AIPM: Areawide Integrated Pest Management

Frank G. Zalom
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Pest – any organism that interferes with the activities and desires of humans – (as defined by *FIFRA*)

Pest control – as early as 2500 BC, the Sumerians used sulfur to control plant diseases, insects, mites (also mentioned in Greek and Roman literature)

Pesticides –

- Inorganic and botanical pesticides such as arsenic, lime-sulfur and nicotine became commercially available in the late 1800's

Pesticides

Synthetic organic pesticides such as DDT was important during WWII to control public health pests

Paul Muller (1948)
Nobel Prize for Medicine

Agricultural and public health uses expanded greatly after the war.

Pesticides

Rapid adoption

- relatively inexpensive
- easy to use
- Effective
- predictable results

Pesticides

Things start to go wrong

- non-target species impact
  - secondary pests
  - wildlife
- pest resistance to pesticides
- soil and water contamination

Integrated Pest Management - IPM

An alternative strategy

"Integrated pest management is an approach that employs a combination of techniques to control the wide variety of potential pests that may threaten crops. It involves maximum reliance on natural pest population controls, along with a combination of techniques that my contribute to suppression - cultural methods, pest-specific diseases, resistant crop varieties, sterile insects, attractants, augmentation of parasites or predators, or chemical pesticides as needed."

Council on Environmental Quality, 1972

Integrated Pest Management - IPM

- Multiple tactics (*in a synergistic way*)
- Multidisciplinary
- Ecosystem-based
- Knowledge-intensive
- Risk reduction focus

IPM - Benefits

- Reduces risk to human health
- Reduces risk to non-target organisms and the environment
- Increases economic benefits by adopting best management practices and reducing unnecessary control inputs
- Mitigates risk of pest resistance

IPM – Often pest and site specific

IPM typically addresses a *localized pest population* and is typically practiced by the person responsible for past control at the site …

- on a farm
- in a dairy
- in a park
- in a dwelling
- etc.

Some pests are not easily managed by individuals in a site-specific manner

In the case of a *highly motile key pest* that is difficult to control, an uncoordinated approach provides opportunities for the pest population to build up over the entire area, overwhelming the capacity to control the pest even in well-managed fields.

Often leads to:

- Increased injury to humans, crops, animals and landscapes
- Increased use of pesticides to control the pest (with associated costs, development of resistance, and risk to humans and the environment
- Disruption of existing IPM systems, especially those that incorporate natural biological control agents

AIPM – Areawide Integrated Pest Management

Typically addresses pests that are particularly motile:

Migration of a pest from areas where controls cannot or are not being applied to sites where they cause health, economic, or environmental harm prevents their *successful and sustainable control or elimination* from those sites.

In such circumstances, the overall reduction of the pest population in the area, region or community where it occurs through a *coordinated community-wide approach* will be more successful and sustainable than uncoordinated controls applied by individuals on the properties that they manage.

AIPM – Areawide Integrated Pest Management

AIPM is also particularly useful for sites that are not suitable for management in isolation such as:

- Natural areas – forests
- Urban areas – street trees, urban forests
- Disease vectors – mosquitoes, ticks

Similar to IPM in that emphasis is on implementing systems-based strategies that utilize multiple tactics that emphasize prevention, avoidance, monitoring, and suppression using practices that are biologically-based and reduce risk to human health and the environment

AIPM – differs from conventional pest management of local pest populations in several important ways:

Focus on managing pest populations in all the niches in which they occur

(conventional strategy focuses narrowly on protecting people, the crop, livestock, buildings, etc. from direct attack)

Detailed multi-year planning and organization

(conventional strategy tends to be reactive and is implemented independently by the affected individuals)

AIPM – differs from conventional pest management of local pest populations in several important ways:

Tends to utilize advanced technologies that may be difficult or less effective when used by individuals

- Cultural, physical or mechanical controls
- Biological control releases
- Semiochemicals (including pheromone mating disruption)
- Treatment (or elimination of alternate) of hosts on public lands and private gardens)
- Sterile insect technique (SIT)
- Resistant or tolerant plant varieties
- etc.

Some classical examples of AIPM:

Cottony-cushion scale – importation and release of Vedalia beetle in 1887 saved citrus industry in California

Cottony cushion scale - Found in LA in 1876

Vedalia beetle – Introduced from Australia in 1887

Complete success

First example of ‘classical biological control’

Some classical examples of AIPM:

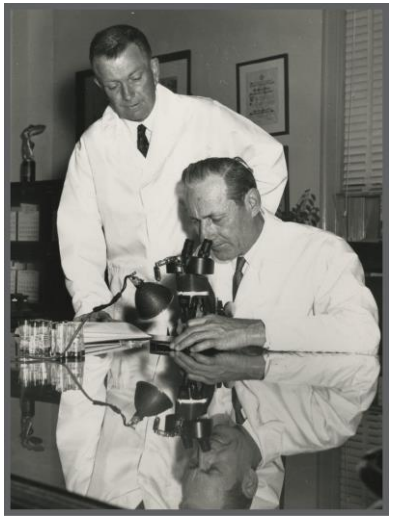
Yellow fever mosquito (*Aedes aegypti*) - strict sanitation program implemented to prevent breeding of the mosquito, first used for successful control in Havana, Cuba (1898). Program implemented in Panama by William Gorgas allowed the building of the Panama Canal

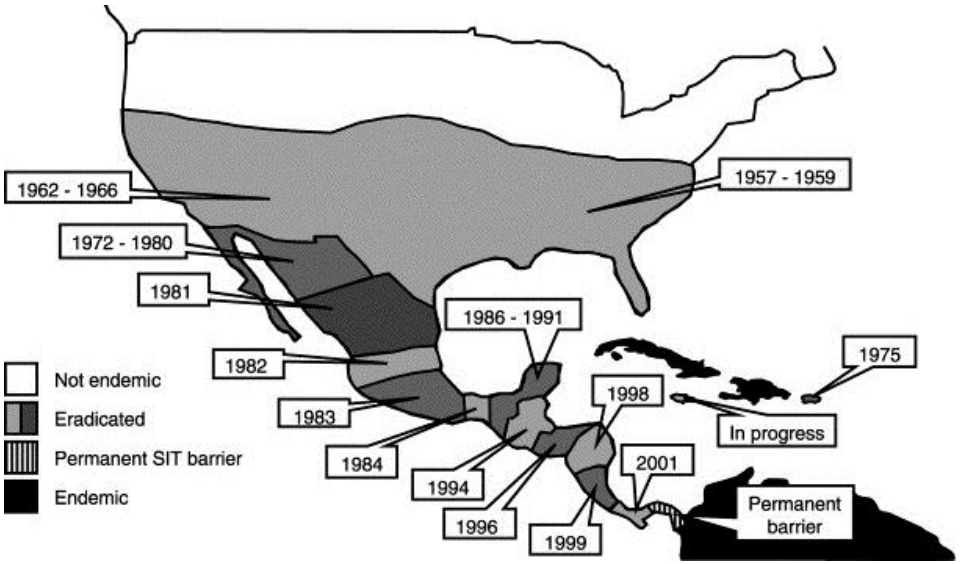
34,000 workers died from yellow fever before the US took over construction in 1904

William Gorgas

Some classical examples of AIPM:

Screwworm fly – SIT program involving release of millions of sterile flies to prevent the successful mating of endemic flies





E.F. Knipling and
R. Bushland

European Grape Vine Moth:

Found in Napa and Sonoma counties in 2009, and 9 counties by the end of 2010

Contamination and bunch rot

Benefits of AIPM:

Experience has shown that pest suppression on an areawide basis can be *more economical* than on a farm-by-farm or site-by-site basis for reducing losses caused by highly mobile and invasive pests:

- Sustainable, long term management of the pest
- Shared resources to enable utilization of technologies and expertise that are unavailable or more expensive for individuals
- Avoidance of external costs (including development of pesticide resistance, reduction of naturally-occurring biological control agents, and harm resulting to humans and the environment caused by use of disruptive control tactics)

What are AIPM programs?

- Address mobile key pests on farms, in natural areas, or in urban areas
- Pest control at a scale larger than a single field, ranch, building or land parcel
- Systems thinking
- Utilize multiple management tactics for control to produce a more sustainable, long term solution
- Focused on reduced-risk practices, resource conservation and sustainability
- Synergistic partnerships – local/regional/Federal collaborations as appropriate
    - Multi-institutional
    - Public/private
    - Community engagement

AIPM panel participants:

AIPM principles are applicable to a diversity of pests in different types of ecosystems across the United States. We have invited four panelists who will describe what AIPM strategies look like for some specific pests, and challenges to their successful control.

- Urban pests: Dr. Faith Oi, University of Florida
- Aquatic pests: Dr. Lee Van Wychen, Weed Science Society of America
- Forestry pests: Dr. Paula Shrewsbury, University of Maryland
- Agricultural pests: Dr. Kelley Tilmon, Ohio State University

AIPM: Areawide Integrated Pest Management

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Areawide IPM "Urban"

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pmu PEST MANAGEMENT UNIVERSITY

UF UNIVERSITY of FLORIDA IFAS Extension

POPULATION BIOLOGY/GENETICS

Molecular Markers Reveal Infestation Dynamics of the Bed Bug (Hemiptera: Cimicidae) Within Apartment Buildings

WARREN BOOTH,[1,2] VIRNA L. SAENZ,[1] RICHARD G. SANTANGELO,[1] CHANGLU WANG,[3] COBY SCHAL,[1] AND EDWARD L. VARGO[1]

- Jersey City apt building infestations started by two or more introductions followed by extensive spread

(These are the types of maps used in litigation.)

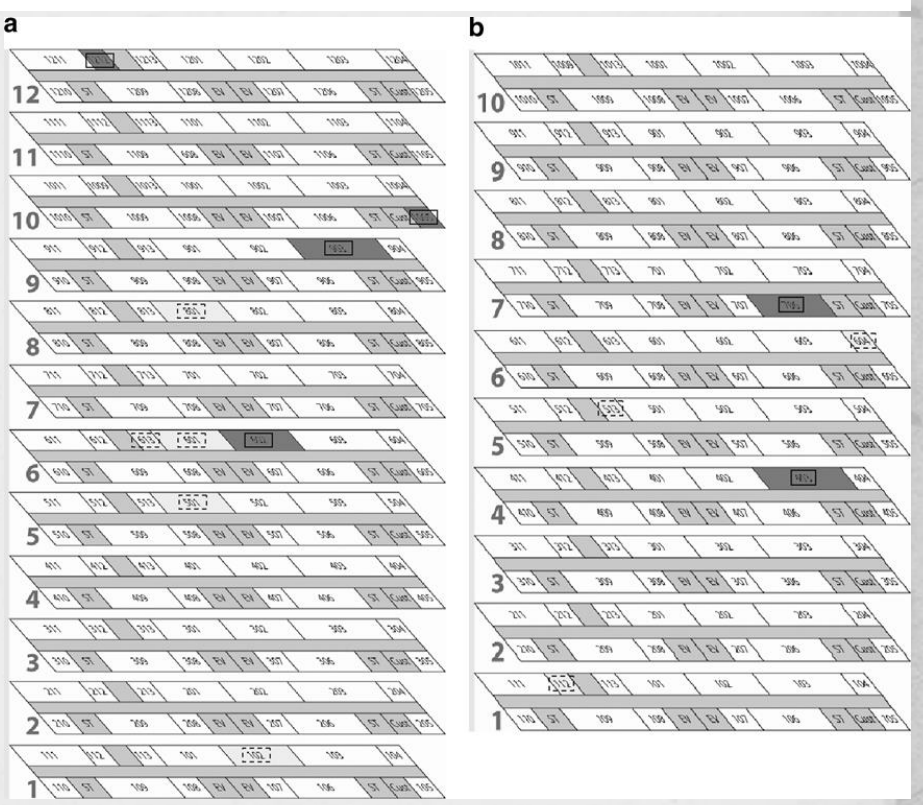

Fig. 2. Building floor plans: Jersey City: (a) JC-A and (b) JC-B. Sampled rooms indicated by shading. JC-A and JC-B cluster 1, dark gray (outlined with solid black rectangle); cluster 2, light gray (outlined with dashed black rectangle).

