Plum Pox Virus Status Report

* Summary of the International Meeting at UC Davis
* Sep 29-30, 2014

Sponsors

UC Davis –
- Fruit & Nut Research & Info Center
- Dep't of Plant Sciences
- College of Ag & Environmental Sciences
- Dep't of Plant Pathology
- Foundation Plant Services

USDA –
- Ag Research Service

National Plant Diagnostic Network, Western Region
Calif Tree Fruit, Nut Tree & Grapevine Improvement Adv Board
California Dep't of Food & Ag
California Specialty Crops Council
California Fresh Fruit Association
National Peach Council
Almond Board of California
California Dried Plum Board
California Cherry Board
Del Monte Foods, Inc
Gerawan Farming, Inc

Speakers –

Delano James – Canadian Food Inspection Agency

Marc Fuchs – Dep't of Plant Pathology, Cornell Univ

Phil Baugher, Adams County Nursery, Pennsylvania

Rick Mumford, Food & Env Research Agency, United Kingdom

Sylvie Dallot, French National Institute for Ag Research

Tadeusz Malinowski, Polish Research Institute of Horticulture

Ruth Welliver, Pensylvania Dep't of Agriculture

Timothy Gottwald, USDA ARS, Fort Pierce, Florida

Bill Schneider, USDA ARS, Fort Detrick, Maryland

Maria Badenes, Valencian Institute of Ag Investigations, Spain

Ralph Scorza, USDA ARS, Kearneysville, W Virginia

Margaret Kelly, NY State Dep't of Agriculture

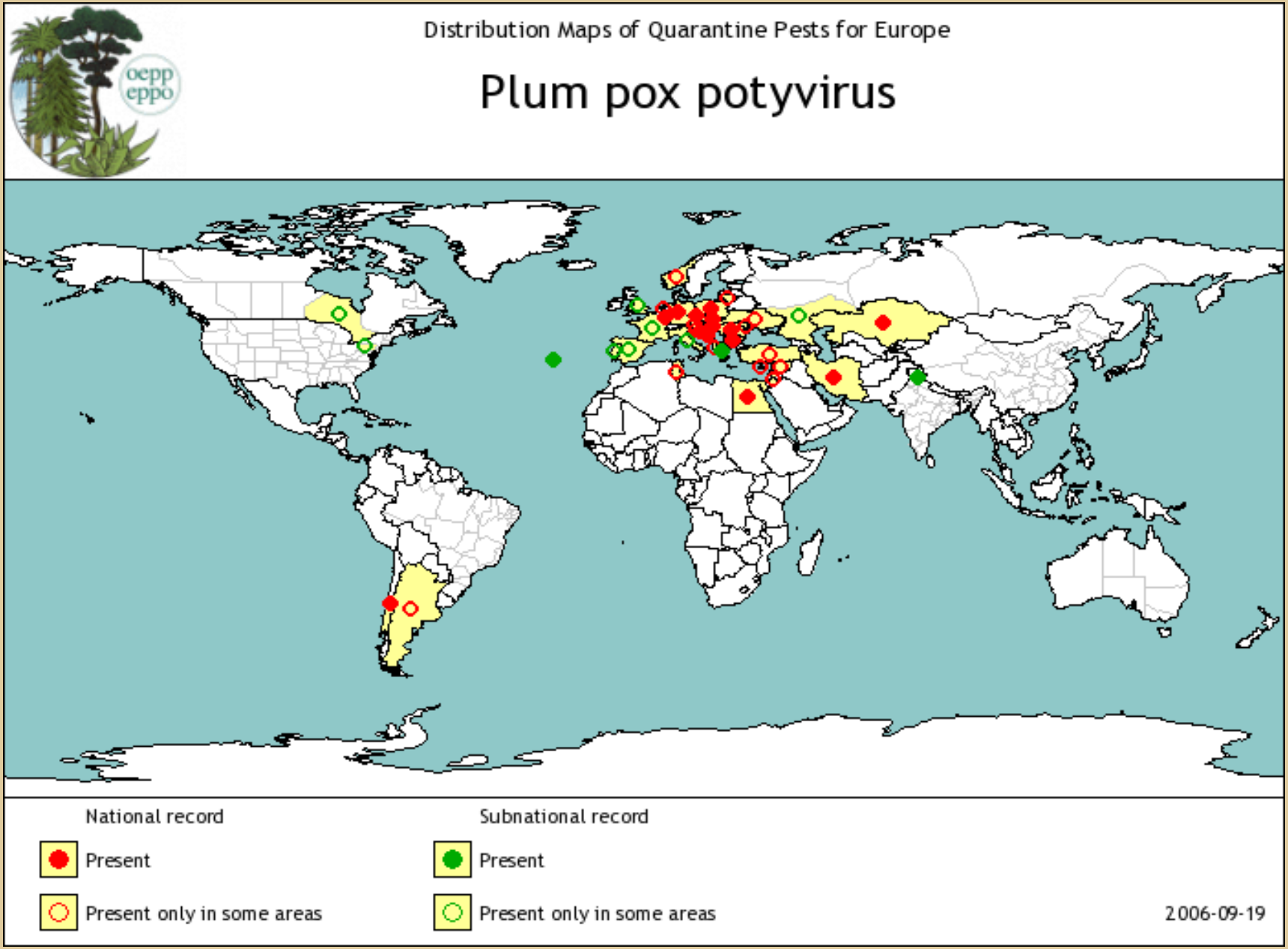
Michael Guidicipietro, USDA APHIS, SF, CA

Plum Pox Virus
aka ‘Sharka’

- Plum Pox Virus (PPV) is a virus that infects plants in the genus *Prunus* - plums, peaches, apricots etc.
- Plum Pox is the most serious disease of stone fruits in Europe.
- The virus has several strains : D, M, C, W and EA strains.

Spread & Distribution of PPV

* 1917 – Bulgaria (first observation)
* 1932-60 – Yugoslavia, Hungary, Romania, Albania, Czechoslovakia, Germany, Russia
* 1960’s – England, Turkey, Netherlands, Switzerland, Greece
* 1970’s – France, Italy, Belgium
* 1984 – Spain
* 1992 - Chile
* 1999 –Pennsylvania
* 2000- Ontario, and Nova Scotia
* 2004 - Argentina
* 2005 - China
* 2006 –New York and Michigan



Map provided by EPPO (European and Mediterranean Plant Protection Organization)
http://www.eppo.org/QUARANTINE/virus/Plum_pox_virus/PPV000_map.htm

Plum Pox Virus
Why is this a problem?

* Plum pox virus or PPV does not kill trees but causes yield losses and reduces the marketability of fruit.
* In Europe, reported losses of 80-100% in susceptible cultivars.
* PPV was originally on the select agent list. It was removed in 2005 but is still a regulated pathogen in the U.S.

Photo John Hammond, USDA-ARS

Prunus Hosts

- **Peaches**
- **Plum**
- **Apricots**
- **Nectarines**
- **Almonds**
- **Sweet cherry**
- **Tart cherry**
- **Some ornamental and wild native *Prunus* species**

Photo: Terry Spivey, USDA Forest Service http://www.ipmimages.org

Photo: Peggy Greb, USDA Agricultural Research Service http://www.ipmimages.org

Plum Pox Virus
What does it look like?

- **Fruit**
  - Lightly pigmented rings.
  - Necrotic or brown areas.
  - Infected plums and apricots can be deformed and have rings on the surface of the seed.
- **Leaves**
  - Yellow veins and yellow to light green rings.
- **Flowers**
  - Streaking on the petals
  - Pigmented ring patterns

Photo Biologische Bundesanstalt für Land- und Forstwirtschaft Archive , www.ipmimages.org

Photos Top: K.D. Hickey, Penn State University and Bottom: R. Scorza, USDA

Symptoms

- Leaves
  - Yellowing and browning ring patterns, bands, or blotches
- Fruit
  - Yellowing and browning ring patterns, bands, or blotches
  - Misshapen or deformed

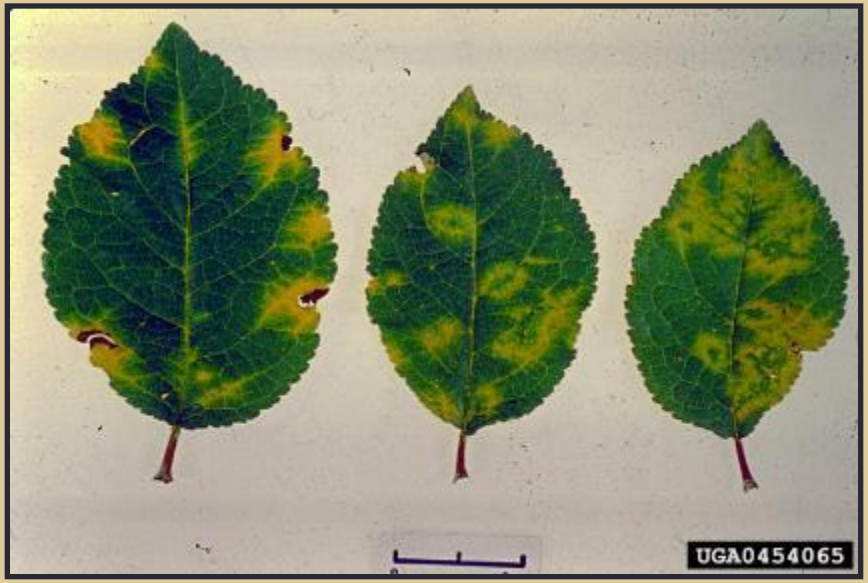


Photo: Biologische Bundesanstalt Archives, Germany
http://www.ipmimages.org

Symptoms

Flowers

- **Streaking on the petals**
- **Pigmented ring patterns**

Prunes with PPV

Discolored &
blotchy fruit

premature fruit drop

Myrobalane (Prunus cerasifera) – PPV-D

Transmission

- Introduction to new regions through propagative materials and distribution of contaminated materials
  - Live nursery stock
  - Grafts
  - Budwood

