The background image shows several green alfalfa leaves. One leaf in the foreground has a small hole and a dark, irregular mark, likely from insect damage. A small, light green caterpillar is visible on the lower left edge of this leaf. Another leaf to the right also shows signs of damage. The overall scene is set against a dark, blurred background.

Alfalfa weevil insecticide resistance:  
A challenge and case study for insecticide  
resistance in field crops

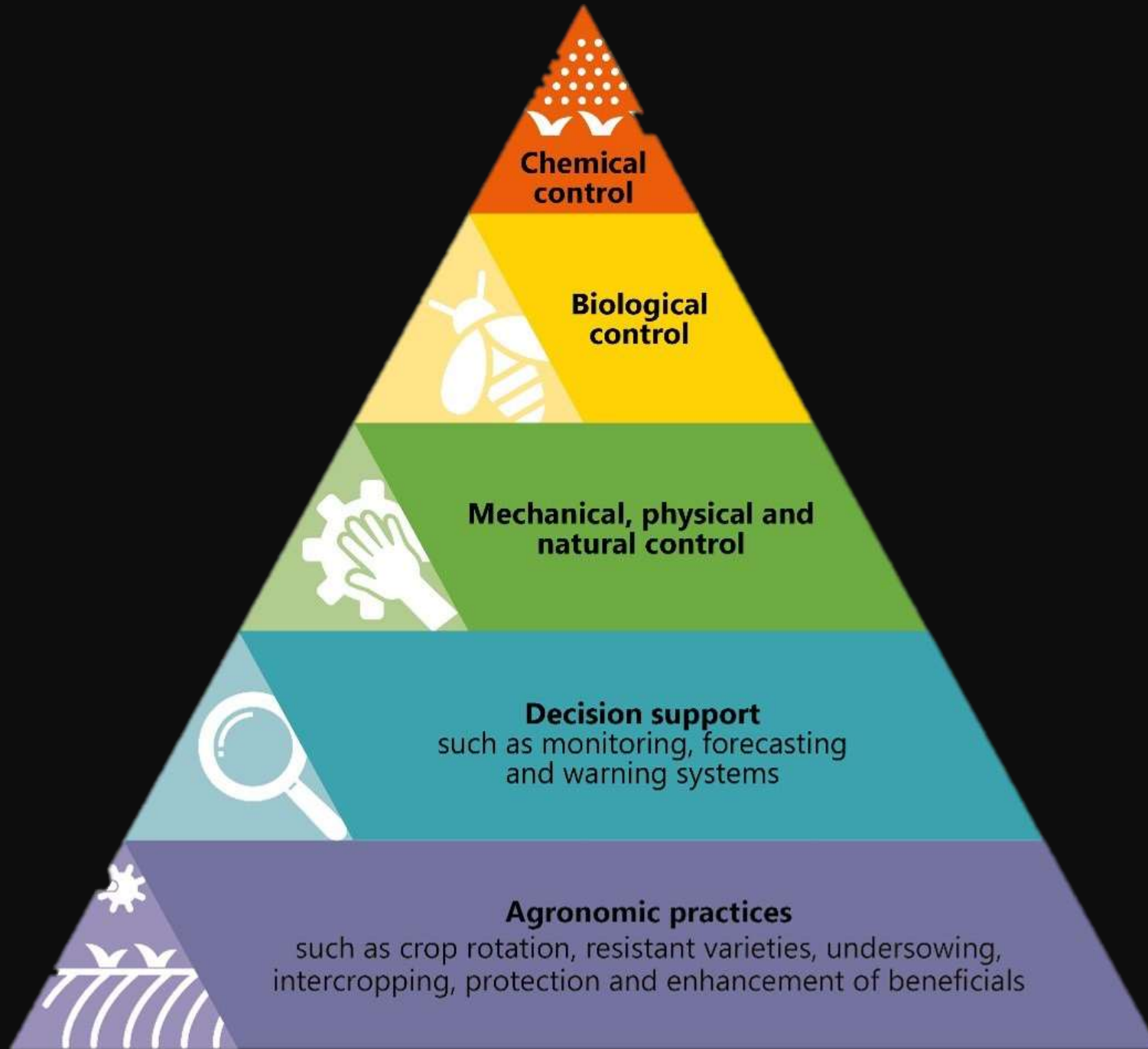
Ian Grettenberger – UC Davis  
Field and Veg. Crop Entomology CE Specialist



