Invasion Biology:

Science and Policy

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The Grand Challenges Agenda for Entomology Invasive Arthropods Summit • Vancouver, BC • 9-10 November, 2018

Invasive Species Summit

Vancouver, BC 11/10/18

Invasion Databases:

Scientific Goldmines

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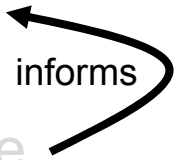
Surveillance Program Data

1. Protection—biosecurity
2. Understanding—science



Cost for Detecting One Adult Fly in California

- ~~An~~nual surveillance costs = $20 million
- ~~60~~-year cost = >>$1 billion
- ~~Nu~~mber adult tephritids captured > 5,500

Cost/fly:
$180,000/fly

Invasion Databases

Port Information Network (PIN)

Global Eradication and Response Database (GERDA)

Pest incursion response

Taxon: *Bactrocera dorsalis* Hendel (Diptera: Tephritidae), oriental fruit fly

Location: San Diego, California, United States

Incursion and investigation

Detection date: 6 September 1974

Infestation size: 81585 ha

Management decision: attempt eradication

Eradication programme

Programme start date: September 1974

Programme end date: May 1975

Eradication date: May 1975

Cost: 0.75 million USD in 1975 (equivalent to approx. 2.235 million USD in 2015)

Outcome: confirmed eradication

Control tools used

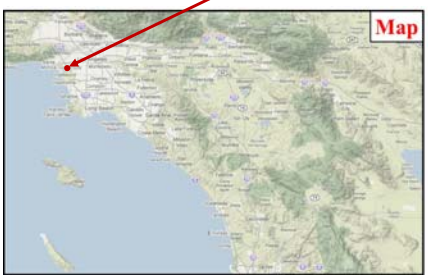
- Lure and kill
  From September 1974 to April 1975
  Male annihilation
- Quarantine/movement control
- Pesticide/antibiotic
  From September 1974 to May 1975
  Protein bait spraying

- Species/date (*B. dorsalis*; Sept, 1974)
- Location (San Diego)
- Infestation size (81,000 ha)
- Management decisions (eradicate)
- Cost ($2.2 million)
- Control tools (bait spray)

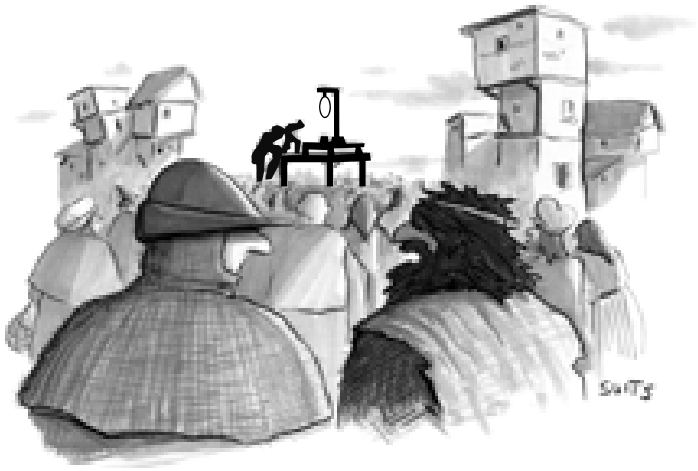
Oriental Fruit Fly Detection Database

Date	City	Adults	Larvae	Total	Year	Lat	Long
7/14/2005	Costa Mesa	1	0	1	2005	34.102	-118.353
6/30/1997	Covina	1	2	3	1997	34.044	-117.640
7/16/1997	Covina	1	0	1	1997	37.587	-122.079
7/16/1997	Covina	1	0	1	1997	37.939	-121.684
7/17/1997	Covina	3	0	3	1997	34.094	-117.913
7/18/1997	Covina	2	0	2	1997	33.944	-118.408
7/23/1997	Covina	1	0	1	1997	33.833	-118.358
9/21/1976	Culver City	1	0	1	1976	32.743	-117.099
8/11/1988	Culver City	0	0	0	1988	33.862	-118.269
9/6/1995	Cupertino	1	0	1	1995	34.029	-118.498
8/2/2007	Cupertino	1	0	1	2007	32.965	-117.037
7/27/1977	Cypress	1	0	1	1977	34.228	-118.237
7/28/1977	Cypress	1	0	1	1977	34.044	-118.204
8/30/1977	Cypress	1	0	1	1977	34.022	-118.492
11/2/2005	Cypress	1	0	1	2005	33.638	-117.902
8/6/1988	Daly City	1	0	1	1988	37.421	-122.152
8/29/2001	Dana Point	1	0	1	2001	34.197	-118.589
9/10/1997	Del Aire	1	0	1	1997	33.961	-118.400
9/10/1997	Del Aire	5	0	5	1997	33.965	-118.311
9/10/1997	Del Aire	1	0	1	1997	33.893	-118.382
10/2/1997	Del Aire	3	0	3	1997	33.947	-118.366
10/2/1997	Del Aire	1	0	1	1997	34.162	-119.170
10/2/1997	Del Aire	1	0	1	1997	34.026	-117.905
9/9/1997	Diamond Bar	1	0	1	1997	33.947	-118.400
9/11/1997	Diamond Bar	1	0	1	1997	34.156	-118.140
9/13/1997	Diamond Bar	1	0	1	1997	34.026	-117.818
12/1/1997	Diamond Bar	1	0	1	1997	33.781	-118.407
5/5/2011	Diamond Bar	1	0	1	2011	33.692	-117.781
6/19/2000	Dixon	1	0	1	2000	34.013	-118.082
7/12/1989	Downey	1	0	1	1989	38.635	-121.459
7/31/1989	Downey	1	0	1	1989	33.923	-118.358
3/30/1992	Downey	1	0	1	1992	33.809	-118.131
8/26/1993	Downey	1	0	1	1993	37.323	-121.915
8/30/1993	Downey	1	0	1	1993	33.828	-118.019
11/8/1995	Downey	2	0	2	1995	34.343	-119.047
1/21/1975	E. San Diego	1	3	4	1975	32.742	-116.994
8/13/1986	E. San Diego	1	0	1	1986	33.774	-118.170
7/12/2001	East Los Angeles	1	0	1	2001	33.942	-118.421