Photo: Carroll E. Younce, USDA Agricultural Research Service http://www.ipmimages.org

Transmission

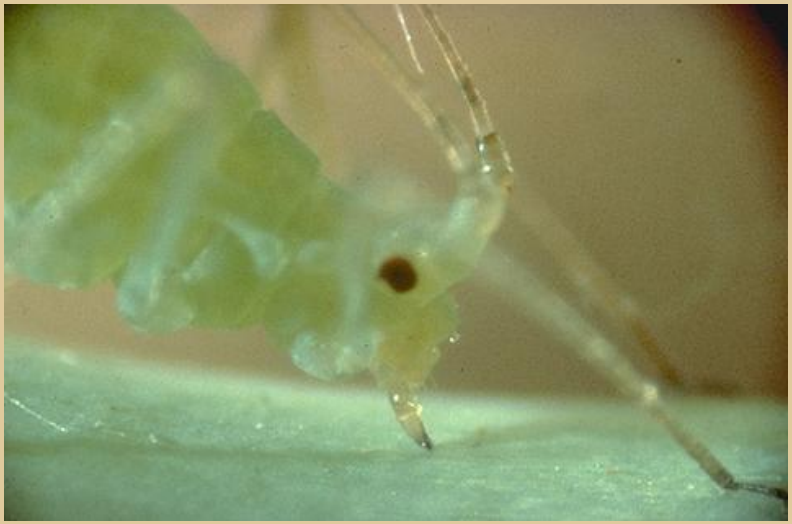
- PPV transmitted by at least 20 aphid species
- Most important vectors in Pennsylvania:
  - *Myzus persicae*
  - *Aphis spiraecola*
- Transmitted by transient (moving through orchard) and colonizing (staying in the orchard) aphids

Myzus persicae

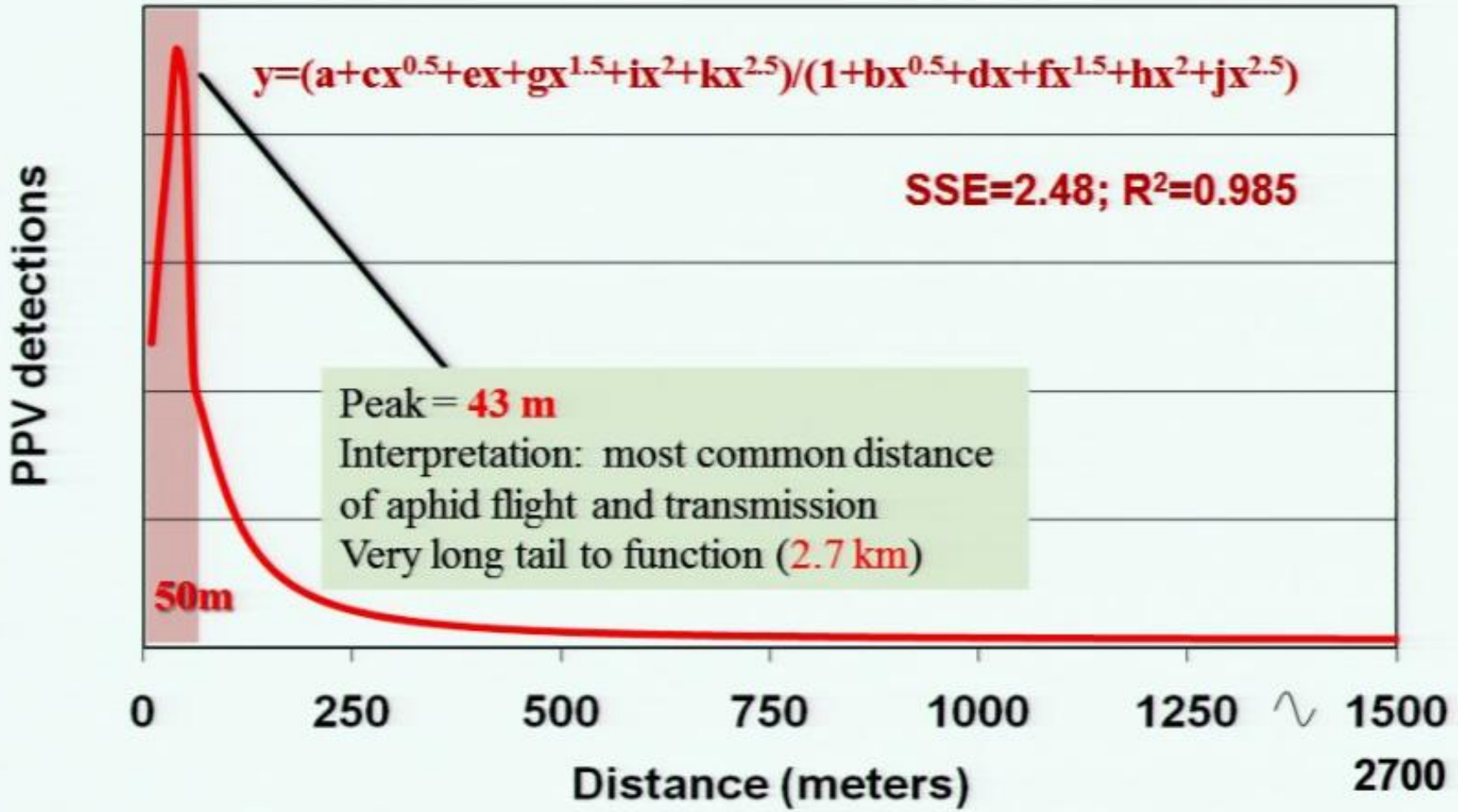
Photo: Scott Bauer, USDA Agricultural Research Service http://www.ipmimages.org

Transmission

* Piercing-sucking mouthpart probes vascular tissue of plants while feeding, PPV sticks to the food canal
* Injected into another plant as aphid feeds
* PPV can be acquired by probes as brief as 30 seconds
* PPV transmitted usually within 1 hour
* Most aphids cannot transmit virus over 120 meters from initial source plant

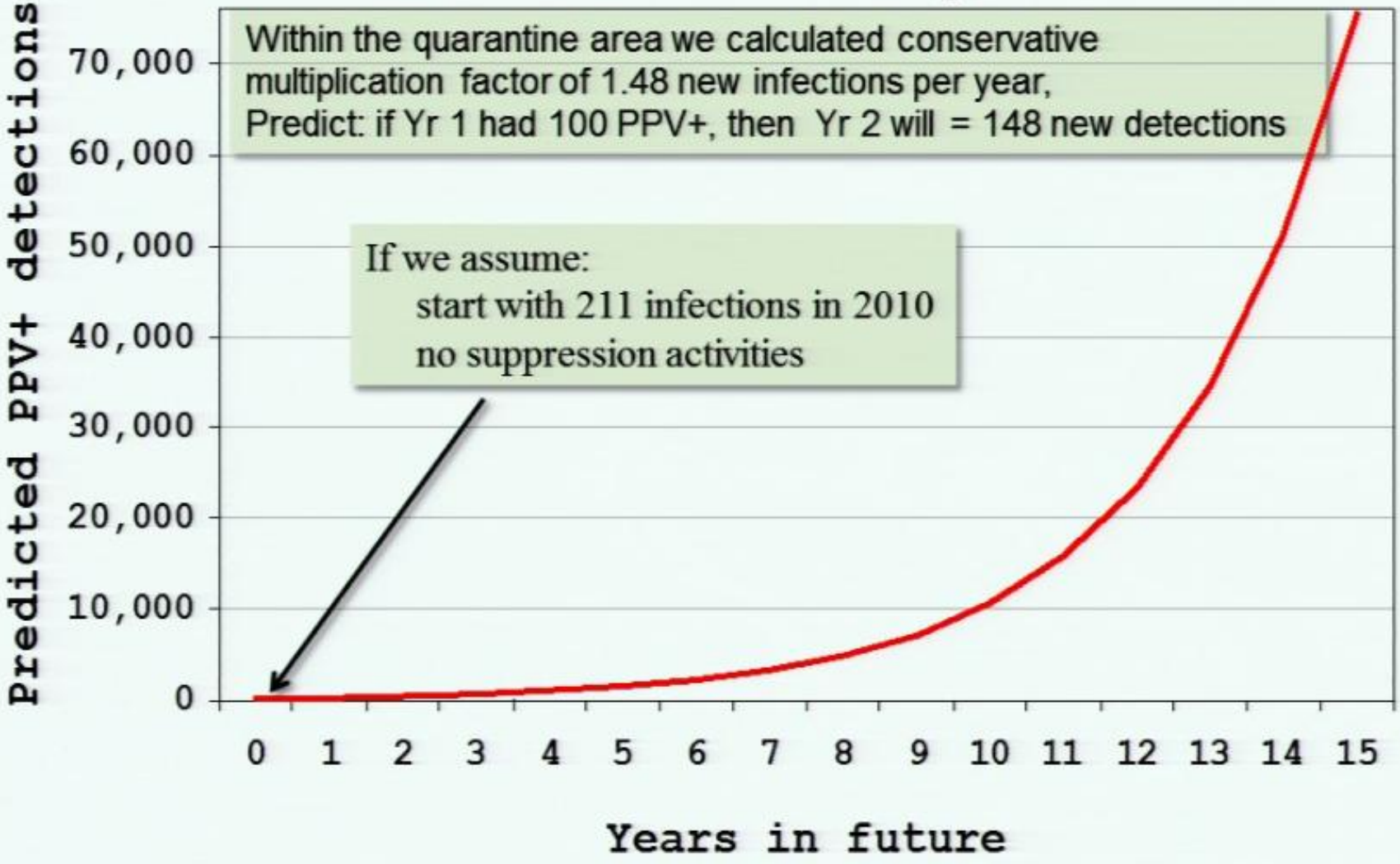


PPV Distribution: Pulse-Peak Decay Function



- Number of detections rise sharply at short distances (first 50m)
- Then declines based on an Inverse Power Law equation.
- Distribution extended out to 2.7km (theoretically much further)

