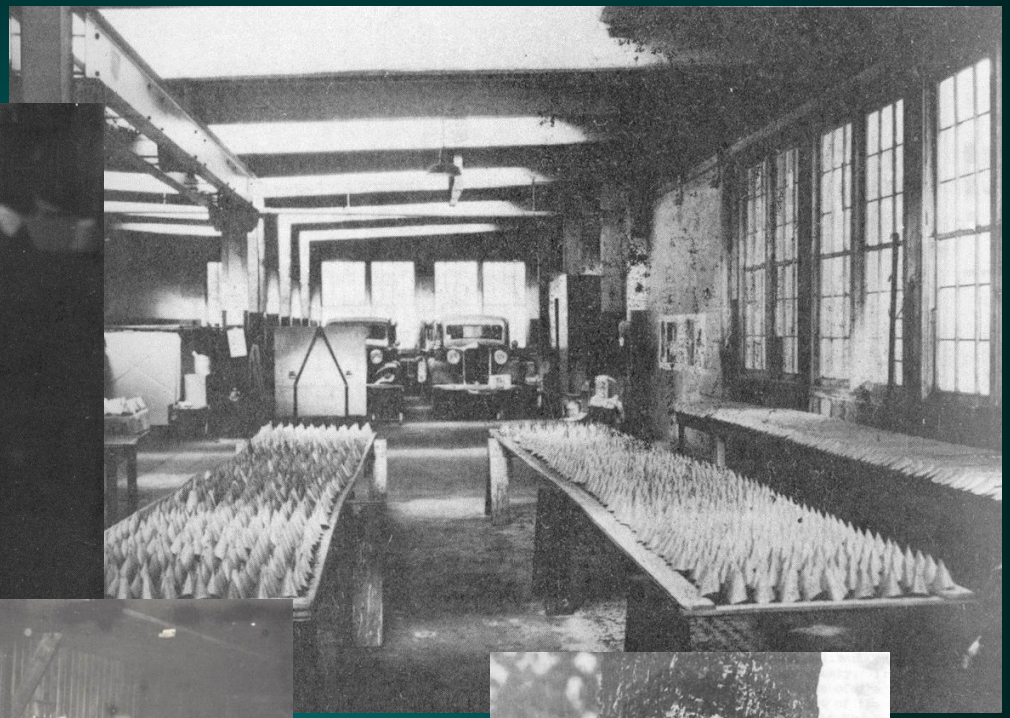


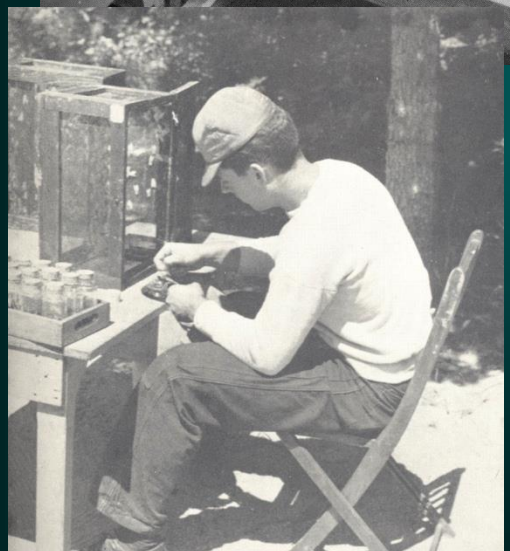
Extraction of female abdominal tip extracts for use in pheromone trap surveys

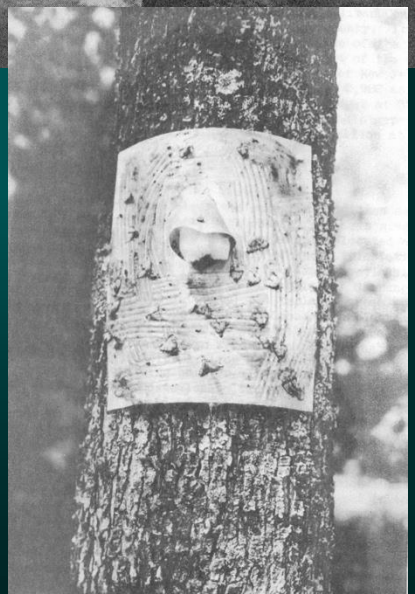
Collection of pupae in Portugal

Collection of pupae in Massachusetts

Extraction of female abdominal tip extracts for use in pheromone trap surveys







Potent Sex Attractant of the Gypsy Moth:
Its Isolation, Identification, and Synthesis

with an untreated sample indicated that the active component was not an aldehyde or ketone. Similar spotting of the sample with phosphoric acid,

1972

Gypsy Moth Control with the Sex Attractant Pheromone

Mass trapping or permeation of the air with pheromone can prevent male gypsy moths from finding mates.

Morton Beroza and E. F. Knipling

The gypsy moth [*Porthetria dispar* (L.)], a serious defoliator of forest, shade, and orchard trees in northeastern United States, is spreading rapidly to the South and gradually to the West and threatens to become a national problem.

There is deep division among scientists, administrators, environmentalists, and public officials about whether its spread can be stopped or should be stopped. On some occasions we read of citizens and township officials begging for relief from the moth's depredations;

expansion of th
The way in whic
lem has been ha
cized (*1*), but th
up with practica
ceptable solution
In this article
lem and discus
using the recentl
mone of the gyp
bat this insect.

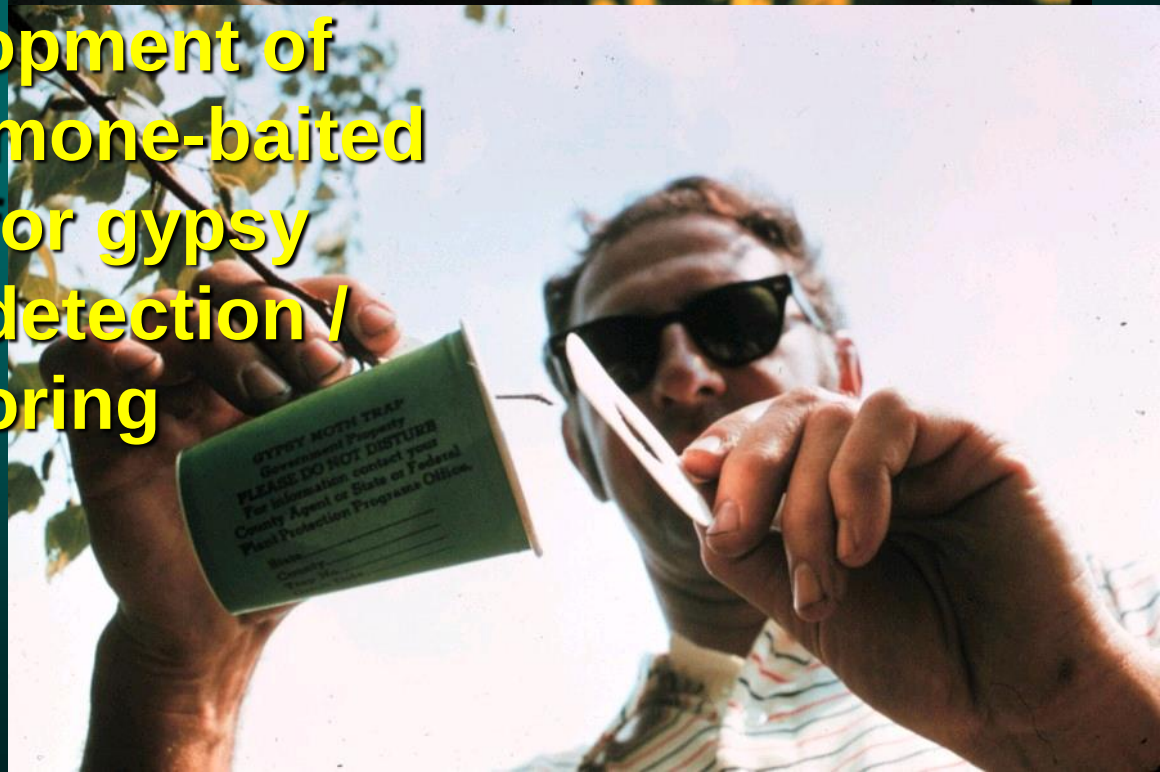
History

The gypsy mo
Asia, and North
to Medford, Mas
the purpose of p
industry; unfort
accidentally esca
established, but
until 20 years la
devastating popu
following comm
is typical (*3*).

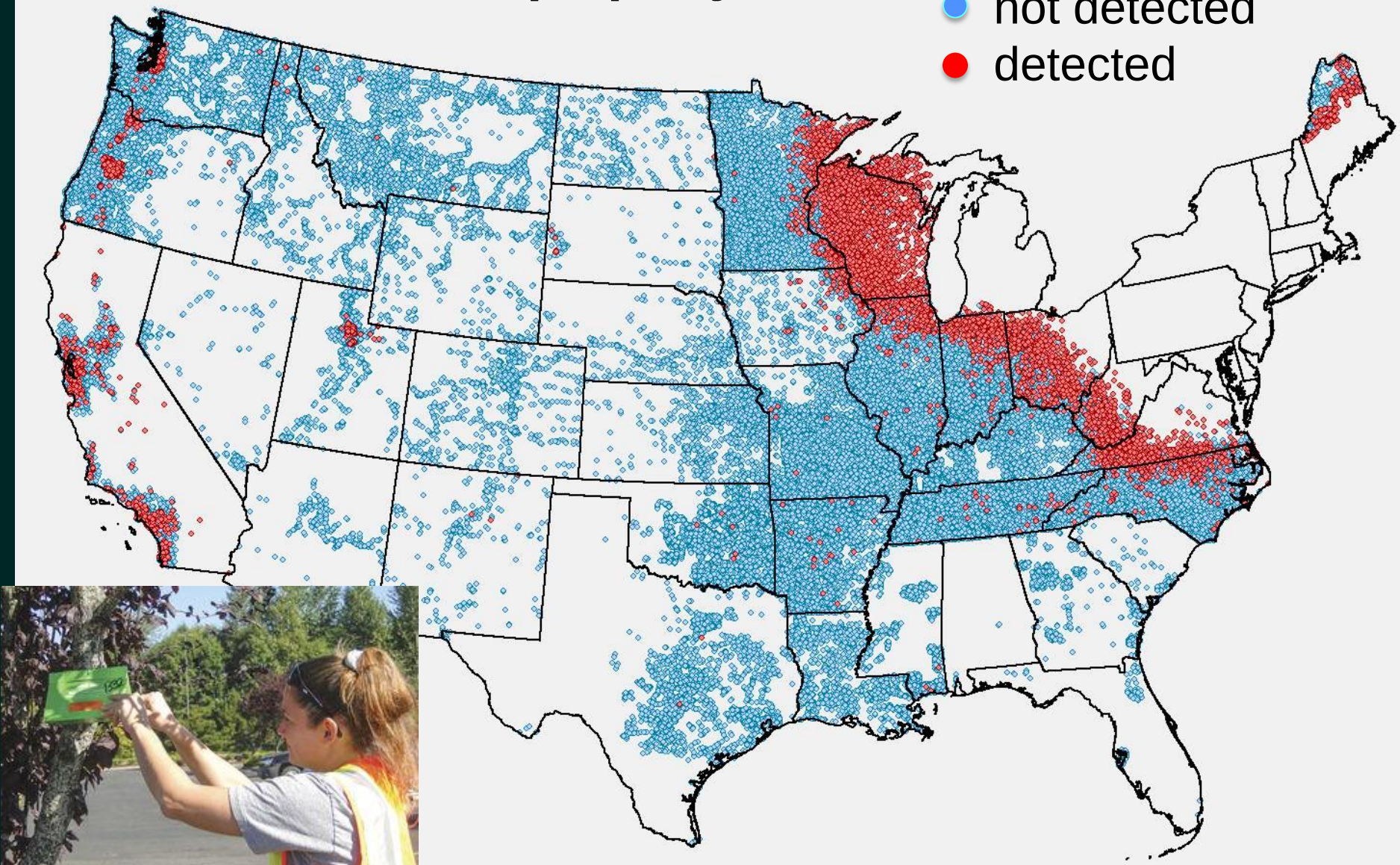
V.
ant
ence,

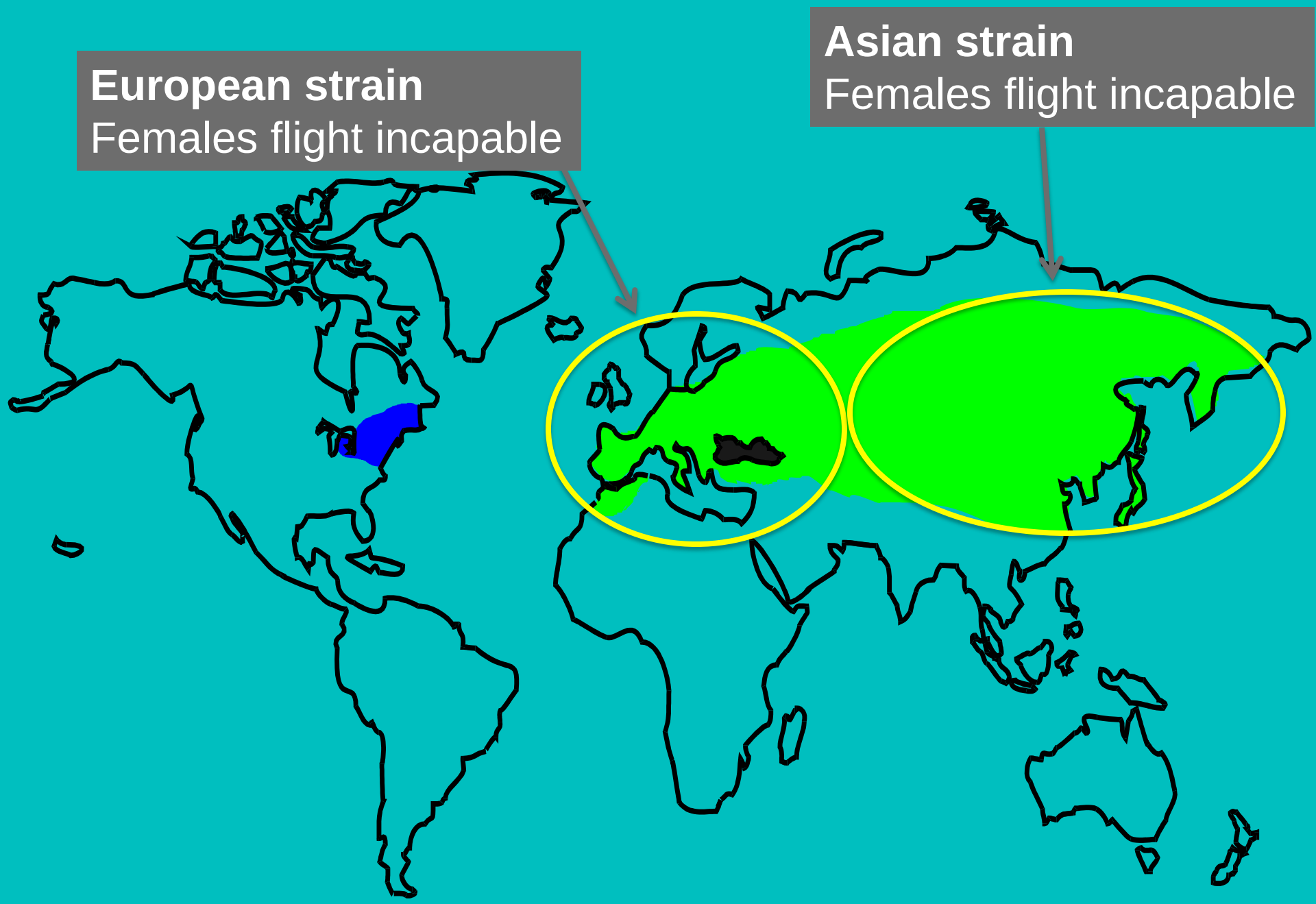
Iwaki, S., S. Marumo, T. Saito, M. Yamada, and K. Katagiri. 1974. Synthesis and activity of optically active disparlure. J. Am. Chem. Ssoc. 96: 7842-7844.