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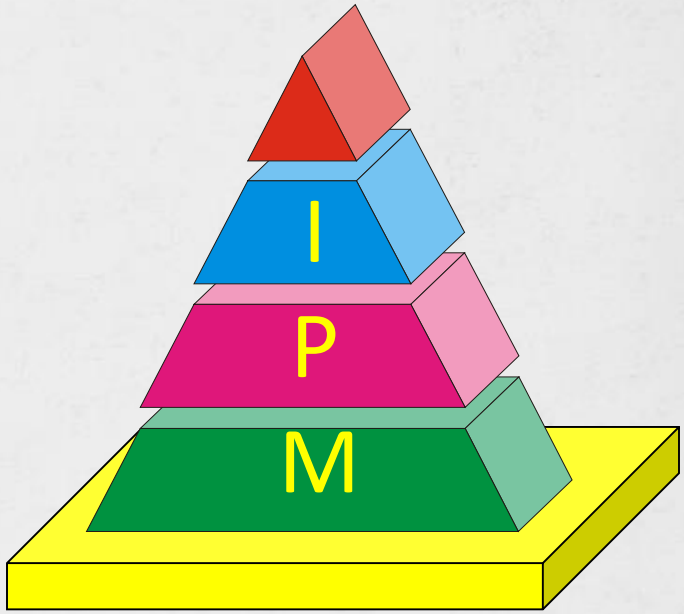
IPM is a Process, Not a Miracle

- Prevent
- Inspect/monitor
- Identify
- Employ tactics
- Document
- Evaluate



IPM Tactics

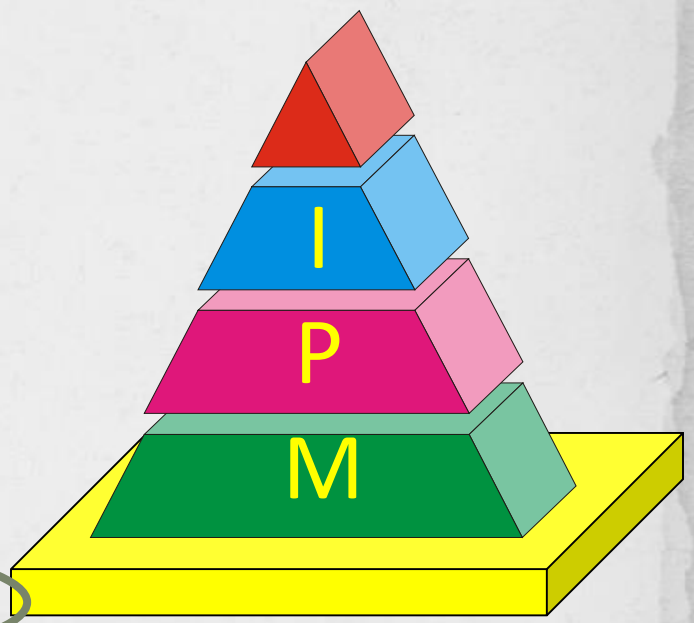
Pesticides

Biological Control

Physical and Mechanical Control

Cultural and Sanitation Practices

Education and Communication



IPM (Integrated Pest Management) – an integration of technologies used to reduce pests and pest conducive conditions. *Common sense pest control.*

The Other IPM

Integrated People Management

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- Damage is with grain of wood
- Contains carton/mud
- Which termite?
- EVIDENCE, DAMAGE, LIVE?

What type of termite?
How do you know?
Conducive conditions?
EVIDENCE, DAMAGE, LIVE?

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All Life Stages

Red imported fire ant stings have white pustules

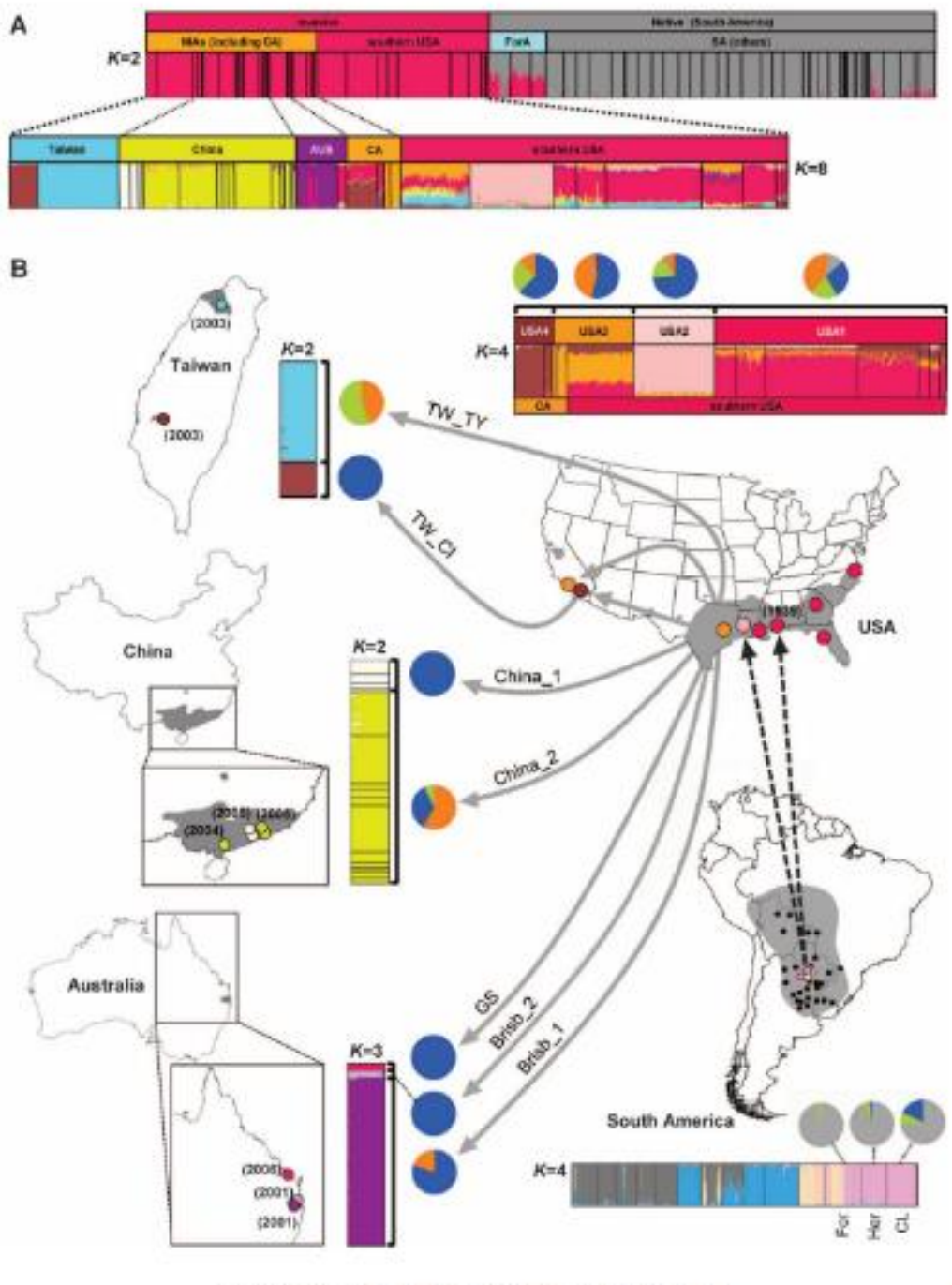
Pustules on an infant's hand formed by fire ant stings. Photo by Kelly Palmer. eXtension.org

- Generally takes ~24 hr to develop pustule
- Some will not develop a pustule
- Anaphylaxis in <1% of those stung
  - Rarely, death

RIFA: Potential Trade Impacts

- 322 unique mtDNA haplotypes (i.e., genes inherited together from a single parent)
  - 311 confined to ants in native range
- Only 3 haplotypes found in newly invaded areas
  - These 3 haplotypes appear to be the most common in the U.S.

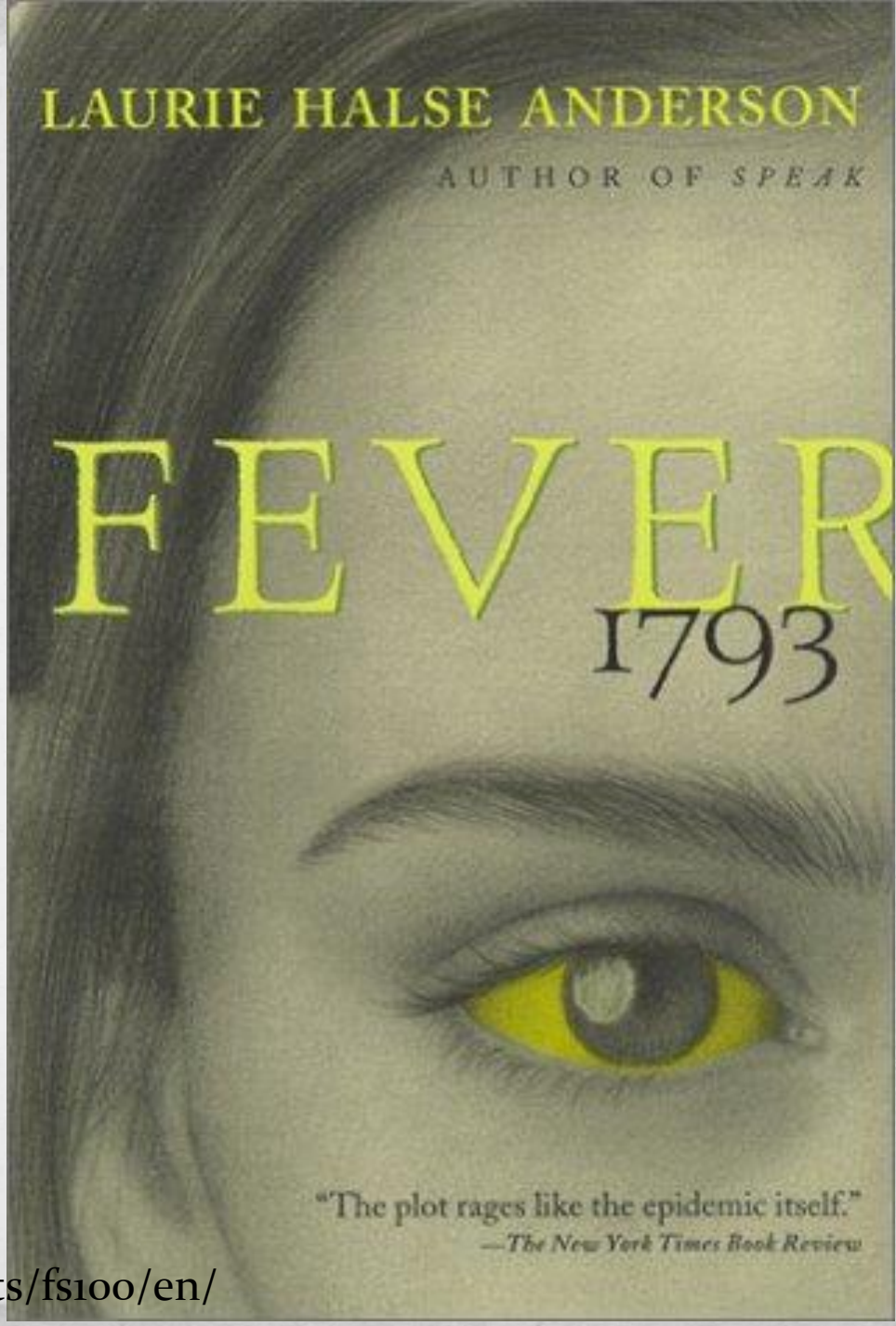
(Science 2011)



