How Biology and Policy Affect Your Mosquito Control Options

https://www.fightthebite.net/download/annualreport/AnnualReport2017.pdf

California Department of Public Health, Vector-Borne Disease Section

October 25, 2018

Overview

- 5 levels of the Integrated Vector Management pyramid
- Selective pressures & resistance
- Permits and impaired waterways
- Control options, pesticide formulations and application methods

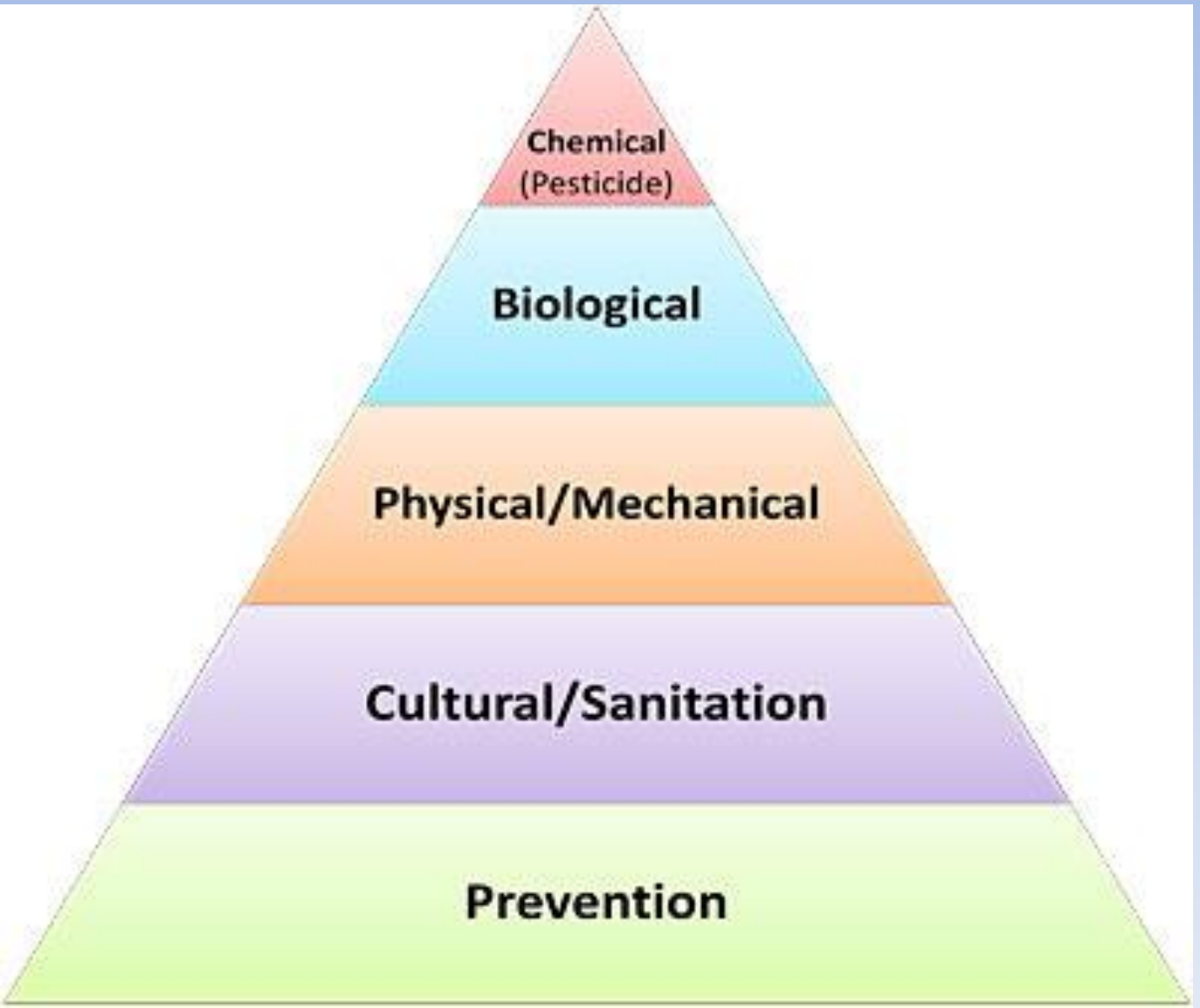
Integrated Vector Management (IVM)

IVM is the preferred modern approach to vector control, with pesticide use being the last option. Chemicals are used only after the other steps have proven ineffective.

Contrary to popular opinion, responsible agencies aren't running around spraying chemicals willy-nilly.

Based upon the modern approach of Integrated Pest Management (IPM) in agricultural systems.

IVM/IPM Pyramid



Each ascending step generally becomes more complex and costly.

Prevention

An ounce of prevention is worth a pound of cure.

When I say prevention, think public outreach.

- **Radio ads**
- **Billboards**
- **Door-to-door campaigns**
- **County fair booths**
- **Movie theater commercials**
- **Mosquito repellant handouts**
- **School programs**

