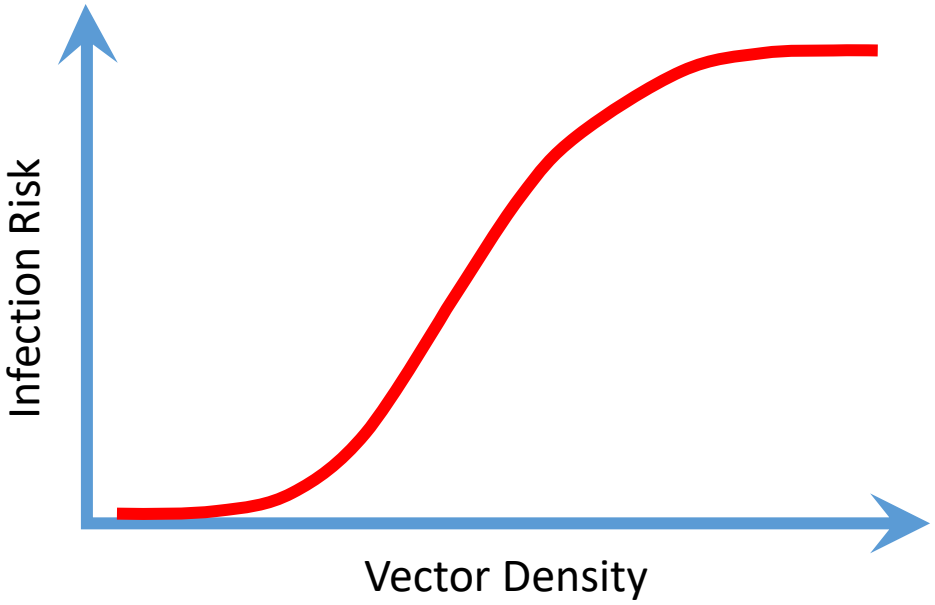

Thoughts on Integrated Mosquito Management

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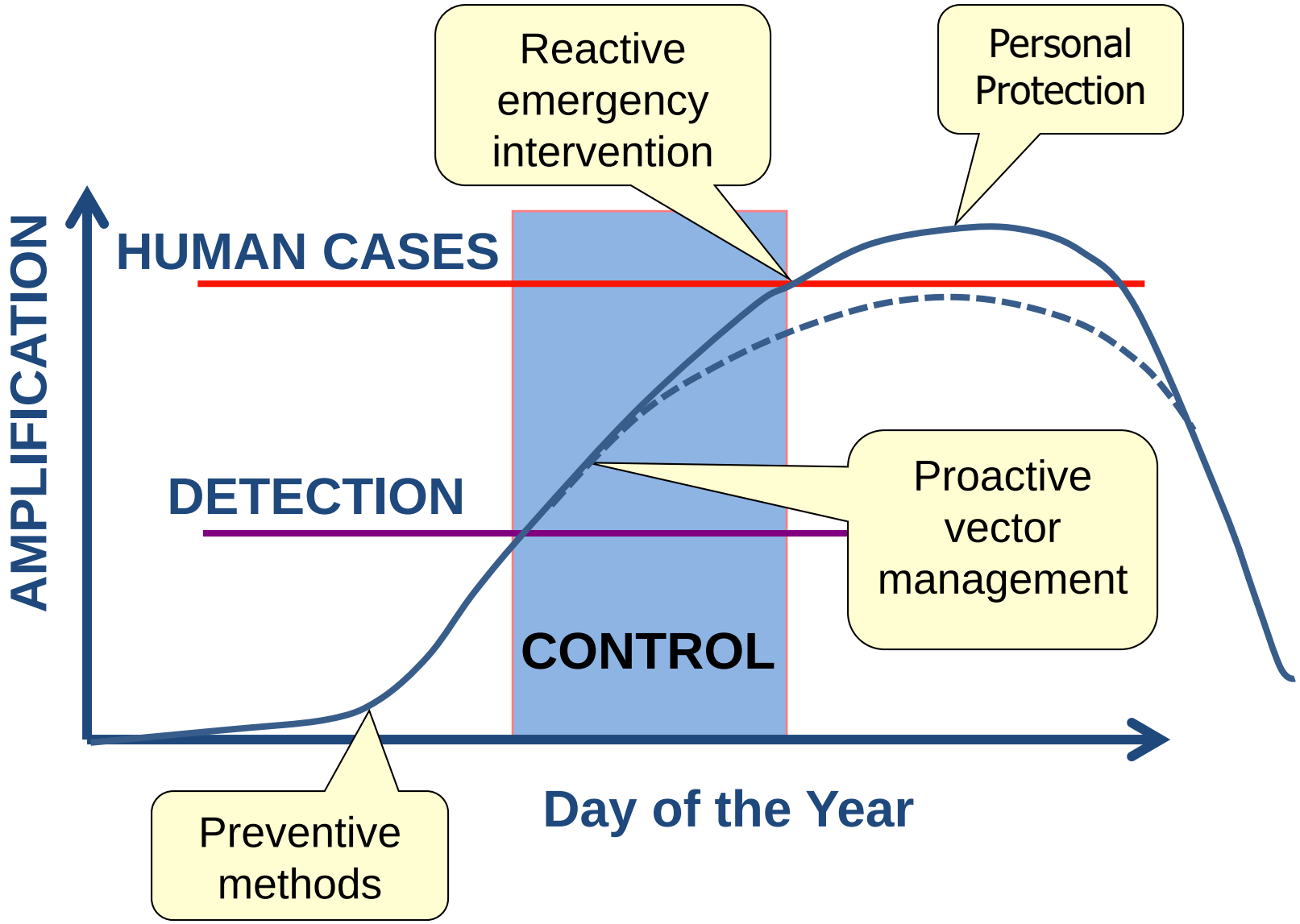
UNIVERSITY OF CALIFORNIA