Development of Pheromone-baited traps for gypsy moth detection / monitoring



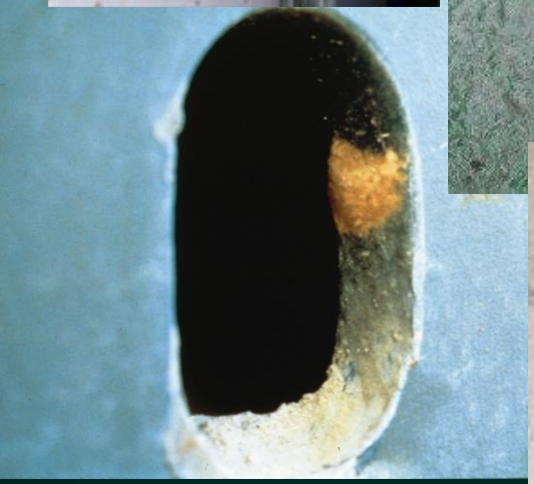
Gypsy Moth Trapping Locations, 1974-2014
~100,000 traps per year




European strain
Females flight incapable
Asian strain
Females flight incapable

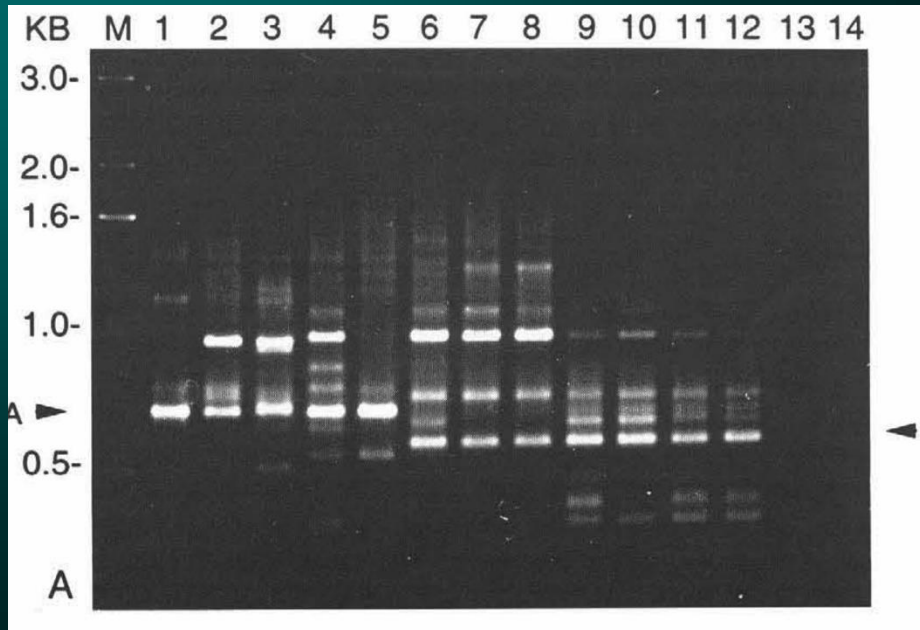
Asian gypsy moth egg masses contaminate maritime cargo

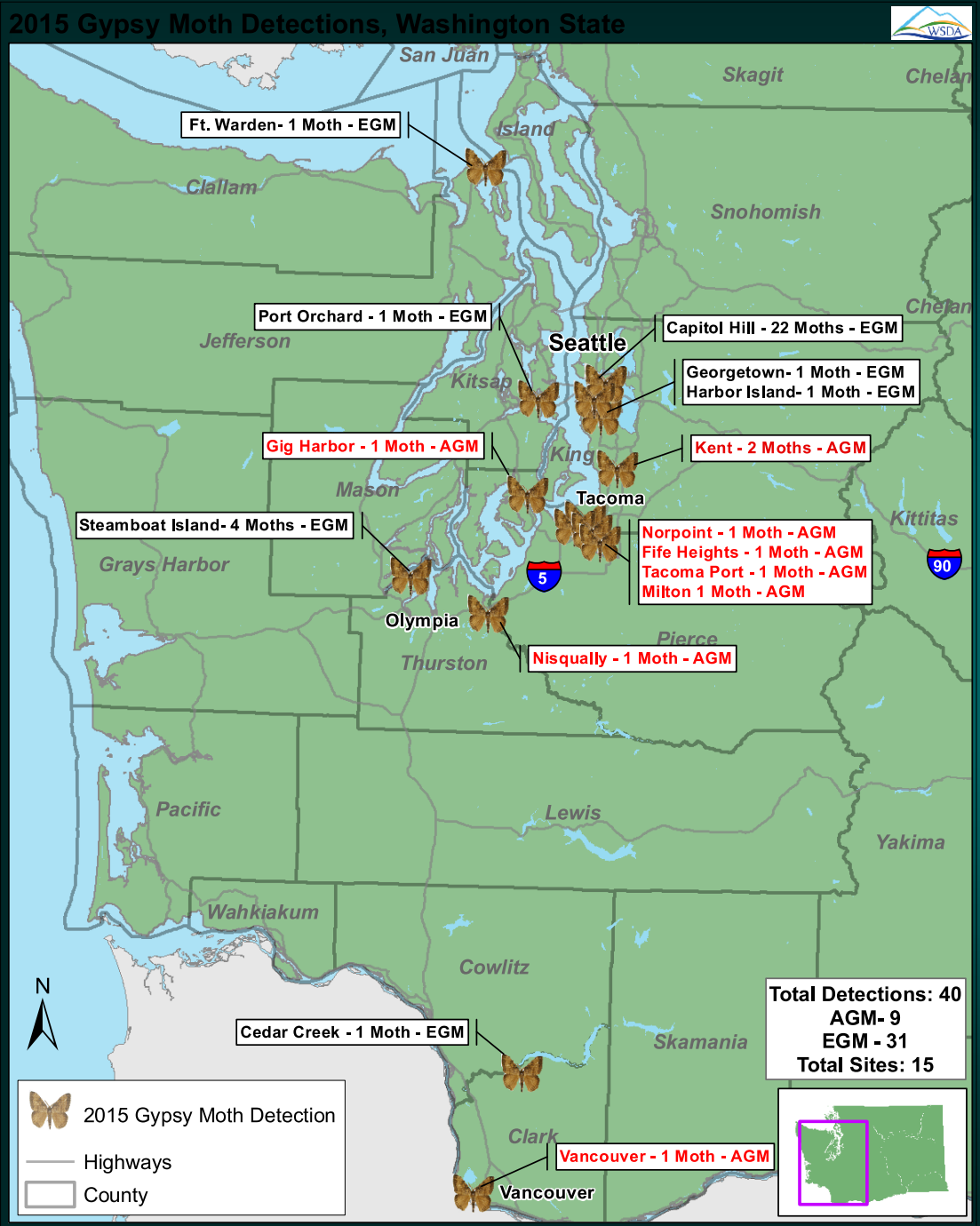
- Ship superstructures
- Containers
- Automobiles
- Bulk steel



DNA analysis of each trapped male performed at USDA APHIS CPHST laboratory.

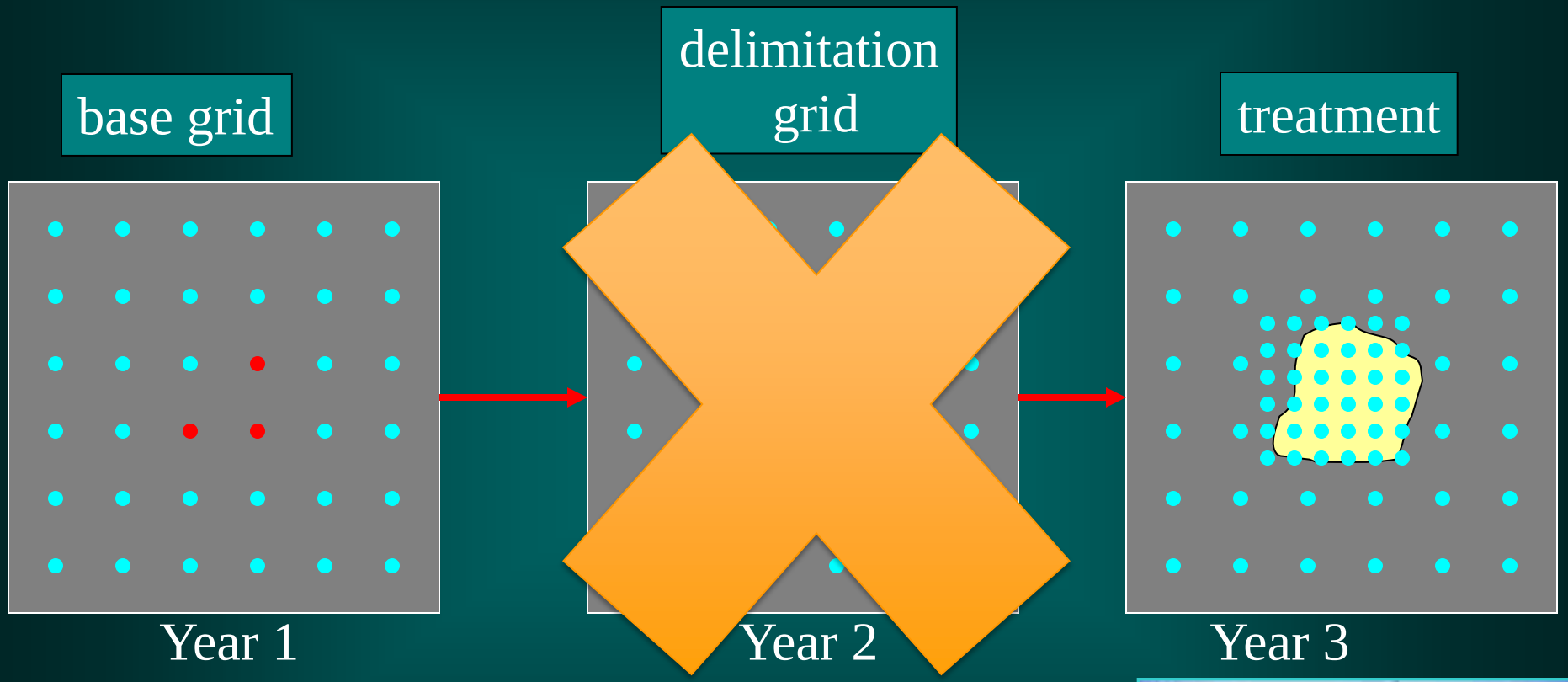
DNA extraction is followed by a PCR with the nuclear FS1 marker (specific to gypsy moth) and a second mitochondrial PCR/dual restriction enzyme digestion.