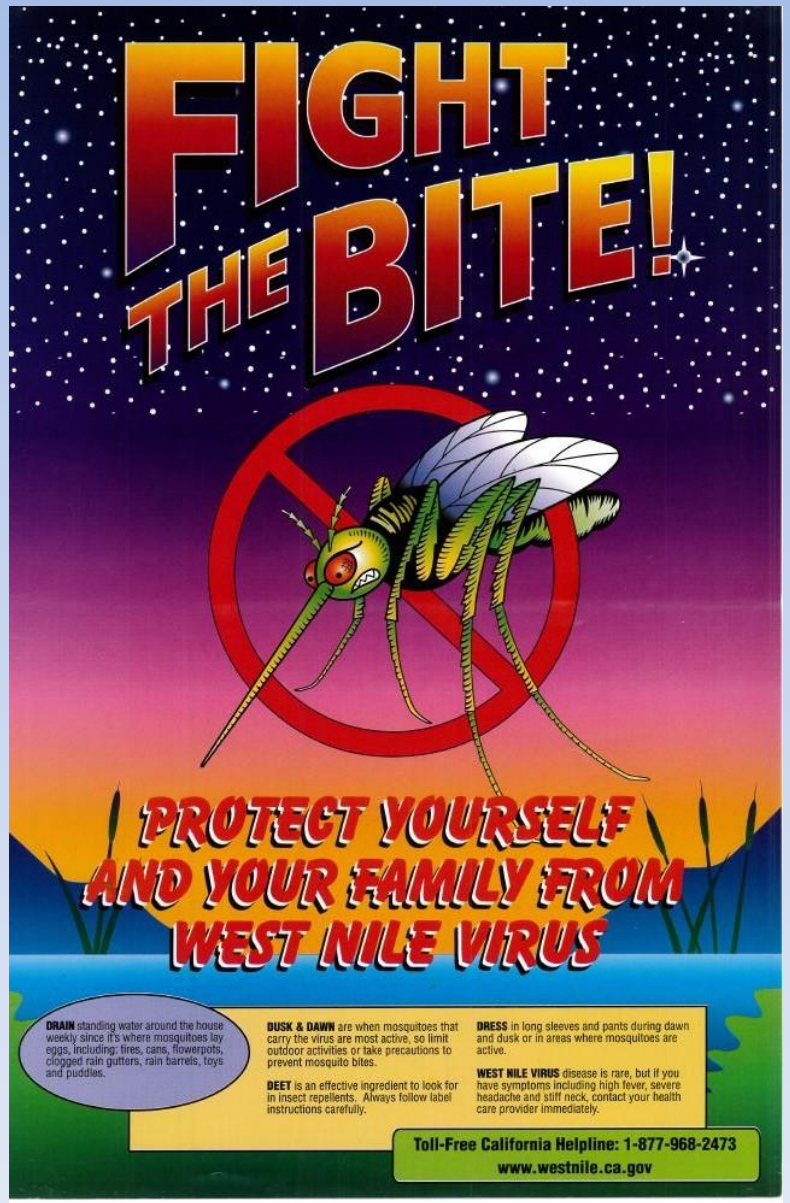
Prevention

We want to teach the public the 5 Ds of Prevention (written with WNV in mind):

- **Drain: Eliminate standing water around the house. Check tires, cans, clogged rain gutters, rain barrels, etc.**
- **Dusk and Dawn: WNV mosquitoes most active during this time**
- **Dress: Long sleeves and pants**
- **Deet: Use repellents**


Chemical (Pesticide)
Biological
Physical/Mechanical
Cultural/Sanitation
Prevention

Prevention


FIGHT THE BITE!
PROTECT YOURSELF AND YOUR FAMILY FROM WEST NILE VIRUS
DRAIN standing water around the house weekly since it's where mosquitoes lay eggs, including: tires, cans, flowerpots, clogged rain gutters, rain barrels, toys and puddles.
DUSK & DAWN are when mosquitoes that carry the virus are most active, so limit outdoor activities or take precautions to prevent mosquito bites.
DEET is an effective ingredient to look for in insect repellents. Always follow label instructions carefully.
DRESS in long sleeves and pants during dawn and dusk or in areas where mosquitoes are active.
WEST NILE VIRUS disease is rare, but if you have symptoms including high fever, severe headache and stiff neck, contact your health care provider immediately.
Toll-Free California Helpline: 1-877-968-2473
www.westnile.ca.gov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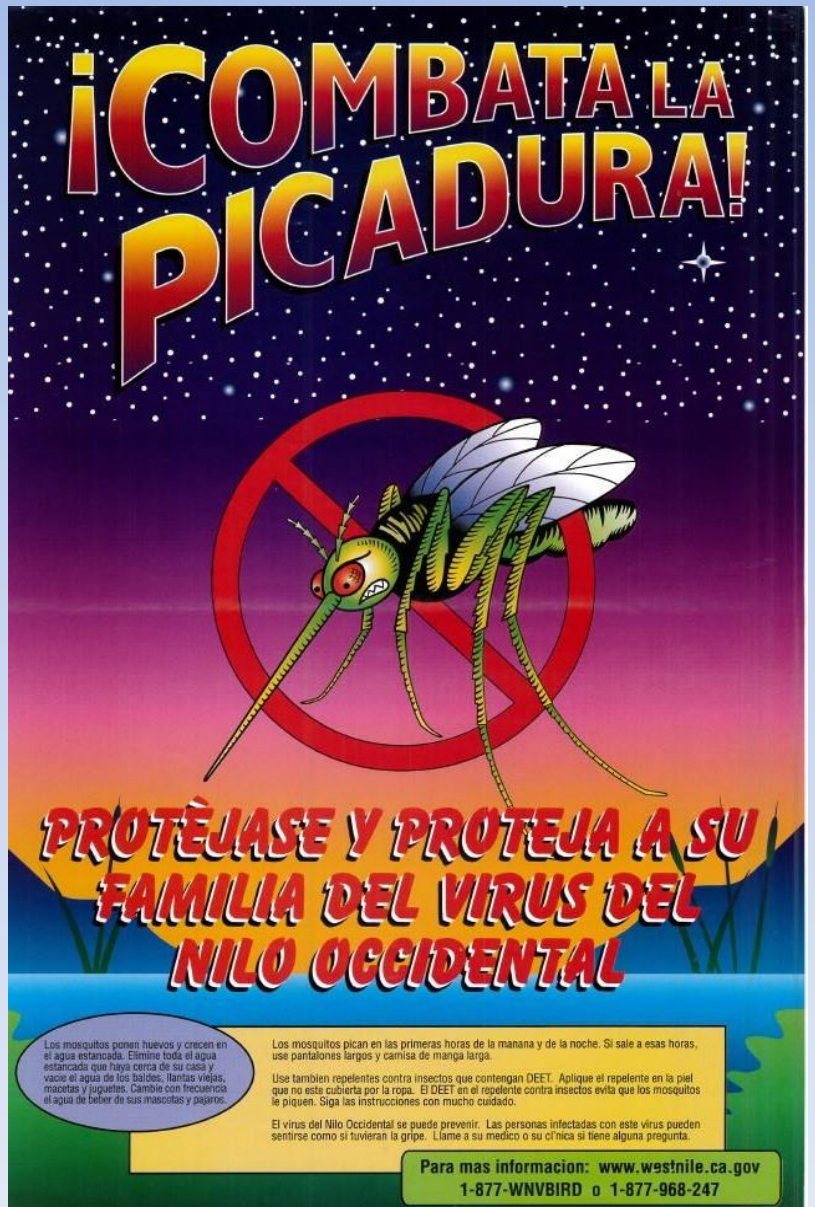
Prevention


¡COMBATA LA PICADURA!
PROTÈJASE Y PROTEJA A SU FAMILIA DEL VIRUS DEL NILO OCCIDENTAL
Los mosquitos ponen huevos y crecen en el agua estancada. Elimine toda el agua estancada que haya cerca de su casa y vacie el agua de los baldes, llantas viejas, macetas y juguetes. Cambie con frecuencia el agua de beber de sus mascotas y pajaros.
Los mosquitos pican en las primeras horas de la manana y de la noche. Si sale a esas horas, use pantalones largos y camisa de manga larga.
Use tambien repelentes contra insectos que contengan DEET. Aplique el repelente en la piel que no este cubierta por la ropa. El DEET en el repelente contra insectos evita que los mosquitos le piquen. Siga las instrucciones con mucho cuidado.
El virus del Nilo Occidental se puede prevenir. Las personas infectadas con este virus pueden sentirse como si tuvieran la gripe. Llame a su medico o su cl'nica si tiene alguna pregunta.
Para mas informacion: www.westnile.ca.gov
1-877-WNVBIRD o 1-877-968-247