Pacific Southwest Center of Excellence in Vector-Borne Diseases

Integrated Mosquito Management



Integrated Vector Management

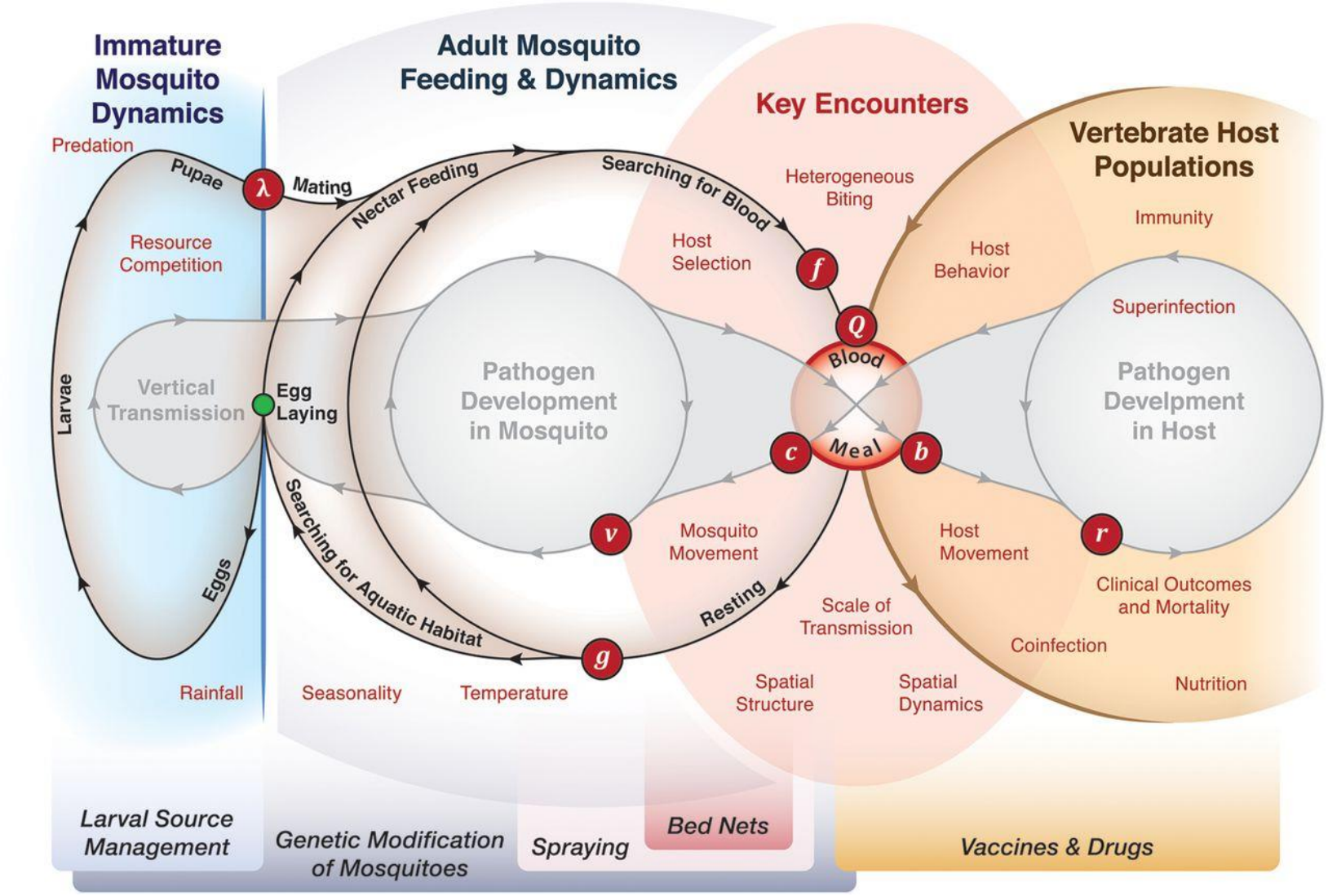
WHO:

“IVM is a rational decision-making process for the optimal use of resources for vector control. The approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control.”

WHO: Global Strategic Framework for IVM

- **Advocacy, social mobilization, regulatory control** for public health and empowerment of communities.
- **Collaboration within the health sector and with other sectors** through the optimal use of resources, planning, monitoring and decision-making.
- **Integration of non-chemical and chemical vector control methods**, and integration with other disease control measures.
- **Evidence-based decision making** guided by operational research and entomological and epidemiological surveillance and evaluation.
- **Development of adequate human resources, training and career structures** at national and local level to promote capacity building and manage IVM programs.