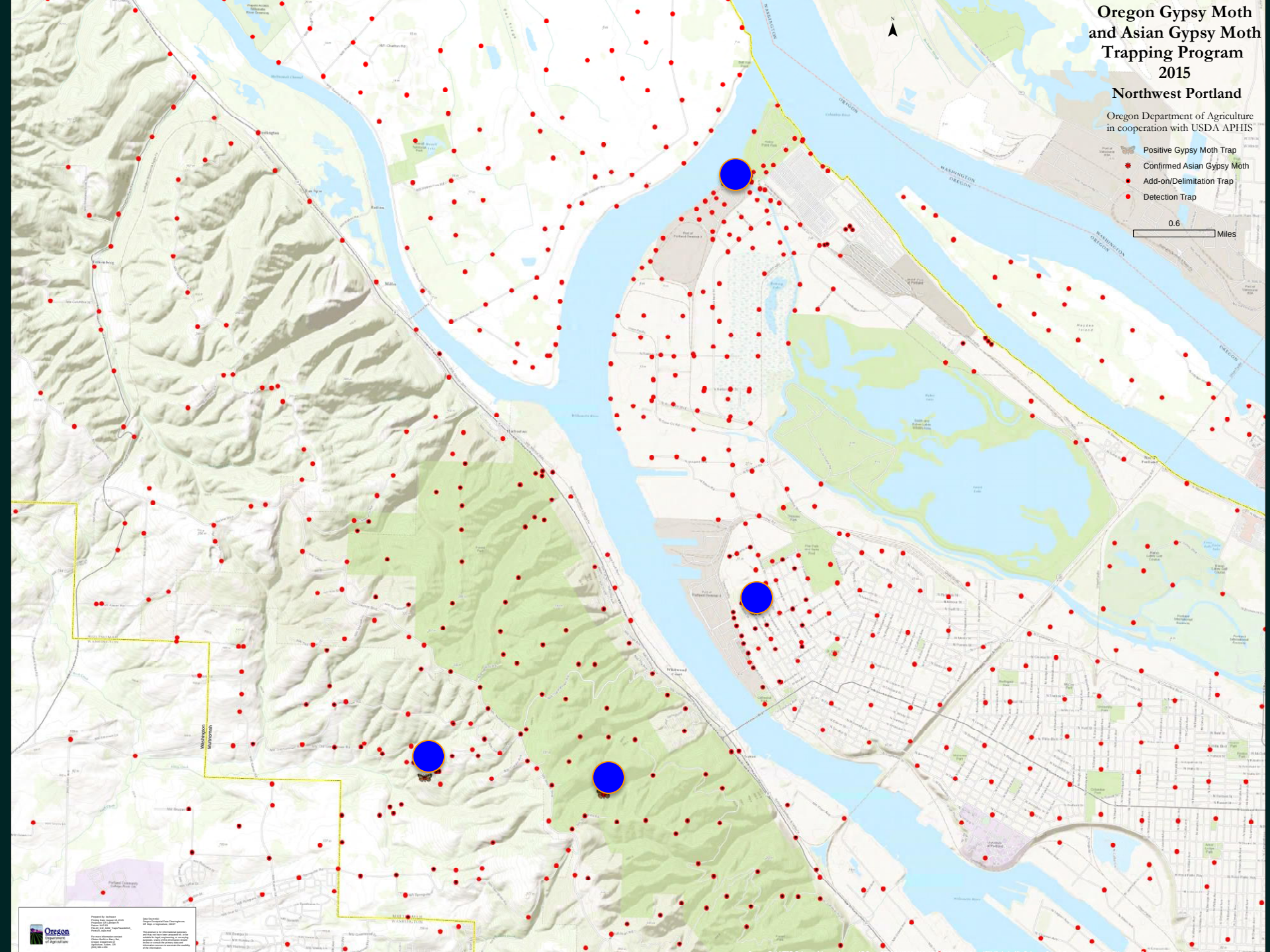
2015 Gypsy Moth Detections, Washington state

Use of pheromone traps to locate and delimit isolated colonies of Asian gypsy moth



- 0 moths/trap
- >0 moths/trap

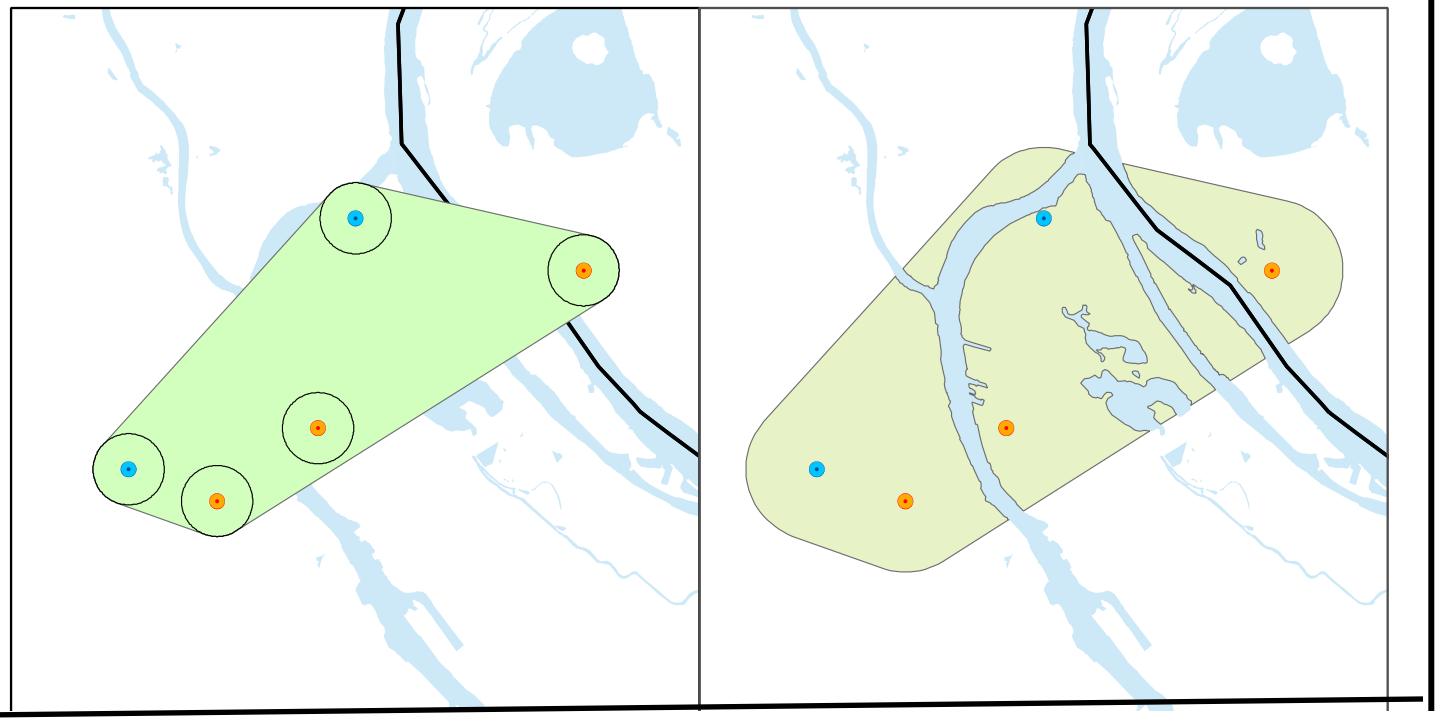
treatment


Oregon Gypsy Moth and Asian Gypsy Moth Trapping Program
2015
Northwest Portland
Oregon Department of Agriculture
in cooperation with USDA APHIS
Positive Gypsy Moth Trap
Confirmed Asian Gypsy Moth
Add-on/Delimitation Trap
Detection Trap
0.6
Miles
N
Washington
Multnomah

USDA
United States
Department of Agriculture

Gypsy Moth Technical Working Group
Portland \ Vancouver: 0.5 buffer on EGM \ AGM

APHIS
Animal and Plant
Health Inspection Service



Aerial application of
Bacillus thuringiensis

Public Outreach

FOX 12 OREGON

Advertisement

WEATHER VIDE

Oregon Dept. of Ag
@ORagriculture
Follow

#ORgypsymoth treatment begins this weekend in N. Portland. Map & more info available @ tinyurl.com/gs9s48x

7:09 PM - 13 Apr 2016

3 2

REPAIR
State Tax Credits Ending in 2017

spraying set to begin over Portland

M EDT
PM EDT
ECT

TV) - Helicopters will spray insecticide over
s to keep gypsy moths out of the Rose City.

The Oregon Department of Agriculture's Asian gypsy moth eradication project is set to begin early Saturday morning.

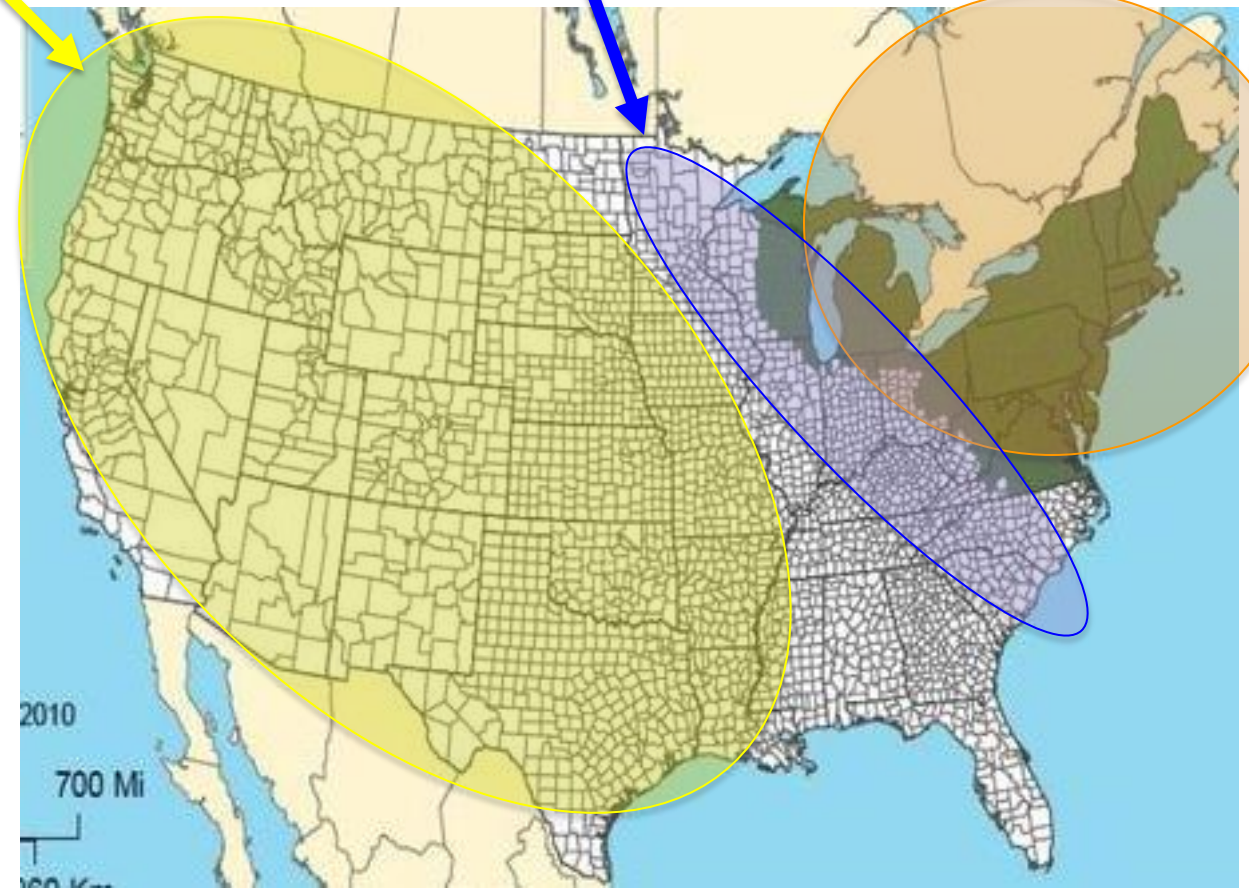
Bacillus thuringiensis var. kurstaki, or Btk,
curring bacterium that has been used in other