Chemical (Pesticide)
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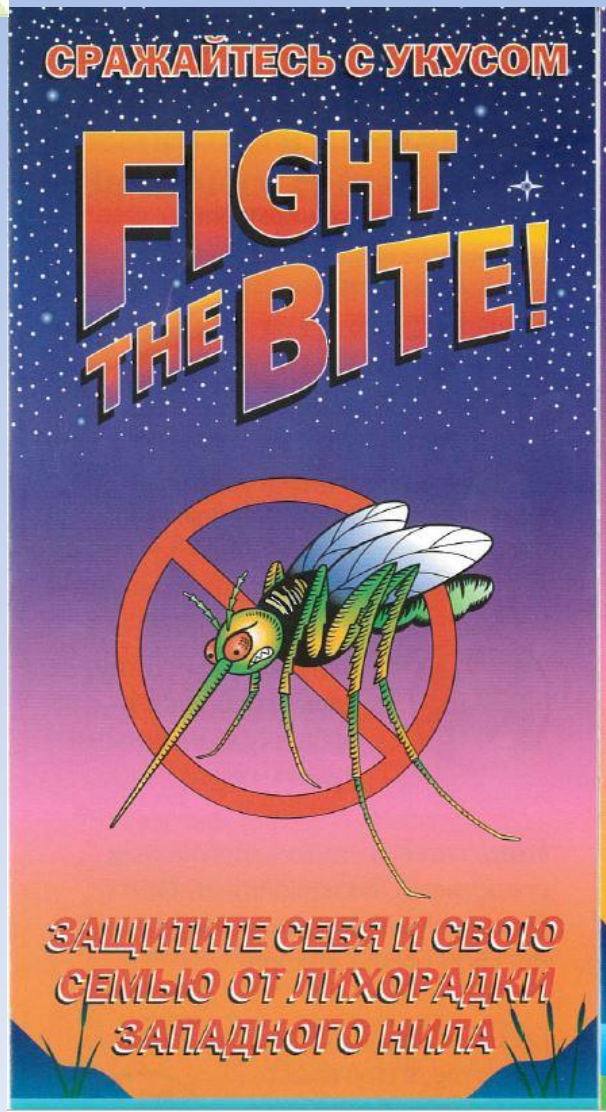
Prevention


СРАЖАЙТЕСЬ С УКУСОМ
FIGHT THE BITE!
ЗАЩИТИТЕ СЕБЯ И СВОЮ СЕМЬЮ ОТ ЛИХОРАДКИ ЗАПАДНОГО НИЛА


ចូរប្រយុទ្ធការពារ នឹងសត្វមូសកំណាច!
ចូរការពារខ្លួនអ្នក និងគ្រួសារ
របស់អ្នក ពីមេរោគ
វីរុស ណាល វីរុស (West Nile Virus)
ដើម្បីឲ្យបានជ្រាបពត៌មានផែមទ្បែត :

Prevention

Remember, YOU are the face of the district.

- **Knowledge**
- **Patience**
- **Agility**
- **Other languages?**

Advantages:

- **An educated public will be an involved public: children**
- **Good PR**

Disadvantages:

- **Time consuming, can be labor intensive**

Prevention

Advantages will always outweigh the disadvantages.

2011 *Aedes albopictus* infestation detected because the public notified the district about "day biting mosquitoes."

Concerned communities won't change their minds regarding pesticides, but maybe you can calm their fears enough to do your job.