Transmission Theory for Mosquitoborne Pathogens



Smith DL et al. Recasting the theory of mosquito-borne pathogen transmission dynamics and control. *Trans R Soc Trop Med Hyg*. 2014;108(4):185-197.

Mosquito-borne viruses with humans as amplifying hosts (e.g., dengue, Zika)

Mosquito-borne zoonoses (e.g., WNV)

What do <u>you</u> want to know?

Entomological Inoculation Rate

- Rate at which a person is bitten by infectious vectors per day

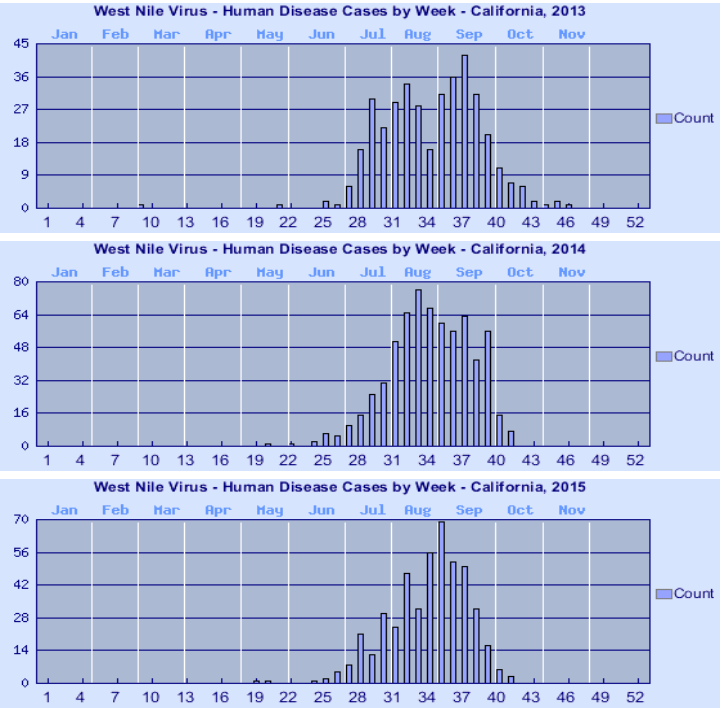
$$EIR = ma\phi\theta$$

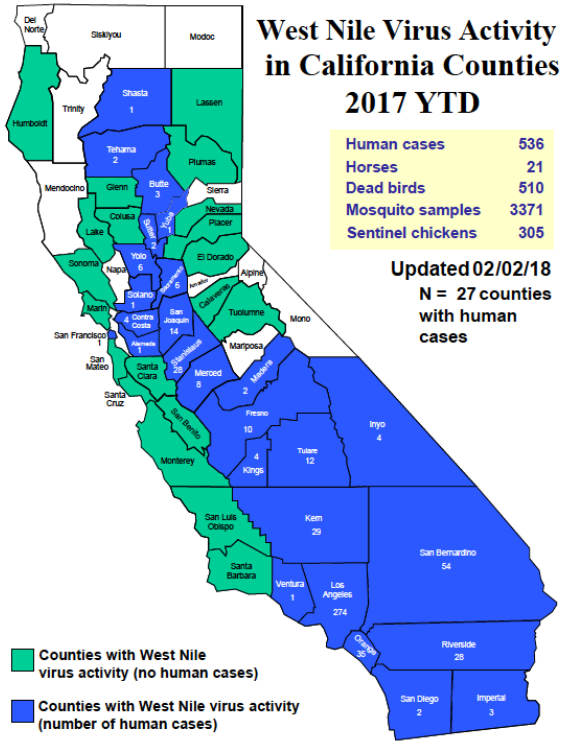
- Depends on
  - ***m*** = *mosquitoes / person* = how many vectors are "out there" (expressed per person)
  - ***a*** = *bites / day* = how often each vector bites
  - $\boldsymbol{\phi}$ = *human bites / all bites* = proportion of the bites on humans
  - $\boldsymbol{\theta}$ = *transmitting vectors / all vectors* = proportion of vectors that are infectious (infected and ready to transmit)

But we can't directly measure the inoculation rate…

EIR component (ideal)		Data (what we know)
m	Ratio of mosquitoes to humans	Mosquito counts from traps
a	Mosquito biting rate	Can be estimated as a function of temperature
ϕ	Proportion of mosquito bites on humans	Varies seasonally, and can be informed by several studies on host selection
θ	Proportion of mosquitoes that are infect**ious**	Proportion of mosquitoes that are infected, determined through testing of female mosquitoes pooled in batches of ≤ 50

Surveillance for Human Disease





- Human disease cases
  - Active vs. passive detection
  - Usually the most important outcome (to us)
  - In some areas, the only available data
  - First indication of a problem for new introductions

Why can't we just monitor disease cases for zoonotic pathogens like WNV?