		Lat	Long
9/21/76	Culver City	32.743	-117.099
Date	City	precise location	

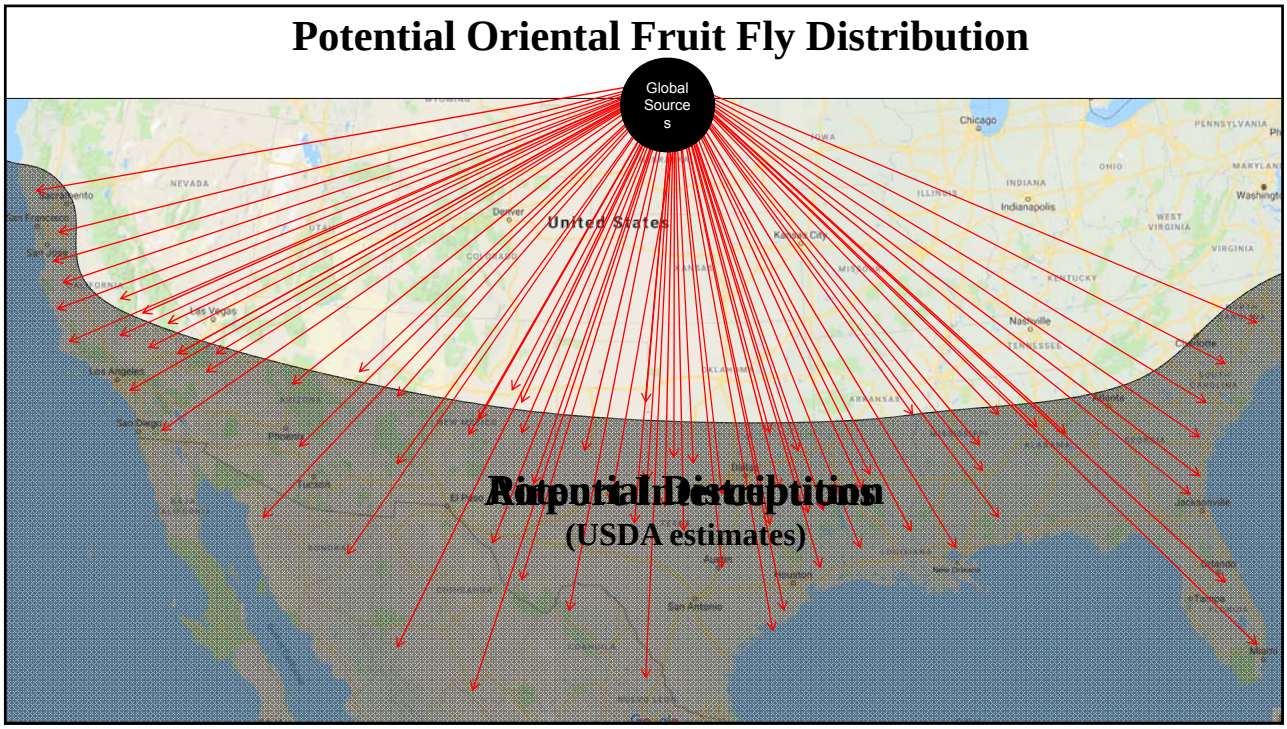


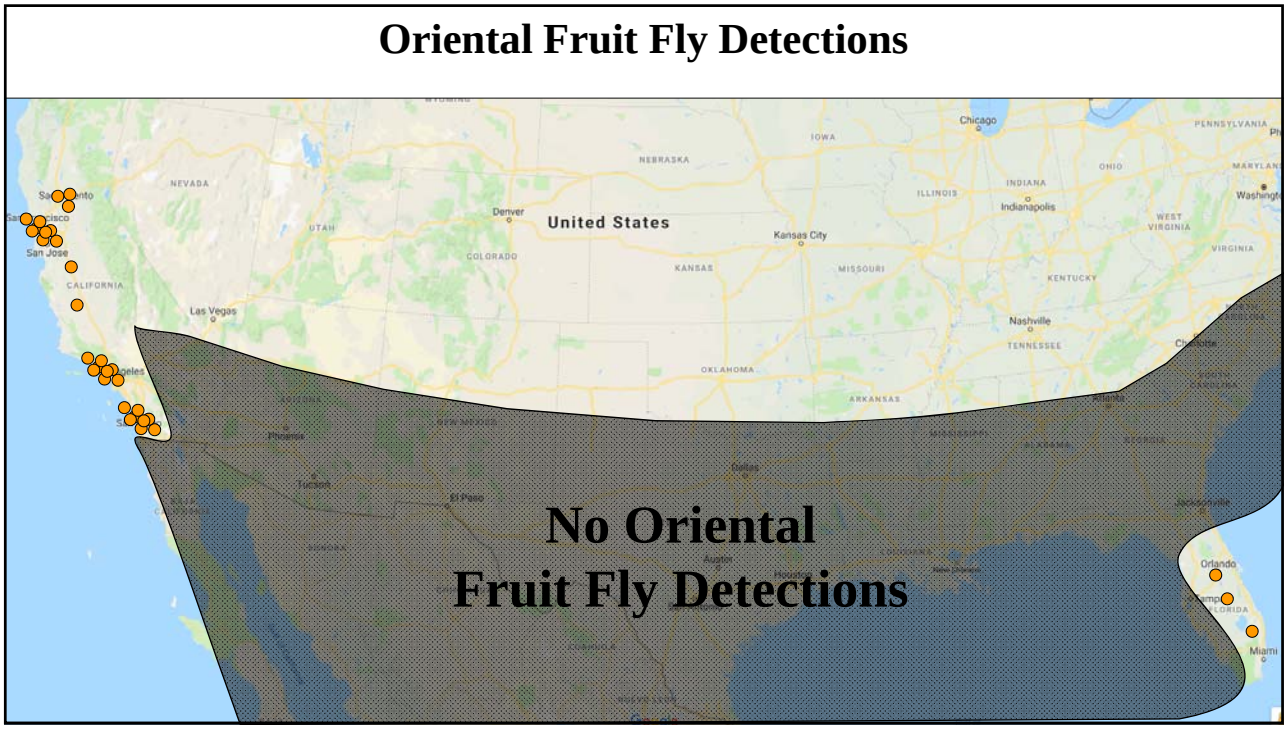
Hanging Offense



"He analyzed the fruit fly data"