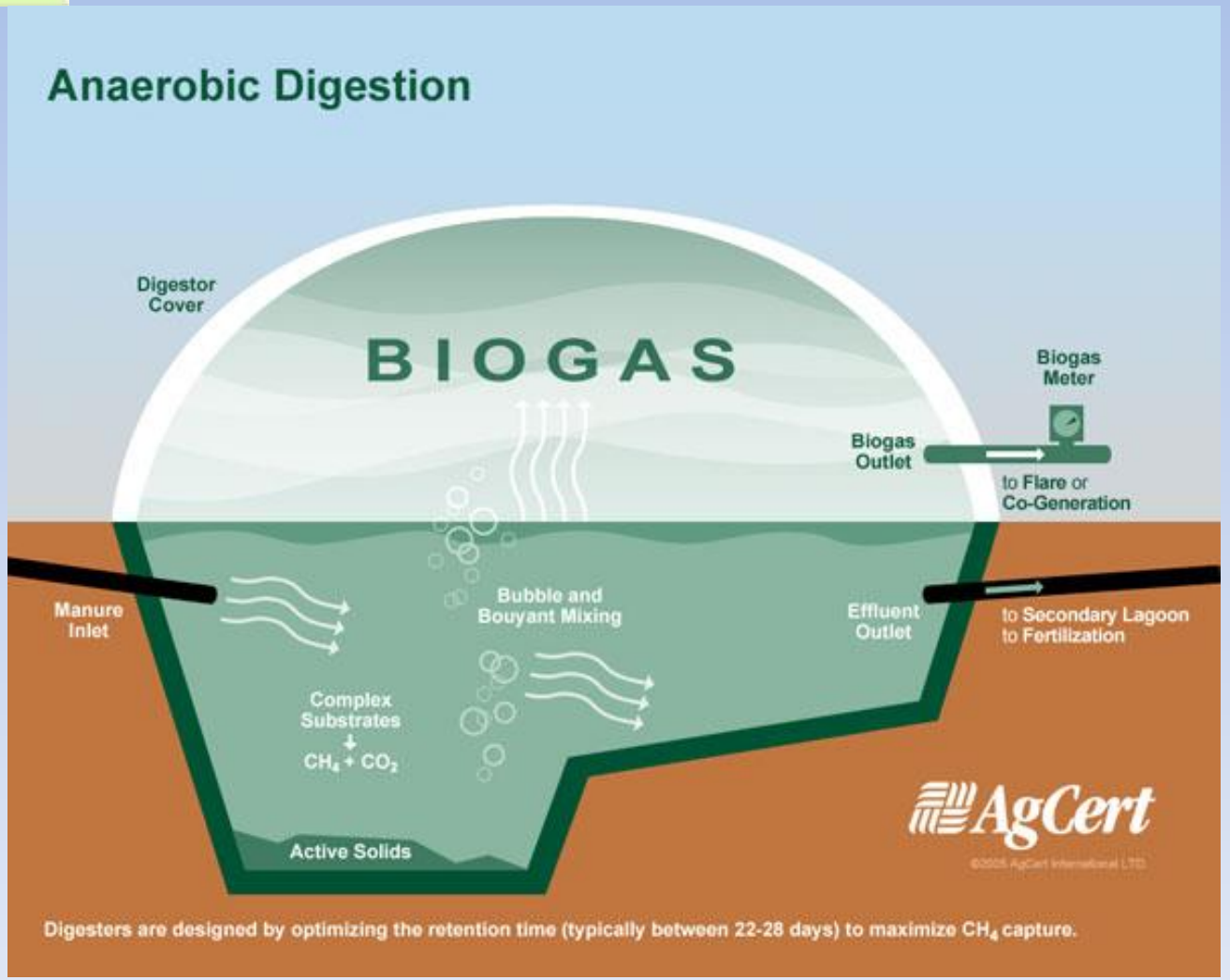
Cultural/Sanitation

The elimination of pest sources through policies or practices. If done properly, this can be a win-win proposition.

Example:

- **The policy of manure management to reduce fly numbers.**

Cultural/Sanitation



http://www.climatetechwiki.org/sites/climatetechwiki.org/files/images/extra/media_image_1.png.jpg

Cultural/Sanitation

The elimination of pest sources through policies or practices.

Examples:

- **Switching from flood irrigation to drip lines to prevent mosquito breeding**

Cultural/Sanitation

Advantages:

- **May save money: community "buy-in"**
- **May save time**

UC Extension, abatement districts can be contacted for expertise.

Disadvantages:

- **May be time consuming**
- **May require constant repetition/vigilance**

Physical/Mechanical

Making physical changes to an area by mechanical means to prevent pests.

Think ecological management.

Scale can range from a guy with a shovel to multi-million dollar projects.

Weigh costs vs. the benefits.

Physical/Mechanical

Mowing and removing cattails and weeds.

Physical/Mechanical

Cleaning weeds and debris out of drainage ditches.

Physical/Mechanical

Draining swampy areas to prevent mosquito breeding.

Physical/Mechanical

Altering river channel. Elimination of flood plain.

Physical/Mechanical

Removal of beaver dams

- **Often involves population control**

Physical/Mechanical

Advantages:

- **Physically changing an area can prevent or reduce the number of pests without the use of chemicals**
- **Alterations may be a long term solution**
- **Operating costs savings**

Disadvantages:

- **Sensitive habitats**
- **Presence of protected species**
- **Constant maintenance to remain pest free**

Physical/Mechanical

Herbicides can be used to clear path to mosquito source. Also used to remove aquatic vegetation to facilitate source treatment.

Biological/Biocontrol

Making use of natural enemies (predators, parasites, pathogens) to reduce a pest's numbers.

Gambusia affinis

Biocontrol

***Gambusia affinis*:**

- **Native range: northern Mexico through southern Indiana and tributaries of the Mississippi River**
- **Males: a minimum of 43 days to reach sexual maturity**
- **Females: a minimum of 21 days.**
- **Mating to birth: 16-28 days. Brood interval: ~21 days. 60 young.**

Biocontrol

Sacramento-Yolo Mosquito and Vector Control District produces between 2,500 and 5,000 pounds of *Gambusia* annually.

Biocontrol

Guppies (*Poecilia reticulata*):

- **Native range: South America**
- **Used in highly polluted environments: sewage pools, dairy lagoons, chicken ranch ditches and slightly acidic sources**
- **Useful in areas with low dissolved oxygen unacceptable to *Gambusia***
- **Used in areas where you don't want fish all year**

Biocontrol

Advantages:

- **Natural enemies will reduce the numbers of pests without the use of chemical pesticides**
- **Some populations can be self-sustaining**

Disadvantages:

- **Not always an option because of sensitive habitats or the presence of protected species**
- **Slow acting solution or not very effective**
- **Repeated applications required?**
- **Ecological disruption**

Chemical/Pesticide

The use of chemical pesticides to control a pest is the last option in the IVM/IPM pyramid.

Example: Fogging a residential neighborhood with a chemical pesticide.

Chemical/Pesticide

Advantages:

- **Immediate reduction in pest numbers**
- **Useful to prevent or manage disease outbreaks**

Disadvantages:

- **The use of chemical pesticides can promote resistance among pest populations**
- **Non-target issues: BEES!!**
- **Drift–related contamination**
- **Persistence in the environment**
- **Expensive to fly planes, operate trucks, pay for product, etc.**

Limited Number of Tools in the Toolbox

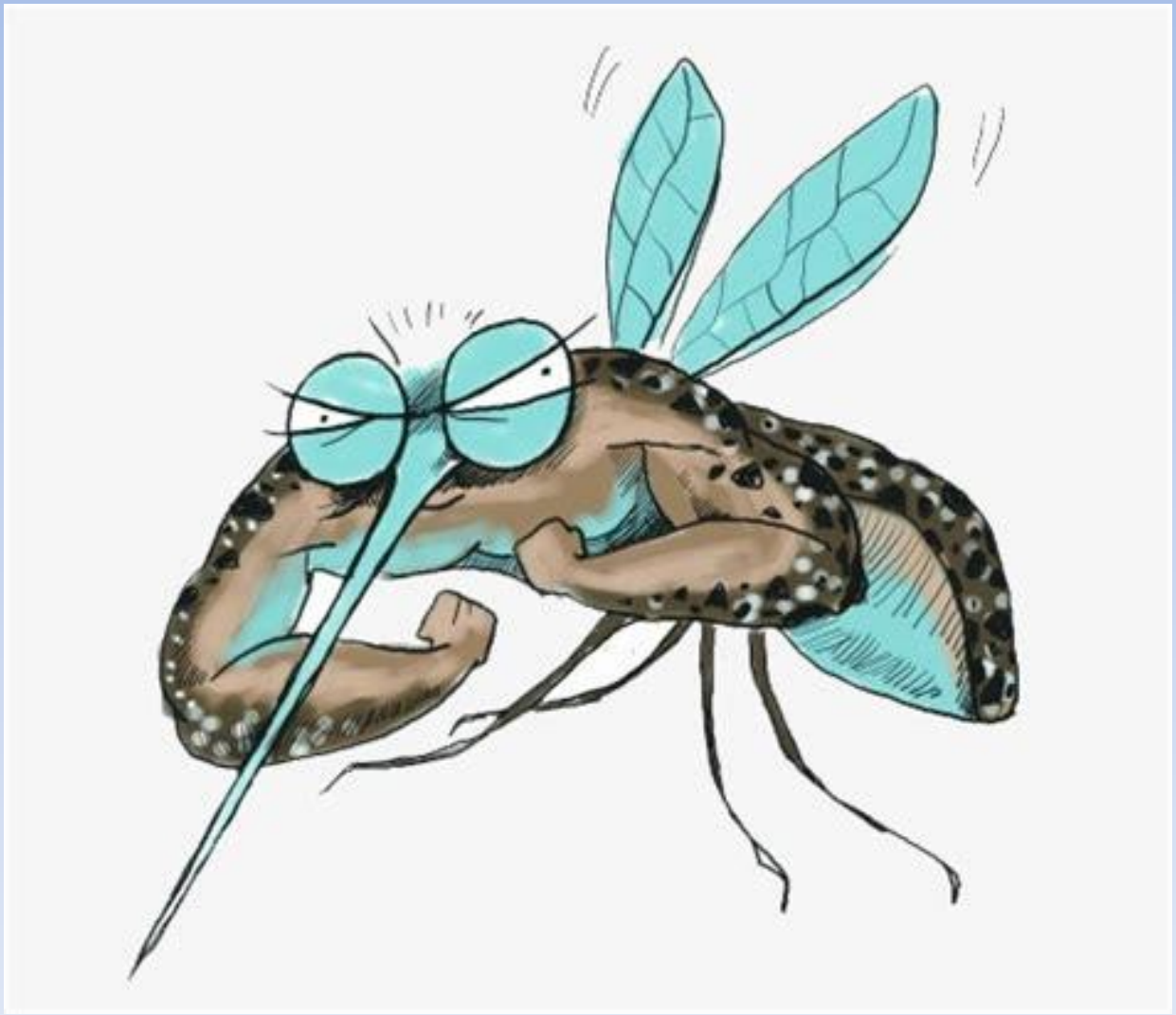
Long story short, IVM was designed for environmental protection and the prevention of pesticide resistance.