Gypsy Moth Management

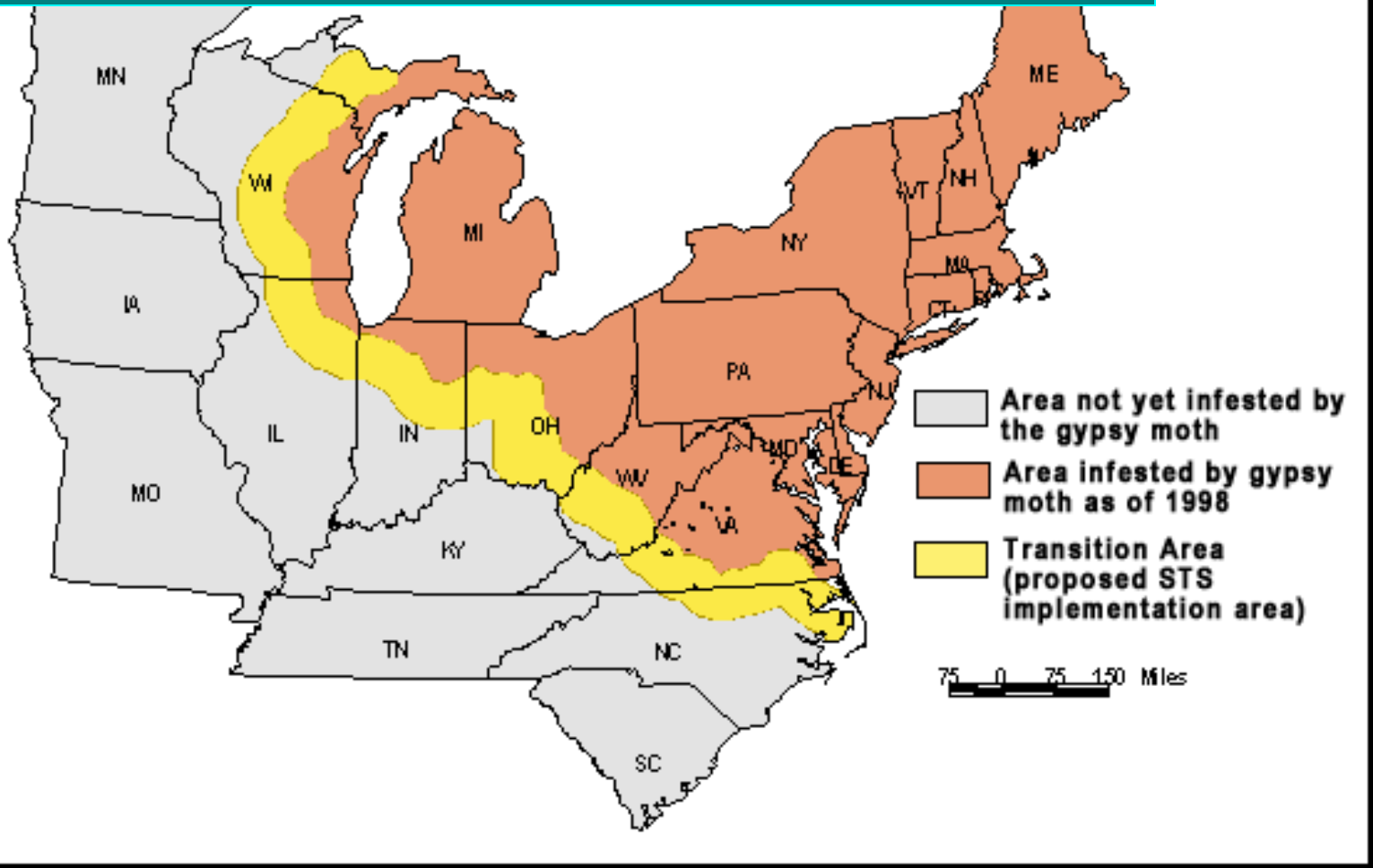
Detection / Eradication

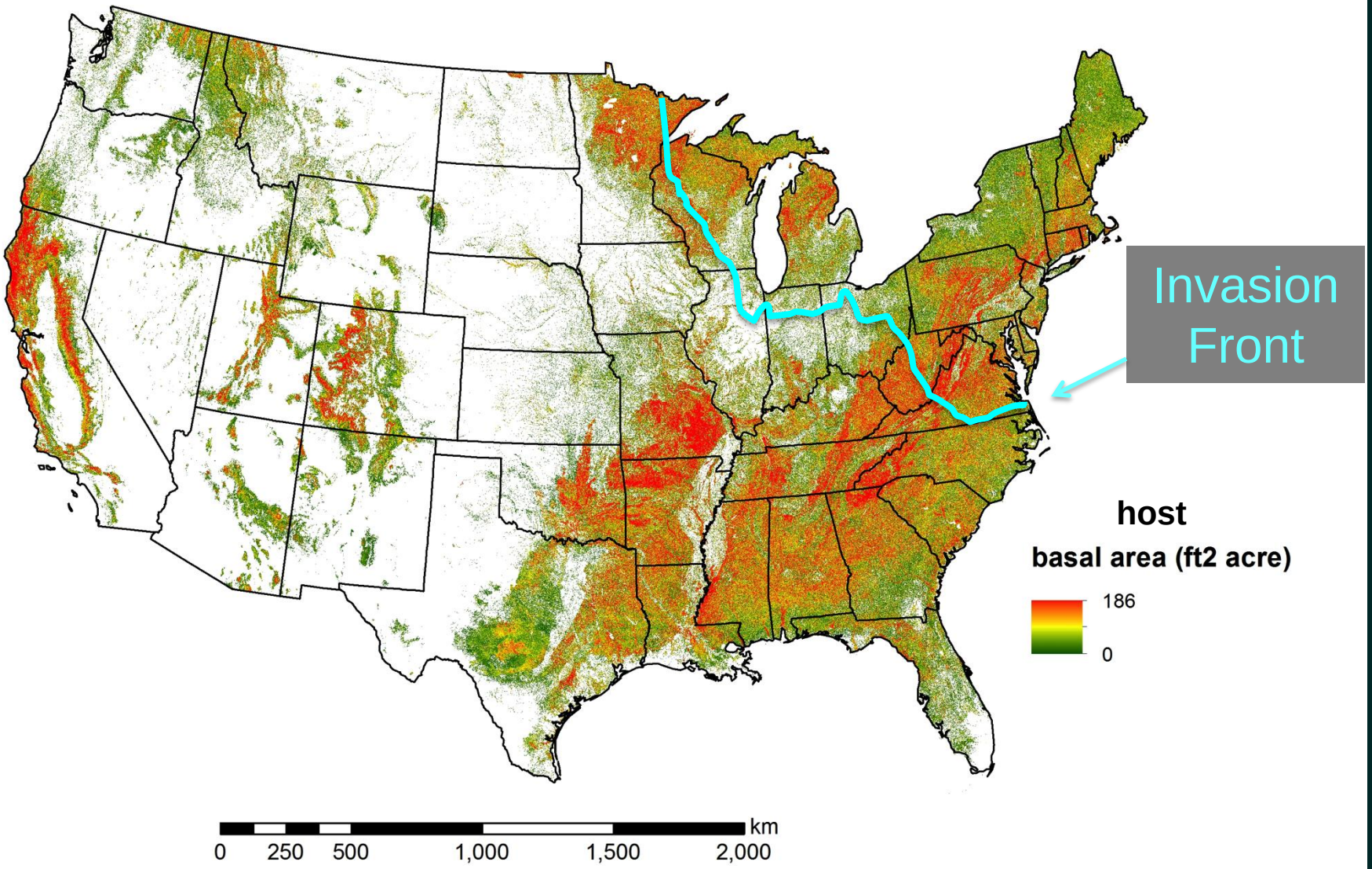
Slow the Spread

Suppression

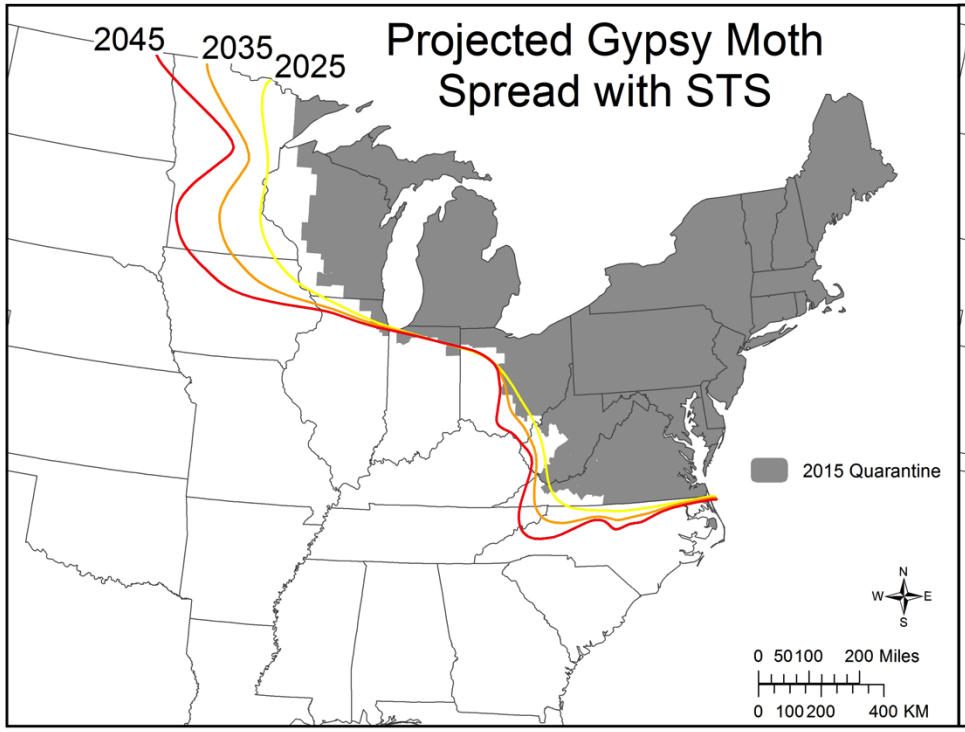


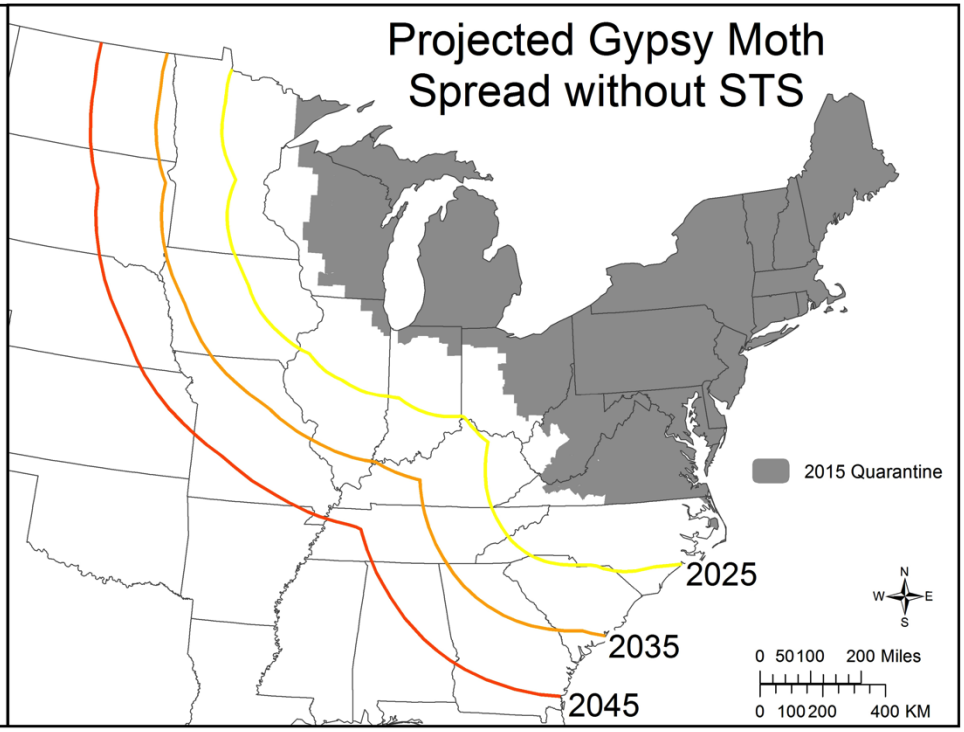
Gypsy Moth "Slow the Spread" (STS) Project




Invasion Front
host
basal area (ft2 acre)
186
0
km
0
250
500
1,000
1,500
2,000

Projected reduction in spread reflects historical impacts of STS program on spread





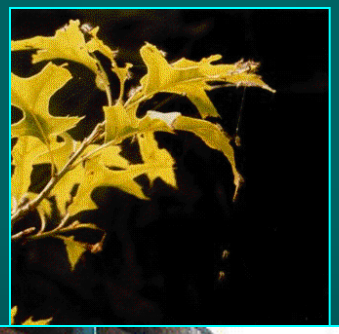
Stratified Diffusion (Hengeveld 1989)

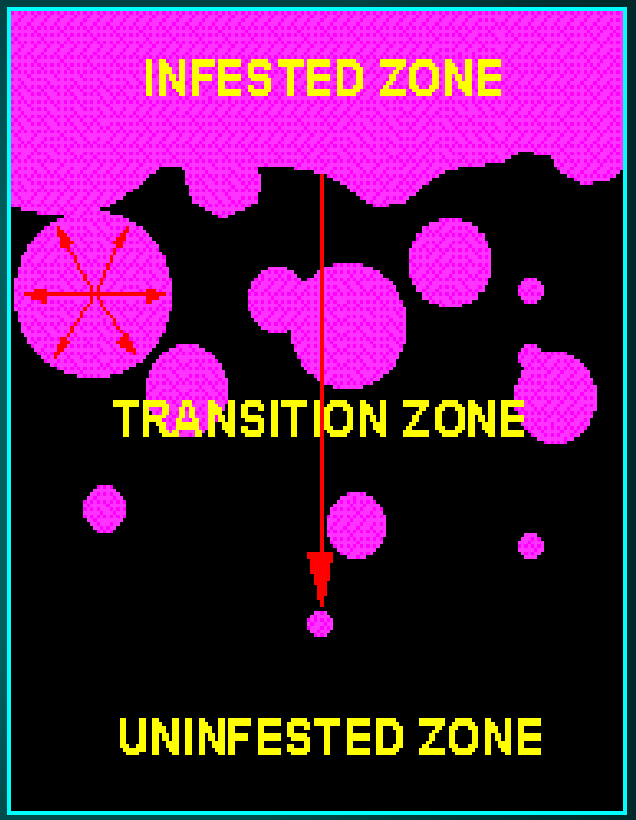
- Two forms of dispersal:

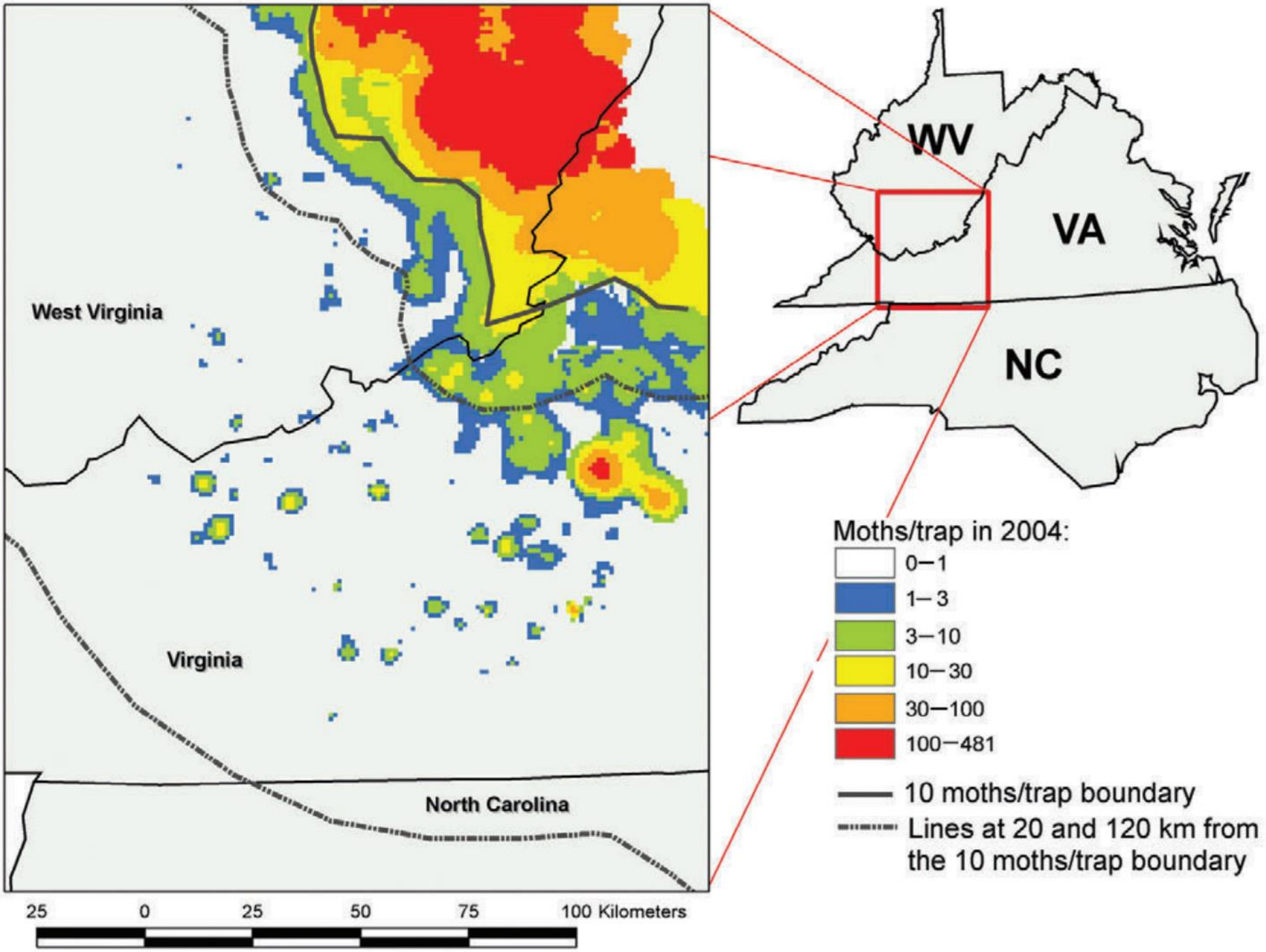
  short distance, continuous

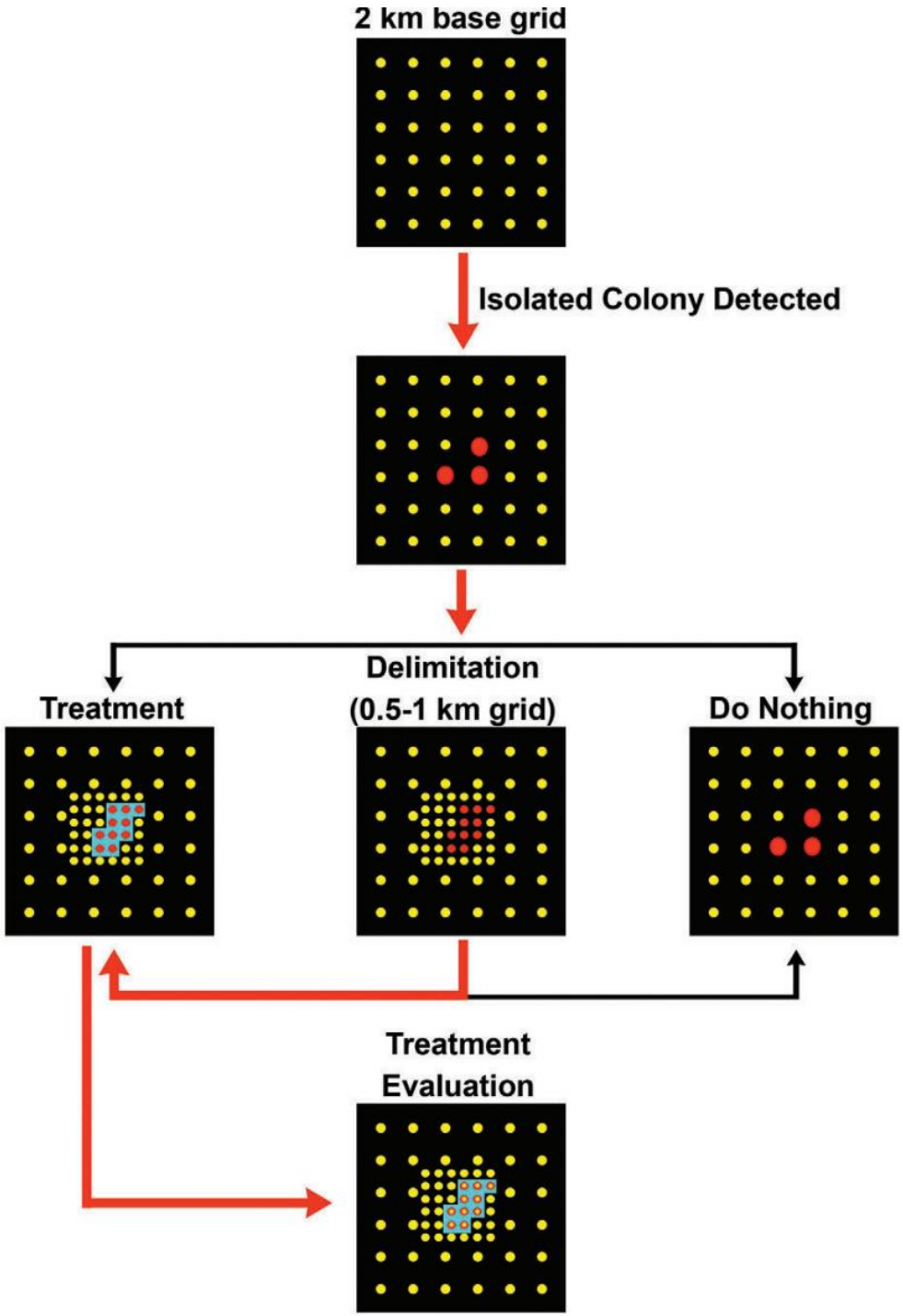
  long distance, stochastic

- Population growth

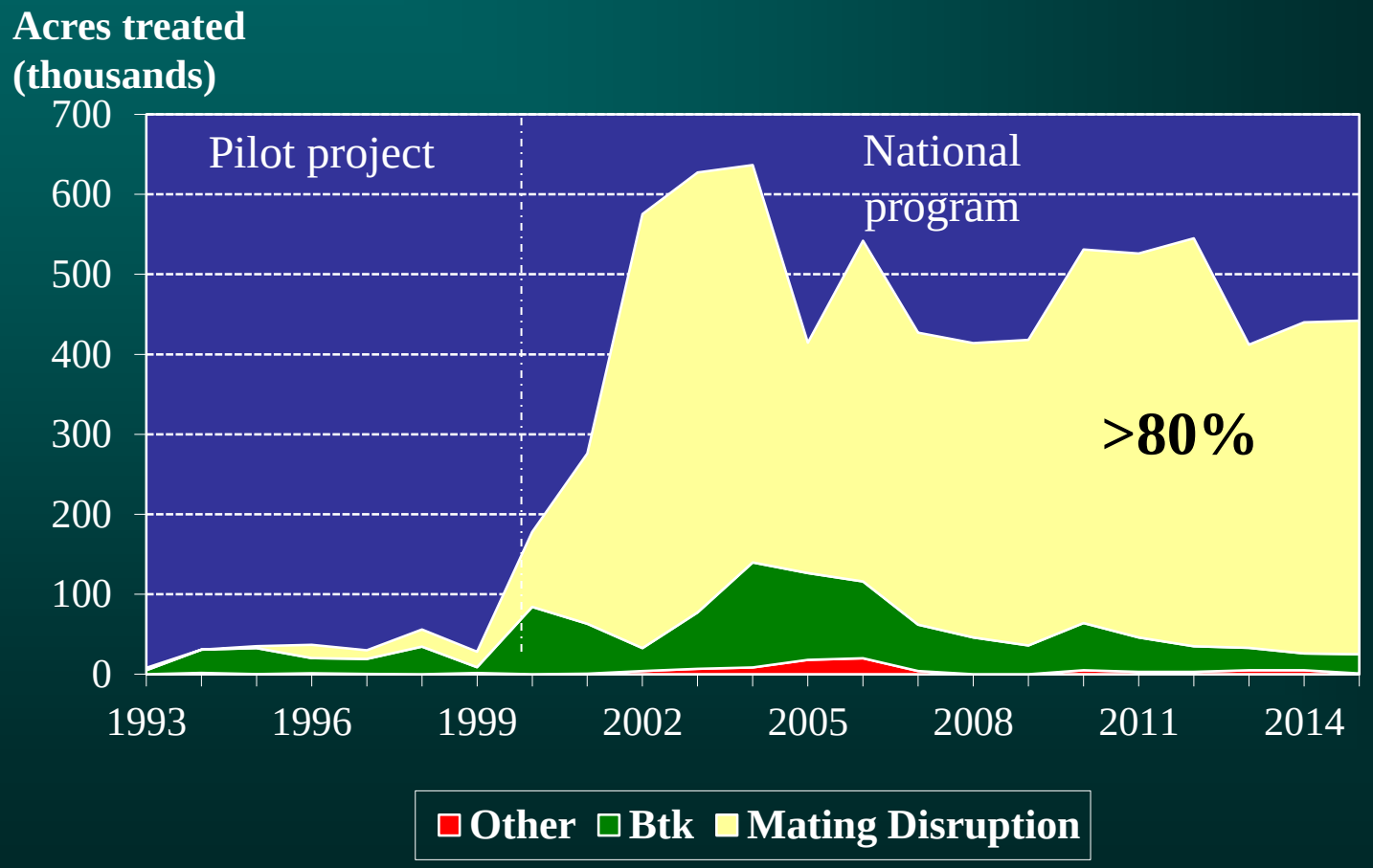





West Virginia
Virginia
North Carolina
25 0 25 50 75 100 Kilometers
WV
VA
NC
Moths/trap in 2004:
0–1
1–3
3–10
10–30
30–100
100–481
10 moths/trap boundary
Lines at 20 and 120 km from the 10 moths/trap boundary


2 km base grid
Isolated Colony Detected
Delimitation
(0.5-1 km grid)
Treatment
Do Nothing
Treatment
Evaluation

Treatments dominated by mating disruption



HERCON DISRUPT II Gypsy Moth is a controlled-release pheromone dispenser formulation designed to lower incidence of gypsy moth, Lymantria dispar, mating by disrupting normal male flight orientation to females. This reduction in mating will help suppress the larval (caterpillar) population that causes damage by feeding on the leaves of hardwoods and evergreens.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

At least two weeks before adult gypsy moth emergence, apply 30.4 grams active ingredient (170 grams (6 oz) of product) per application per acre using air or ground equipment. Apply a second application if adult gypsy moth emergence is extended or delayed. An inert sticker material should be used with DISRUPT II Gypsy Moth to hold flakes on treated foliage or plant parts. The Hercon applicator equipment is specifically designed to mix the proper amount of DISRUPT II Gypsy Moth flakes and inert sticker at the time of application.

Use in such areas as forests; residential, municipal and shade tree area; recreational areas such as campgrounds, golf courses, parks and parkways; ornamental, shade trees; forest plantings; shelter belts; and rights of way and other easements.

Application must be done by or under the supervision of a qualified person to insure proper rate and method of application

DISRUPT II Gypsy Moth can be used as a pest management tool by lowering incidence of gypsy moth mating in low-level populations. In areas of heavy infestation, DISRUPT II Gypsy Moth is recommended as a follow-up to larvicidal treatments as part of an Integrated Pest Management program.

HERCON Environmental

Made in the USA by
HERCON ENVIRONMENTAL
Aberdeen Road, Emigsville, PA 17318-0457

® **HERCON** and **DISRUPT** are registered trademarks of Aberdeen Road Company

Hercon®

DISRUPT® II

GYPSY MOTH
MATING DISRUPTANT
Population Suppressant

ACTIVE INGREDIENT:

[Z] - 7,8 - epoxy - 2 - methyloctadecane 17.9%
INERT INGREDIENTS: 82.1%
TOTAL: . . . . . .
100.0%

NET WEIGHT: kg [lb.]*

KEEP OUT OF REACH OF CHILDREN
CAUTION

Read Directions and Precautionary Statements Before U

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

Precautionary Statements: Keep out of reach of children. Do not open container until ready to use.

Personal Protective Equipment (PPE): Applicators and other handlers must wear long-sleeved shirt and long pants, waterproof gloves and shoes plus socks. Follow manufacturers instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendations: Users should wash hands before eating, drinking, chewing gum, using tobacco products or using the toilet.

HAZARDS TO THE ENVIRONMENT

Keep out of lakes, streams, and ponds. Do not contaminate water by cleaning of equipment or disposal of waste.

STORAGE AND DISPOSAL

Storage: Store in sealed containers in cool, dry place. Keep partially used containers tightly sealed.

Pesticide Disposal: Do not contaminate water, foods or feed by storage or disposal. Open dumping is prohibited. Wastes resulting from use of this product may be disposed of on site or at an approved waste disposal facility.

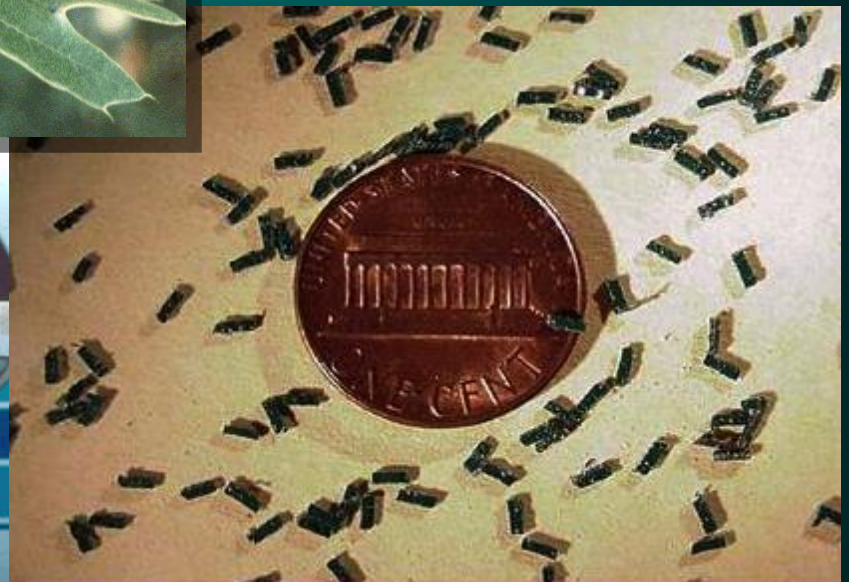
Container Disposal: Completely empty bag into application equipment. Wrap bag and place in trash collection.

Note: Use of pheromones and limiting the use of conventional insecticides will help maintain the population of beneficial parasites and predators. This can assist in biological control of gypsy moth and other pests, and therefore compliment pest management. DISRUPT II Gypsy Moth can be used as a pest management tool by lowering the incidence of gypsy moth mating in low-level populations. In areas of heavy infestation, DISRUPT II Gypsy Moth is recommended as a follow-up to larvicidal treatments as part of an Integrated Pest Management program.