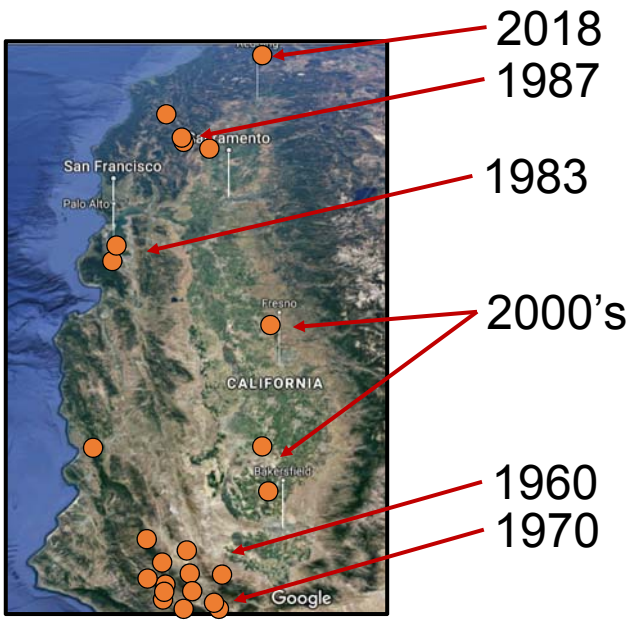
Oriental Fruit Fly Detections in U.S.


Potential Oriental Fruit Fly Distribution
Global Source s
United States
Potential Distribution
(USDA estimates)


Oriental Fruit Fly Detections
United States
No Oriental
Fruit Fly Detections

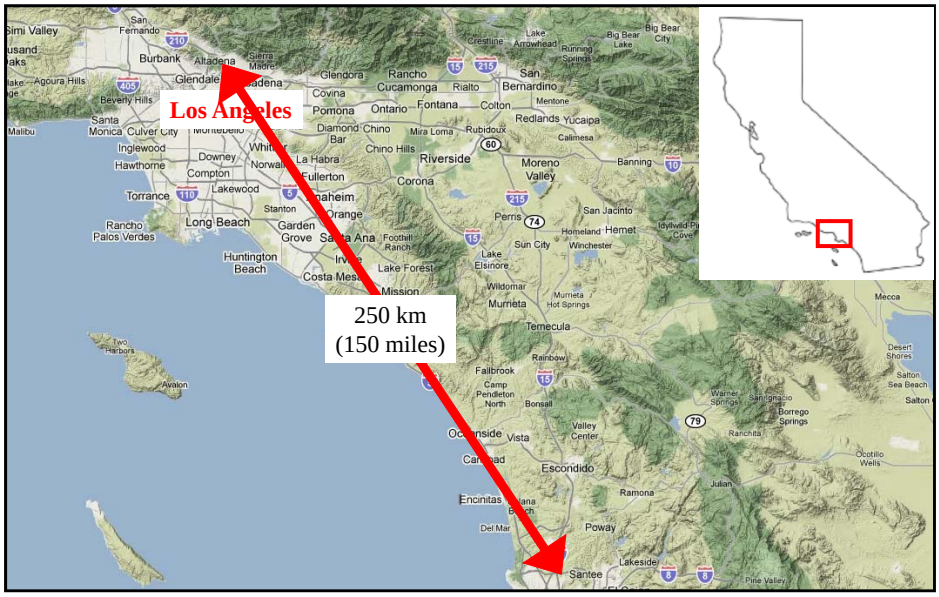
Oriental Fruit Fly Detections in California (1960-2018)