Unfortunately, we have a finite number of pesticides labeled for mosquito control.

Many pesticides are either related chemically, by mode of action, or both. Resistance in one product can lead to cross resistance.

Collective nightmare: Your products won't work because of resistance.

Pesticide Resistance



What is Pesticide Resistance?

Pesticide resistance is the ability of pests to avoid the post exposure lethal effects of pesticides.

This can happen through spontaneous mutations in populations resulting in genes that confer pesticide resistance, or because a small proportion of the population carries a gene for pesticide resistance naturally.

Selective Pressure

Before we talk about resistance further, you'll need to understand the concept of selective pressure.

Selective pressures can be anything: Pesticides, weather, predators, diseases, food type or availability, etc.

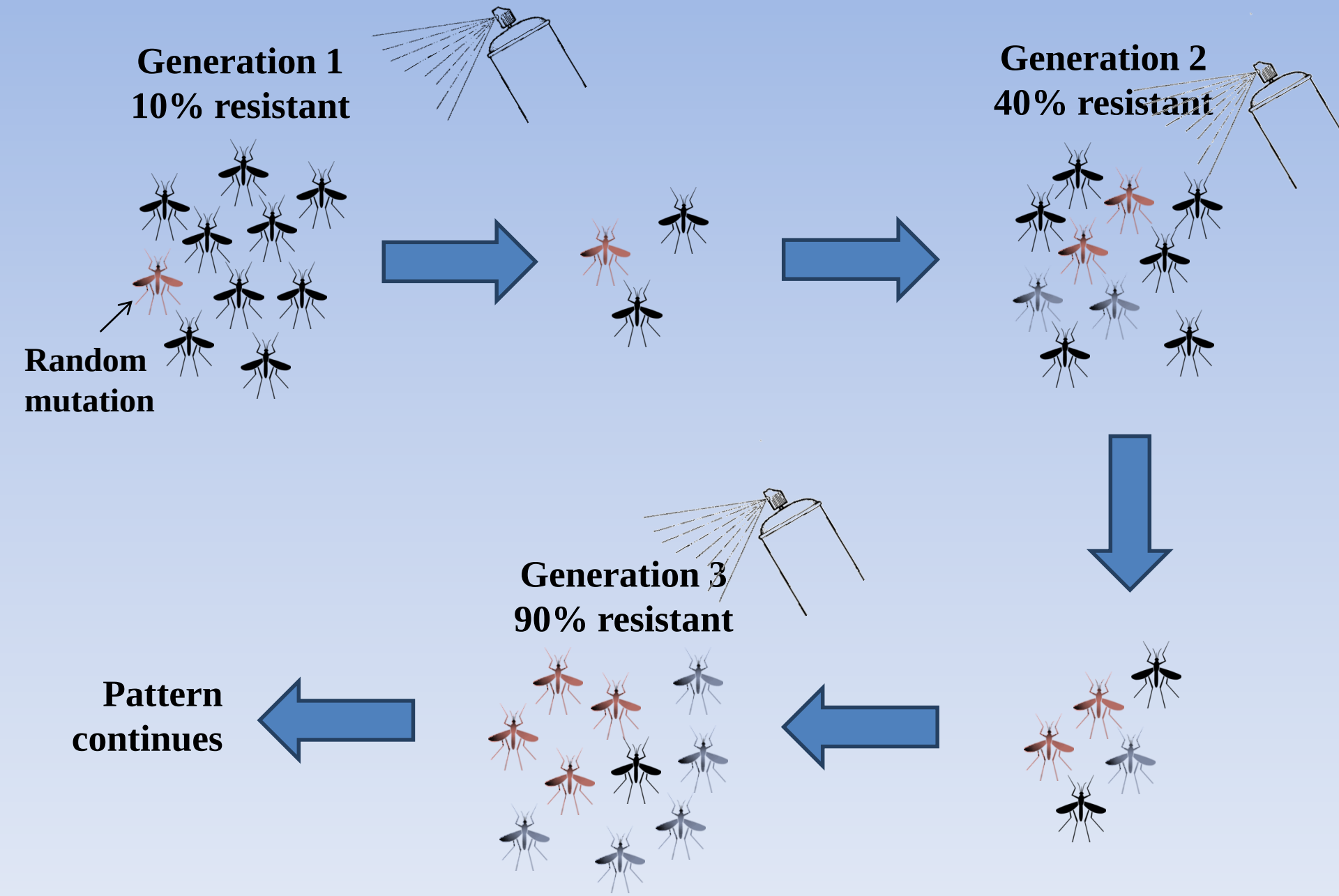
Selective pressures interact with the physical or behavioral characteristics of a population leading to differential survival and reproduction.

Selective Pressure

Every species contains genetic variation within populations.

If you don’t reproduce, you’re effectively dead.