*8.5 KG [18.7 LB] of product will be sufficient to treat 50 acres at 30.4 g AI/acre

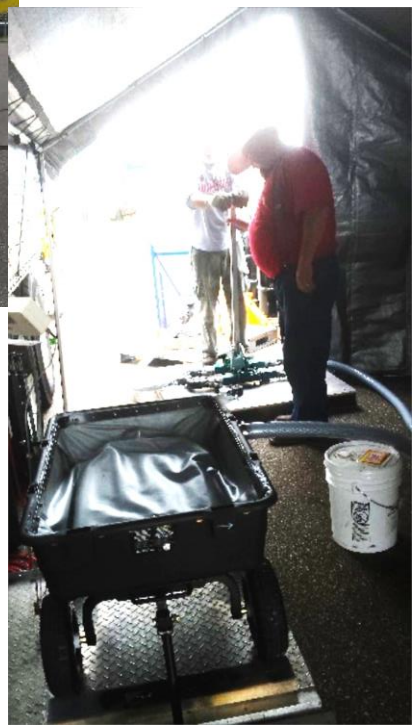
EPA REG. NO. 8730-55

Hercon “Flakes”

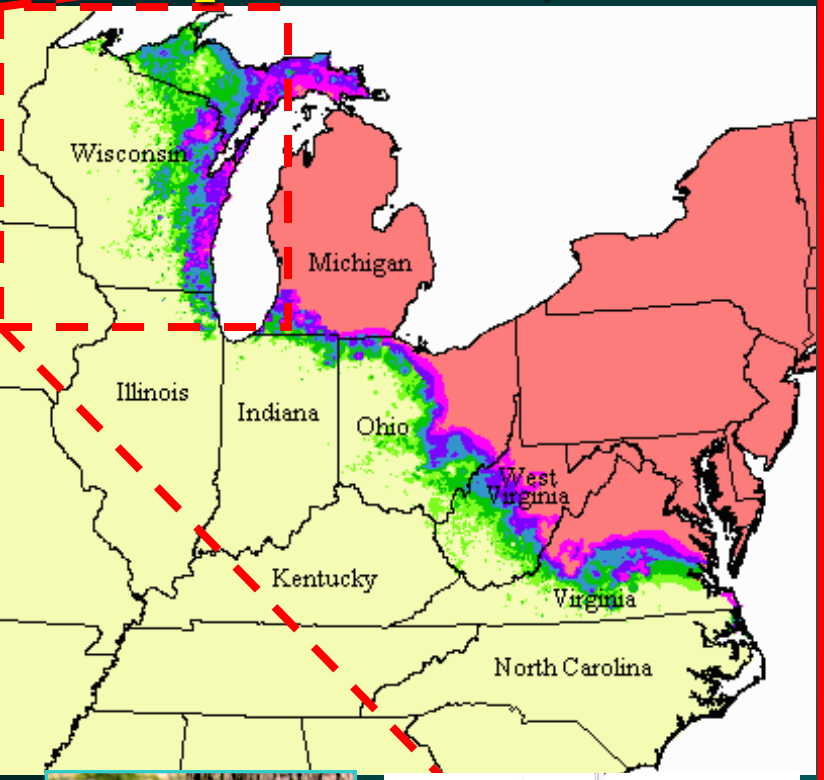


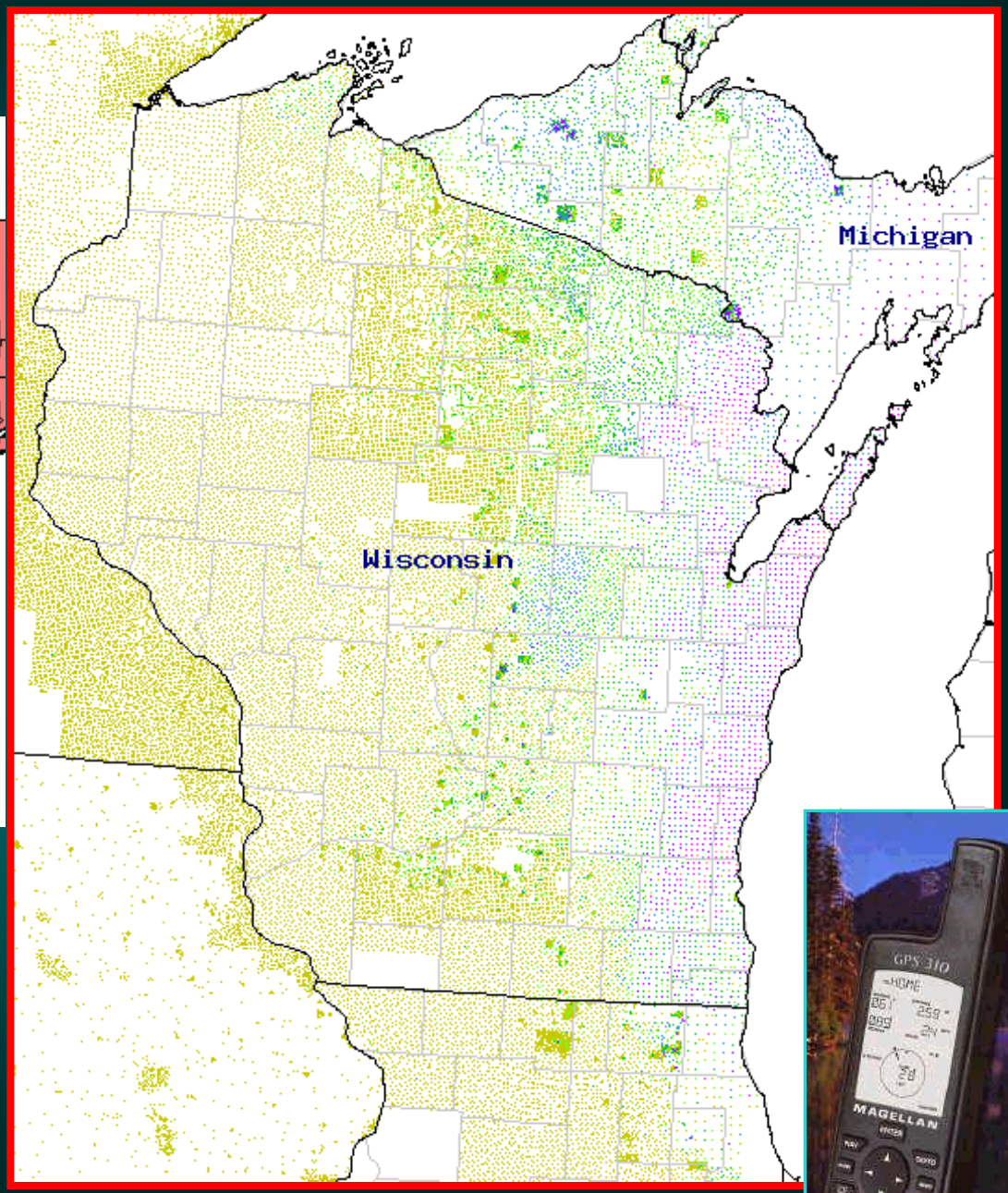
SPLAT GM

ISCA Technologies, Inc.
EPA Registration #80286-4



Wisconsin pheromone trap locations, 2000

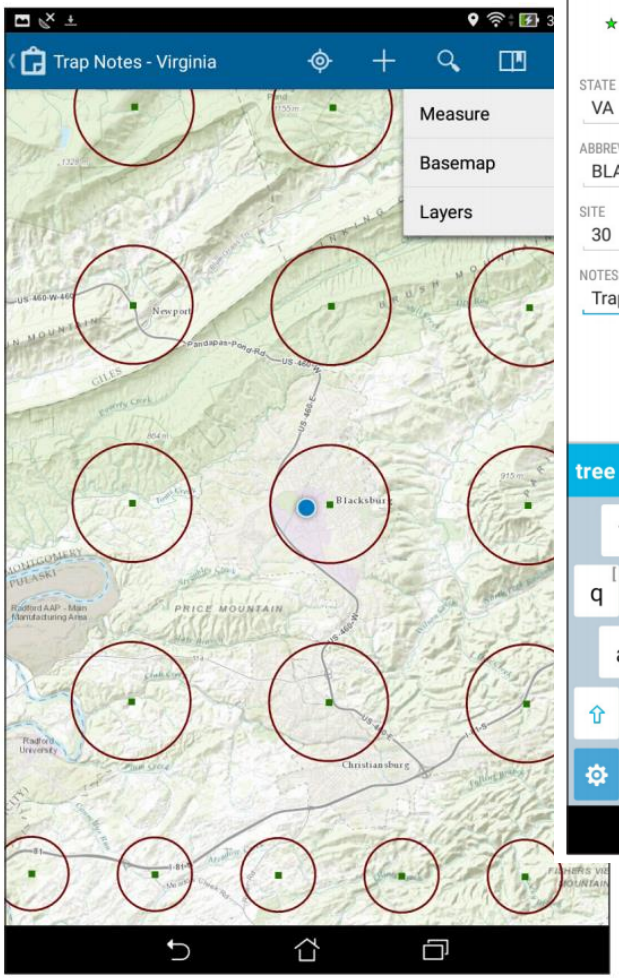


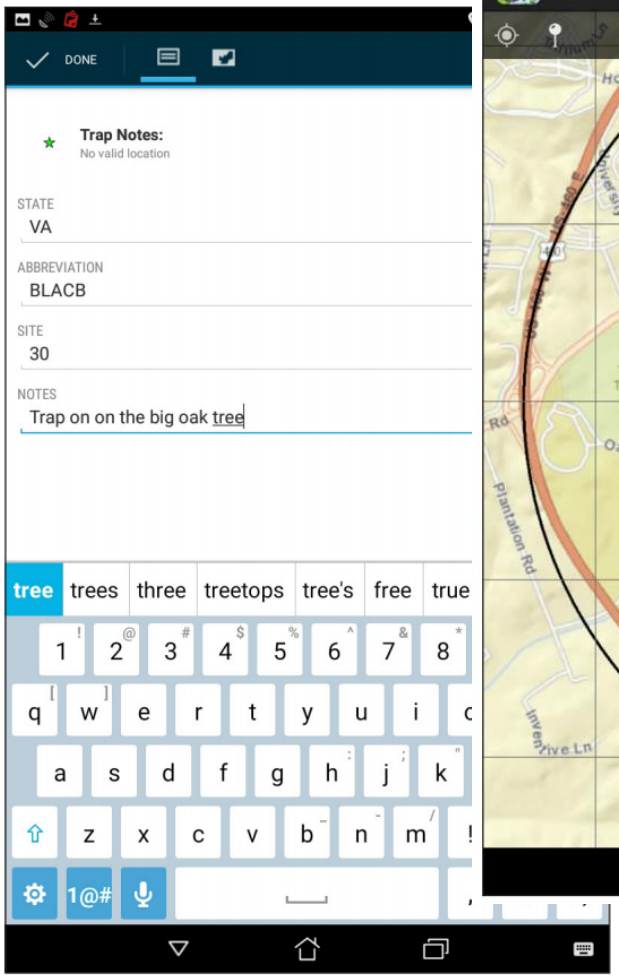


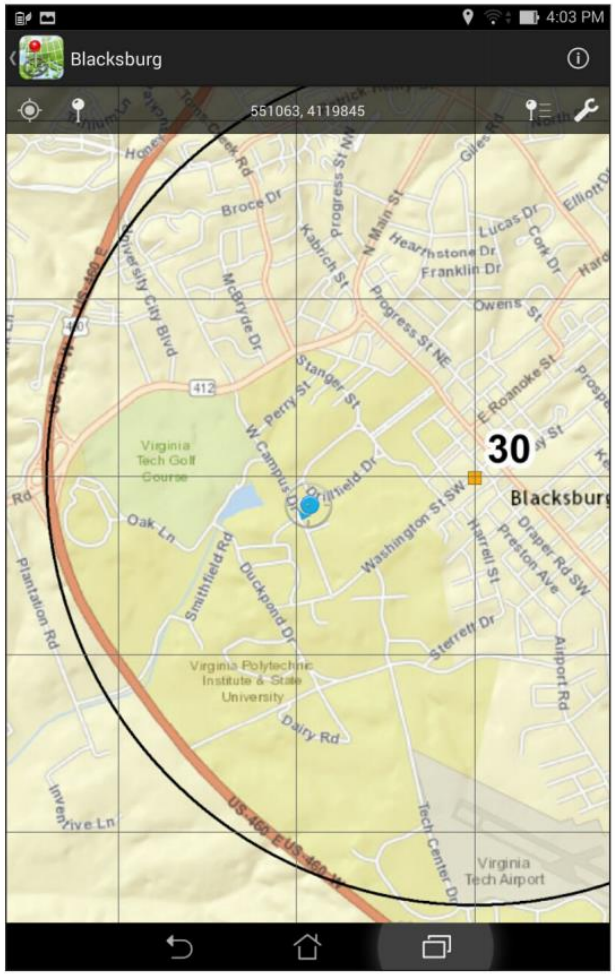
milk carton trap

delta trap

“Trapper Gadget” software for handheld devices (IOS or Android)







STS Data Flow

trapper
supervisor

Quality Control

planners

recommend actions

Block coordinates

Trapping data

SQL Database

Arc GIS

Decision Algorithm

Web portal

http://yt.ento.vt.edu/da

Trap locations

Virginia Tech
University
server

applicator

trapper

yt.ento.vt.edu/da/

Apps | 7-Day Forecast for... | apps v | Editorial Manager... | News | Popular | Imputation maps -... | mine flood maps | USGS Real-Time W... | Other Bookmarks

STS Slow the Spread of the Gypsy Moth

Slow the Spread Foundation, Inc.

http://yt.ento.vt.edu/da/

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Traps and Treatment | Baselayers | Reports | Documentation

Catch

2016 Year

- [x] Catch
- [ ] Krig
- [ ] Treatment Evaluation
- [ ] Mothlines
- [ ] Population Growth
- [ ] 5% Moth Flight
- [ ] 95% Moth Flight