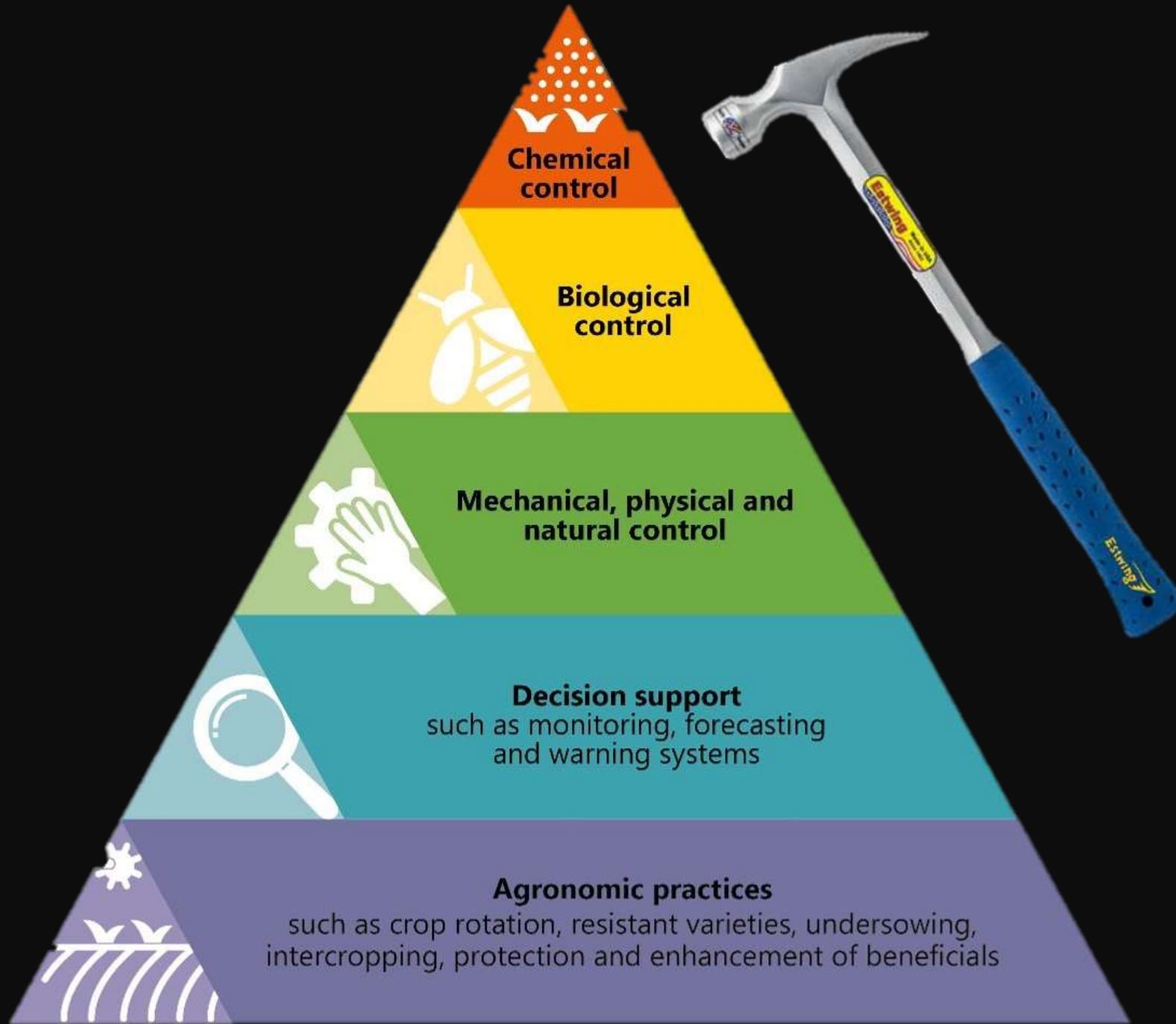


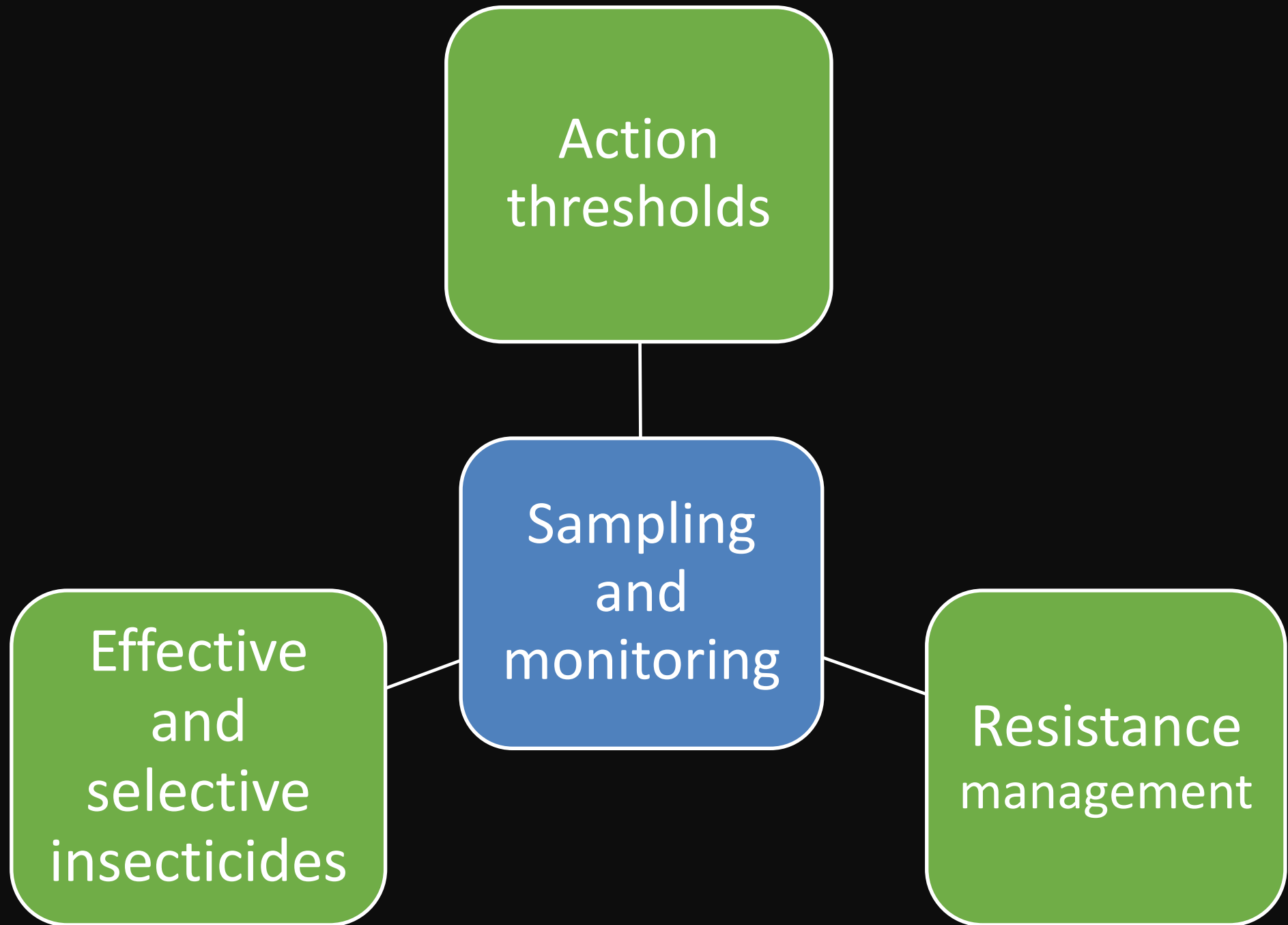












Action thresholds

Sampling and monitoring

Effective and selective insecticides

Resistance management

**EVERYTHING WILL CHANGE**



**EVERYTHING HAS CHANGED**



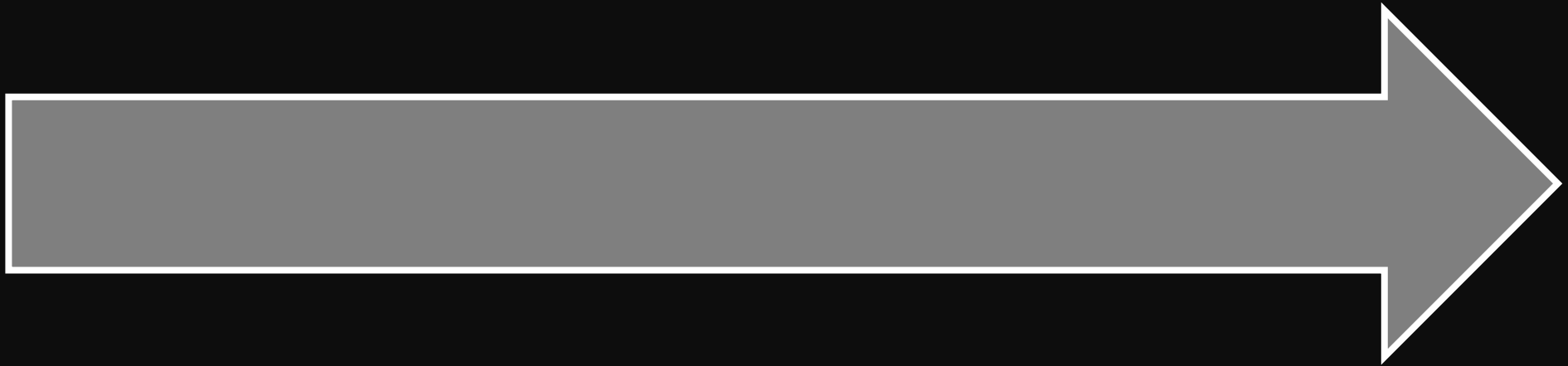