Yellow fever

- Yellow fever is an acute viral *hemorrhagic* disease transmitted by infected mosquitoes
  - Yellow=jaundice
- 200,000 cases of yellow fever
  - 30,000 deaths
  - Worldwide, yearly
  - 90% in Africa
- Family Flaviridae

http://www.who.int/mediacentre/factsheets/fs100/en/



Dengue Hemorrhagic Fever

Effective vaccine is available, if you can get it

March 12, 2018, NYT

UPDATE

Thinking of Going to Brazil? You Will Need a Yellow Fever Vaccination

The Centers for Disease Control and Prevention says that an outbreak of the virus means that travelers should get the vaccine before a trip.

Carried by mosquitoes, the virus has spread to the very edge of Brazil's largest cities, including São

237 deaths in the season already

"If you vaccinate 30 million people, you'll get about 30 deaths," he says....

".... But if yellow fever infected 30 million people, two million could die."

Estimated lifetime cost of microcephaly: $4.1 million USD

Congenital Zika Syndrome:
…infected with Zika virus before birth (CDC)

- Severe microcephaly; skull has partially collapsed
- Decreased brain tissue with a specific pattern of brain damage…
- Damage to the back of the eye…
- Congenital contractures, such as clubfoot or arthrogryposis
- Hypertonia restricting body movement soon after birth

How do we accomplish AIPM?

- We need more “boots on the ground” for surveillance.
  - There is no national surveillance system for non-agricultural, non-plant pests.
- We need well-trained, field-ready entomologists who can recognize invasive species and resurging pests; then come up with a plan to effectively “control, contain, and clean up.”
- In short, we need resources that will support the implementation of the National IPM Roadmap.

Areawide IPM – Aquatic Weed Control

Dr. Lee Van Wychen
Director of Science Policy
The National and Regional Weed Science Societies

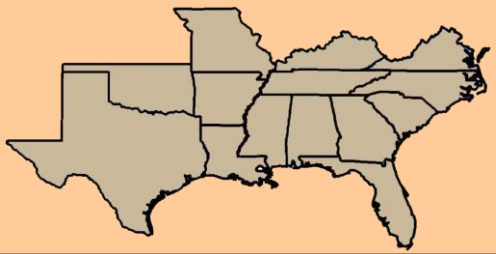
WSSA
WEED SCIENCE SOCIETY OF AMERICA
www.wssa.net

NORTHEASTERN
WEED SCIENCE SOCIETY

North Central
Weed Science Society
NCWSS

WESTERN SOCIETY OF WEED SCIENCE

Southern Weed Science Society



APMS
Aquatic Plant Management
Society, Inc.

Outline

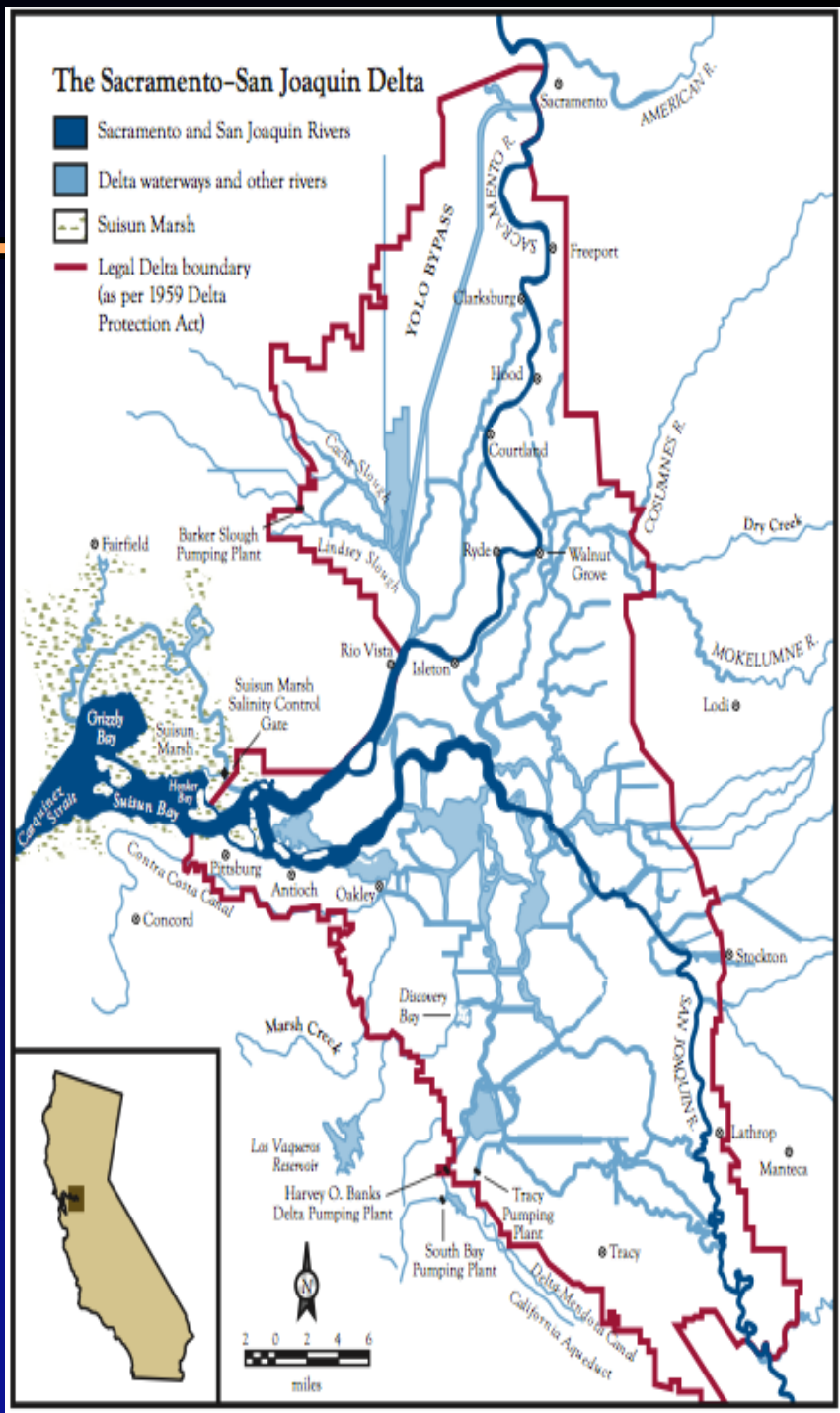
1. Delta Region Areawide Aquatic Weed Project:
   http://ucanr.edu/sites/DRAAWP
   - Sacramento/San Joaquin River Delta importance
   - Aquatic Weed Targets
   - Stakeholder Collaboration
   - Research and Assessment

2. Other Successful Weed AIPM Projects:
   TAME Melaleuca; TEAM Leafy Spurge

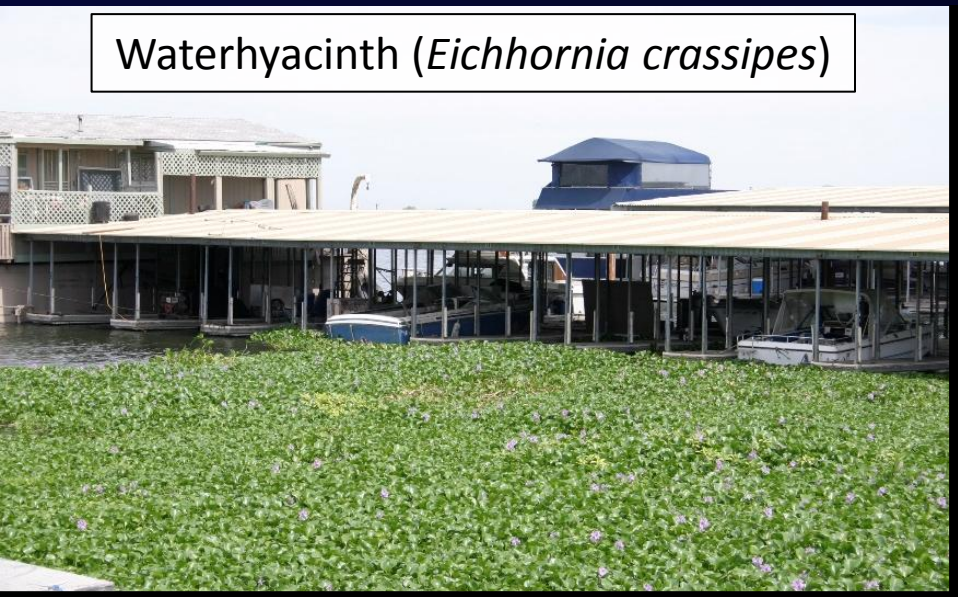
3. Take Home Message

Sacramento / San Joaquin River Delta

- Largest freshwater estuary on the West Coast (68,000 surface water acres)
- Irrigates 4 million acres of Central Valley cropland valued at $25 billion
- Provides drinking water to 25 million people in CA
- Habitat for 56 rare, threatened or endangered species
- 2 million recreational boat trips per year, 100 marinas
- Stockton and Sacramento ports ship 4 million tons/yr