California Oriental Fruit Fly Invasion

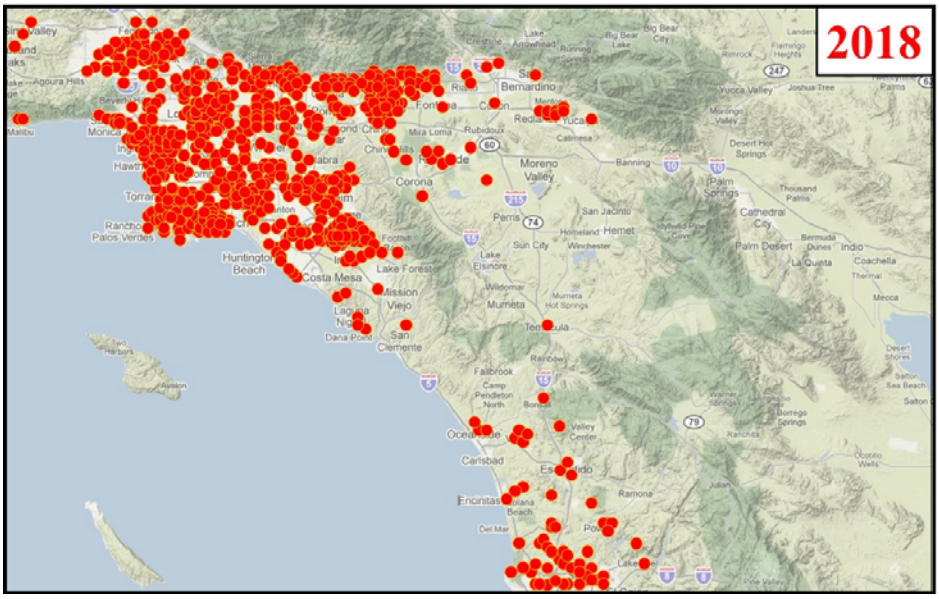


Detections every year for 50 straight years

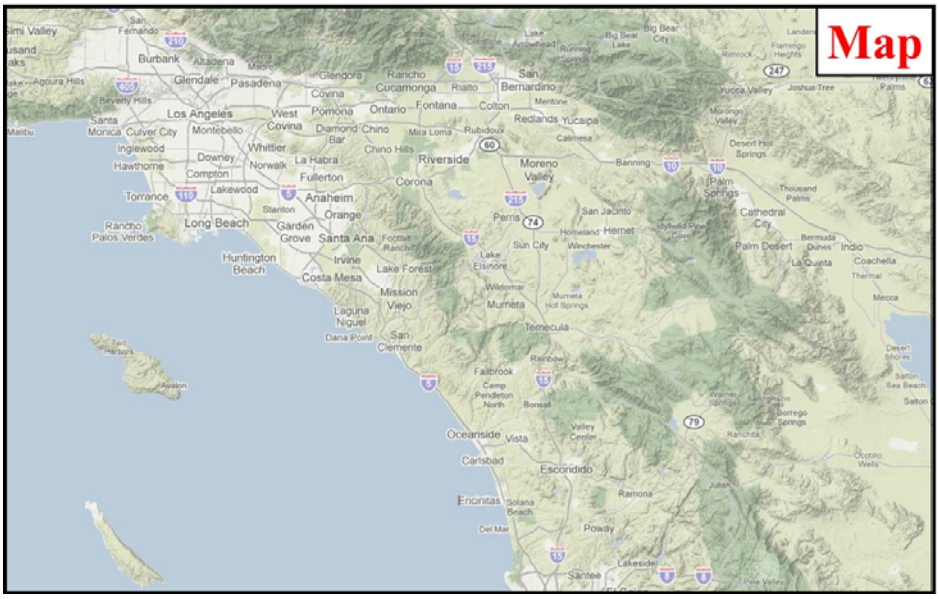
Los Angeles Basin



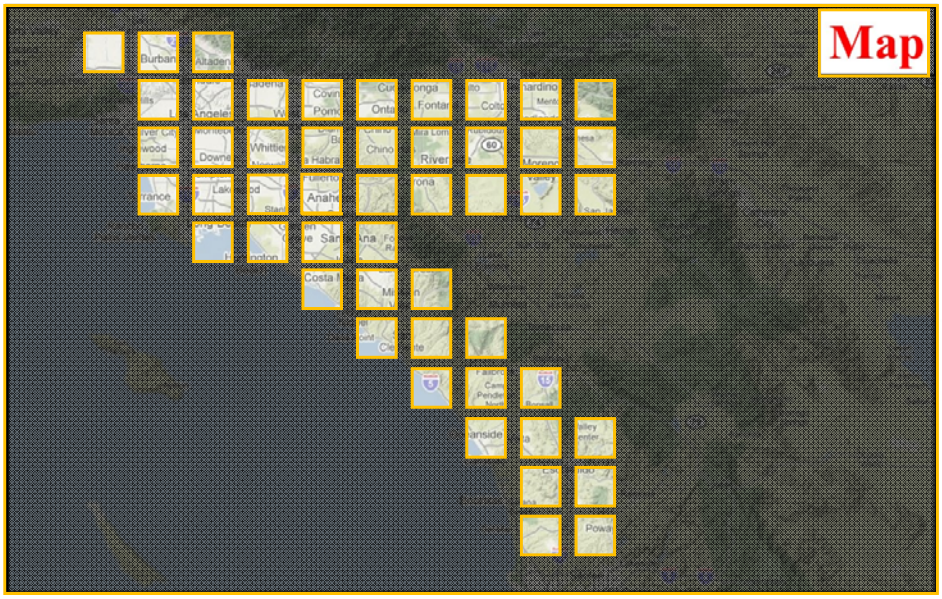
Oriental Fruit Fly Cumulative Detections (1960-2018)