**DON'T LIKE CHANGE?**



**LOOKS LIKE YOU NEED A NEW  
JOB**



Insecticide resistance





Pest genetics

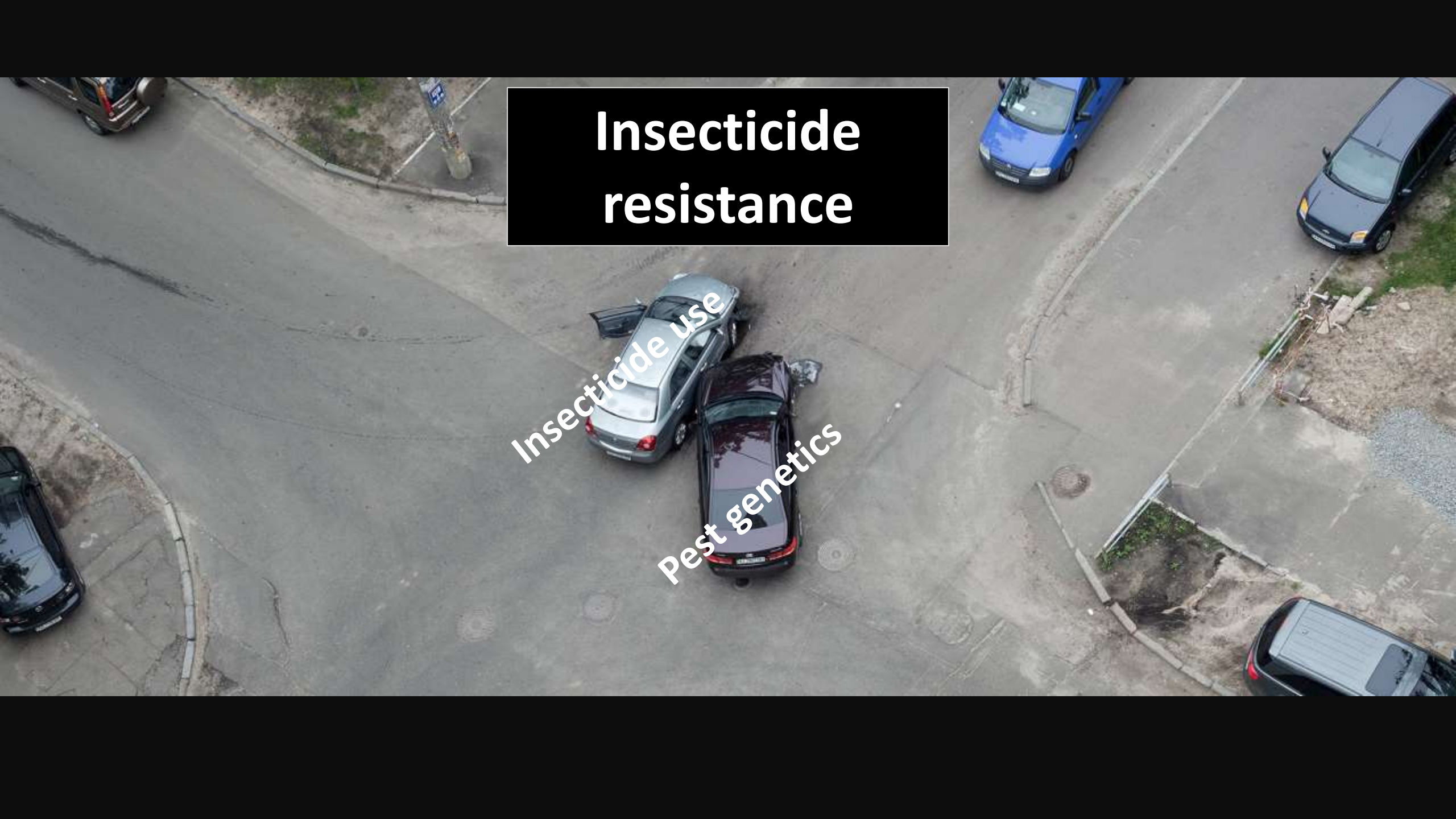
Insecticide use



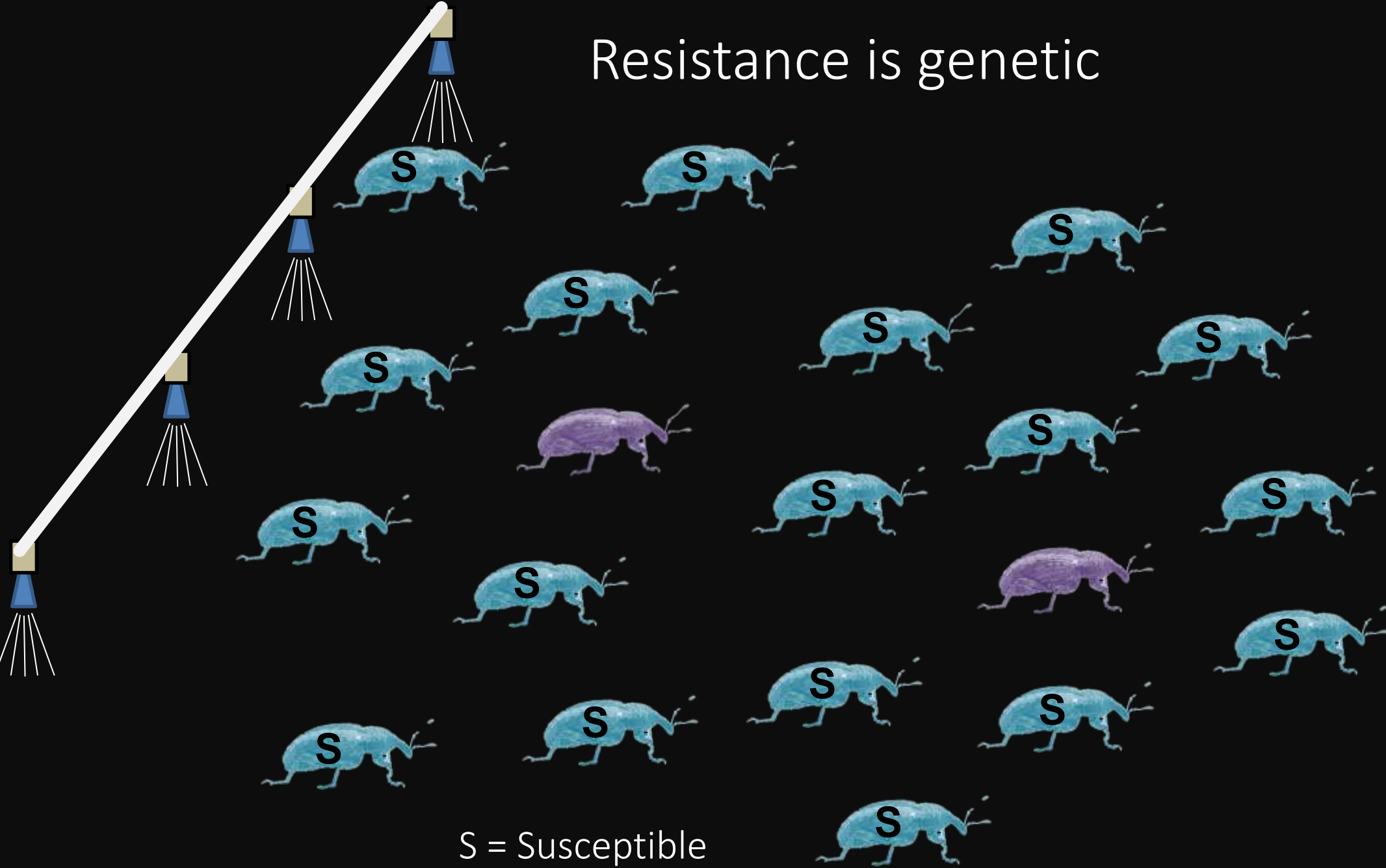