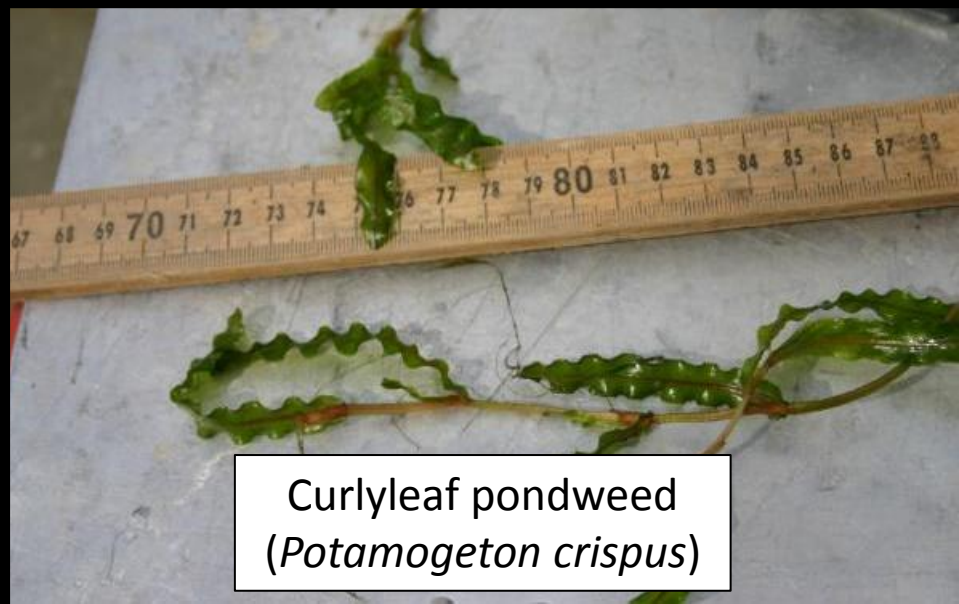
Major Delta Weeds



Waterhyacinth (*Eichhornia crassipes*)

Brazilian egeria (*Egeria densa*)

South American spongeplant (*Limnobium laevigatum*)



Curlyleaf pondweed (*Potamogeton crispus*)

Agencies and Academic Departments Involved In the Delta Region Areawide Aquatic Weed Project

USDA United States Department of Agriculture
Agricultural Research Service

Delta Region Areawide Aquatic Weed Project

USDA Agricultural Research Service

California State Parks Boating and Waterways

NASA

UCDAVIS Department of Plant Sciences
College of Agricultural and Environmental Sciences

University of California Agriculture and Natural Resources

Sacramento - San Joaquin Delta Conservancy
A California State Agency

San Joaquin County Mosquito & Vector Control District
Protection through Prevention

Contra Costa Mosquito & Vector Control District

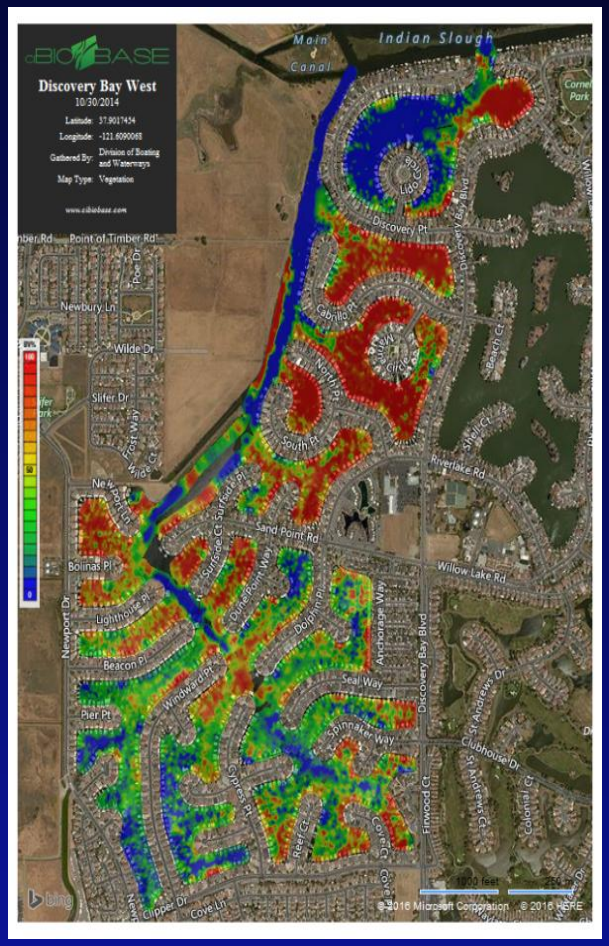
AIC University of California Agricultural Issues Center

- Many other Federal, CA State, and Local agencies are involved as cooperators
- Also private interest groups, marina owners

Integrated Aquatic Weed Management

- Manual removal (handpicking)
- Mechanical control ($50,000/ac)
- Biocontrol
  - Release of five insect species on two weeds by USDA ARS and CDFA
- Chemical control
  - Glyphosate ($400/ac – floating weeds)
  - 2,4-D
  - Fluridone ($5,000/ac- submersed weeds)
  - Imazamox
  - Penoxsulam
  - Diquat

Hydroacoustic Assessment of Brazilian Egeria Treatments

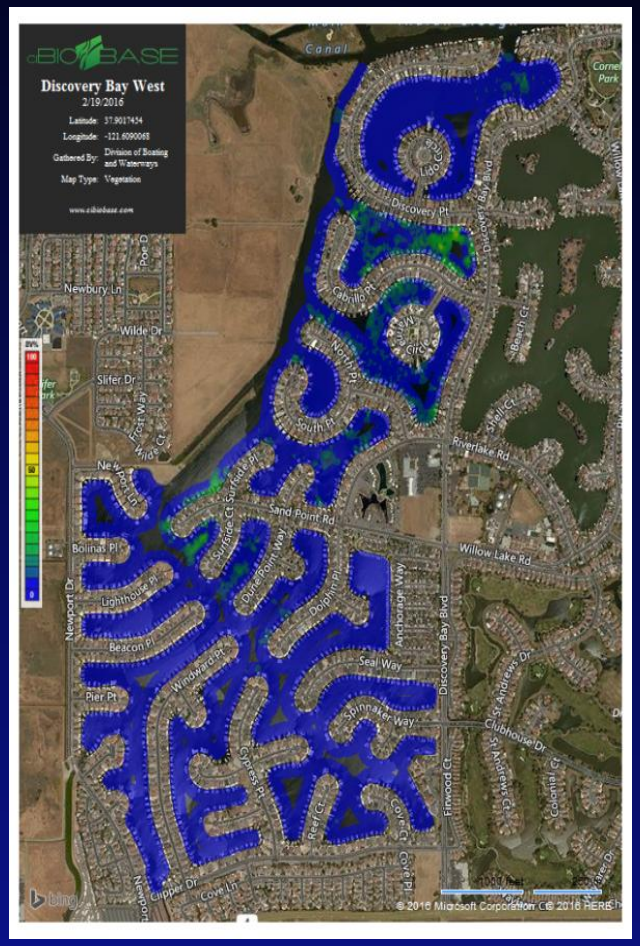


Before fluridone treatment
OCT 2014

Red – abundant submersed plants

Green – moderate submersed plants

Blue - few to no submersed plants



1 yr after fluridone treatments
FEB 2016

TAME Melaleuca AIPM Project

http://tame.ifas.ufl.edu

TAME MELALEUCA

A Century of Melaleuca in South Florida

For more information on melaleuca and its management, visit the TAME Melaleuca Web site

http://tame.ifas.ufl.edu

Project Coordinator: Cressida Silvers
USDA-ARS Invasive Plant Research Laboratory
Ft. Lauderdale, FL
(954) 475-0541

USDA ars UNIVERSITY OF FLORIDA IFAS

February 2004

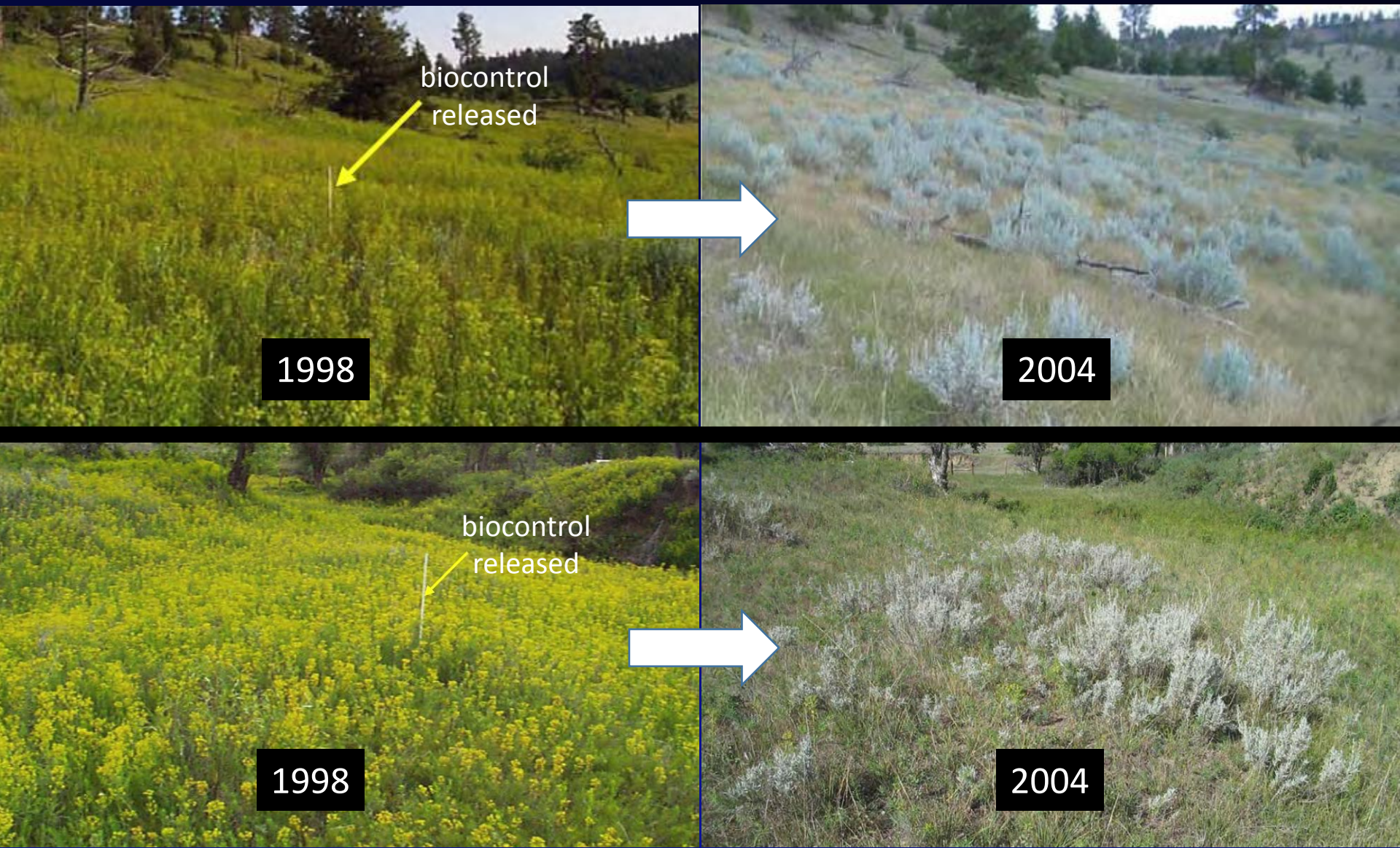
http://tame.ifas.ufl.edu

The Green Menace from Down Under

First brought to Florida from Australia around 1900, melaleuca (MEL-ah-LUKE-ah) found widespread use as an ornamental tree and as a soil stabilizer on levees and spoil islands. It was even used in early attempts to dry up the Everglades. However, as is often the case when species are introduced beyond their natural range without the associated enemies (e.g. insects, viruses) that control their population, the plant soon became a nuisance. It faced little opposition and quickly spread beyond the areas where it was intentionally planted. Melaleuca was first reported in Everglades National Park in 1967, and by 1993 was estimated to cover 488,000 acres in South Florida. Eventually, melaleuca colonized up to 20 percent of all natural land south of Lake Okeechobee. Melaleuca is now listed by federal and state agencies as a noxious weed, making it illegal to possess, sell, cultivate, or transport melaleuca in Florida.