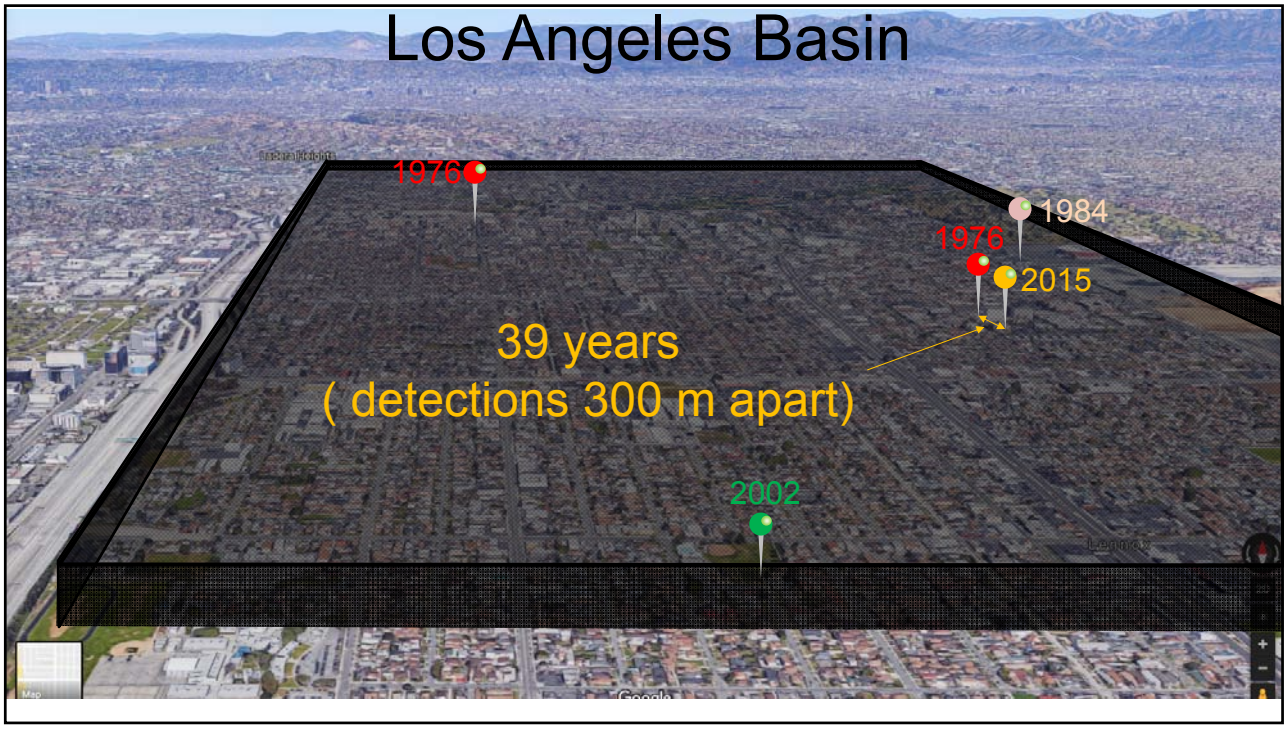


Oriental Fruit Fly Detections (1960-2018)



Oriental Fruit Fly Detections
(1960-2018)





Policy-related Questions Detection Databases Can Answer

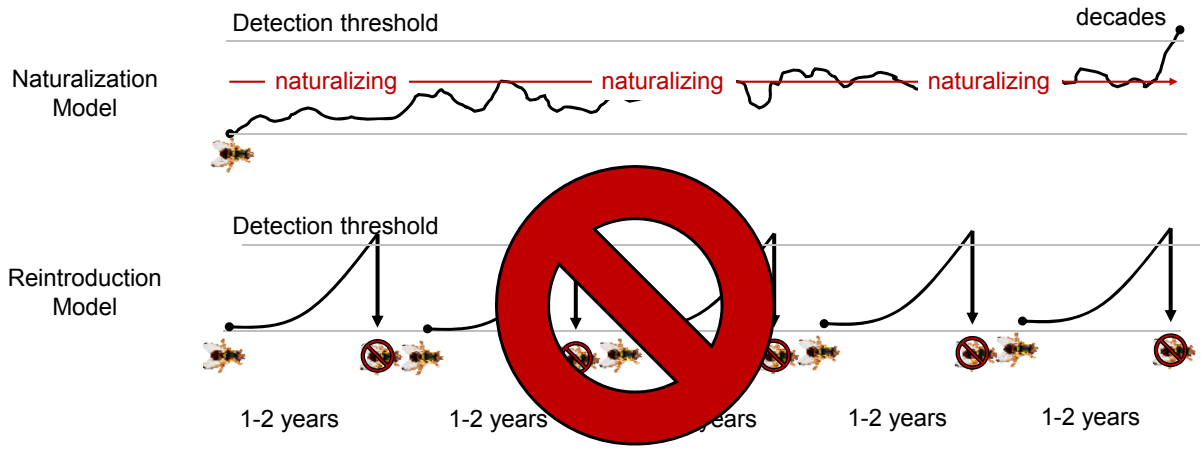
QUESTION #1:

Why have oriental fruit fly outbreaks been occurring annually for the past 50 years in California and only one other state?

ANSWER:

Because this fruit fly is permanently established in the state.

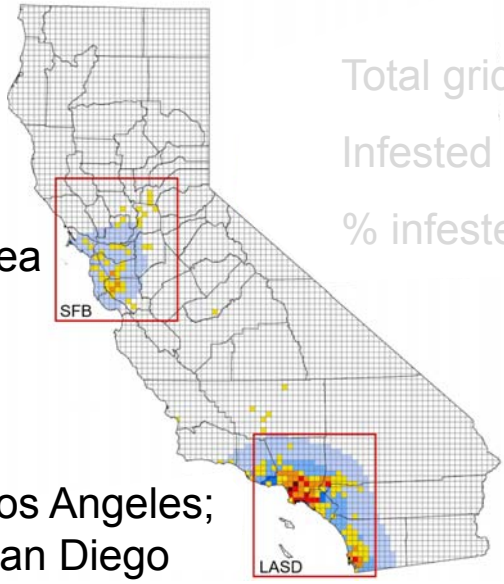
Reintroduction versus Naturalization Models



QUESTION #2:

What is the probability of a first outbreak in a randomly-chosen 100 km^2 (10 x 10 km) grid cell in state?