# Insecticide resistance

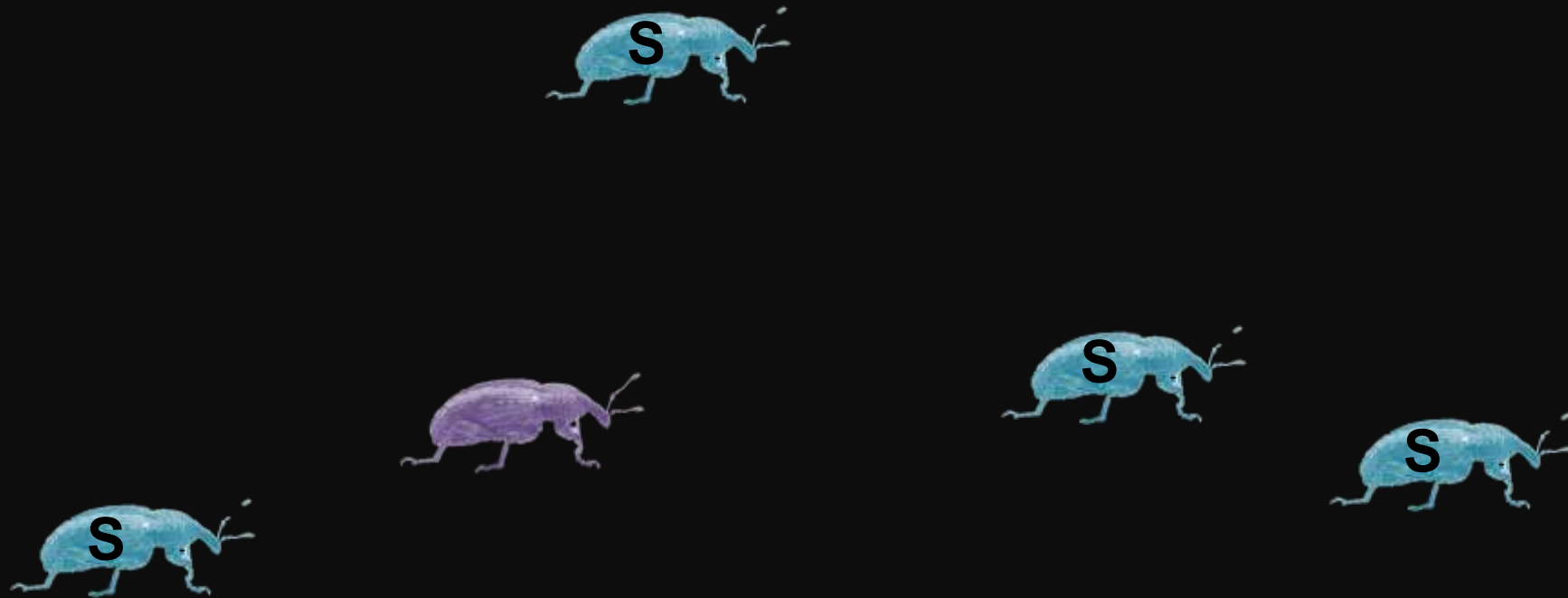
Insecticide use

Pest genetics



# Resistance is genetic



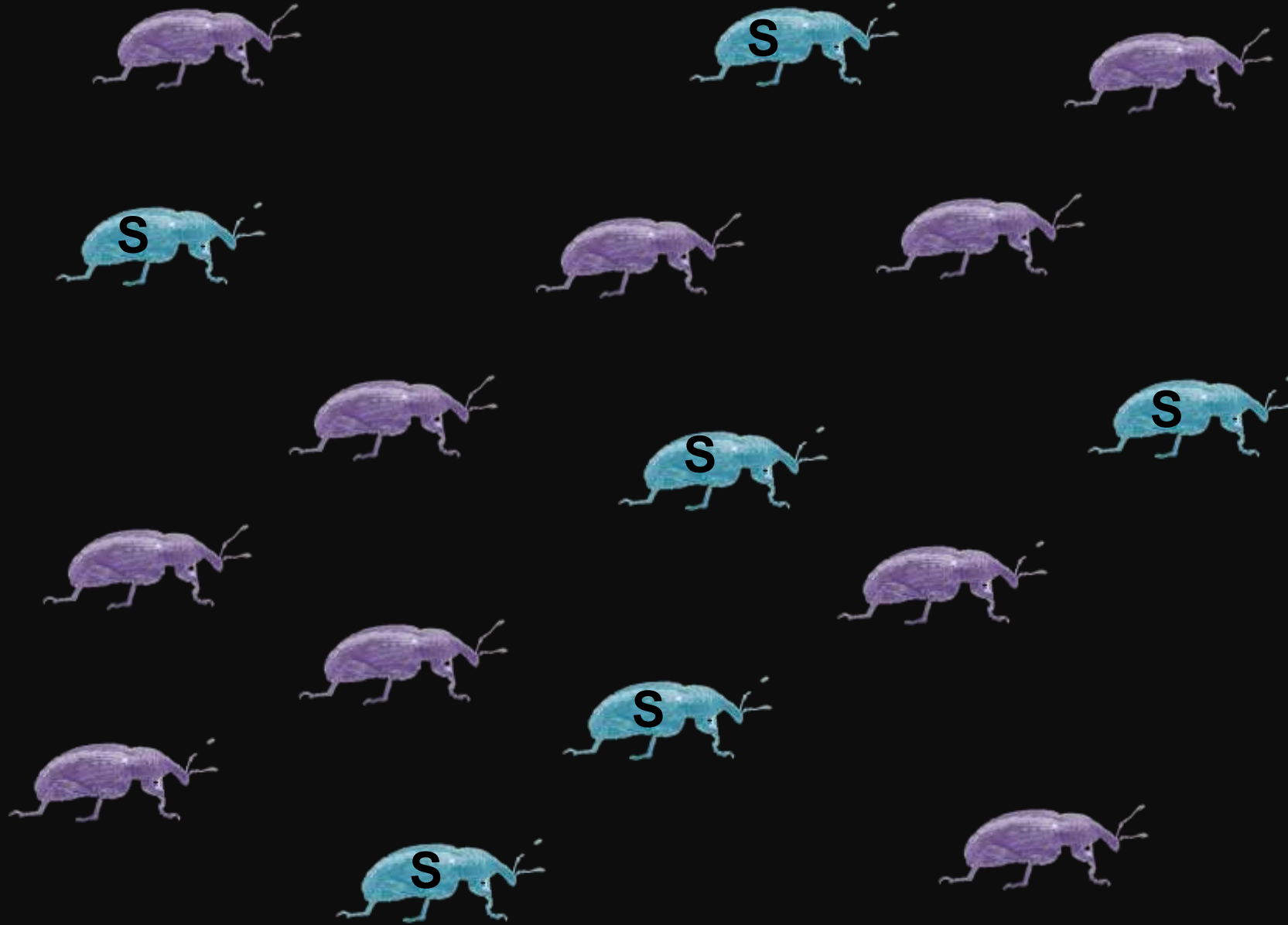


Mating





In the future...



An aerial photograph of a street intersection. A large white arrow points from the bottom right towards the top left. The text "Pest genetics" is written in white, bold, sans-serif font along the length of the arrow. The background shows a paved road with several manhole covers, a blue car, a dark grey car, and a black car. There are also some utility poles and a small patch of grass on the sidewalk.

**Pest genetics**





An aerial photograph of a street intersection. A large white arrow points from the bottom-left towards the top-right, following the path of the road. The text "Insecticide use" is written in white, sans-serif font along the length of the arrow. The street is paved with asphalt and has several manhole covers. There are several cars parked or driving on the street: a blue car, a dark grey car, and a black car. A utility pole is visible on the left side of the road.