TEAM Leafy Spurge AIPM Project

www.team.ars.usda.gov



Take Home Message

WHY AREAWIDE IPM?

- Research, Coordination and Integration over a Region
- Multiple Customers and Stakeholders
- Develops Resources and Training that will last Beyond the Initial Research Project


Areawide IPM: Pests of Forest and Urban Trees

Paula Shrewsbury, Ph.D.

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University of Maryland

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UNIVERSITY OF MARYLAND EXTENSION
Solutions in your community

UNIVERSITY OF MARYLAND 18 56

Non-native Forest Pests: Excellent candidates for Areawide IPM

- **Economically and environmentally devastating**
- **Highly mobile; human assisted distribution; pest populations in many states**
- **Impact trees in natural and urban forests, wood industries (diverse habitats)**

Biology and Economic Assessments of Insect "Guilds" – 3 "Poster Pests" (of ~450 non-native forest and urban tree pests)

1. Guild 1 – Boring Insects

- **Emerald Ash Borer**, ***Agrilus planipennis***

2. Guild 2 – Sap-Feeding Insects

- **Hemlock Woolly Adelgid**, ***Adelges tsugae***

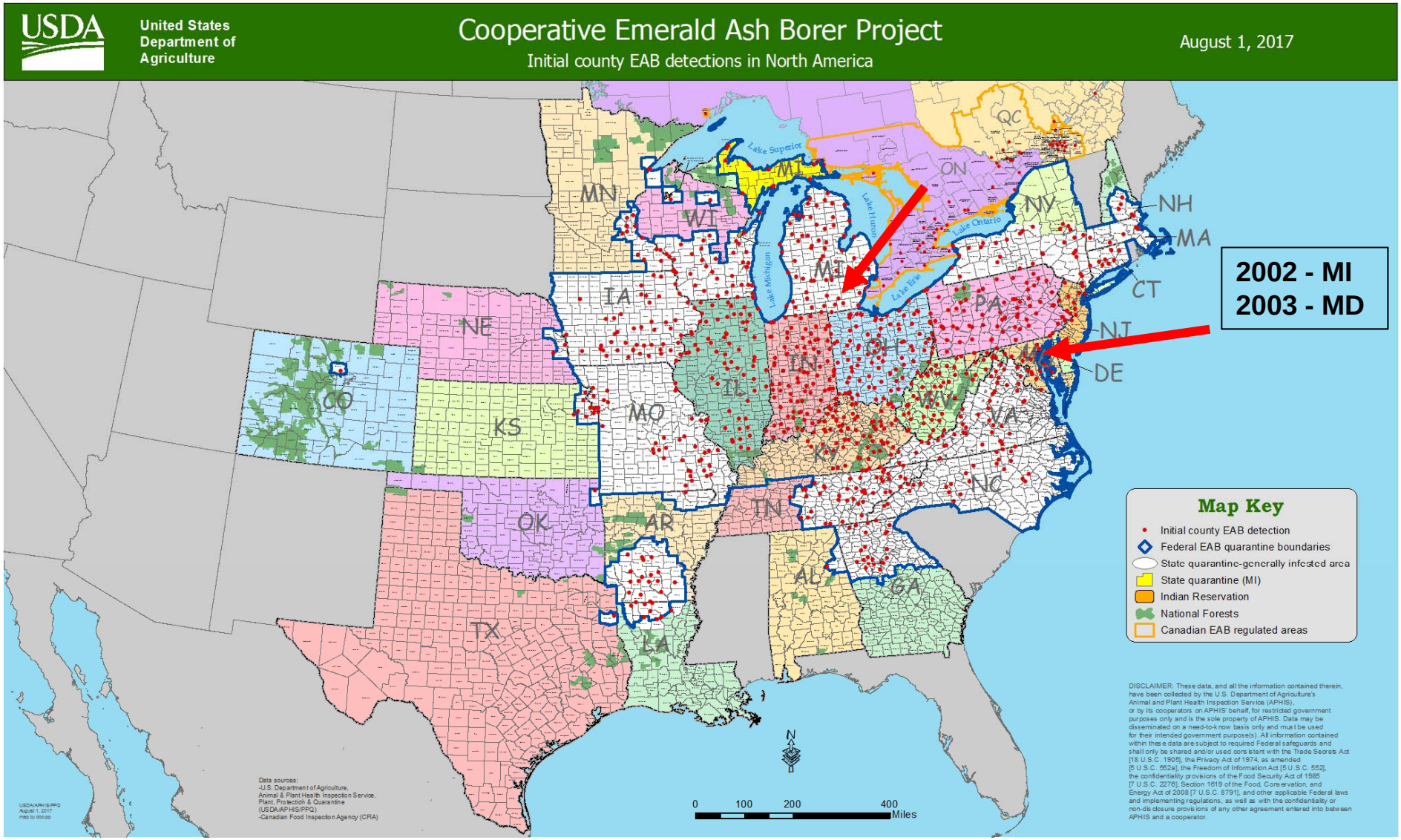
3. Guild 3 - Leaf-Feeding Insects

- **Gypsy Moth**, ***Lymantria dispar***

Aukema et al. 2011

Emerald Ash Borer (EAB)

EAB has killed > 100 million trees in 32 states, 3 Canadian provinces



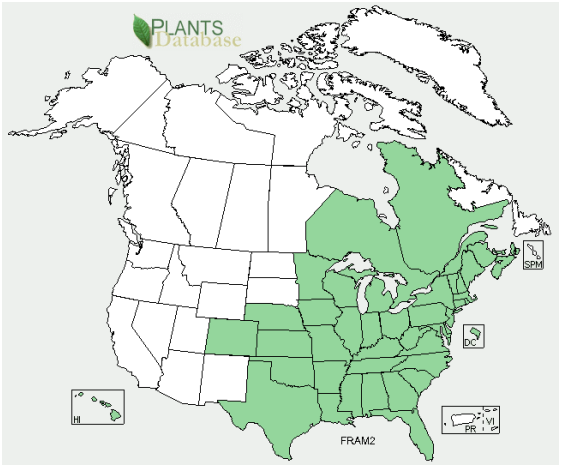
http://www.emeraldashborer.info

2002 - First detected in North America

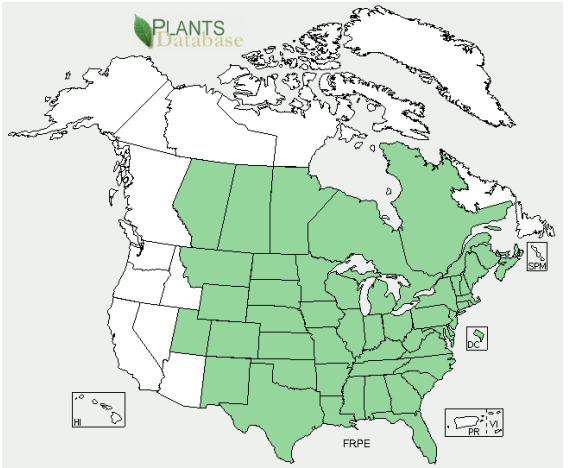
What's at stake?

- **~100% ash mortality (1-3 yrs)**
- **All 16 native species susceptible**
- **~8 billion ash in US forests, wetlands**
- **30-90 million ash in urban forests**
- **Management costs and losses: > $20-60 billion**
- **Ash saw timber value: $25 billion**
- **Baseball bats**

White ash: *Fraxinus americana*



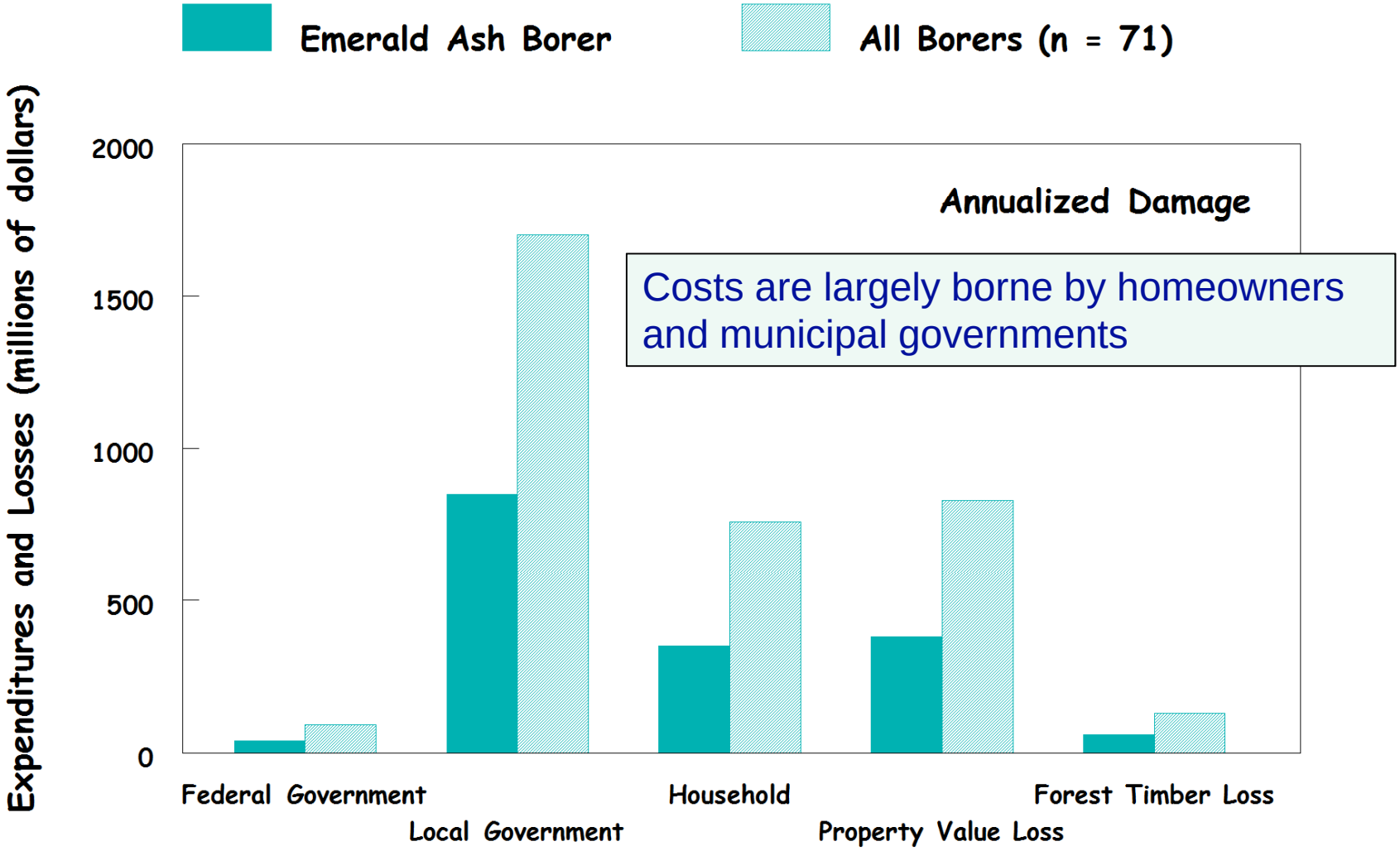
Green ash: *Fraxinus pennsylvanica*



What's at stake?