California Divided into 10 x 10 km grids



Total grids = 4,353

Infested grids = 166

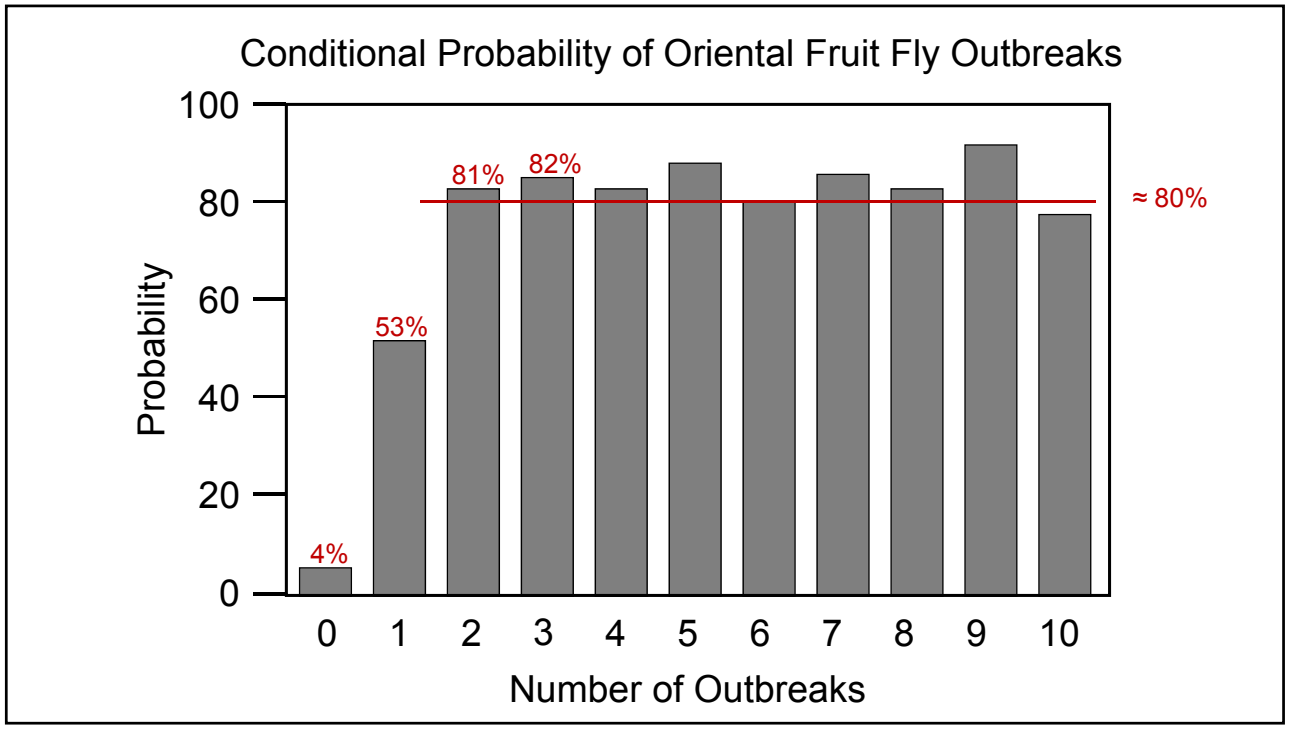
% infested = 3.8%

Bay Area

Los Angeles;
San Diego

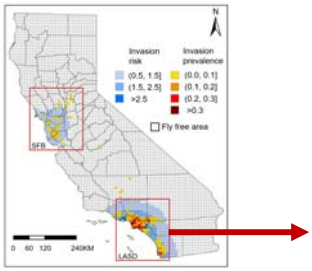
QUESTION #3:

What is the probability of a second and subsequent outbreaks?

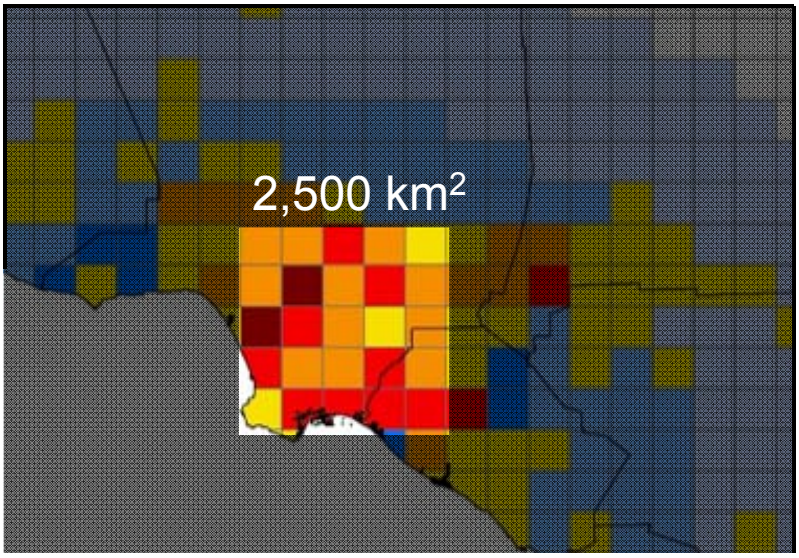


QUESTION #4:

What is the distribution of outbreak risk in the state?



Los Angeles Basin



QUESTION #5:

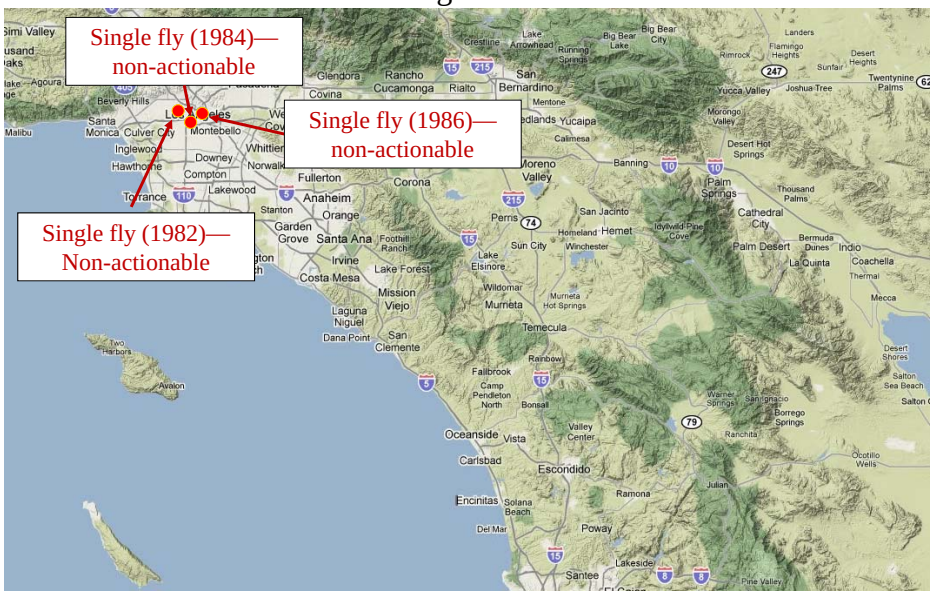
What does capture of a single fly mean?