- **Need to monitor enzootic cycles in mosquitoes and birds to viral amplification before reaching high risk for humans or horses.**
- **Reporting delays for human and equine disease cases typically make the reports too late to guide control efforts**
- **"Noisy" spatial distribution due to small numbers of disease cases (low incidence) that might not reflect actual risk**
- **Variation in exposure and vulnerability of at-risk populations make them a spatially variable and insensitive indicator of risk.**

Surveillance: Mosquitoes

- <u>Abundance</u>
  - Many ways to measure
    - Trapping
    - Active sampling
  - Different life stages of the vector
    - Mosquitoes: eggs, larvae, pupae, adults
  - Useful for evaluating control
  - Must establish baselines to compare across time and space

Surveillance: Mosquitoes

- <u>WNV Infection Prevalence</u>
  - Trap live mosquitoes weekly
  - Identify to species
  - Test by RT-PCR in groups of 1-50
  - Estimate infection prevalence

Real-Time RT-PCR
TaqMan® One-Step RT-PCR Kit
Applied Biosystems® 7900 HT
Fast Real-Time PCR System

Surveillance: Vertebrate Testing

- **Infection in hosts (Dead Birds)**
  - Less useful for viruses in live birds (short viremia)
  - Sometimes eval. for subset of pop. e.g., dead birds

- **Serological testing (Sentinel Chickens)**
  - Chickens tested every 2 weeks
  - % seroconverting provides a measure of transmission intensity
  - A few agencies also monitor seroprevalence in humans, wildlife

Benefits and Costs of Vector Management

<u>Benefits</u>

- Reduction in disease
- Reduction in pests
- Improved quality of life, reduced economic burden

<u>Costs</u>

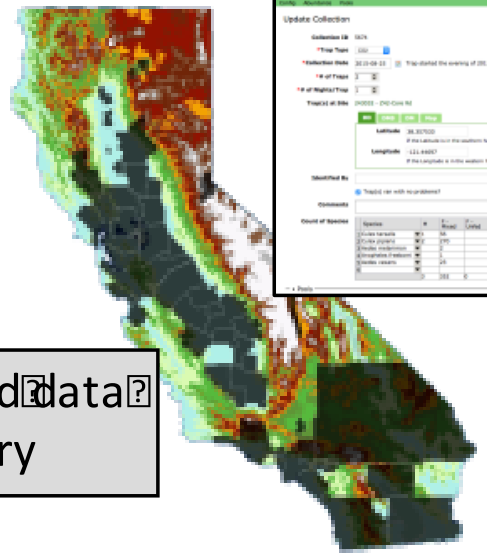
- Financial
- Human resources
- Human exposure to insecticides
- Non-target impacts
- Insecticide resistance

IVM best practices: data management

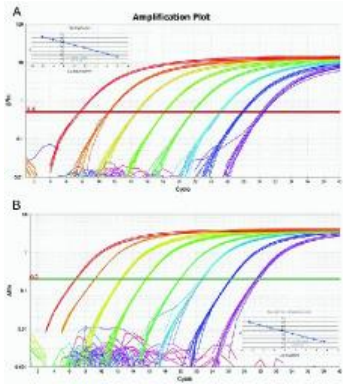
- Standardized record-keeping at the local level that ensures utility across spatial scales
- Data should be useful for
  1. Defining the problem (e.g., infection risk)
     - Extent
     - Intensity
  2. Measuring effects of interventions