Actions

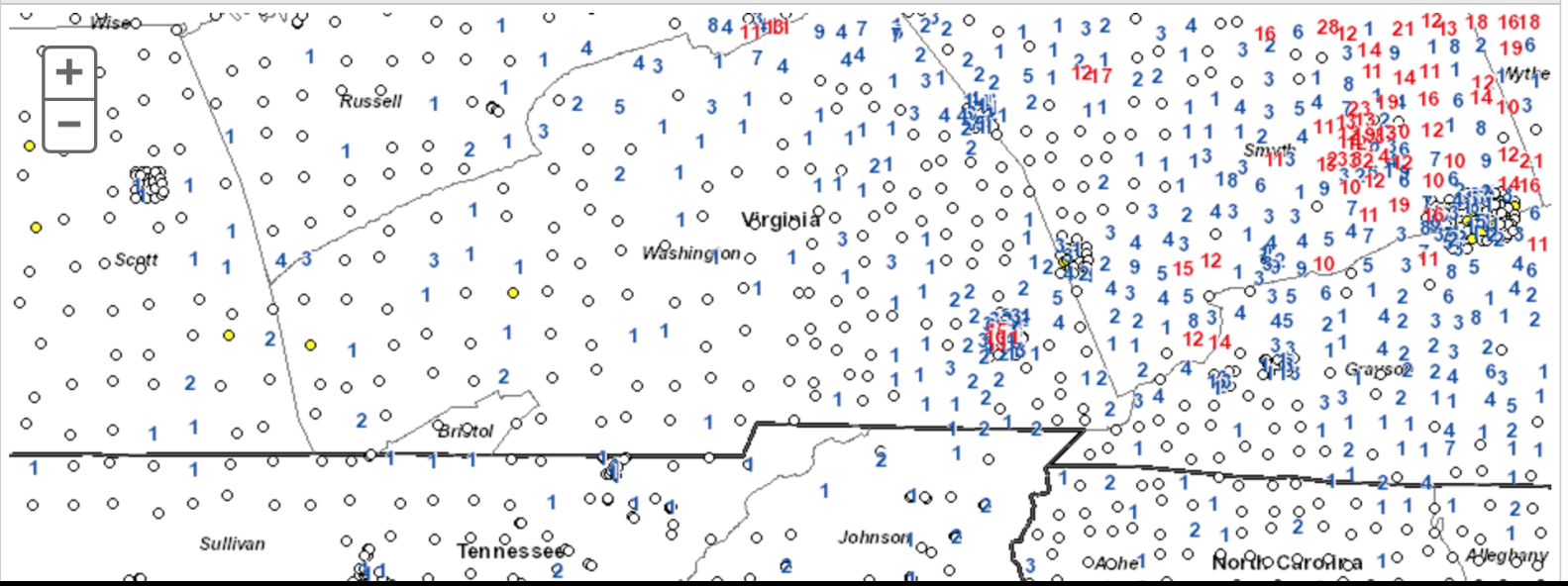
2017 Year

- [ ] PPAs
- [ ] Delimits
- [ ] Treatments
- [ ] Lifestages
- [ ] Project Bounds
- [ ] DA Bounds
- [ ] Previous Treatments
- [ ] 2nd Year MD Treatments