ANSWER:

Ominous sign—100 % probability of eventual outbreak

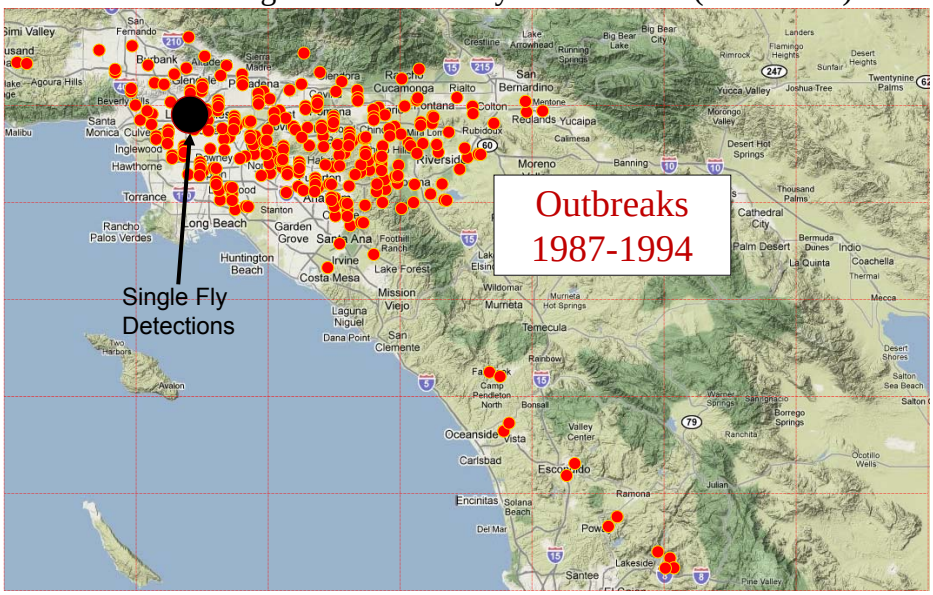
Mediterranean Fruit Fly

Los Angeles Basin



Mediterranean Fruit Fly

Los Angeles Basin History of Outbreaks (1987-2009)



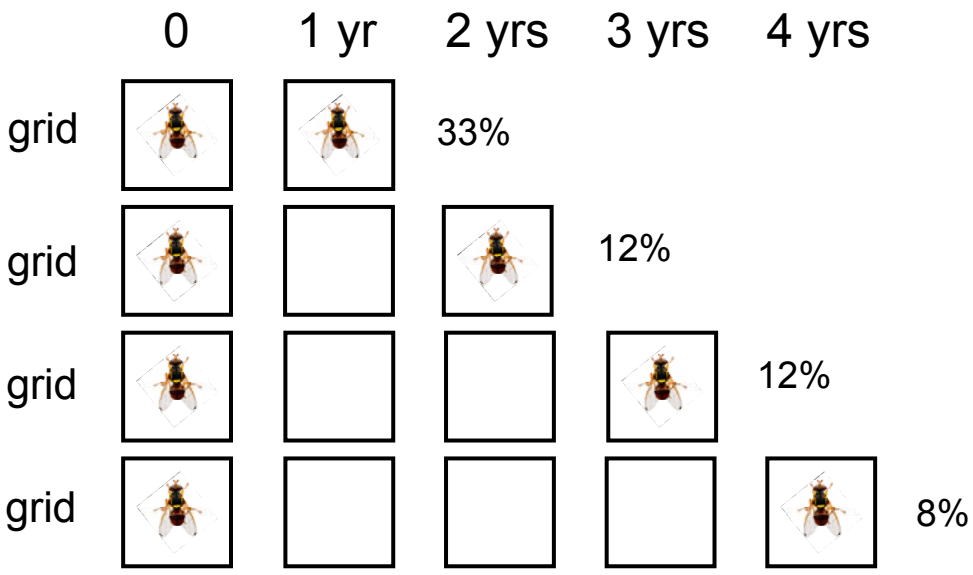
QUESTION #6:

What does zero capture mean?

ANSWERS:

1. **Meaningful** if never captured a fly in region
2. **Less meaningful** if captured fly previously in region

Oriental Fruit Fly Outbreak Interval in LA Basin



QUESTION #7:

How concerned should grower be in located just outside regulated area?

ANSWER:

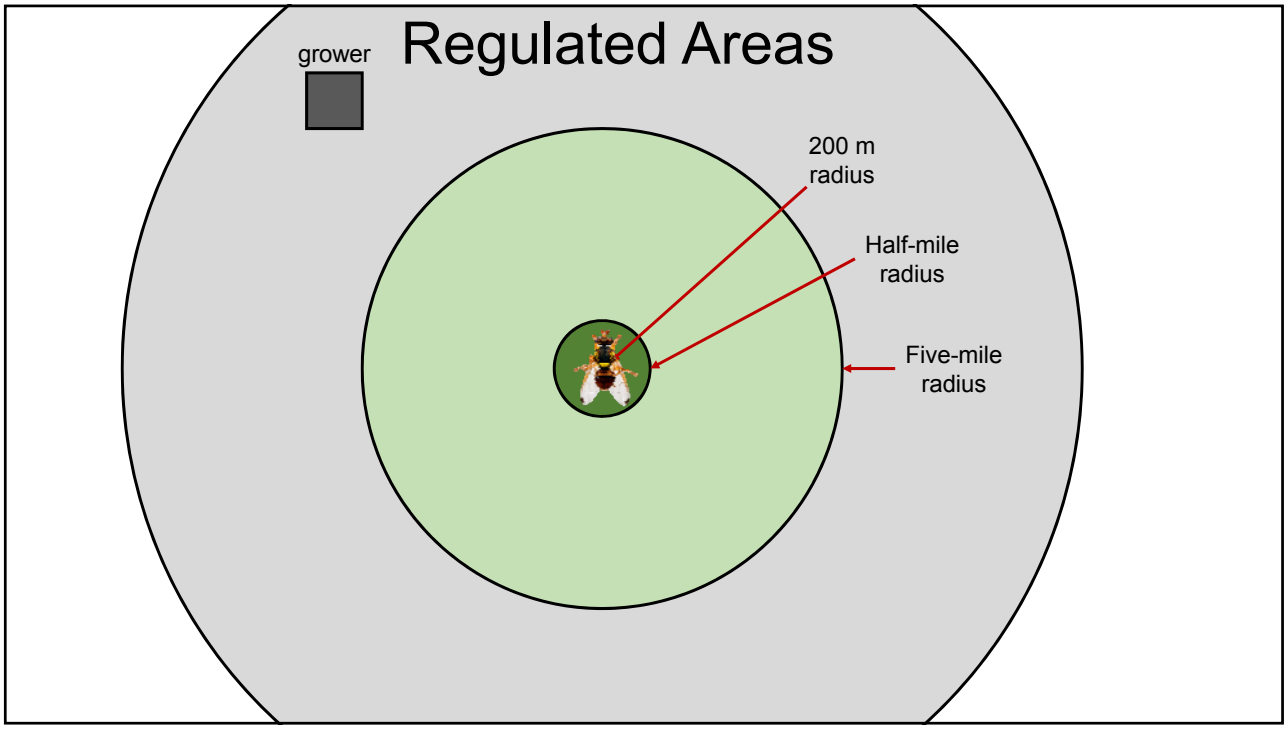
Very concerned in both immediate and longer term

Oriental fruit flies found in Sacramento, county says. Here's the plan to eradicate them

BY HANNAH HOLZER
hholzer@sacbee.com

August 28, 2018 02:45 PM
Updated August 28, 2018 07:07 PM

A local infestation of oriental fruit flies, an exotic invasive species that attacks over 230 different fruits, vegetables and plants, has been found in Sacramento, county officials said Tuesday.



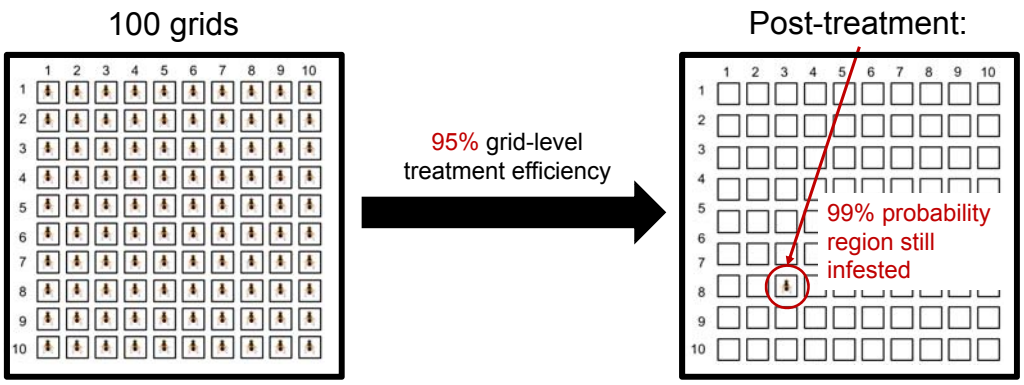
Policy Implications

Science informed policy

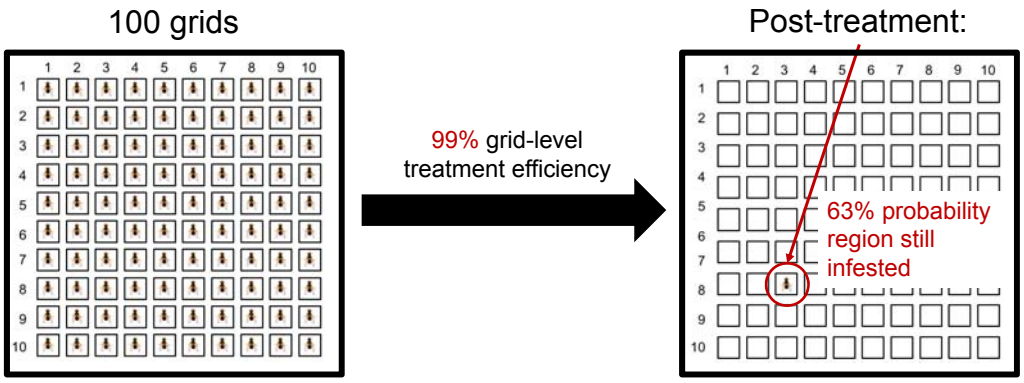
Current	Informed
1. 100% eradication success	Low-level population
2. One fly non-actionable	One fly actionable
3. Three generation no detection rule	Maintain program
4. Post-program complete re-set	High vigilance
5. No risk information for growers	Risk information available

Why is eradication so difficult?

Spatial Redundancy in Pest Invasions



Spatial Redundancy in Pest Invasions



Probability of Eradication (E)

$$E = 1 - s^{n}$$

Number of spatial units

Efficiency fraction

Basic principle of eradication:

As pest distribution increases *arithmetically*, the difficulty of eradication increases *geometrically*.

Extension of principle:

If pest distribution increases *geometrically*, the difficulty of eradication increases *super-geometrically*.

Closing thoughts:

- ~~Da~~tabases—e.g., Agriculture Data Act of 2018
- ~~Er~~adication—re. cancer staging
- ~~Inv~~asion science—closer to policy
- ~~Mi~~cro-demography—small populations
- ~~Po~~licy forum—Science Magazine

Thank you