Estimated PPV Reproductive rate Ontario, Canada - R_0= 1.48



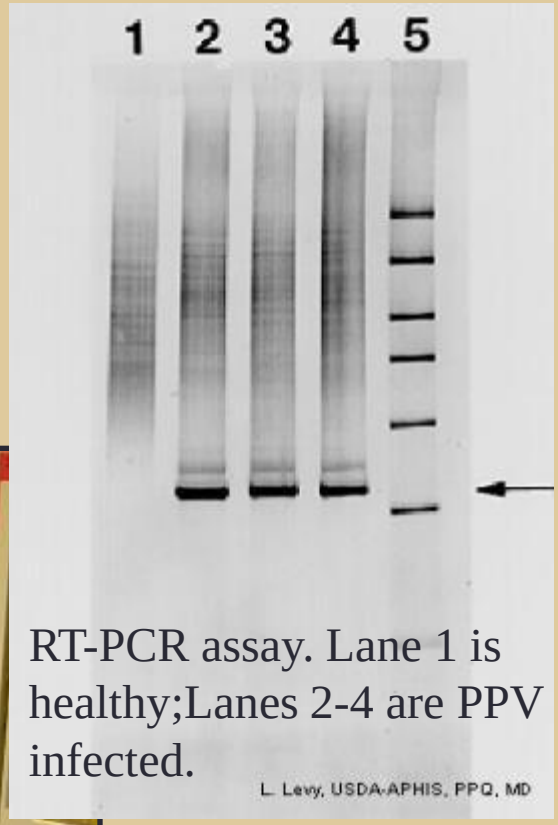
Detection

* PPV physical symptoms may not appear for 3 years after initial infection if at all.
* Serological and molecular tests used to detect virus before symptoms occur – **ELISA**.
* Diagnostic hosts, such as *Chenopodium foetidum*, can be used to detect PPV by mechanical inoculation from suspect hosts
* Woody indicator plants are also useful for detecting the virus by chip budding to hosts. This method allows for the differentiation of the M and D strains based on symptoms**.**

Chenopodium foetidum

Detection

* More sensitive and accurate detection of PPV possible through RT-PCR (reverse transcription polymerase chain reaction) technology
* Currently, rapid detection of PPV with RT-PCR is achieved with Real-Time PCR
* PCR can make diagnosis with low concentration of the virus
* About 5000 times more sensitive than ELISA



RT-PCR assay. Lane 1 is healthy;Lanes 2-4 are PPV infected.

Courtesy L.Levy. Reproduced from L. Levy, V. D. Damsteegt, R. Scorza, and M. Kölber, Plum Pox Potyvirus Disease of Stone Fruits, 2000, APSnet feature, http://www.apsnet.org/online/feature/PlumPox/Top.html

Real-time PCR utilized for rapid PPV detection. (Photo Dawn Dailey-O'brien, Cornell University)

Control

- No chemical controls available to prevent, eliminate, or cure PPV in the field.
- If you suspect PPV,
  - contact your local cooperative extension agent http://www.csrees.usda.gov/qlinks/partners/state_partners.html
  - NPDN lab

    http://www.npdn.org

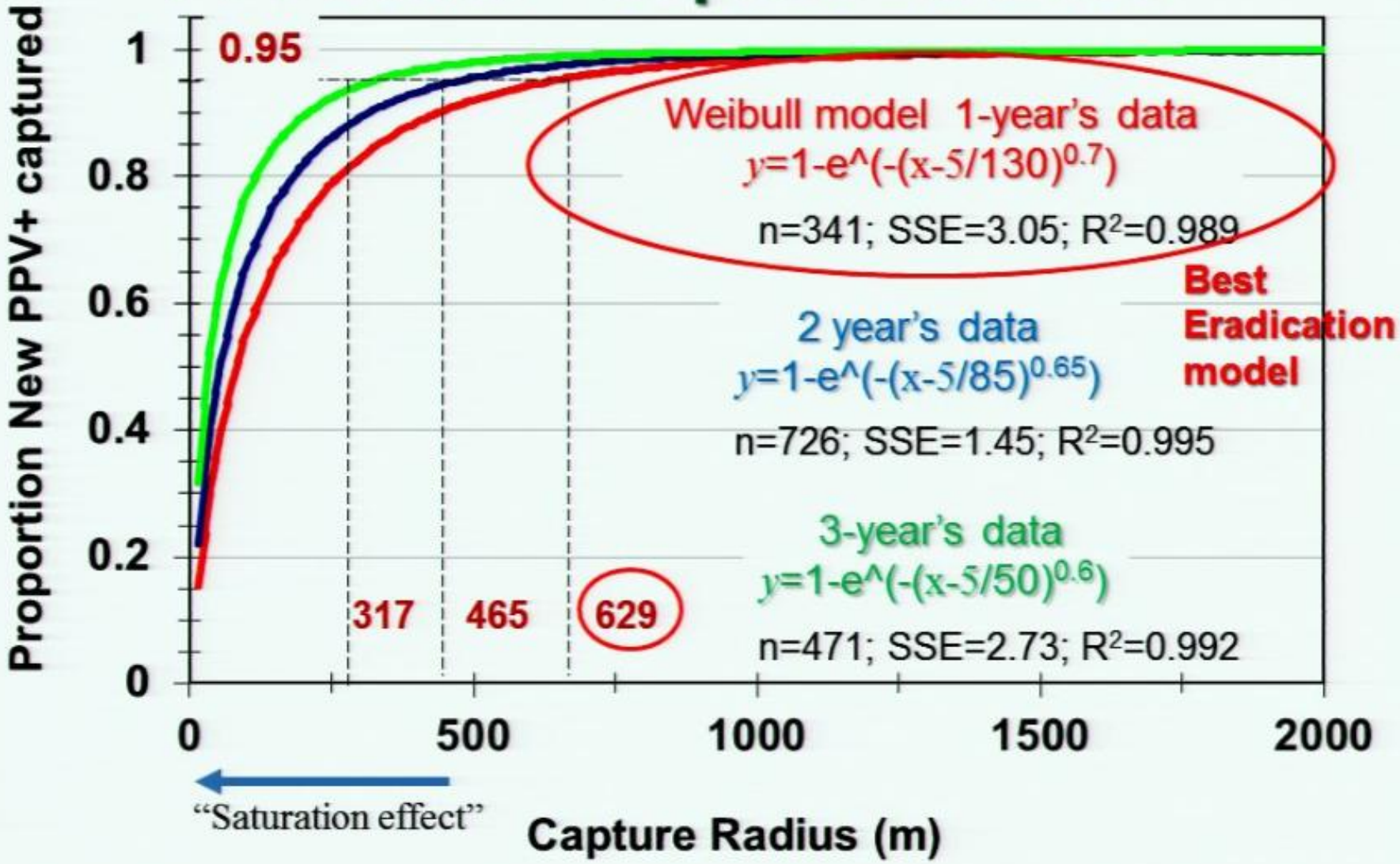
Photo: John Hammond, USDA Agricultural Research Service, http://www.ipmimages.org

Control

- Insect Control -
  - Insecticides do not effectively control aphid populations.
  - Only one infected aphid is needed to spread PPV.
  - Positive trees should be destroyed.

Photographer: Whitney Cranshaw, Colorado State University http://www.ipmimages.org

Retrospective analyses: PPV Buffer = Capture Distance



- Weibull model provided the best approximation of *proportion capture over distance*

Control

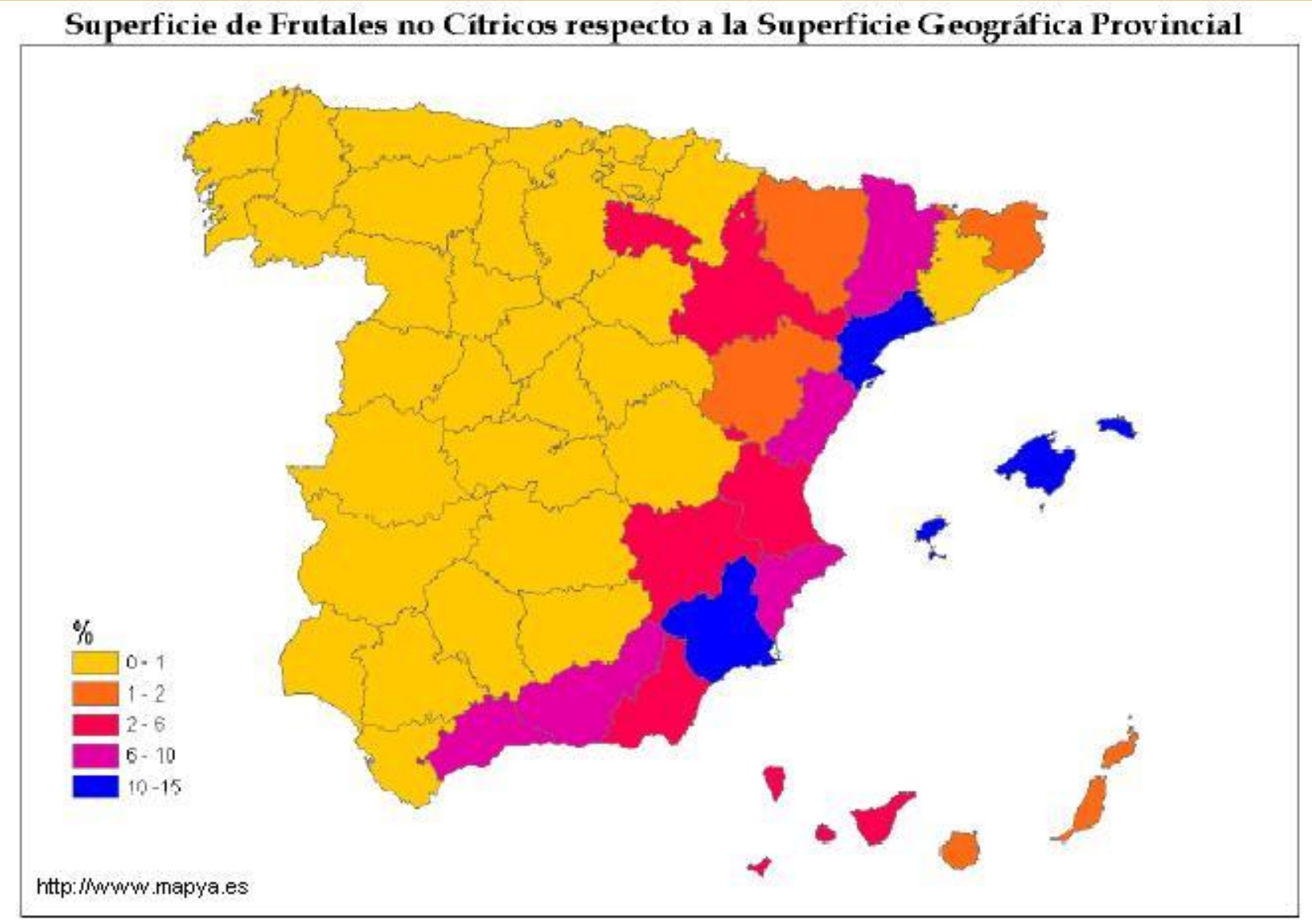
* Plant Breeding and Genetic Engineering
  * Breeding plant resistance from naturally occurring genes in fruit trees.
  * Genetic engineering may allow scientists to enhance resistance.