Remember, the generation time of mosquitoes, depending on the temperature, can be a couple of weeks or less.


Generation 1
10% resistant
Random
mutation
Generation 2
40% resistant
Generation 3
90% resistant
Pattern
continues

Resistance to Pesticides

124 of 127 Merced County *Aedes aegypti* samples were homozygous resistant to pyrethrin and pyrethroid pesticides. Inconclusive results were obtained from three samples.

Resistance Management

Evaluate the efficacy of your products and rotate if necessary

- **Bottle Bioassay (Lab)**

Resistance Management

Evaluate the efficacy of your products and rotate if necessary

- **Efficacy trials (Field)**

Permits. This is California…

NPDES Permit

NPDES: National Pollution Discharge Elimination System.

Permit authorized by the Clean Water Act of 1972. Designed to reduce pollution in streams, lakes, rivers, wetlands, and other waterways from point source discharges.

In 2011 this became applicable to pesticide applications, including vector control, to or near Waters of the U.S.

For pesticide treatments to Waters of the U.S., the California State Water Resources Control Board has the mandatory NPDES permit.

Definition: Waters of the United States

1. **All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;**

2. **All interstate waters including interstate wetlands;**

3. **All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:**

i. **Which are or could be used by interstate or foreign travelers for recreational or other purposes; or**
ii. **From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or**
iii. **Which are used or could be used for industrial purposes by industries in interstate commerce;**

Definition: Waters of the United States

4. All impoundments of waters otherwise defined as waters of the United States under this definition;

5. Tributaries of waters identified in paragraphs (s)(1) through (4) of this section;

6. The territorial sea;

7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (s)(1) through (6) of this section; waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11(m) which also meet the criteria of this definition) are not waters of the United States.

Examples: Waters of the United States

Streams, drainage ditches draining into a stream, catch basins draining into a delineated wetland or rivers are all considered Waters of the U.S.

Dairy Ponds, or catch basins that drain into a sewage treatment plant are not examples of Waters of the U.S.

You should be aware that irrigated agricultural fields usually are not considered Waters of the U.S., until runoff leaves the field.

Definition subject to change!

Impaired Waterways: 303D

Vector control is highly regulated. All pesticide usage has to be reported to CDPR.

Remember, vector control districts aren't alone in applying pesticides

- **Agriculture**
- **Private pest control companies**
- **Illegal marijuana grows**
- **Homeowners**

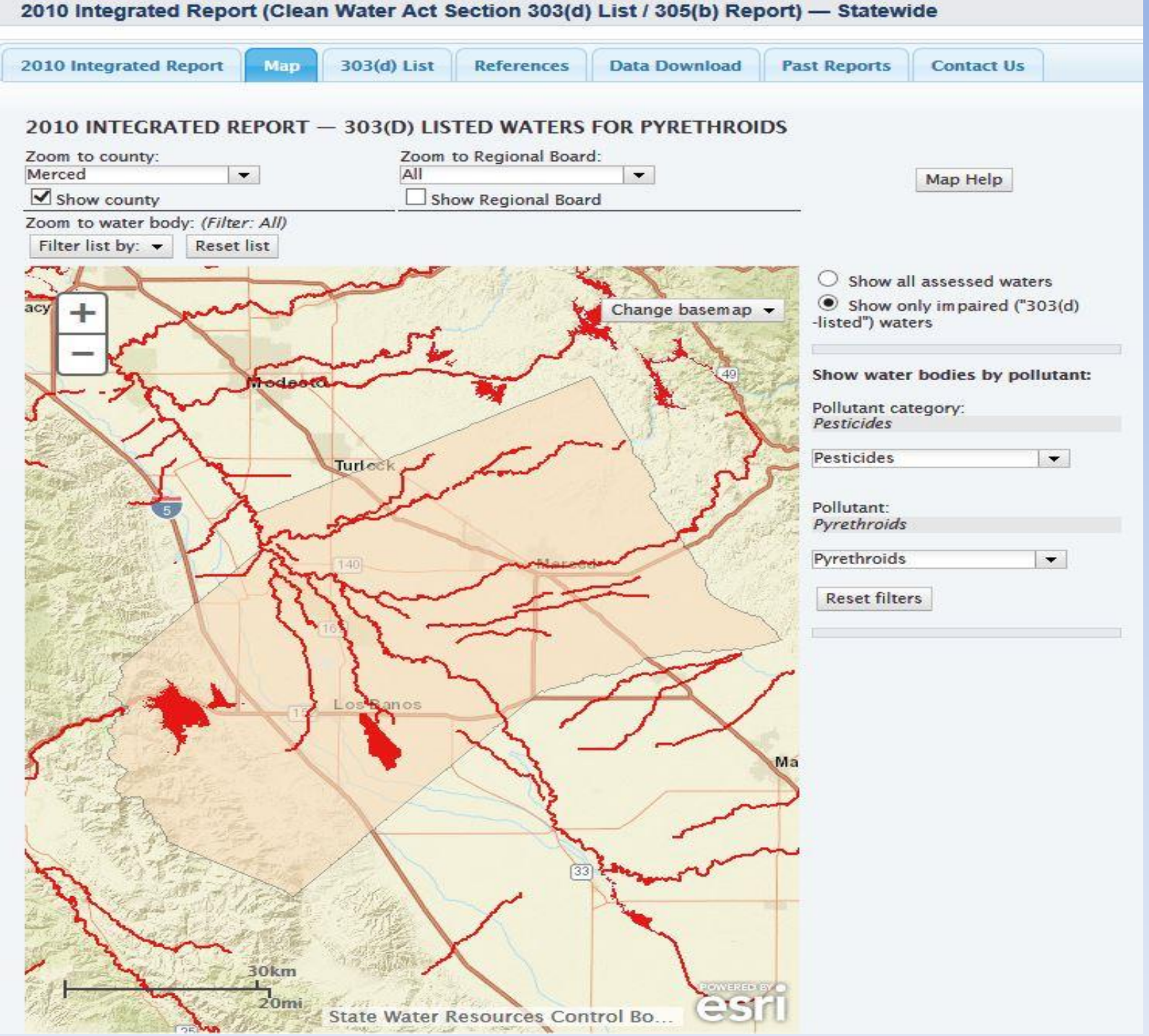
Impaired Waterways: 303D

Identify impaired waterways in your area.

Identify the chemical. You aren't allowed to apply that chemical in the waterway.