- ~Ash is in the olive family (Oleaceae)
- More than 44 other species of organisms have unique associations with ash
- Will these become extinct as well?
- Social costs – trees, gardens affect health and well-being of people

Expenditures and Losses from EAB compared to all non-native borers

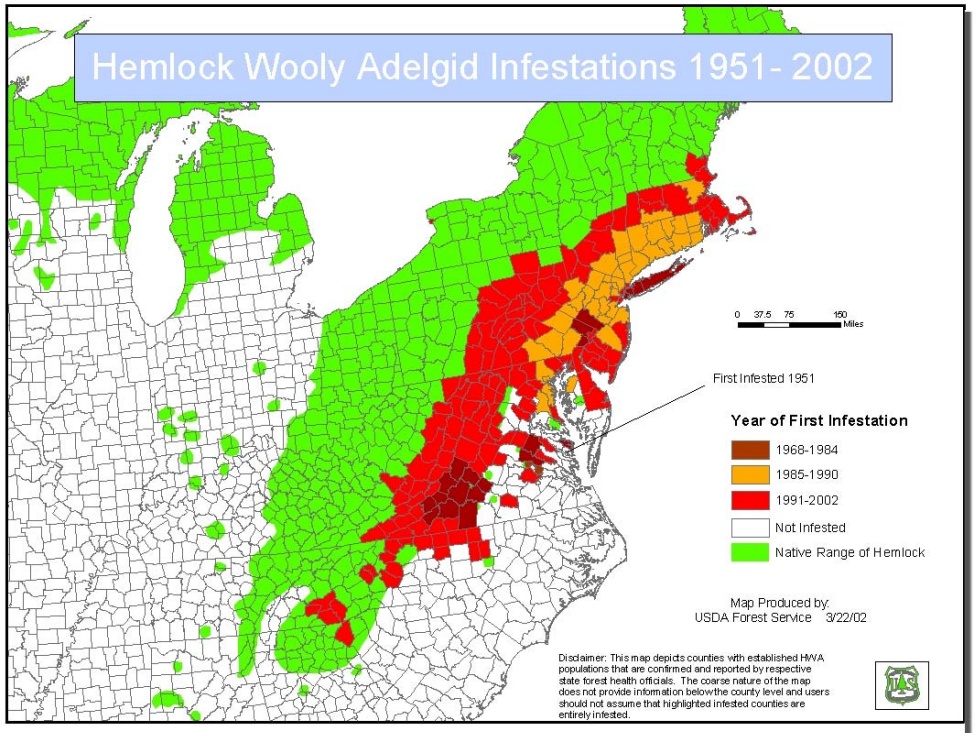


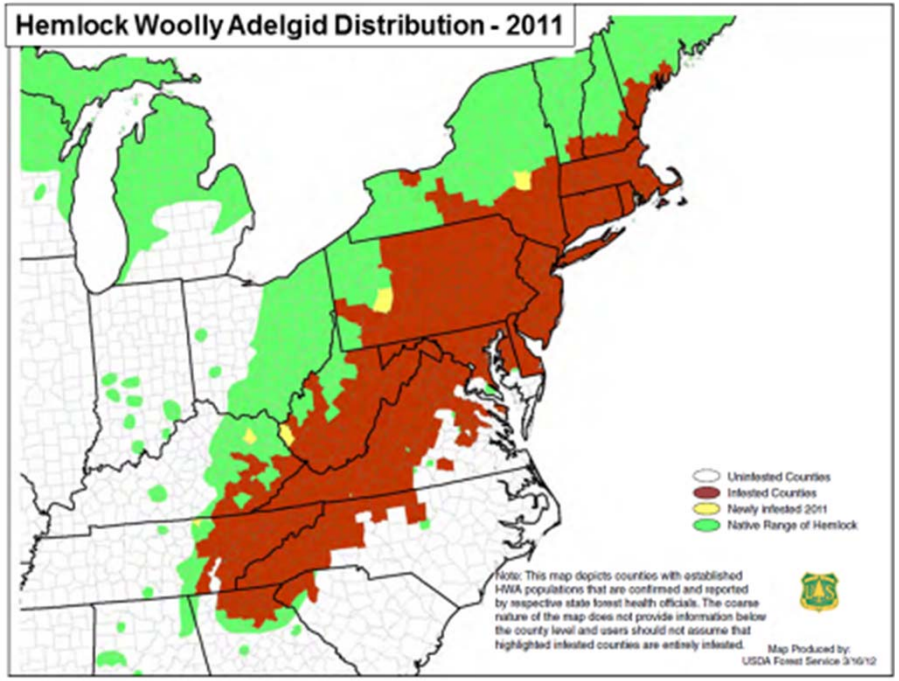
Aukema et al. 2011

Poster Pest: Hemlock Woolly Adelgid

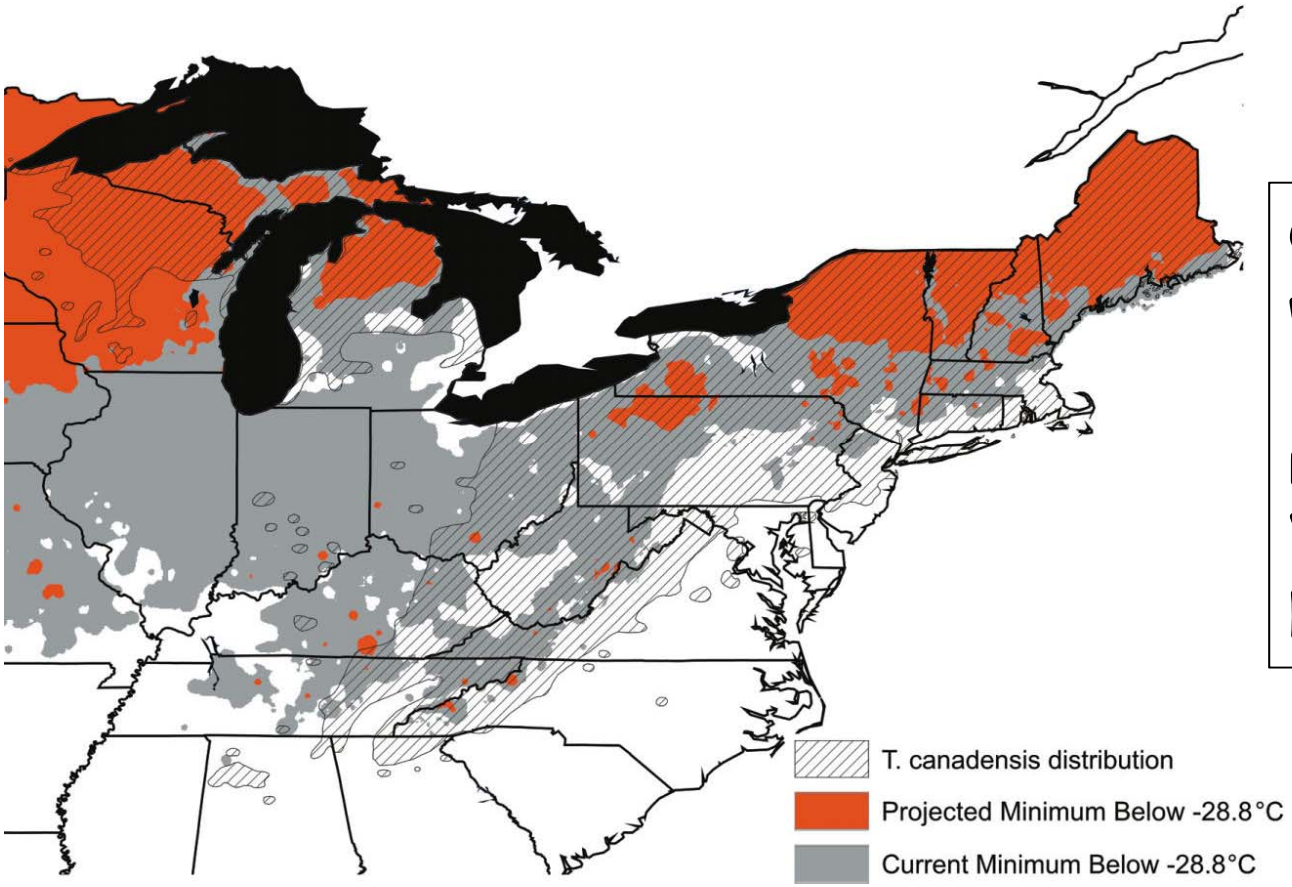
Untreated infestations can lead to tree death in less than ten years