Transgenic C5 Plum resistant to PPV contains the PPV Coat Protein (Photo Scott Bauer, USDA-ARS, http://www.ars.usda.gov/is/graphics/photos/sep01/k8891-19.htm)

The Plant Disease Diagnostic Clinic, Cornell University (2001)

Photo Courtesy R. Scorza. Reproduced from L. Levy, V. D. Damsteegt, R. Scorza, and M. Kölber,

Spain

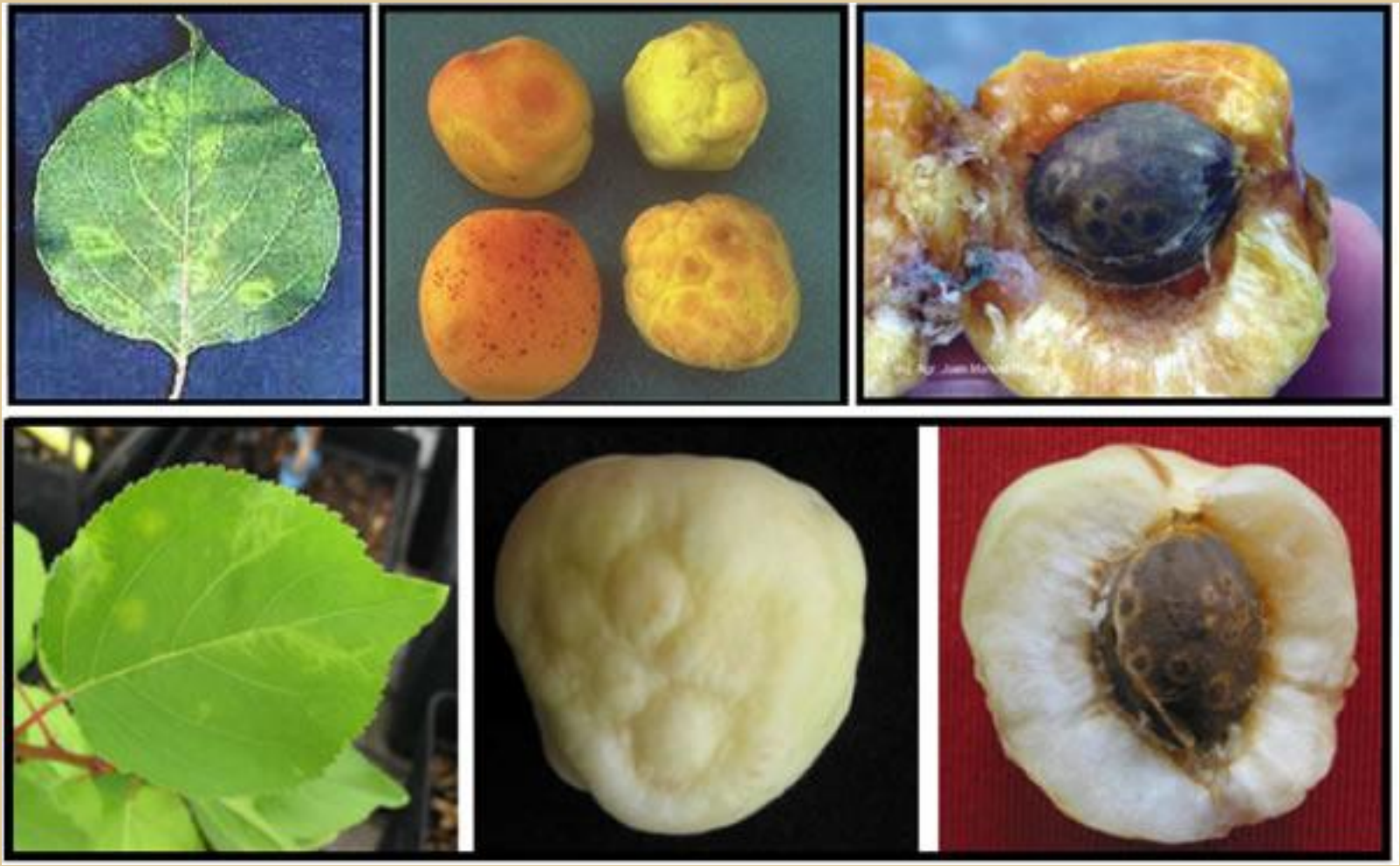

Superficie de Frutales no Cítricos respecto a la Superficie Geográfica Provincial
%
0 - 1
1 - 2
2 - 6
6 - 10
10 - 15
http://www.mapya.es

Red Beaut Plum, developed by California breeder, Fred Anderson

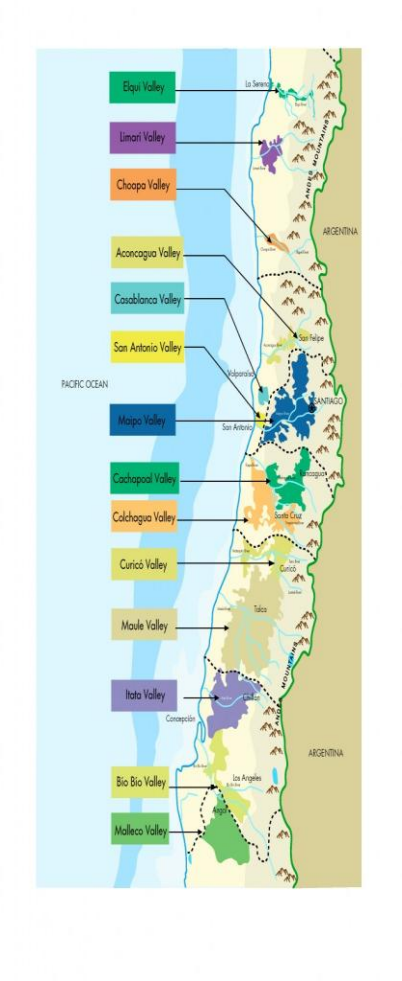
Red Beaut with PPV, disease spread quickly in Spain by infected propagation material

Spain –

First detected in 1984 - within 10 yrs, apricot production fell to 17% of previous volume; infection was too widespread to eradicate. Efforts now are going into developing resistant varieties.



PPV in Chile



"Twenty years after the detection of PPV in Chile, it now seems clear that the disease cannot be eradicated despite the measures undertaken to do so. This necessarily means that in the future the fruit industry must contain and manage the disease, because of which, complementary efforts of the public and private sectors are needed to prevent the virus from spreading. "

From Investigations of the Plum Pox virus in Chile in the past 20 years, by Guido Herrera, Instituto de Investigaciones Agropecuarias INIA