Example: Sumithrin vs. Deltamethrin

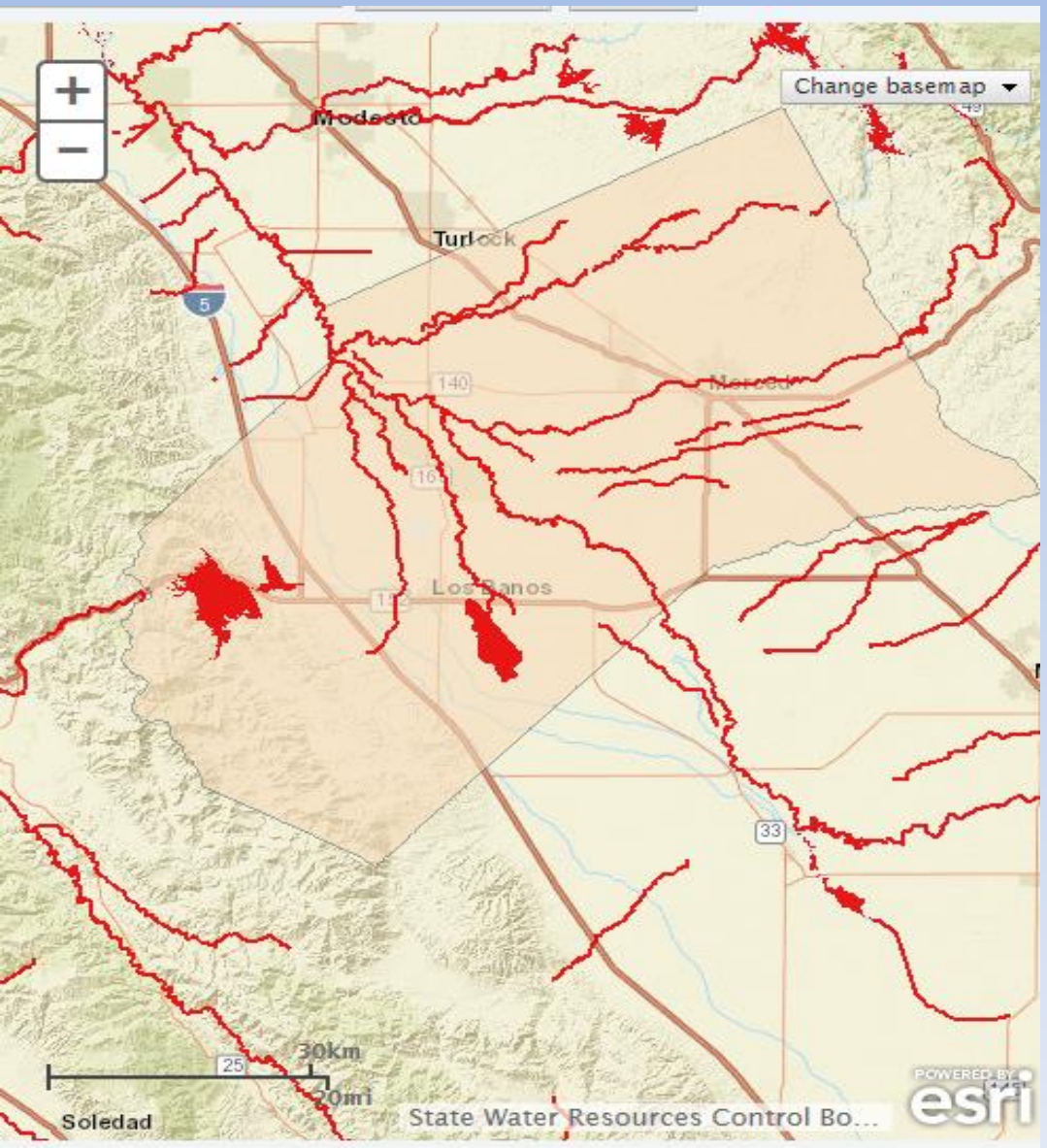
At some level OPs are OPs, pyrethroids are pyrethroids, but…



State Water Resources Control Board.