Legend

Query Results

Map



STS Data Flow

trapper
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recommend ations

Block coordinates

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Web portal

http://yt.ento.vt.edu/da

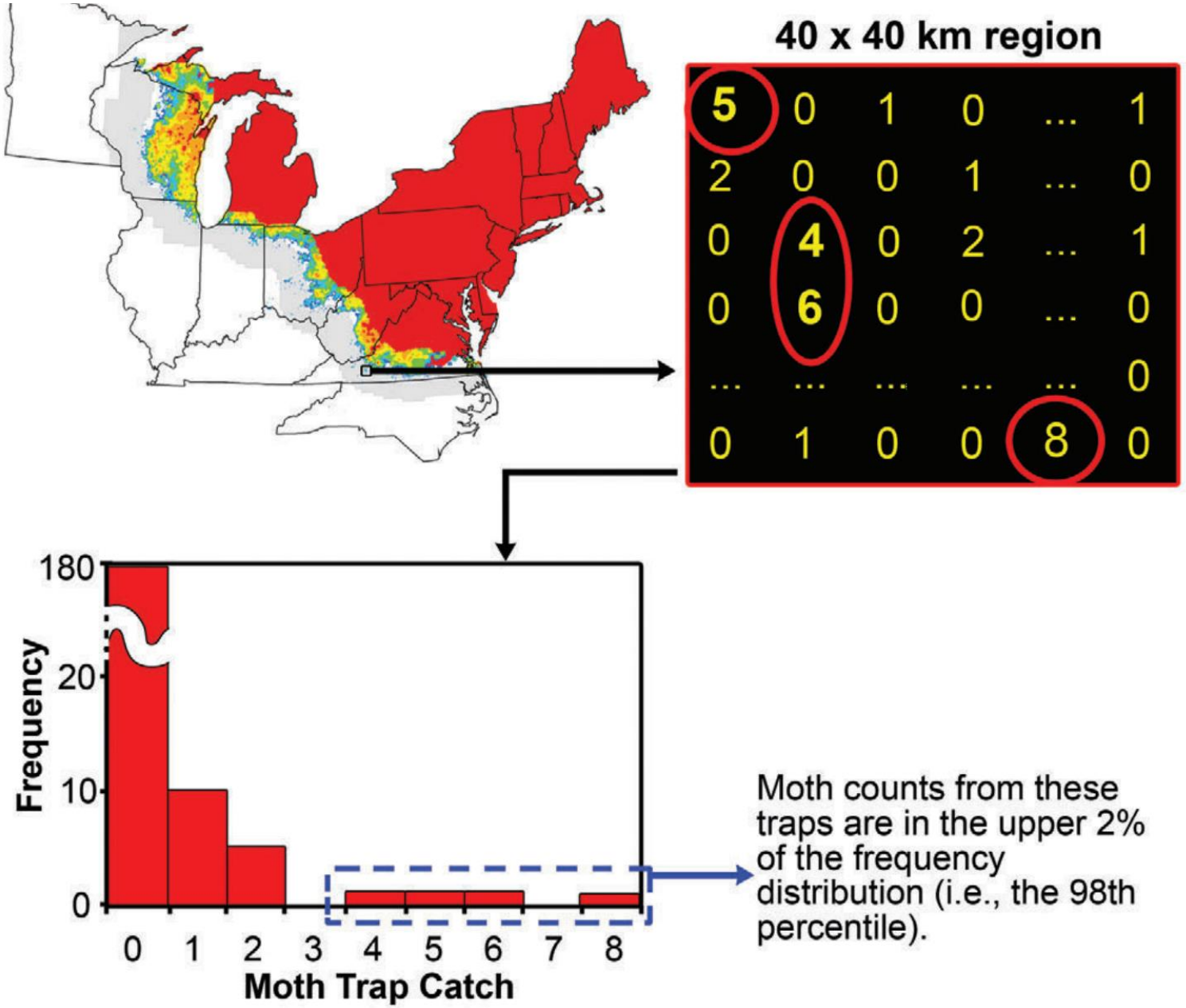
Virginia Tech University server

Trap locations

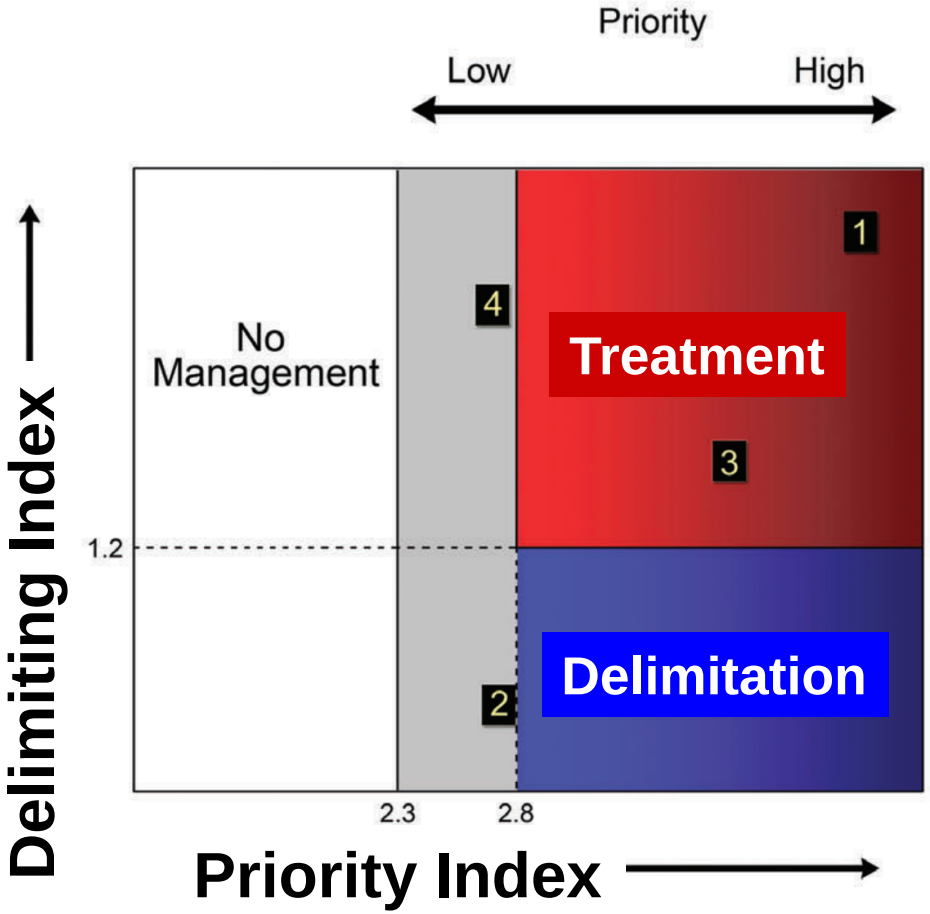
trapper

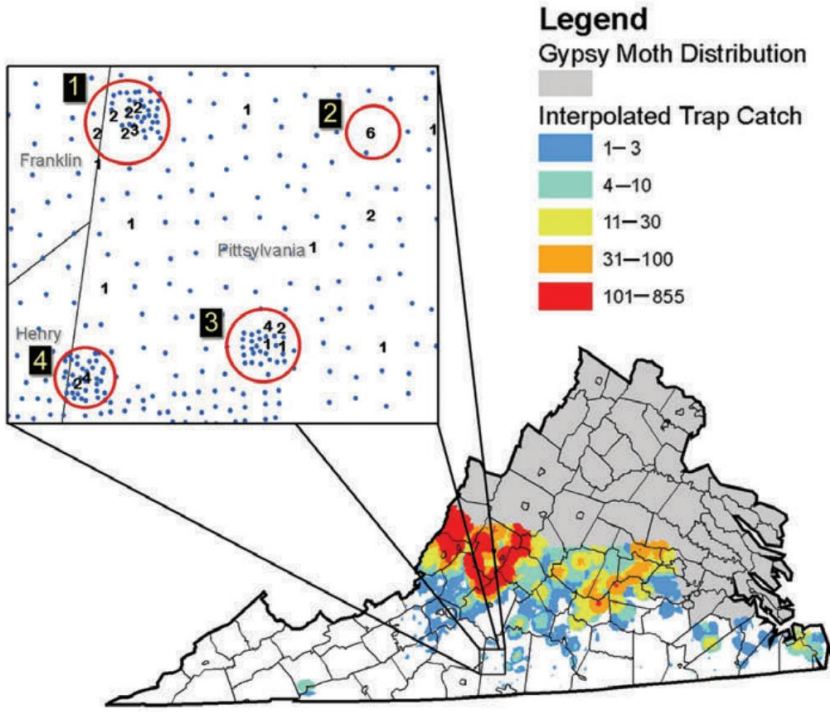
applicator

STS Decision Algorithm: Identification of populations

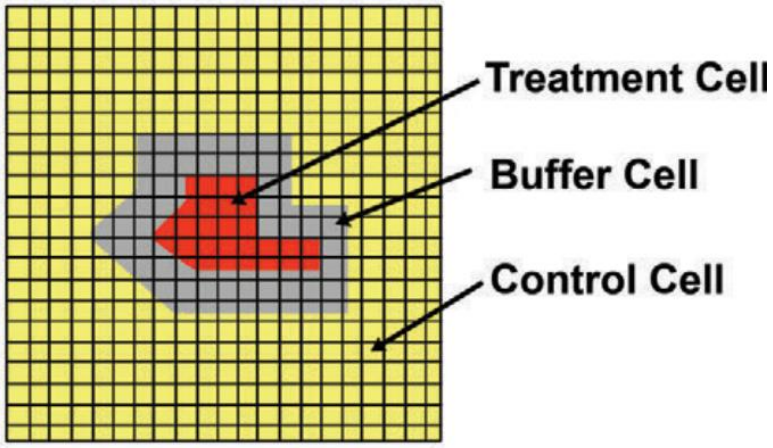


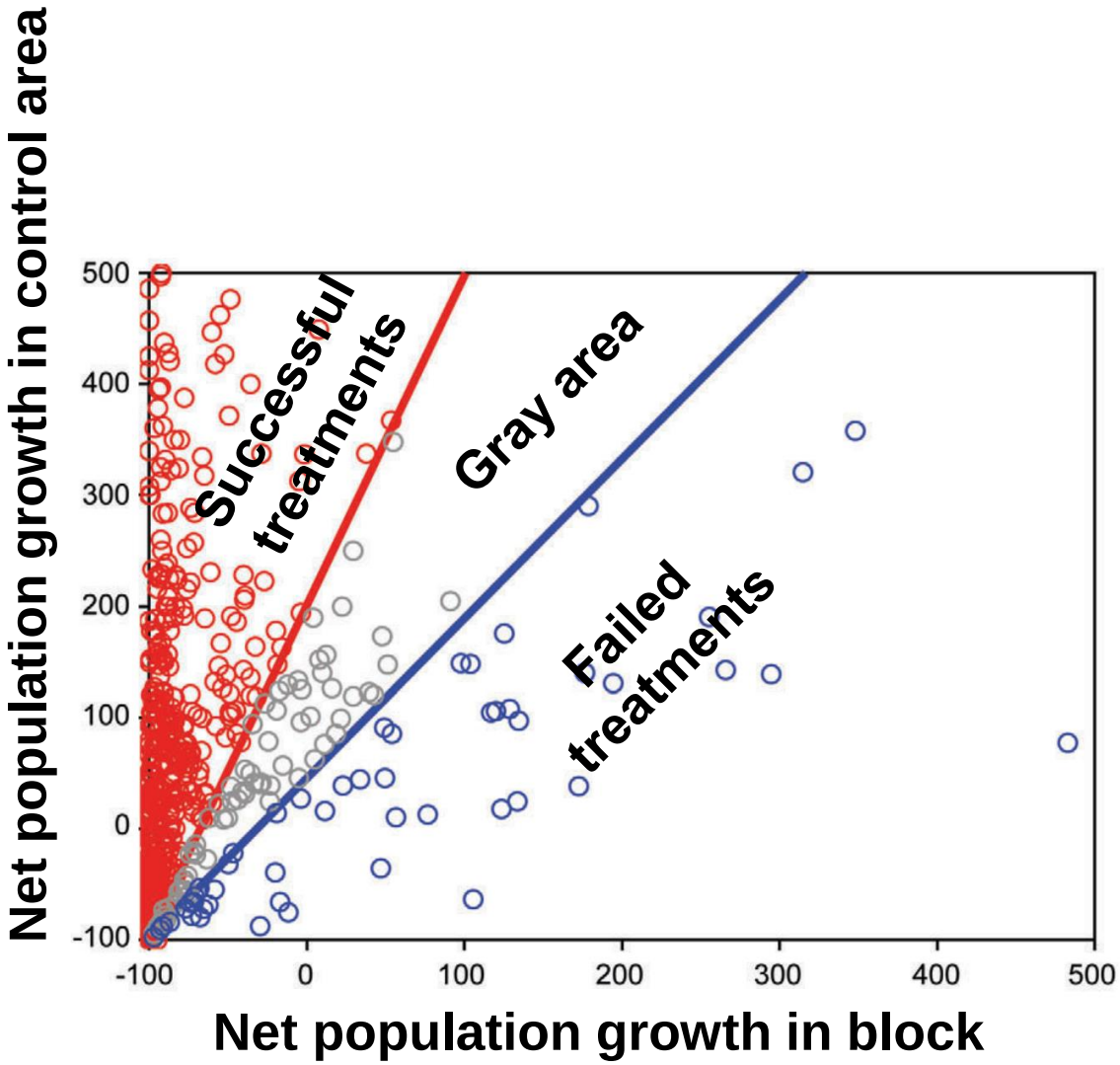
STS Decision Algorithm: Decision recommendation for each population





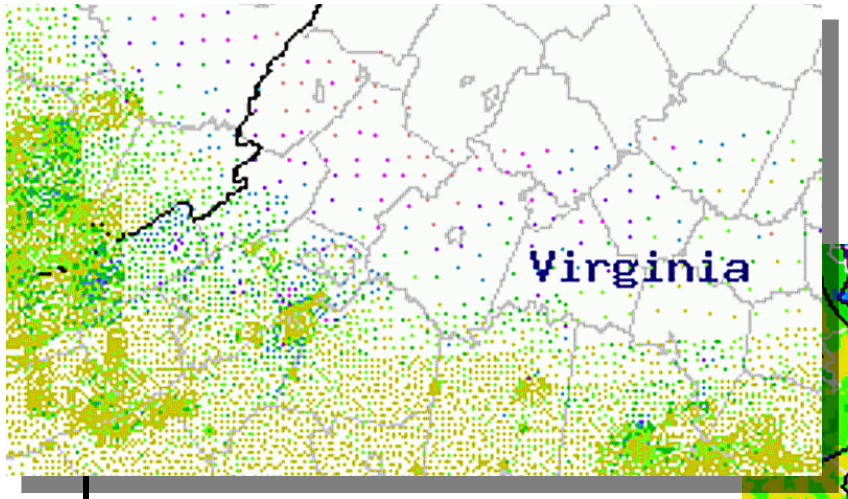
STS Decision Algorithm: Treatment block evaluation

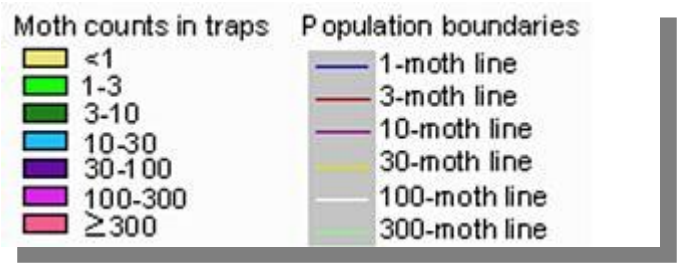




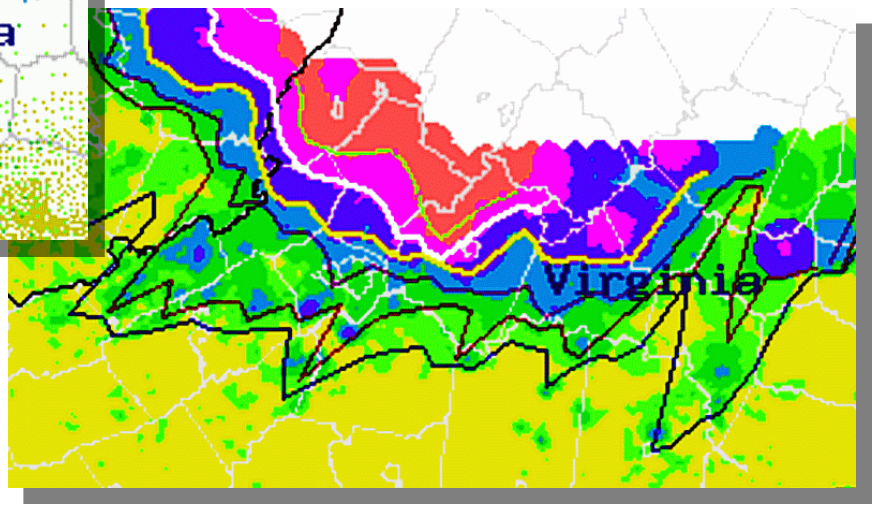
STS Decision Algorithm: Spread rate estimation

Point data….





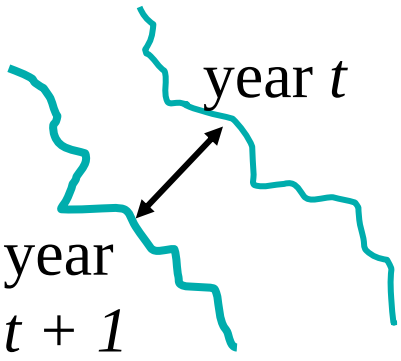
are interpolated…

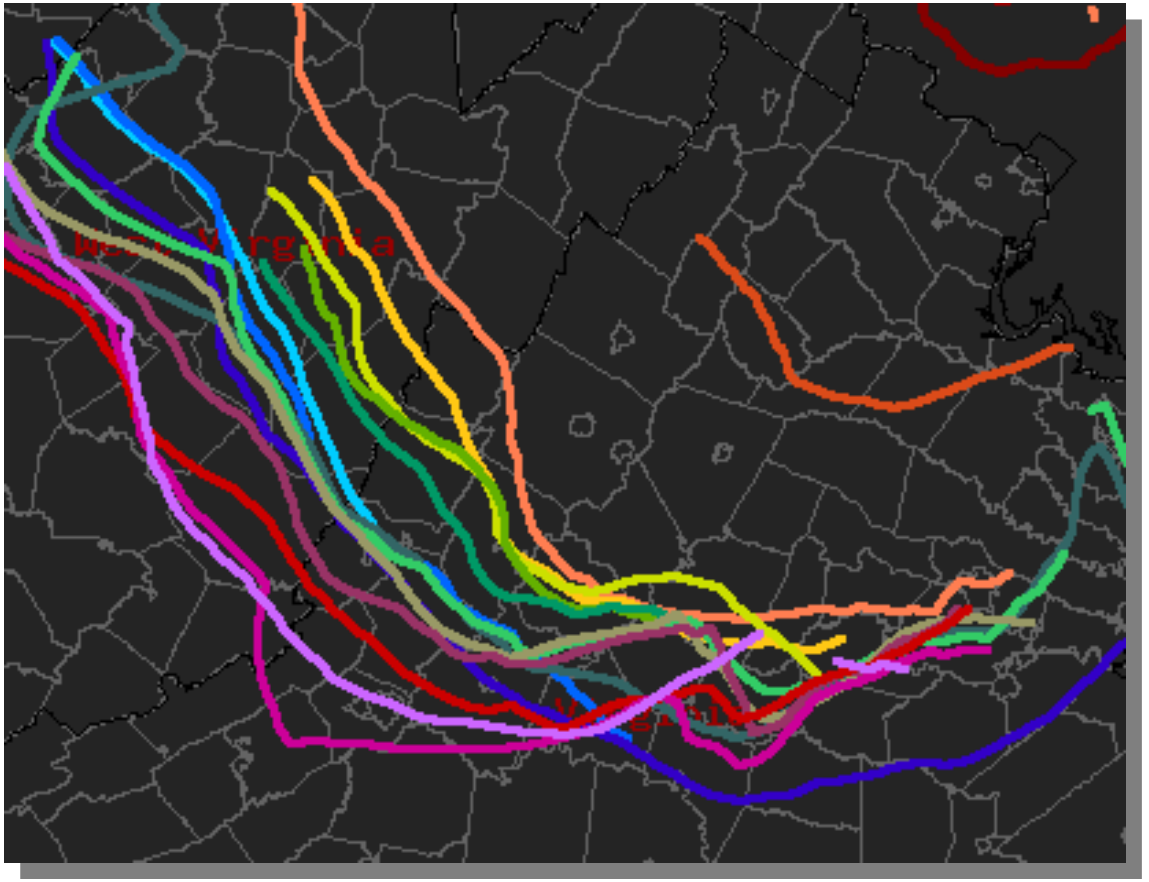


to a surface and moth boundary lines are plotted.

Sharov & Liebhold, 1998

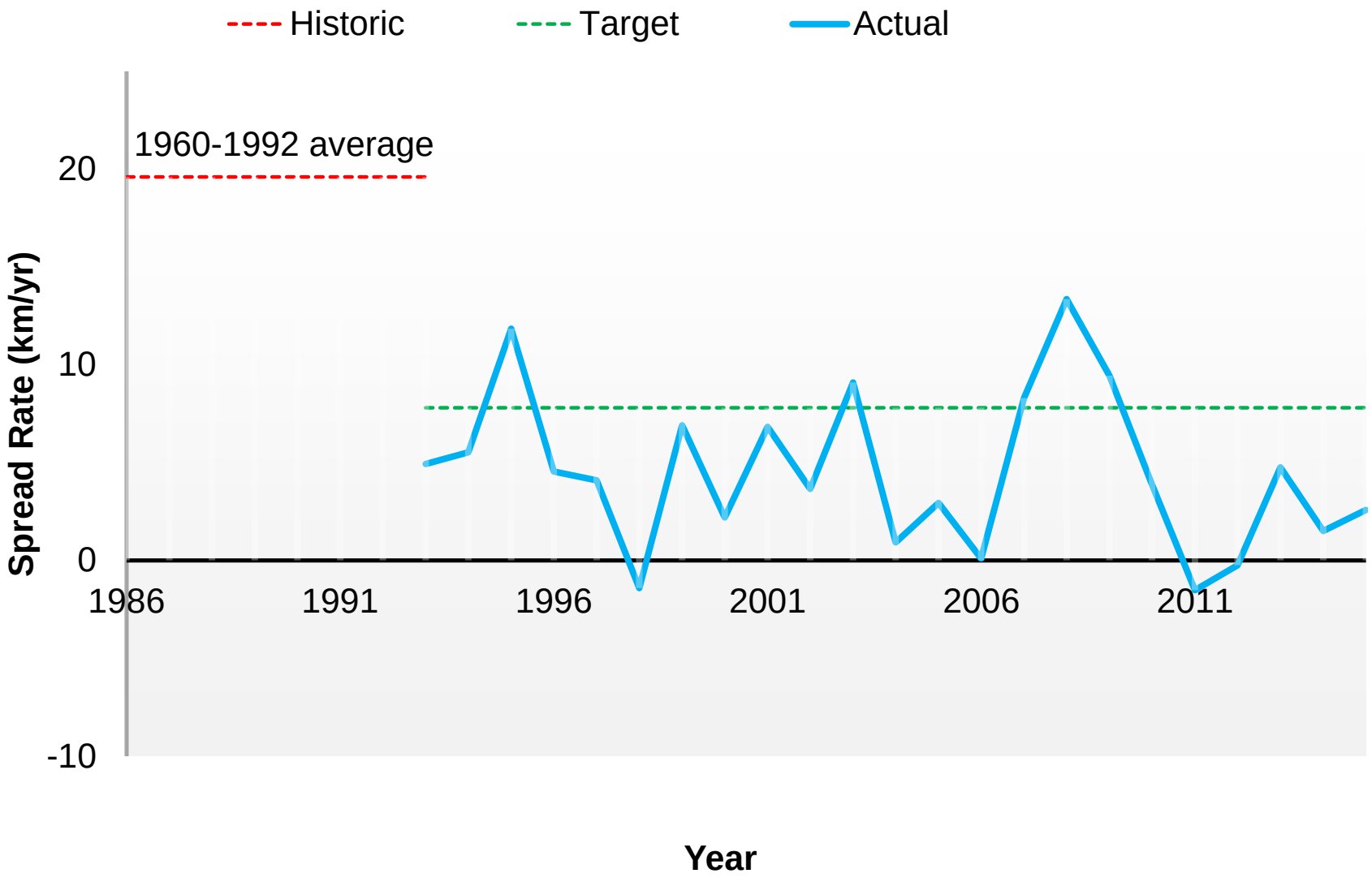
STS Decision Algorithm: Spread rate estimation





$$\text{Spread rate} = \frac{\text{Distance}}{\text{time}}$$

STS has reduced spread by ~80% overall



2016 STS Expenditures

Monitoring: 65,000 pheromone traps, **$4,450,000** (≈$69 per trap)

Treatments 162 blocks totaling 182,816 ha, **$4,430,000** (≈$10 per acre)

Detection / Eradication Funding

USDA APHIS

USDA Forest Service

State Governments

STS Funding

USDA APHIS

USDA Forest Service

Slow the Spread Foundation

State Governments