PPV in Argentina

First detected in San Juan province in 2004 on Red Beaut Plum & Bulida apricot

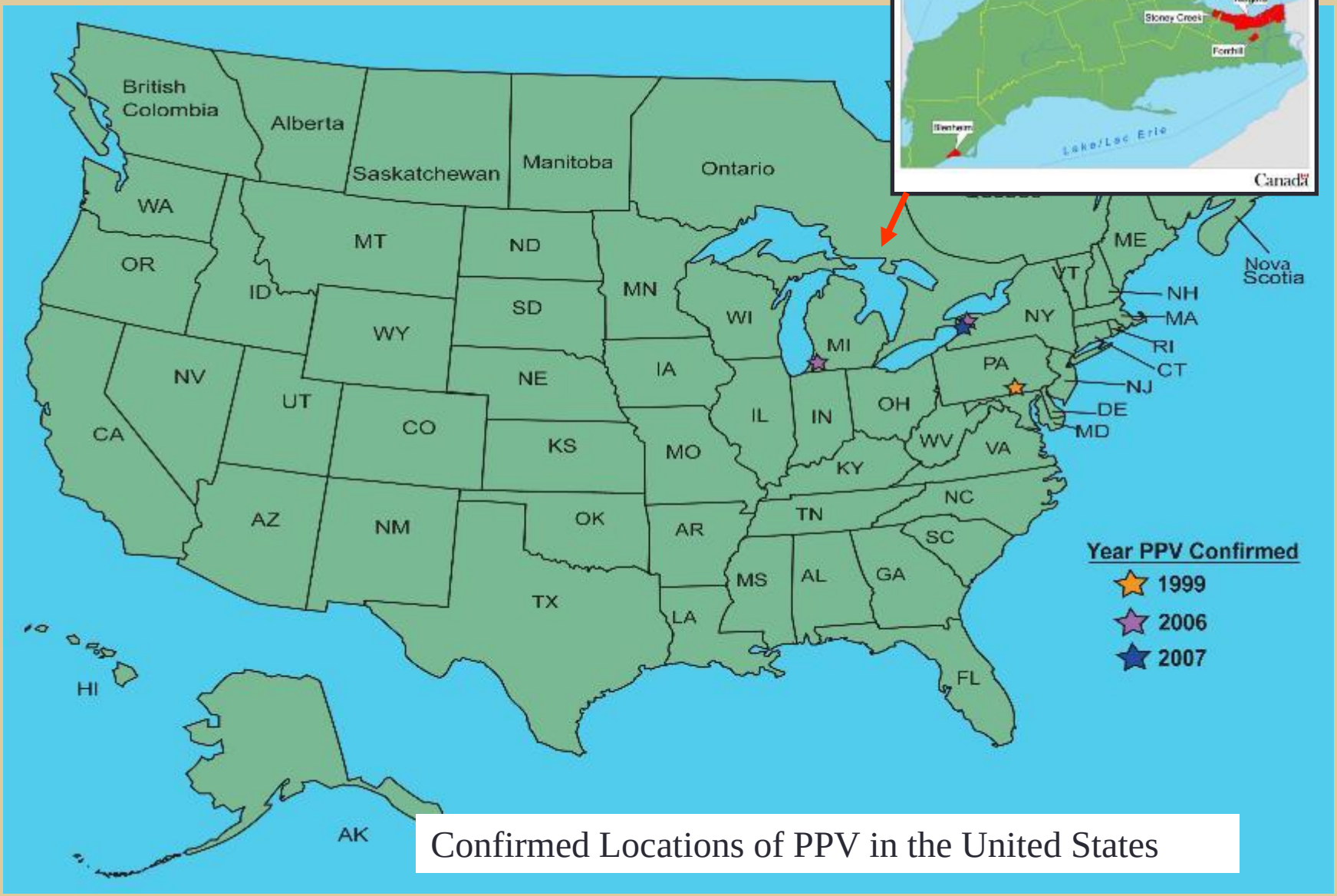
National Emergency declared

Movement of prunus propagation material prohibited without gov't authorization

Set up quarantine zones around first detections, all trees destroyed

Later detected in other growing districts, 243,000 samples analyzed by ELISA, infection rate <1%

PPV in North America



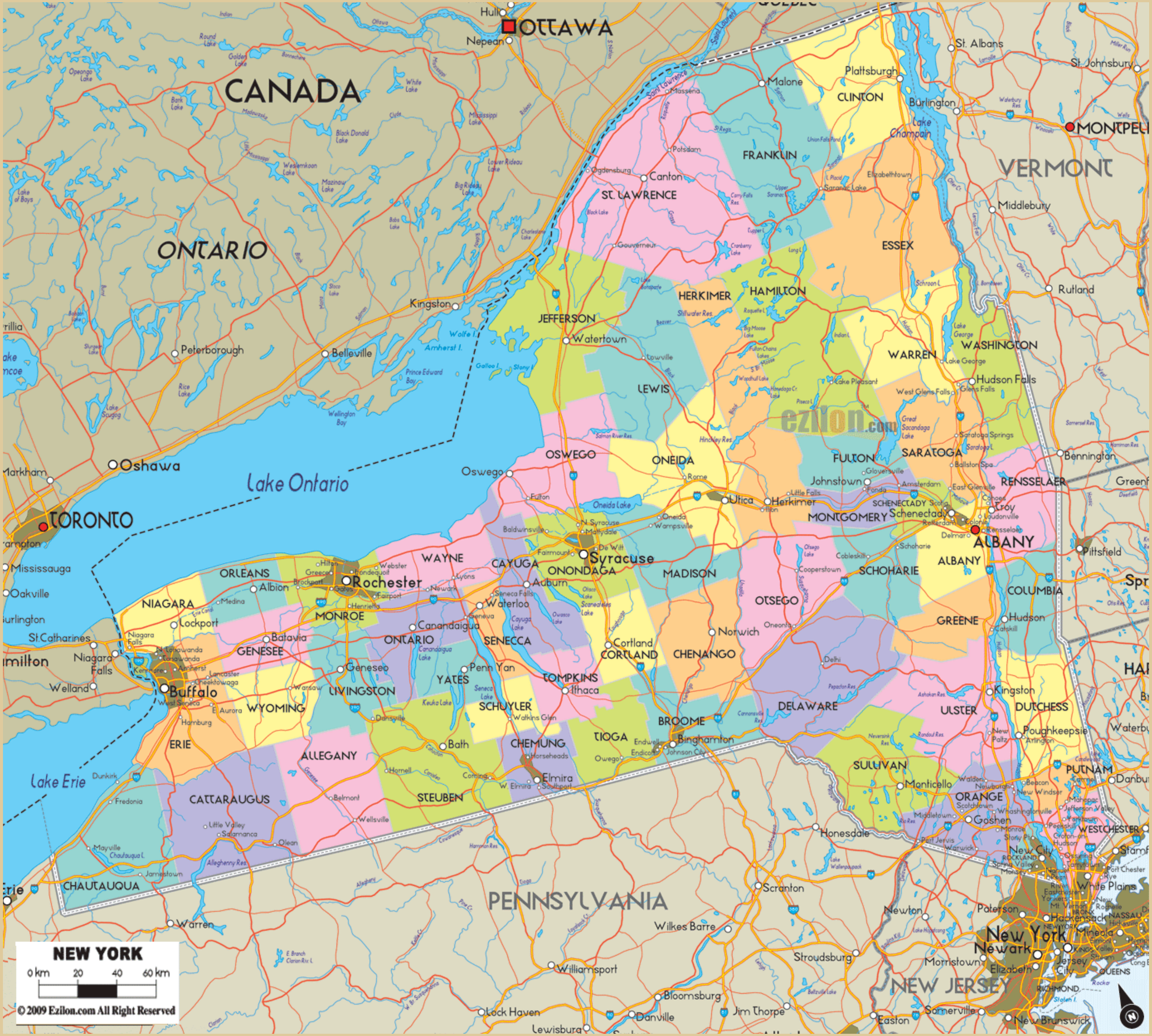
Confirmed Locations of PPV in the United States

North American PPV Epidemic Characteristics

- **U.S. Epidemics:**
  - **Pennsylvania**
    - Discovered in September 1999
    - limited in distribution compared to extent of industry.
    - Deemed eradicable and subsequently declared eradicated Oct 2009
  - **Michigan**
    - Discovered in July 2006 Michigan State Univ.
    - Very limited in extent
    - Deemed eradicable and subsequently eradicated

  - **New York**
    - Discovered in August 2006
    - Limited in incidence and distribution
    - Deemed eradicable (eradication pending)
- **Canadian Epidemics (*believed to predate US epidemics*)**

  - **Ontario**
    - Discovered in June 2000
    - Widespread and diffuse throughout industry
    - Deemed eradicable (partially eradication - program suspended)
  - **Nova Scotia**
    - Discovered in June 2000
    - Localized and contained
    - Deemed eradicable and subsequently eradicated