Clean Water Act Section Impaired Waterways: 303D

Impaired Waterways: 303D

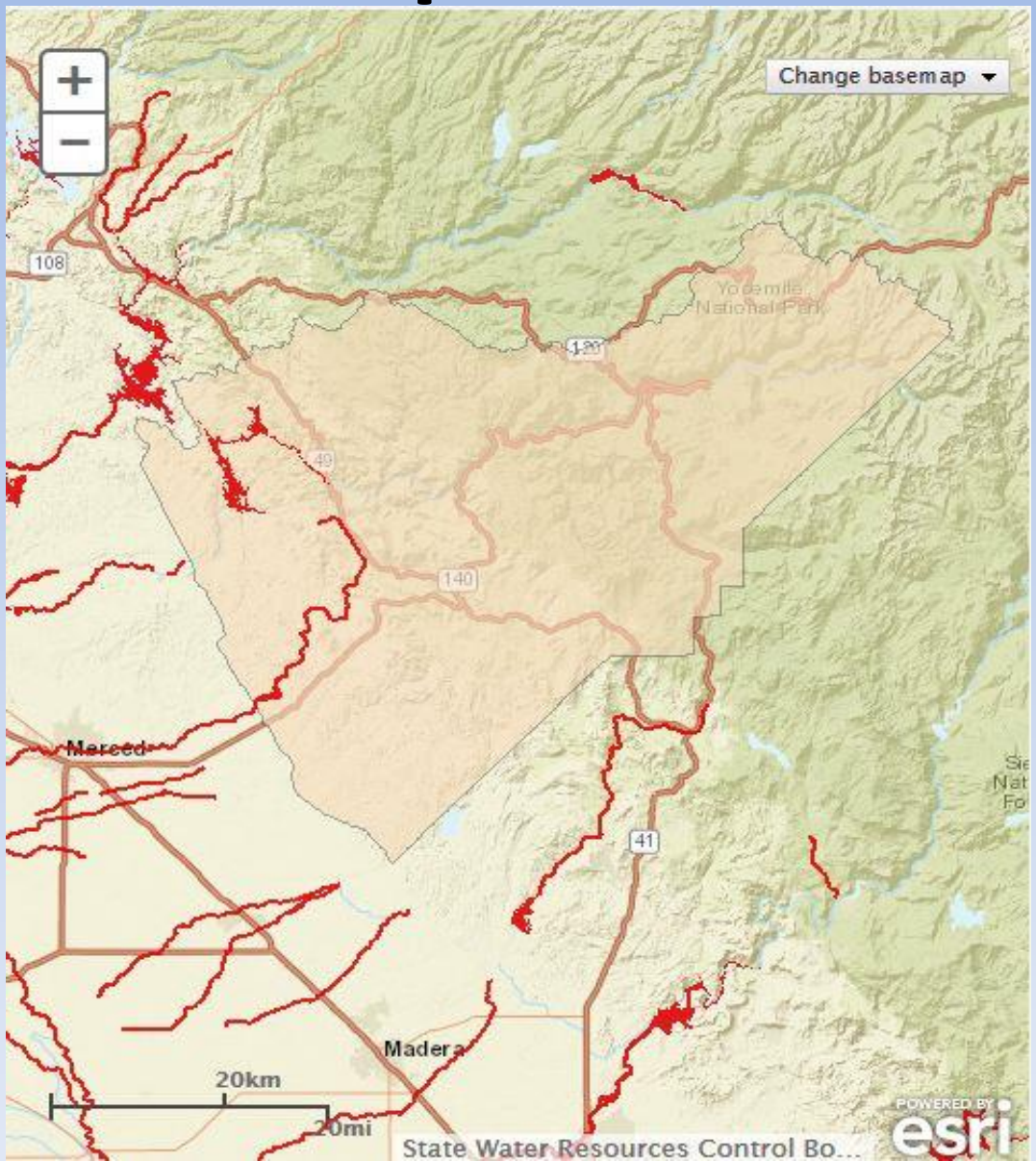


San Joaquin River:

- **Boron (Agriculture)**
- **Chlorpyrifos (Agriculture)**
- **DDT (Agriculture)**
- **Diazinon (Agriculture)**
- **Group A pesticides (Agriculture)**
- **Unknown toxicity (Unknown)**

San Luis Rey Reservoir:
Mercury (Unknown)

Impaired Waterways: 303D



McClure Reservoir

- **Mercury**

Bear Creek:

- ***E. coli***
- **Cadmium**
- **Arsenic**

When Should You Read a Pesticide Label & the Material Safety Data Sheet?

1. Before you buy the pesticide.

2. Before you transport, mix, or load the pesticide.

3. Before you apply the pesticide.

4. Before you store the pesticide.

5. Before you dispose of unwanted pesticide or the empty container.

Mosquito Control Options

One of the best ways to prevent resistance is to rotate products. You don't want to expose susceptible populations to the same selective pressure.

Please note: By discussing a product, I am not endorsing it!

I'm going to discuss control products broadly divided between two categories: Microbial and chemical.

I'm going to divide chemical control into two broad categories: Larvicides and adulticides:

- **Insect growth regulators (IGRs)(Larvicides)**
- **Oils (Larvicides)**
- **Alcohols (Larvicides)**
- **Adulticides**

Microbial Control

Bacillus thuringiensis israelensis **(Bti) (Larvicide)**

- **Naturally occurring soil bacterium**
- **In vector control, used to target mosquito and blackfly larvae**
- **Produces toxins that form crystals that disrupts the insect's digestive tract**
  - **Effective only on first – third larval instars**

Microbial Control

Advantage: Bti is available in different formulations

- **Liquid**
- **Granules**
- **Dunks**
- **Cheaper than *L. sphaericus***
- **Few non-target issues**

Disadvantage: Bti is a “one and done” product

Microbial Control

Microbial Control

Coordinate with city crews before you apply!

Microbial Control

***Lysinibacillus sphaericus* (Larvicide)**

- **Naturally occurring soil bacterium**
- **In vector control, used to target mosquito and blackfly larvae**
- **Produces toxins that form crystals that disrupts the insect's digestive tract**
  - **Effective only on first – third larval instars**

Microbial Control

***Lysinibacillus sphaericus* (Larvicide)**

- **Recycles itself within the environment**
- **Larger number of larvae make "recycling" of spores more effective**

Advantage:

- **Mid/late season "residual"**
- **Few non-target issues**

Disadvantage:

- **More expensive than Bti.**
- **Not as useful in early/midseason**

Insect Growth Regulators (IGRs)

IGRs

- **Larvicides**
- **Target insects only because they affect the hormones ecdysone and juvenile hormone (JH)**
  - **Keeps JH at artificially high levels**
- **Can prevent reproduction, egg-hatch**
- **Can sterilize adults**

Available in many formulations: Liquid, granules, pellets, briquettes.

Chemical Control: Oils

Oils: Golden Bear, BVA2, Cocobear

- **Very light oils**
- **Upon application, will spread quickly and suffocate the larvae and pupae**
- **Effective on all stages of larvae and pupae**

Chemical Control: Alcohol

Agnique MMF

- **MMF: monomolecular film**
- **Much like oil, MMFs spread over the water surface quickly**
- **MMFs drown larvae and pupae by reducing the water's surface tension. Prevents larvae and pupae from attaching to the surface**
- **Effective on all stages of larvae, pupae, and emerging adults**

Disadvantage:

- **Can take several days to act**

Chemical Control: Adulticides

Many adulticides are dispersed through ultra low volume (ULV) applications.

- **Chemical applied as a fine spray at very low application rates**
- **Typical droplet size is 10-30 microns**
- **Drift is necessary**
- **The longer the effective drift of the product, the greater the efficacy**
- **Lateral winds below 10 mph**
- **Temperature Inversions**

Temperature Inversions

Occur when temperatures at ground level are lower than those at higher altitudes (reverse of the normal temperature situation near the surface of the earth).

During inversions, cold air is trapped by the warm air above and there is little vertical mixing of air.

The small droplets produced by ULV sprayers remain suspended in the cool air within several feet of ground level. Droplets stay where host-seeking females occur.

Factors of Pesticide Drift

Formulation of the product; Dusts are more likely to drift, granules least likely.

Sprayer pressure. High pressure sprayers are more likely to produce fine droplets that are more susceptible to drift.

Improper or worn nozzles or excessive pressures.

Size of the Droplet. Small droplets can drift farther than larger ones.

Evaporation. Especially among certain herbicide formulations.

(Normally) Drift Should be Avoided Because:

It wastes resources, including pesticides, fuel, and technician time.

It spreads pesticides into the surrounding environment where they may become illegal residues on food crops, cause health problems, damage wildlife, and have other undesirable effects.

Non-target issues: BEES!

It has been the cause of many damage claims for crop losses. Organic crops!!

Chemical Control: Adulticides

Pyrethrins

- Extracted from the Chrysanthemum flower
- Commonly used products
  - Evergreen 5 - 25

Pyrethroids

- Manmade versions of pyrethrins
- Commonly used products
  - Deltamethrin
  - Lambda CS
  - Duet (Prallethrin and Sumethrin)
  - Zenivex

Chemical Control: Adulticides

Organophosphates

- **Naled (~99% of OPs used)**
- **Malathion**

OPs are important tools in a rotational sense, but have bad press associated with their use.

So, now you know…

- Integrated Vector Management (IVM) pyramid
- Selective pressures
- Resistance
- Permits and impaired waterways
- Control options, pesticide formulations and application methods

Questions?

Used with permission from Dan Piraro.