Hemlock wooly adelgid change in distribution over time





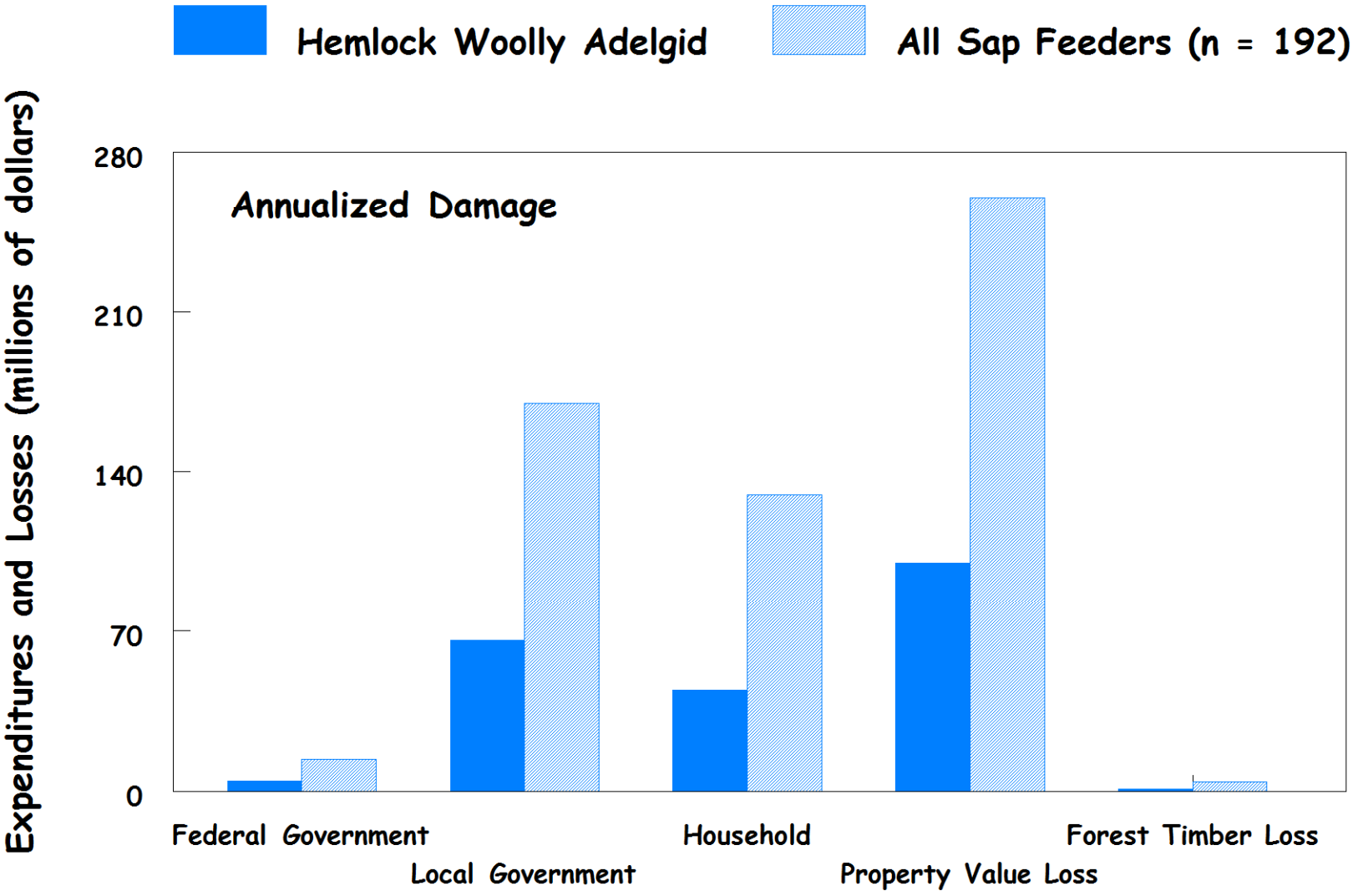
Current distribution of HWA in the US is limited to locations where minimum winter temperatures stay above –28.8C (-20F)



Climate change will greatly increase the range of Hemlock Woolly Adelgid in North America

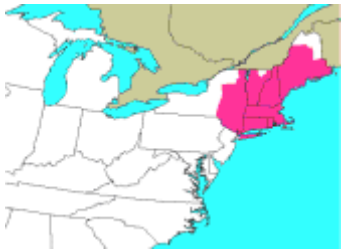
Fig. 3. The current distribution of eastern hemlock (Tsuga canadensis; hatched areas) in the northeastern United States, superimposed on maps of current and projected minimum temperature thresholds for hemlock woolly adelgid survival (red, grey, and black areas). The current distribution of HWA in the US is limited to locations where minimum winter temperatures stay above –28.8 8C (white areas; Skinner et al. 2003). Based on recent climate projections (Fig. 2; Hayhoe et al. 2006), the area of hemlock protected by this extreme cold could be significantly reduced by 2070 (red areas). If HWA adapts to extreme cold (see text), hemlock may be limited to small pockets in the extreme northern portions of Maine, Vermont, New Hampshire, New York, and Wisconsin where temperatures drop below –35 8C (black areas).

Expenditures and Losses from HWA compared to all non-native sap feeders

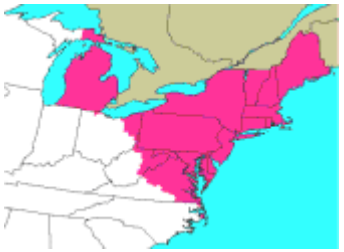


Aukema et al. 2011

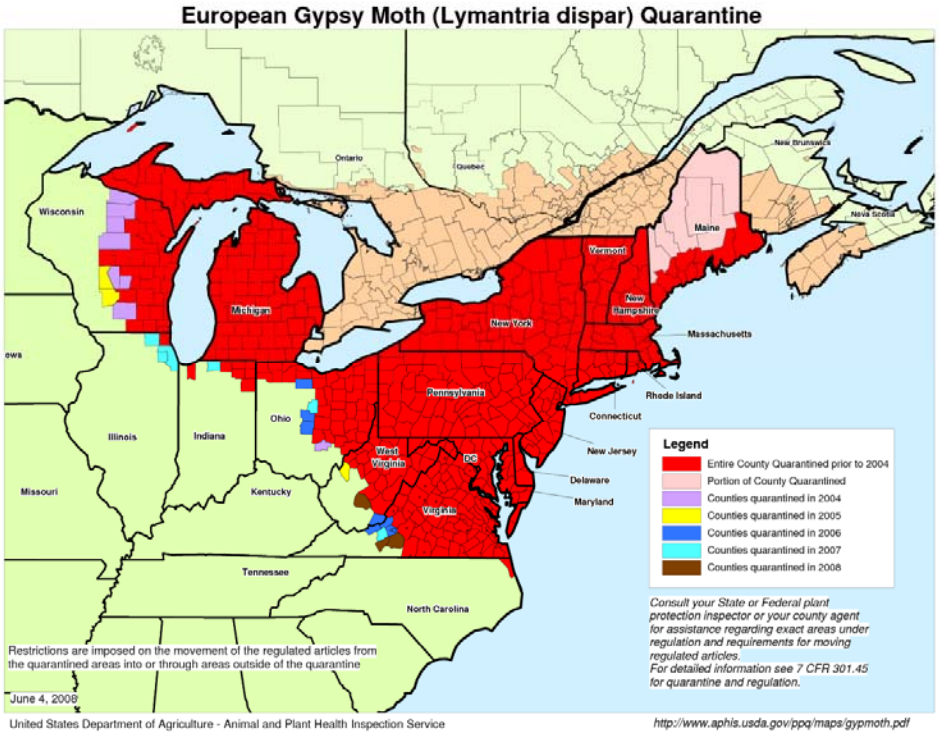
1900



1965

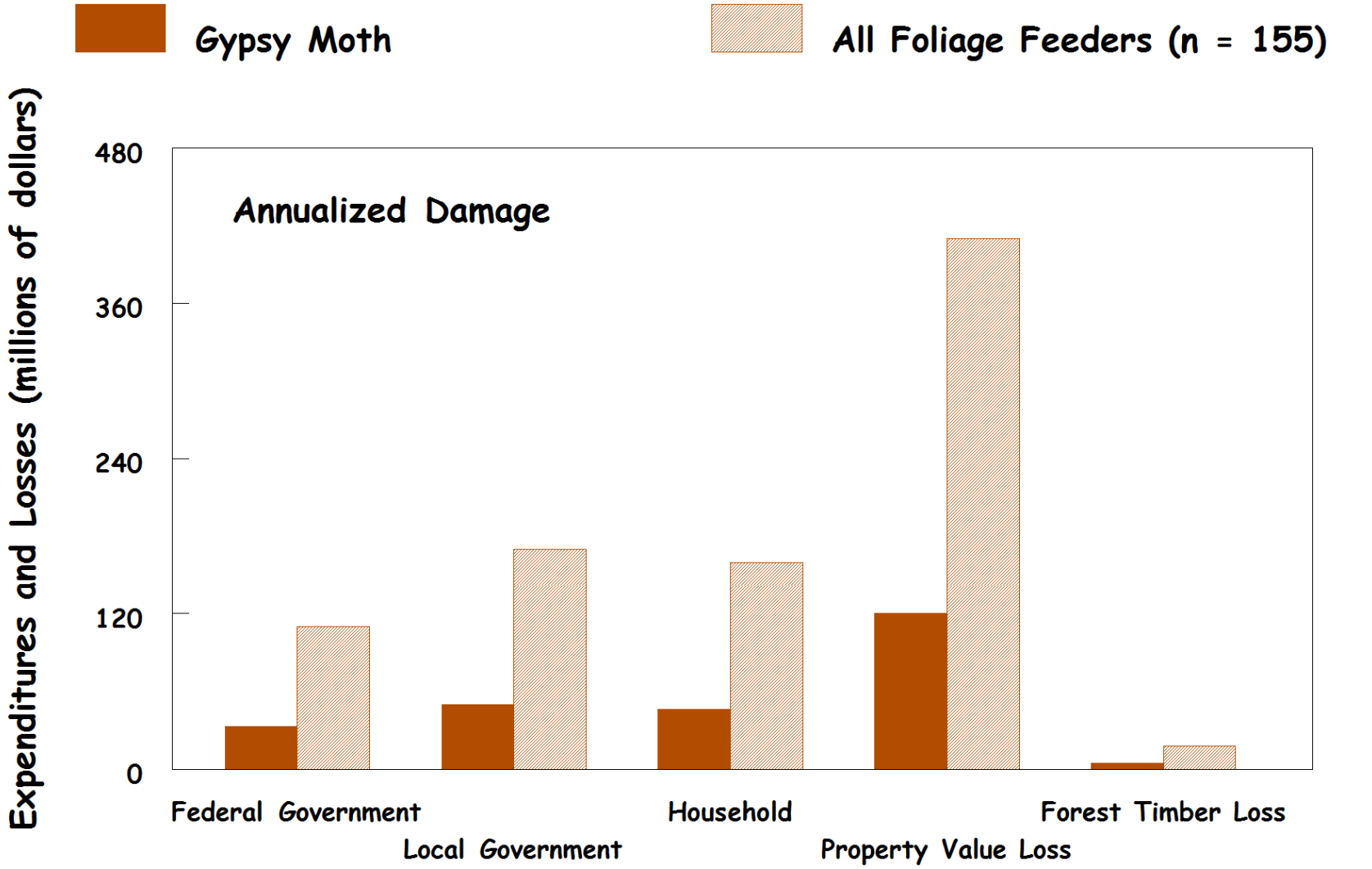


1994



Gypsy Moth on the Move

Expenditures and Losses from GM compared to all non-native foliage feeders



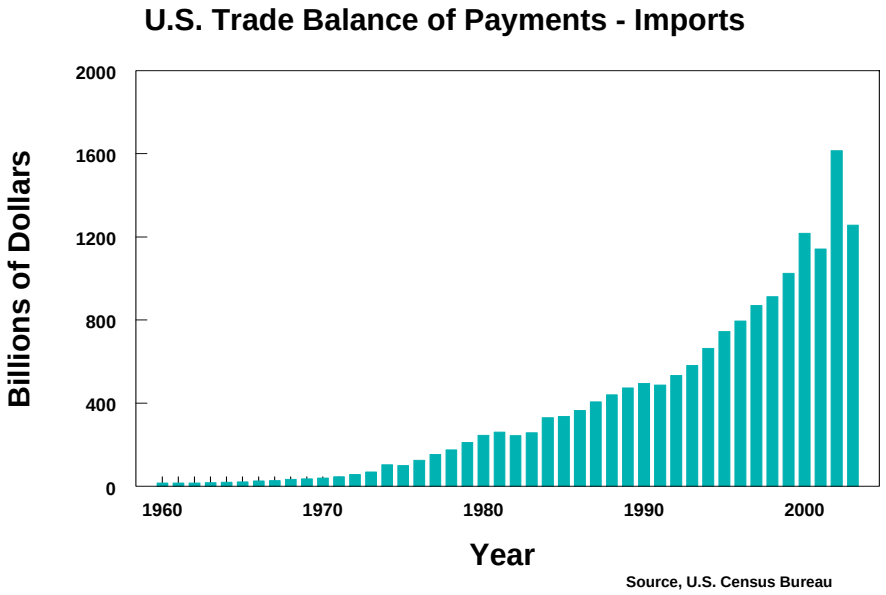
Aukema et al. 2011

Areawide IPM towards reducing economic and environmental effects of invasive forest pests