NEW YORK
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CANADA
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OTTAWA
Hull
Nepean
Kingston
Belleville
Peterborough
Oshawa
Markham
TORONTO
Mississauga
Oakville
Burlington
St.Catharines
Niagara Falls
Welland
Lake Ontario
Lake Erie
QUEBEC
VERMONT
MONTPELIER
St. Albans
St. Johnsbury
Burlington
Middlebury
Rutland
Bennington
Lake Champlain
PENNSYLVANIA
NEW JERSEY
Erie
Warren
Williamsport
Lock Haven
Lewisburg
Bloomsburg
Danville
Wilkes Barre
Scranton
Honesdale
Stroudsburg
Jim Thorpe
Easton
Newton
Morristown
Somerville
New Brunswick
Paterson
Newark
Elizabeth
Jersey City
New York
White Plains
Stamford
Danbury
Pittsfield
CLINTON
Plattsburgh
FRANKLIN
Malone
ST. LAWRENCE
Massena
Potsdam
Canton
Ogdensburg
Gouverneur
ESSEX
Elizabethtown
Saranac Lake
JEFFERSON
Watertown
HERKIMER
HAMILTON
LEWIS
Lowville
WARREN
WASHINGTON
Lake George
Hudson Falls
Glens Falls
SARATOGA
Saratoga Springs
FULTON
Johnstown
Gloversville
Amsterdam
OSWEGO
Oswego
Fulton
ONEIDA
Rome
Utica
Herkimer
Oneida Lake
MONTGOMERY
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Schenectady
Troy
RENSSELAER
ALBANY
Albany
WAYNE
ORLEANS
Albion
NIAGARA
Lockport
MONROE
Rochester
GENESEE
Batavia
ONTARIO
Canandaigua
CAYUGA
Auburn
ONONDAGA
Syracuse
MADISON
SENECA
Waterloo
CORTLAND
Cortland
CHENANGO
Norwich
OTSEGO
Cooperstown
Oneonta
SCHOHARIE
Schoharie
GREENE
Catskill
COLUMBIA
Hudson
YATES
Penn Yan
LIVINGSTON
Geneseo
WYOMING
Warsaw
ERIE
Buffalo
TOMPKINS
Ithaca
SCHUYLER
Watkins Glen
BROOME
Binghamton
DELAWARE
Delhi
ULSTER
Kingston
DUTCHESS
Poughkeepsie
TIOGA
Owego
CHEMUNG
Elmira
STEUBEN
Bath
Corning
ALLEGANY
Belmont
Wellsville
CATTARAUGUS
Olean
Salamanca
Little Valley
CHAUTAUQUA
Mayville
Jamestown
Dunkirk
Fredonia
SULLIVAN
Monticello
ORANGE
Goshen
Middletown
PUTNAM
Carmel
WESTCHESTER
ROCKLAND
New City
BRONX
QUEENS
RICHMOND
NASSAU
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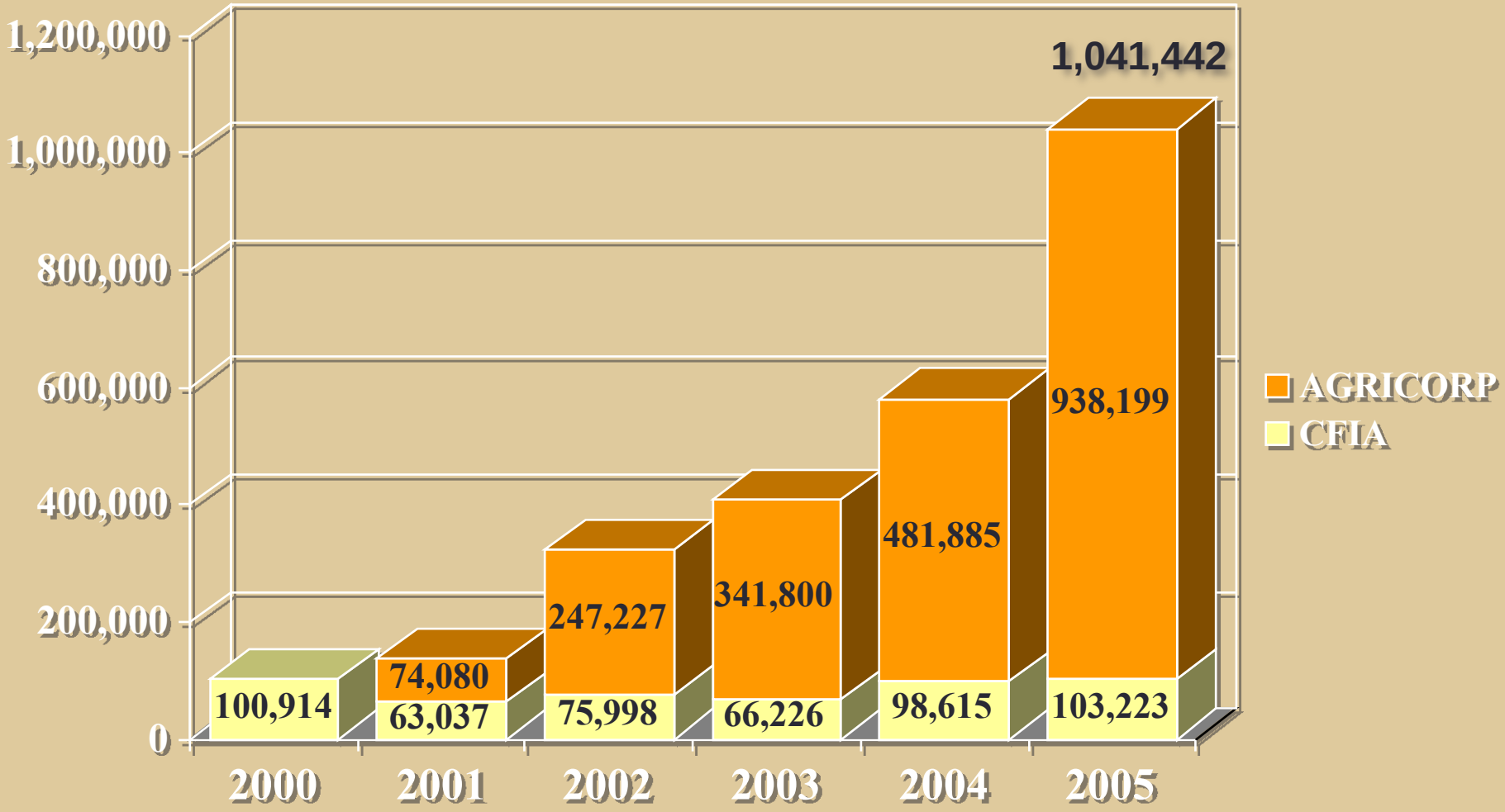
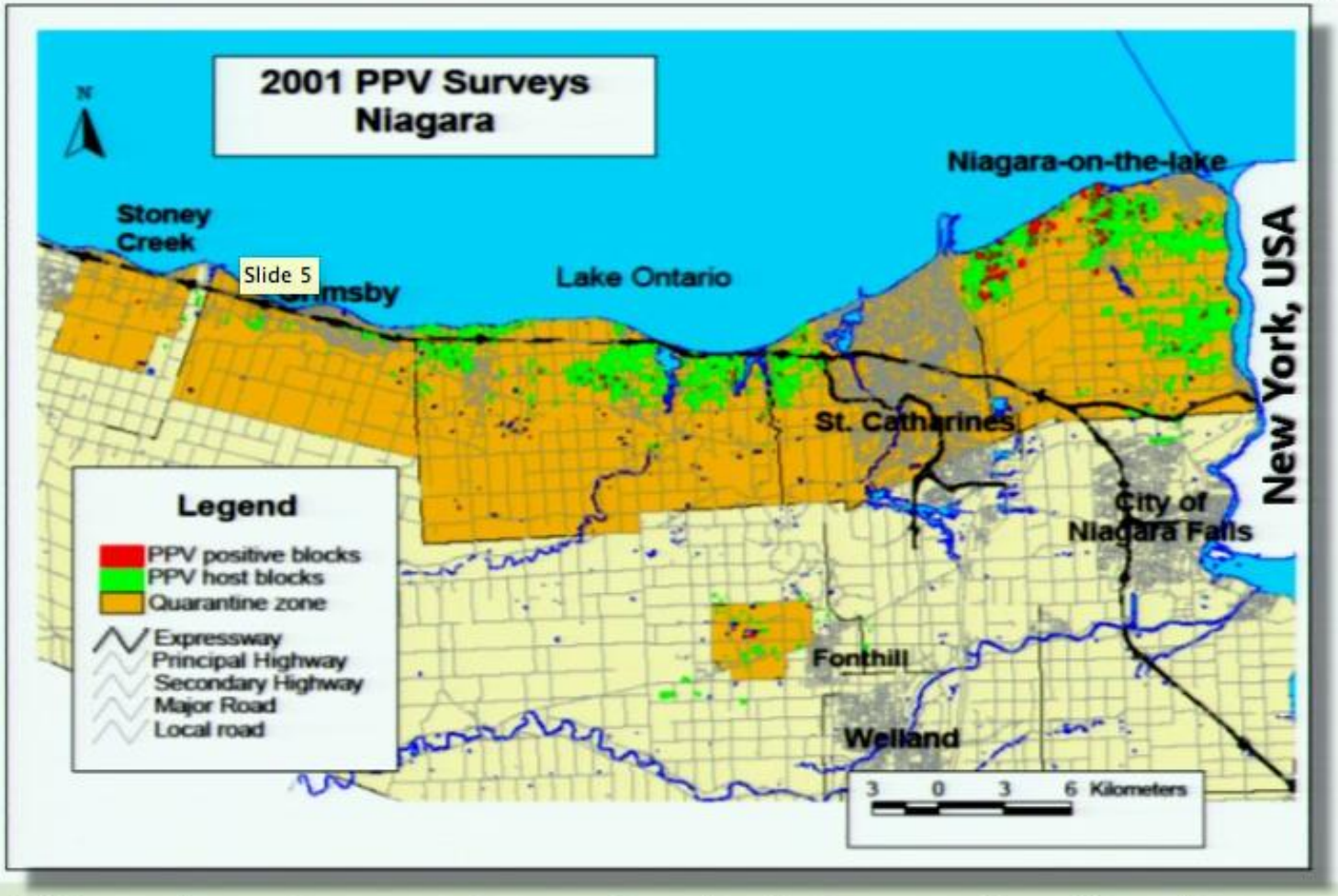
Total Ontario Samples Collected



Contrast: Ontario PPV Eradication Program



Most severe PPV infection adjacent to US and New York stonefruit industry.

Diffuse throughout region and entire industry when first discovered.

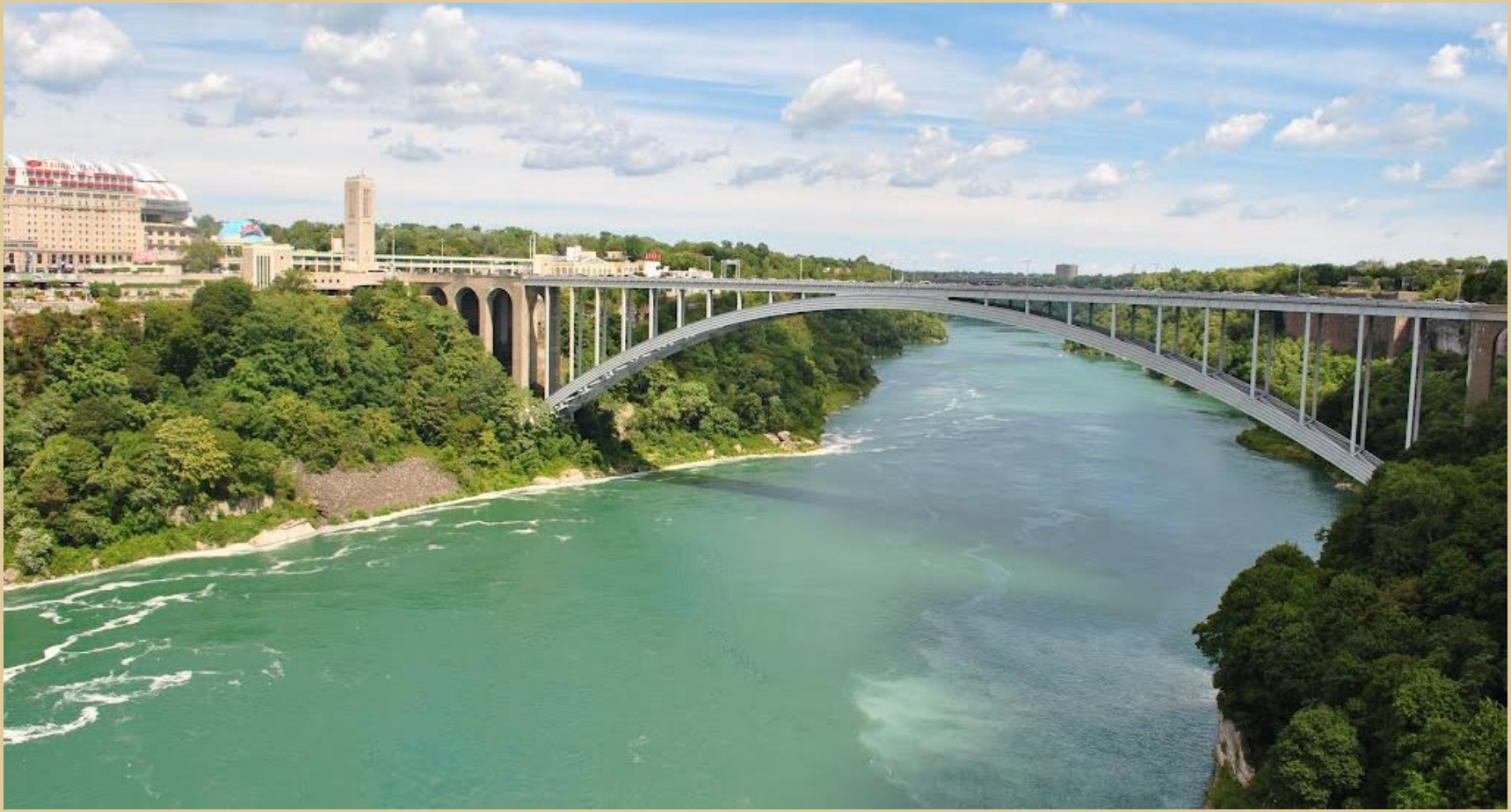
Propagative and aphid spread implicated.