CalSurv California Vectorborne Disease Surveillance Gateway

DART DAVIS ARBOVIRUS RESEARCH & TRAINING



Field data entry

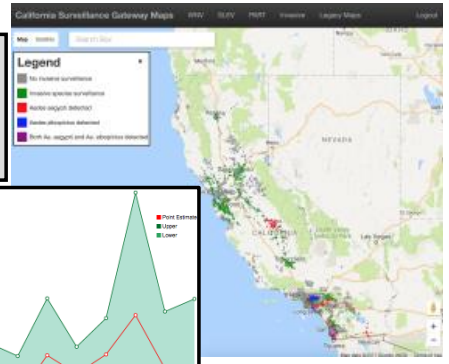


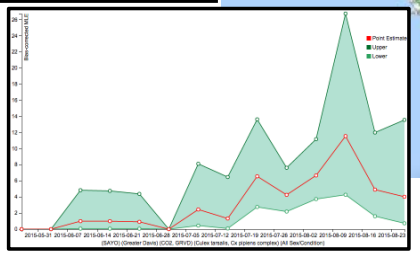
Laboratory data entry

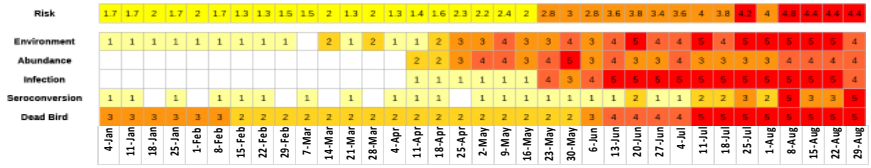
National Databases

CDC ArboNET MosquitoNET

Interactive Maps and Tools







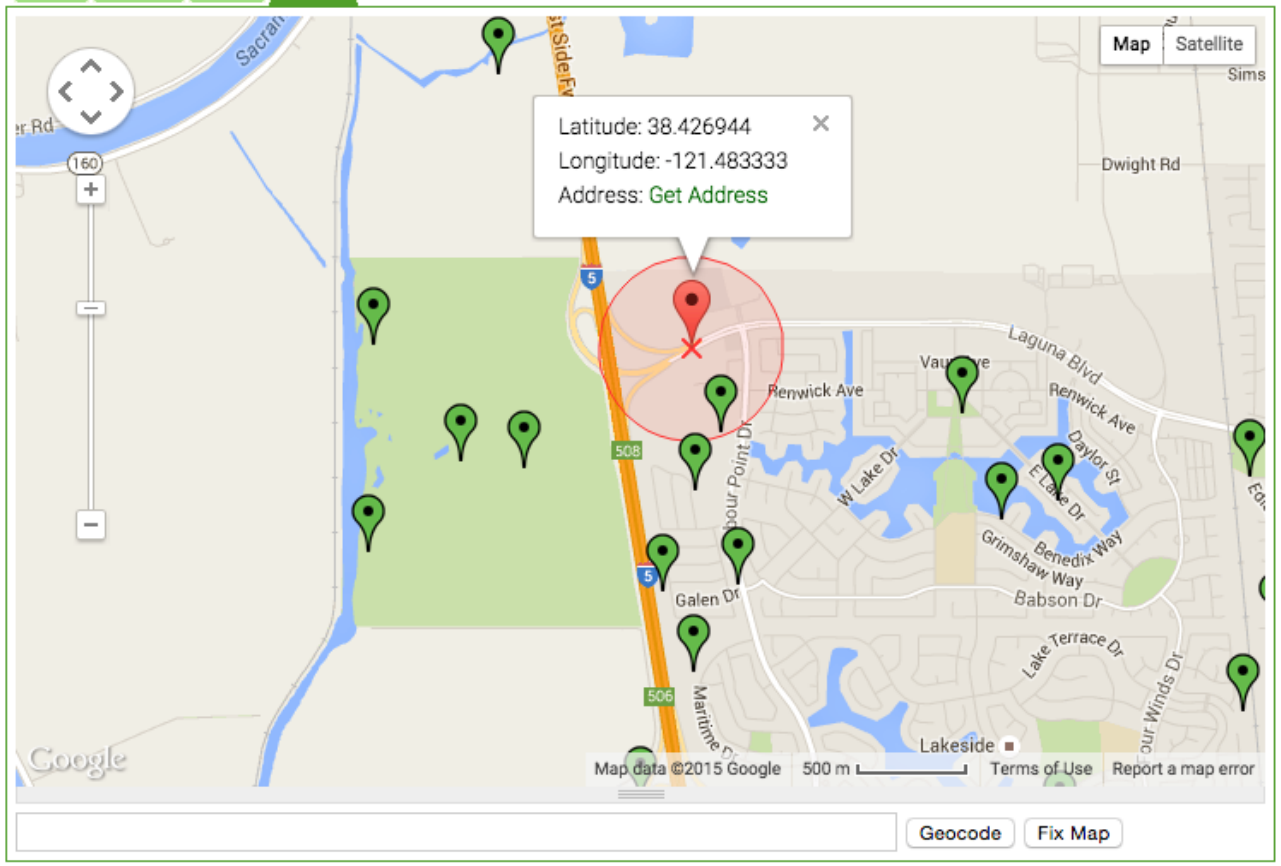
Arbovirus bulletins, Automated emails

Surveillance Site Management

*Site Code SAYO 002304

Site Name Laguna West

*Coordinates DD DMS DM Map



Elevation (m) 3 get

Address

City Elk Grove

CalSurv California Vectorborne Disease Surveillance Gateway

Mosquito Control: Data Entry

Sites | Arthropod | Sentinel | DiSen | Carcass | Diagnostics | Application | Resistance | Tools | Settings | Help | Logout
Config | Abundance | Pools

Update Collection

Collection ID 5674

***Trap Type** CO2

***Collection Date** 2015-08-25 Trap started the evening of 2015-08-24.

***# of Traps** 2

***# of Nights/Trap** 1

Trap(s) at Site 243032 - Z42-Core Rd

DD | DMS | DM | Map

Latitude 38.357533
If the Latitude is in the southern hemisphere, the value must be prefixed by the minus '-' sign.

Longitude -121.44697
If the Longitude is in the western hemisphere, the value must be prefixed by the minus '-' sign.

Identified By

☑ Trap(s) ran with no problems?

Comments

Count of Species

	Species	M	F - Mixed	F - Unfed	F - Bloodfed	F - Gravid	Σ F	Unknown Sex	Eggs	Larvae	Pupae
1	Culex tarsalis	1	56				56				
2	Culex pipiens	2	270				270				
3	Aedes melanimon		2				2				
4	Anopheles freeborni		1				1				
5	Aedes vexans		23				23				
6							0				
		3	352	0	0	0	0	0	0	0	0

Pools

Current Agency

By changing agencies, settings may adjust to accommodate agency-specific rules.

SAYO (Administrator)

☐ Keep block collapsed.

Link Pools

Click here to link unassociated pools to this collection.