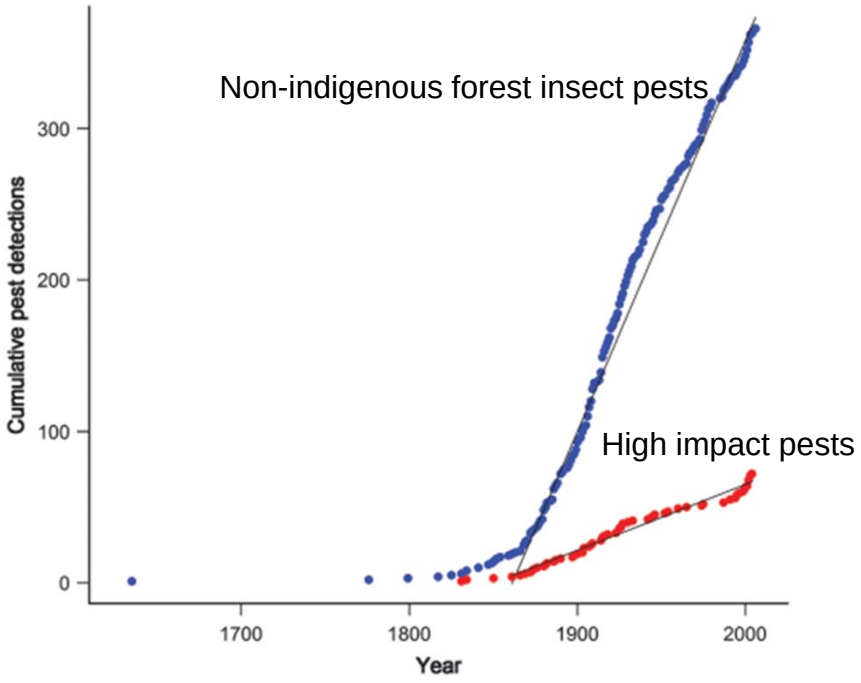
- **Uniform suppressive pressure against the total pest population over generations (broad spatial and temperal scales)**
- **Collaboration and multi-year plan - Everyone must participate!**
  - **Multi-agency, institution; local, regional, national, citizens**
- **Research and Extension to inform government agencies, practitioners, and citizens on sustainable management of invasive insects**
- **Emphasis on systems-based strategies that utilize multiple tactics that emphasize prevention, avoidance, monitoring, and suppression using practices that are biologically-based and reduce risk to human health and the environment**

What lies ahead for forest pests?

Global Economy = Global Biota



“There is a 32% chance that another highly destructive borer will enter the US in the next 10 years”



Aukema et al. 2011

Areawide IPM: Forest pests in natural and urban environments

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Brown Marmorated Stink Bug: An Invasive Areawide Pest

Kelley J. Tilmon, The Ohio State University

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Photo courtesy of John Tooker, Penn State University

BMSB: Pest of Fruit, Vegetable, and Field Crops

ipm.msu.edu

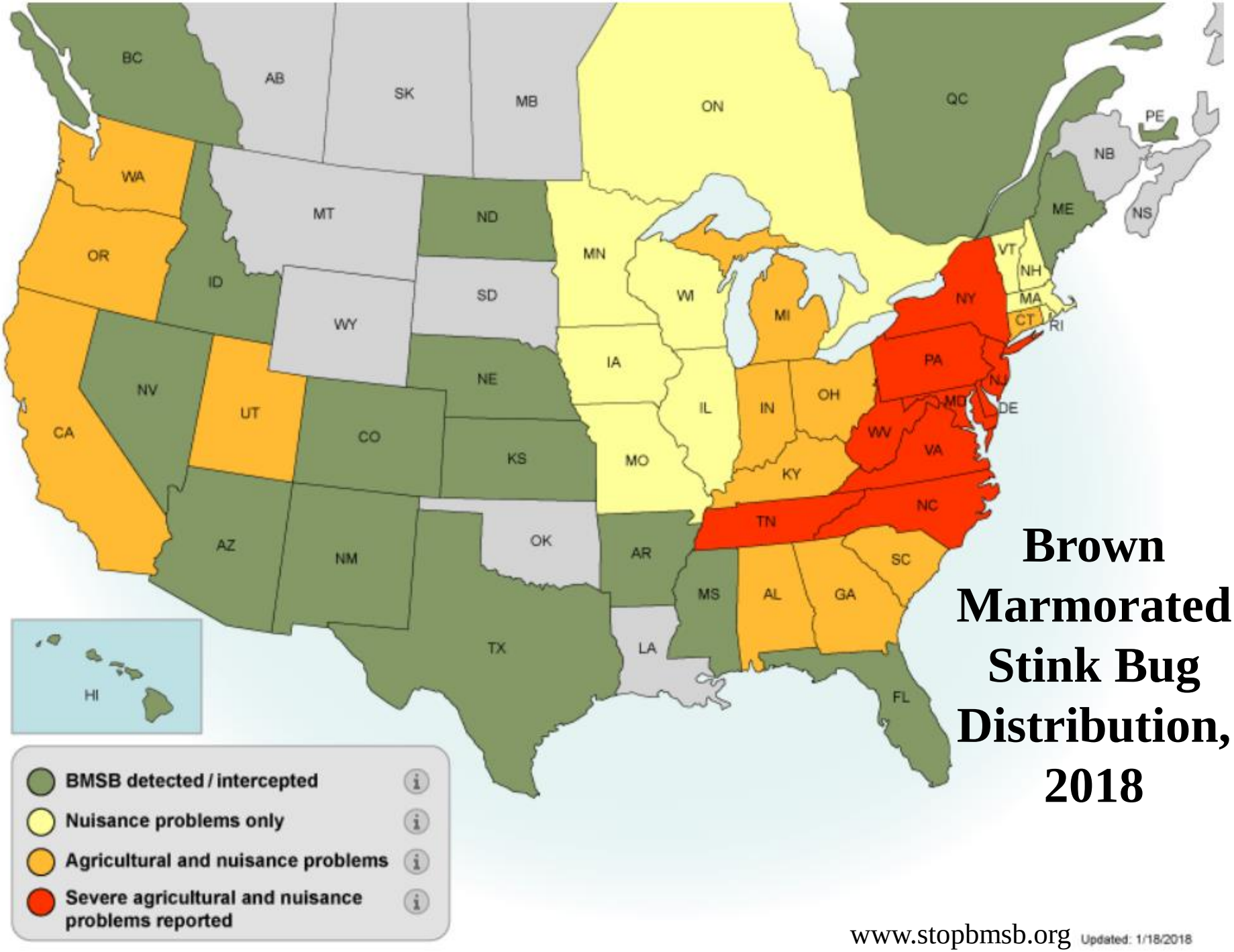
udel.edu

wsu.edu

stopbmsb.org

BMSB in Soybean: Up to 40% Yield Loss

First detection: Allentown, PA – late 1990s



Brown Marmorated Stink Bug Distribution, 2018

www.stopbmsb.org Updated: 1/18/2018

Washington State University

Washington State University

University of Maryland

Washington State Uni

f Maryland

Ohio State University

How Areawide IPM Could Help

- Research to understand how populations in one habitat influence others
- Coordinated monitoring and management in different regions, crops, settings
- Importation biological control to suppress populations region-wide

www.stopbmsb.org

Search

ABOUT US *Project, people, research, reports, publications...*

STINK BUG BASICS *Origins, life stages, photos, look-alike insects...*

WHERE IS BMSB? *Maps, crops, host plants, damage gallery...*

MANAGEMENT *Monitor, manage by crop, behavior and landscape...*

BIOLOGICAL CONTROL *Native natural enemies, samurai wasp...*

MORE RESOURCES *News, videos, español, resource links...*

Overview

The brown marmorated stink bug, *Halyomorpha halys* (Stål), is a voracious eater that damages fruit, vegetable, and nut crops in North America. With funding from USDA's Specialty Crop Research Initiative, our team of more than 50 researchers is uncovering the pest's secrets to find management solutions that will protect our food, our environment, and our farms.

Updates

When Twenty-Six Thousand Stinkbugs Invade Your Home These uniquely versatile bugs are decimating crops and infiltrating houses all across the country. Will we ever be able to get rid of them? *Source: The New Yorker, Mar. 12, 2018.*

Samurai Wasp A key natural enemy of brown marmorated stink bug is the egg parasitoid *Trissolcus japonicus*, also known as the "samurai wasp". These stingerless warriors search for and destroy 60–90% of BMSB eggs in Asia.

A Look at Just How Invasive the Brown Marmorated Stink Bug Is NPR's Ari Shapiro talks with Kathryn Schulz, who writes about the brown marmorated stink bug in the latest issue of *The New Yorker*. *Source: NPR All Things Considered, Mar. 7, 2018.*

Origins of BMSB Learn about the pest's biological roots in Asia, its reach throughout North America, and our team's work to identify, monitor, and manage the risks.

Stink Bugs on Ships Disrupt Japan's Car Exports A pesky insect known as the "stink bug" is preventing thousands of Japanese cars from being delivered to New Zealand. *Source: CNN Money, Feb. 20, 2018.*

Stakeholder Advisory Panel Meeting, January 2018 Download presentations from the BMSB Stakeholder Advisory Panel Meeting, held January 9, 2018.

IPM Crop Perimeter Restructuring The implementation of IPM Crop Perimeter Restructuring (IPM-CPR) for the management of key tree fruit pests may be less costly, more sustainable, enhance biological control, and be just as effective as current standard management methods.

Annual Reports The 2017 annual report for the project "Management of Brown Marmorated Stink Bug in US Specialty Crops" is available for download.

Funding

USDA United States Department of Agriculture National Institute of Food and Agriculture
Specialty Crop Research Initiative

Collaborators

ars
NC STATE UNIVERSITY
OSU Oregon State
UNIVERSITY OF MARYLAND
WASHINGTON STATE UNIVERSITY
Northeastern IPM Center
Cornell University
RUTGERS UNIVERSITY
THE OHIO STATE UNIVERSITY
UNIVERSITY OF MINNESOTA
VirginiaTech
MICHIGAN STATE UNIVERSITY
PennState
University of Kentucky
UNIVERSITY OF GEORGIA
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Stink Bugs in New Places

Thanks! Questions?