500m eradication distance would remove entire industry!

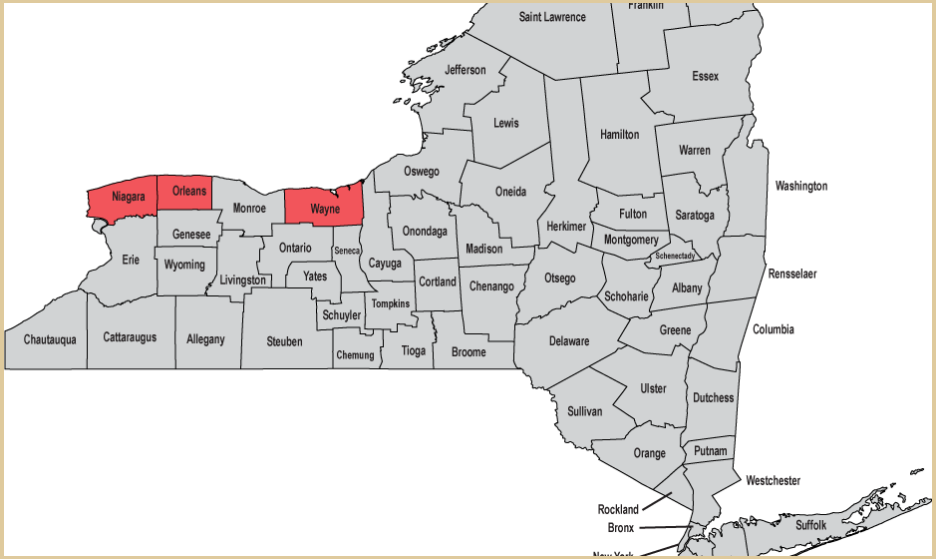
Eradication very difficult and 500m eradication zone nonfeasible!

Thus less harsh methods were adopted.

Niagra river
between NY state & Ontario (Canada)



PPV in New York



Affected counties along Lake Ontario & Niagra river

USDA quarantine officer

Sampling

PPV in Pennsylvania

Tree destruction

Grower Education

Can PPV infect Almonds? YES!

-Verified in France on Non Pareil, etc

-Confirmed by USDA - Butte & Mission varieties

-Infection rate similar to plum & peach, transmitted by aphids

-Infection is persistent (tested over 6 dormant periods)

-And transmissible to other prunus species (a plant reservoir)

-Symptoms are transient (early spring leaf flush only)

Lessons learned

The Bad News

Discovery of PPV in California is probably just a matter of time

Eradication efforts will be a nightmare – quarantine & buffer zones, resistance to tree removal in cities

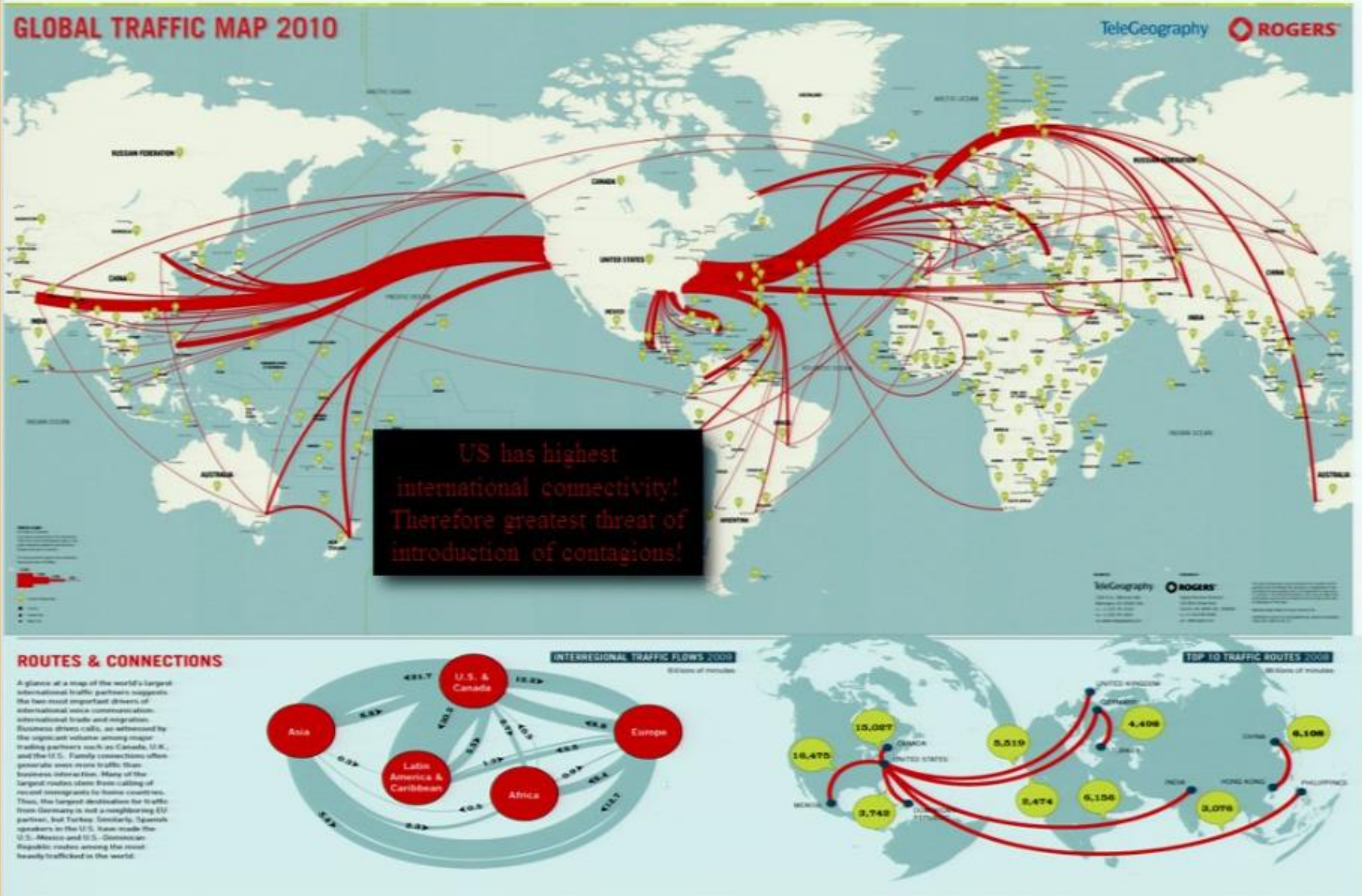
Eradication can work if early detections are immediately addressed & aggressively handled

Prunus orchards with a buffer to adjacent orchards of 2000’ are probably safe

Nurseries located within 2000’ of nearby Prunus orchards may be quarantined

Global International Flights Per Day

Greatest source of pest introductions is via humans moving plant materials


GLOBAL TRAFFIC MAP 2010
TeleGeography
ROGERS
US has highest international connectivity! Therefore greatest threat of introduction of contagious!
ROUTES & CONNECTIONS
INTERREGIONAL TRAFFIC FLOWS 2008
U.S. & Canada
Asia
Europe
Latin America & Caribbean
Africa
TOP 10 TRAFFIC ROUTES 2008
15,027
16,475
5,519
4,406
6,108
3,743
2,474
6,156
3,076