Last Collection #1

Collection #: 5764
Trap Type: GRVD
Trap at Site: 213009
Collection Date: 2015-08-25
# of Trap Nights: 1
Identified By:
Trap Problems?: No
Add Date: 2015-08-25 01:54 PM

Last Collection #2

Last Collection #3

Last Collection #4

Last Collection #5

Used 2015 Pool #s

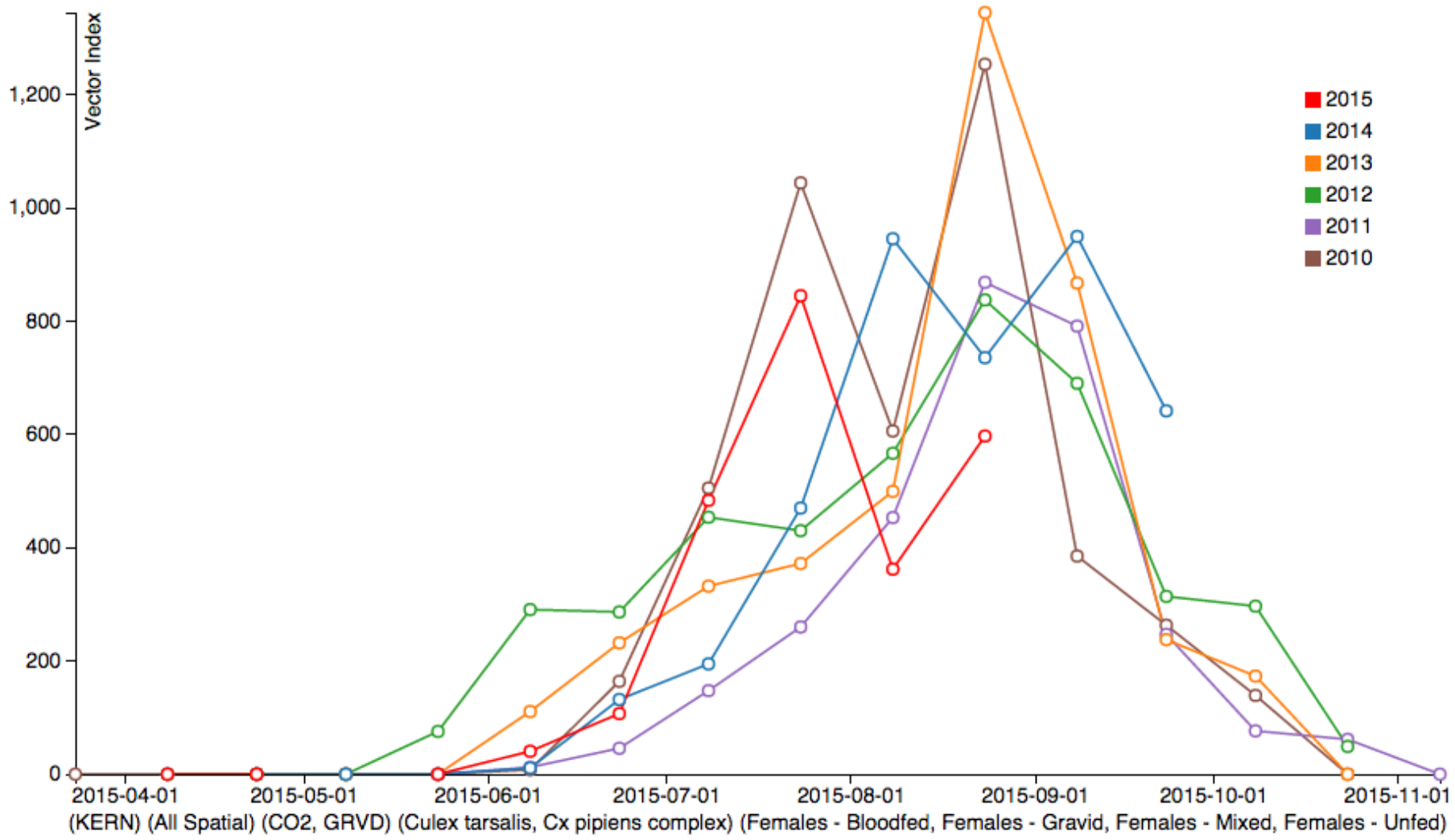
Open 2015 Pool #s

The following ranges are available for use for Surveillance Year: 2015 .

- 4485 - 150000

CalSurv California Vectorborne Disease Surveillance Gateway

Vector Index, Kern County



CalSurv California Vectorborne Disease Surveillance Gateway

California Mosquito-borne Virus Surveillance and Response Plan

Risk Level	Avg. Daily Temperature	Adult mosquito abundance	Mosquito MIR/1,000	Chicken Seroconversions	Dead Bird Infections	Human Cases
1	<56ºF	< 50% 5-yr. Avg.	0	0 in region	0 in region	
2	57-65ºF	50-90% 5-yr. Avg.	0.1 – 1.0	**≥ 1 in region,** 0 in agency	**≥ 1 in region,** 0 in agency	
3	66-72ºF	91-150% 5-yr. Avg.	1.1 – 2.0	1 flock in agency	1 in agency	**≥ 1 in region,** 0 in agency
4	73-79ºF	151-300% 5-yr. Avg.	2.1 – 5.0	2 flocks in agency	2-5 in agency	1 in agency
5	>79ºF	> 300% 5-yr. Avg.	> 5.0	>2 flocks in agency	>5 in agency	>1 in agency