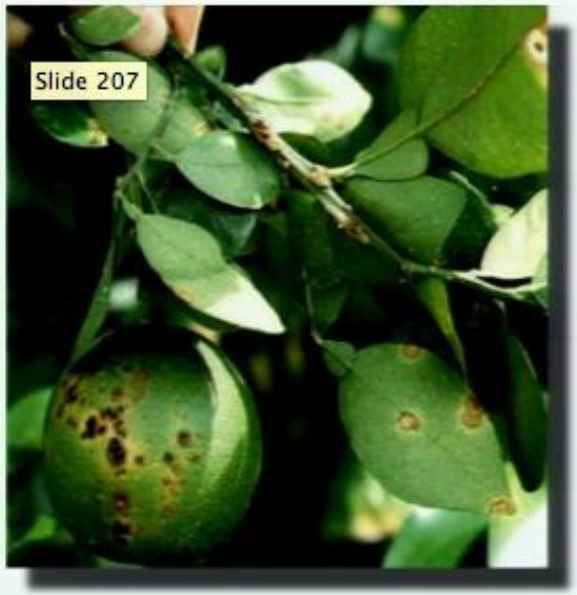
Lessons learned

The Good News

PPV is a slow moving virus

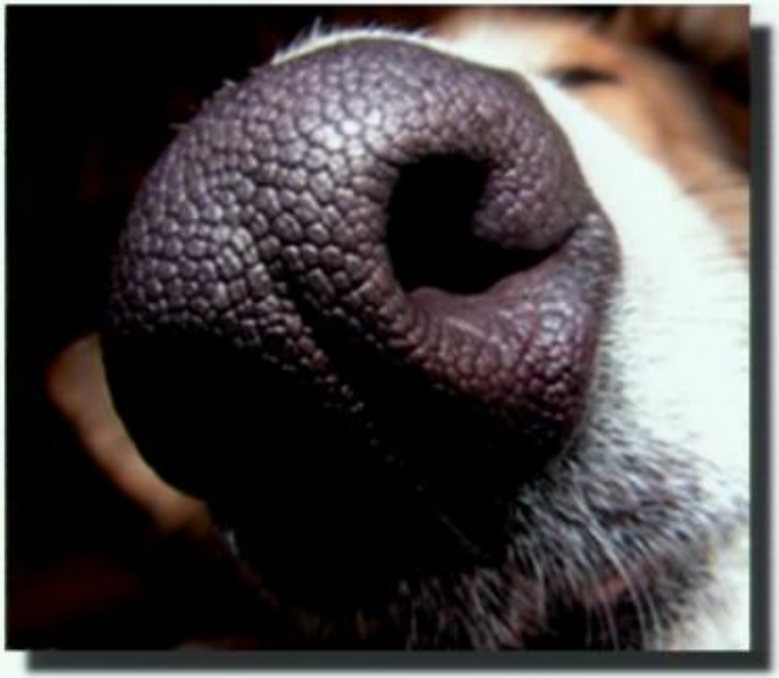
Better phyto – sanitary controls exist in Calif nurseries

If eradication efforts fail, the disease can be “managed”



Canine detection of Citrus Canker HLB, black spot, and other pests and pathogens

A 20,000 year old technology.



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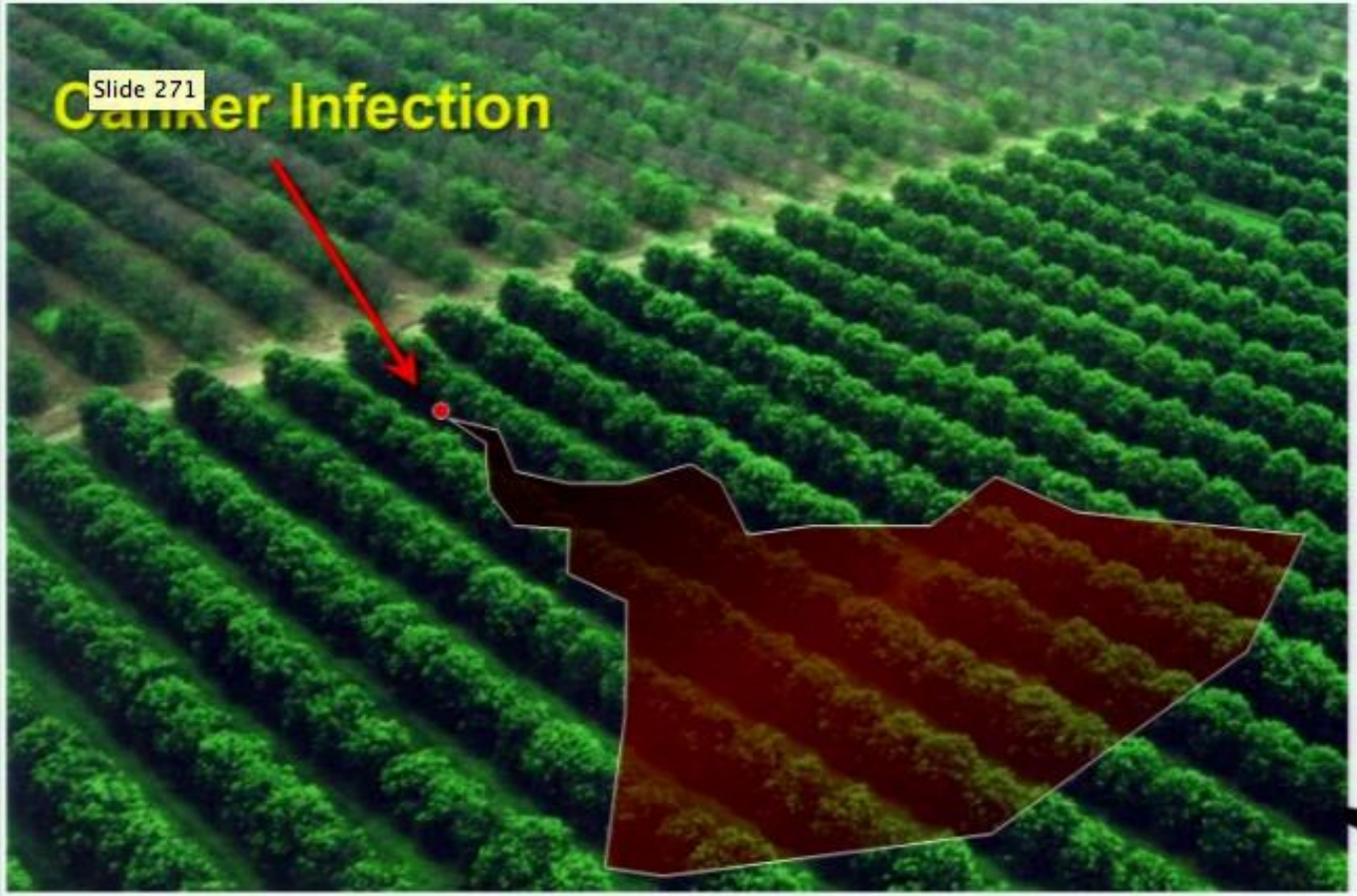
Canine Canker Detection Results:

Canines have been trained to detect citrus canker infected fruit and foliage with ~99.6% accuracy by smell of volatile compounds being given off infected citrus foliage and fruit.

Dog (*Juice*) stops at infected tree, ***alerts*** = detects canker, sits, and will not move forward.

Juice stops at box containing 1 infected grapefruit, ***alerts*** = detects canker, sits, and will not move.



Canker Detection: Scent Cone

- Volatiles give off by canker infections weft downwind in a scent cone.
- Cone is a diffusion gradient, strongest at the source.
- Canine follows concentration upstream to source.

Training to detect HLB: USDA, APHIS MAC funding – 20 more dogs in 2015-16

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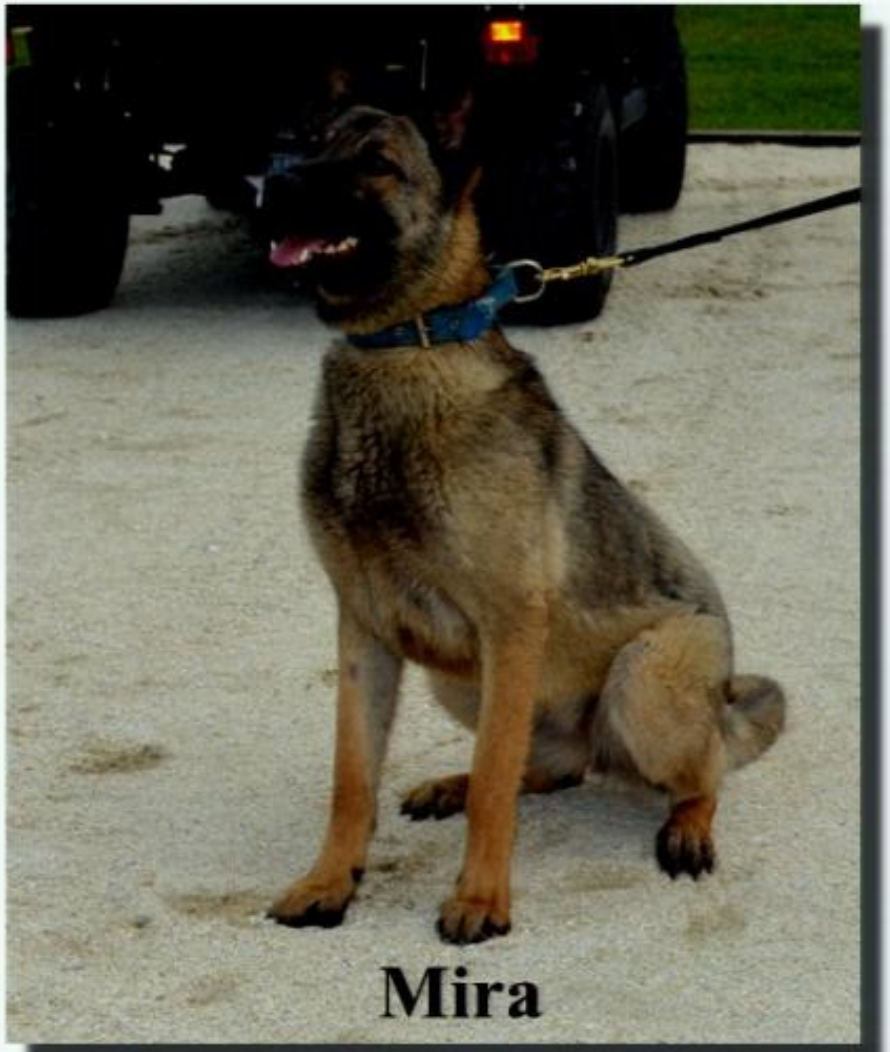

- Newly acquired detector dogs for HLB detection work.
- HLB training began in Mid June 2014
- Currently 100% accurate (no false negatives no false positives)!

Video Recordings of All Speakers

ucanr.edu/sites/plumpox2014