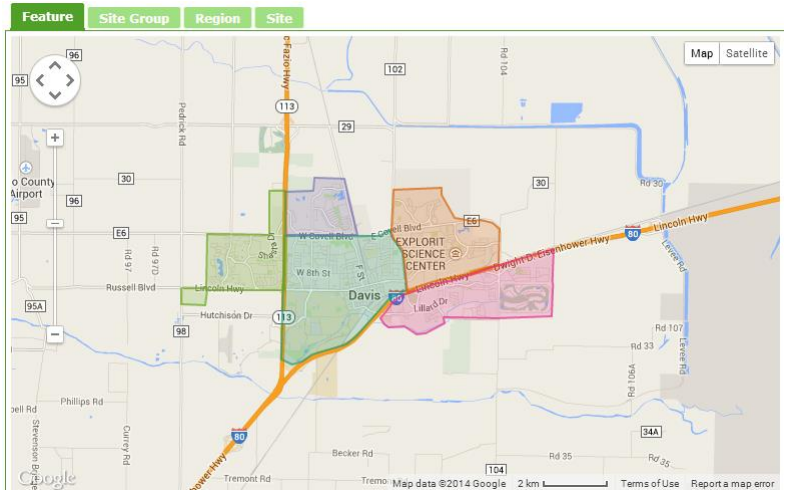
SCORE	RISK LEVEL
1.0—2.5	**Normal season**
2.6—4.0	**Emergency planning**
4.1—5.0	**Epidemic**

On the web at http://westnile.ca.gov/resources.php

CalSurv Gateway Risk Calculator

CalSurv California Vectorborne Disease Surveillance Gateway

Time Interval	2013 by Week
Agency	Sacramento-Yolo MVCD
Spatial Filter	City of Davis
Target	WNV
Trap Type	CO_2-baited traps, gravid traps
Sex	Female mosquitoes
Species	*Culex tarsalis, Culex pipiens*



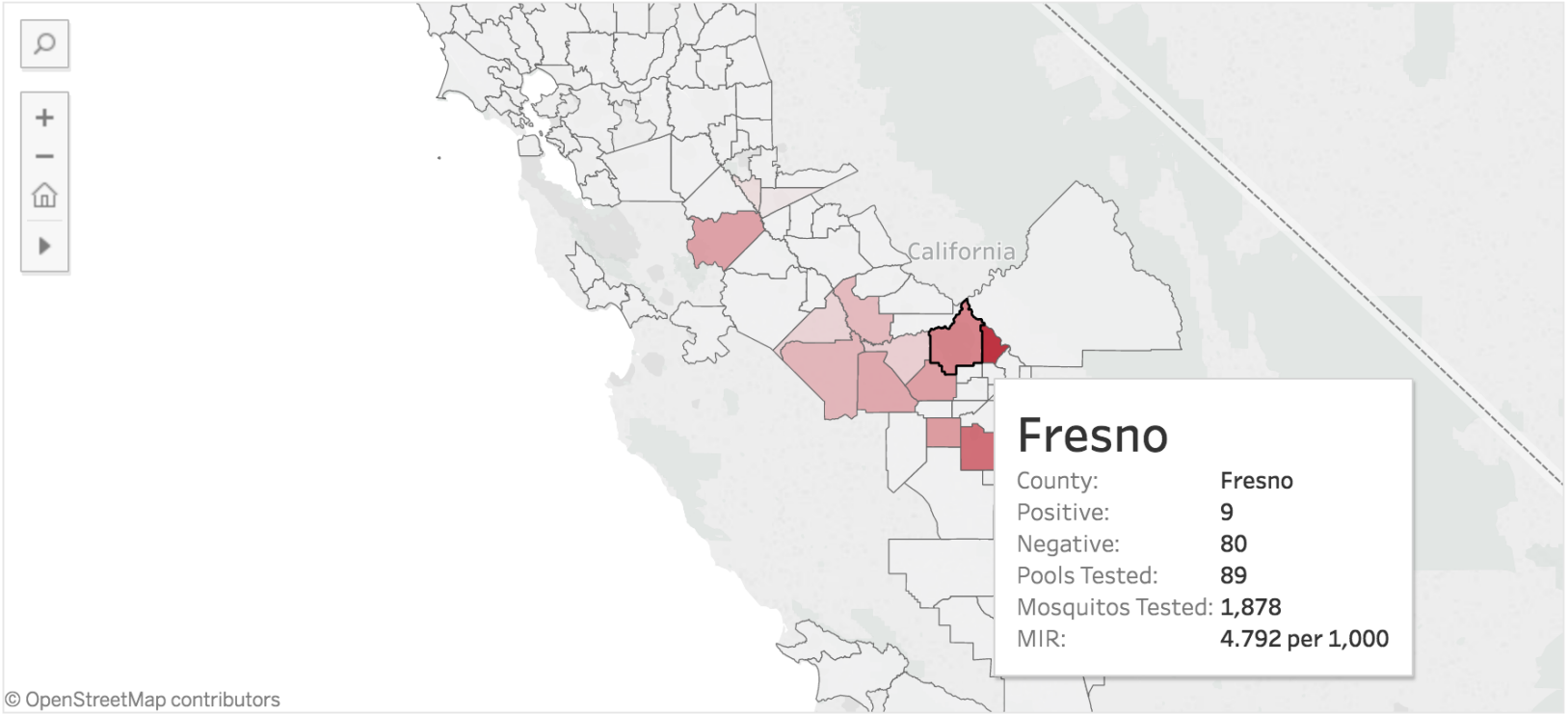
	05/04/2013	05/11/2013	05/18/2013	05/25/2013	06/01/2013	06/08/2013	06/15/2013	06/22/2013	06/29/2013	07/06/2013	07/13/2013	07/20/2013	07/27/2013	08/03/2013	08/10/2013	08/17/2013	08/24/2013	08/31/2013	09/07/2013	09/14/2013	09/21/2013	09/28/2013	10/05/2013	10/12/2013	10/19/2013	10/26/2013	11/02/2013	11/09/2013
Risk	2	2	2.3	2	2.3	2	2.7	2.3	4.3	3.5	4	3	4	3.5	2.3	3.3	4.7	3	3.3	3.5	3.5	3.3	2.8	2.5	2.5	2.3	2.5	3
Abundance	2	4	4	3	4	4	5	5	5	5	2	3	3	4	1	4	5	2	2	5	4	4	4	3	3	2	4	4
Infection		1	1		1	1	1	1	4	4	5	3	4	4		3	4	4	5	3	4	3	1	1	1	1	1	
Seroconversion		1		1		1		1		1		1		1	1	1		1	1	1	1	1	1	1	1	1	1	1
Dead Bird	2	2	2	2	2	2	2	2	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4

tableau | Content | Users | Groups | Schedules | Tasks | Status | A

Home › Open Data Portal › Pool Testing › Dashboard 1

Undo | Redo | Revert | Refresh | Pause | View: Original | Alert | Edit | Share | Download | Comments | Full Screen

Infection Rates



Subcounty	County	Year of Coll..	Month	Trap Type	Test Target	Positive	Negative	Pools Tested	Mo
Alameda	Alameda	2017	August	CO2	SLEV	0	1	1	
Antioch-Pit..	Contra Costa	2017	August	CO2	SLEV	0	23	23	
Arroyo Gra..	San Luis Ob..	2017	August	CO2	SLEV	0	8	8	
Arvin-Lamo..	Kern	2017	August	GRVD	SLEV	0	3	3	
Atwater	Merced	2017	August	CO2	SLEV	0	39	39	
Auburn	Placer	2017	August	CO2	SLEV	0	40	40	
Bakersfield	Kern	2017	August	GRVD	SLEV	0	17	17	

Test Target
SLEV

Trap Type
- (All)
- BBT
- BGSENT
- CDCAGO
- CO2
- FLANNEL
- GRVD
- INSP
- MBT
- MMT
- MODAGO
- NA
- NJLT
- OTHER
- PROKOPACK
- REST
- SWEEPNET

Month
August

Year(s)
2017

MIR
0 — 9.708737864

Highlight County
Highlight County

CalSurv California Vectorborne Disease Surveillance Gateway

- Official state reporting mechanism
- Rapid reporting
  - Immediate reporting of test results to source agency via email
  - Immediate updates to databases & maps
- “Value Added”: tools for data analysis and visualization
- Agencies retain ownership of data
- User-level permissions and passwords
- Data export, including web services
- New tools for tracking pesticide applications & resistance testing

Capacity Building: Challenges

- Limited positions, low salaries, lack of appreciation of the field to make the field attractive as a career option
- Lack of “general”/organismal public health entomology faculty
- Funding of basic/molecular over applied/field research
  - Limited funding for research on vector control
- Public opinion and politics over sound science/lack of appreciation of VBDs by elected officials and public

Capacity Building

- Infrastructure
  - Dedicated funding stream for vectors/VBDs
  - Fee structure to support local vector management
  - Education of elected officials
  - Education of public health administrators
  - Communication: websites, public-facing data, social media, citizen science
- Career tracks
  - Standards for education and certification programs
  - Continuing education
  - Adequate pay scales
  - Internship opportunities

CDC Regional Centers of Excellence in VBDs

Pacific Southwest Center of Excellence in Vector-Borne Diseases

Knowledge & Capacity to Respond to Vector-Borne Diseases in the U.S.

Research

Field Evals of Current Control
- Field vs. lab insect. resistance
- Sustainable use of insecticides

Next-Gen Surveillance
- Improved surveillance
- New traps & diagnostics

Innovative Control + Evaluation
- Novel larvicides
- Genetic control strategies
- Optimizing release-based strategies

Epidemiology & Vector Ecology
- Improved estimates of vector abundance & control efficacy
- Defining targets for intervention

Training

Undergraduate,
Predoctoral,
Postdoctoral
Professional

Continuing Education
- Vector control
- Medical professionals
- Public health agencies

Student Research Grants
- Support supplies & travel for predoc trainees in Region 9
- Foster innovation & collaboration

Collaboration

Community of Practice
- University of California
- California Dept. of Public Health
- Mosquito & Vector Control Assoc. of California

Collaborative Workshops
- Open to public health and vector control in Region 9
- Emphasize core competencies in entomology & insecticide resistance monitoring

Services

Diagnostic Test Development
New Technologies Translation
Vector Genetics
Data Management & Analytics

Diverse Interdisciplinary Team

Entomology, Ecology,
Epidemiology,
Veterinary Medicine, Engineering,
Human Medicine, Public Health,
Vector Control

Study Area (California & Region 9)

Large, diverse human population
Diverse ecological zones & vector-borne disease threats
Long-standing working relationships

UC DAVIS

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Pacific Southwest Center of Excellence in Vector-Borne Diseases

CDPH California Department of Public Health

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MVCAC Mosquito and Vector Control Association of California