Insecticide use



**PEST MANAGER WAITING  
FOR RESISTANCE TO SOLVE ITSELF**







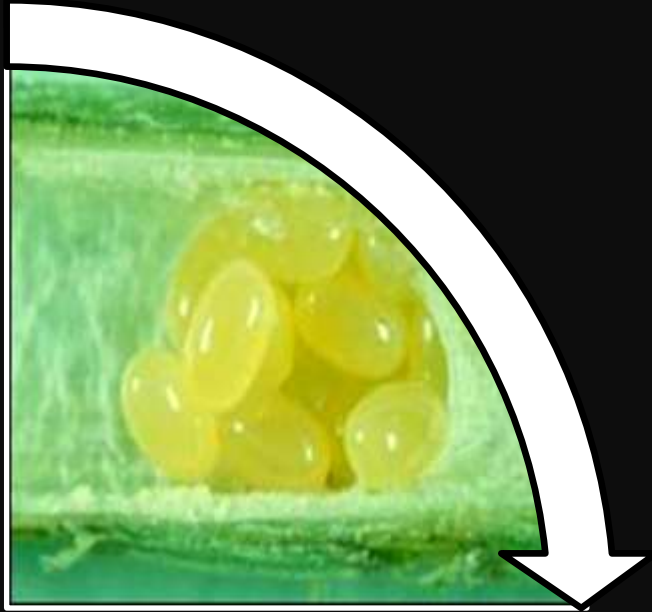






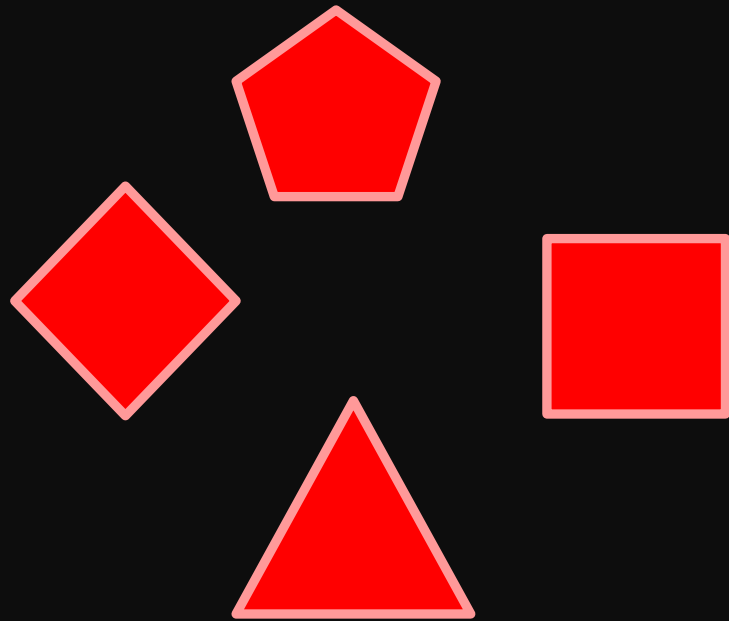






# Problem: Limited modes of actions

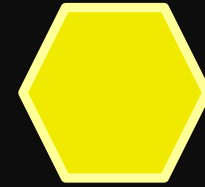
Pyrethroids (3A)



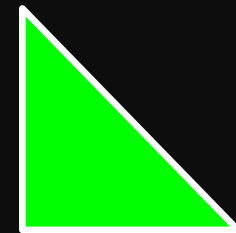
Oxadiazines – Indoxacarb (22A)



Spinosyns-Spinosad (5)

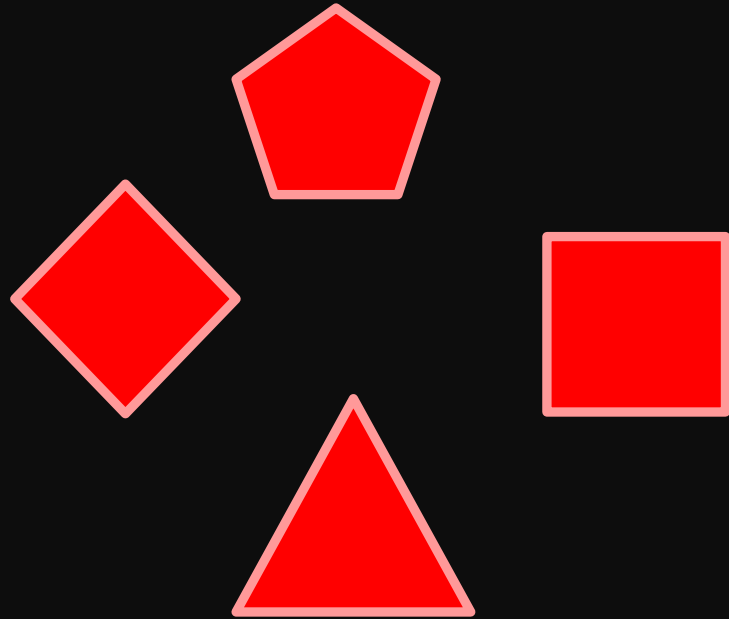


Organophosphates – malathion (1B)



# Problem: Limited modes of actions

Pyrethroids (3A)



Oxadiazines – Indoxacarb (22A)



Spinosyns-Spinosad (5)





# Problem: Pyrethroid-resistant alfalfa weevils

**Growers**  
**Pest control advisors**





**I CAN SEE**

**INTO THE FUTURE**



# Insecticide resistance is frequently not a new issue

## Resistance of the Alfalfa Weevil to Heptachlor<sup>1</sup>

V. E. ADLER and C. C. BLICKENSTAFF  
Entomology Research Division, Agr. Res. Serv.,  
USDA., Beltsville, Md.

Reports (USDA 1962, 1963; Bissell and Harding 1963; Russell 1963) and personal correspondence indicate that in many

**WARNING:** Hazardous If Swallowed, Inhaled or Absorbed Through Skin! In case of contact, immediately remove contaminated clothing and flush skin or eyes with plenty of water; for eyes, get medical attention. Wash thoroughly with soap and water after handling and before eating or smoking, wear clean clothing. Do not apply or allow to drift to areas occupied by unprotected humans or beneficial animals. Keep out of reach of children. **DANGER**—Keep away from heat or open flame. Avoid contamination of feed and foodstuffs. To protect fish and wildlife, do not contaminate streams, lakes or ponds with this material. When container is empty, immediately wash thoroughly and destroy. Never reuse.

**NOTICE:** California Spray-Chemical Corporation makes no warranty, express or implied, concerning this material, except that it conforms to the chemical description on the label. Neither California Spray-Chemical Corporation nor the seller shall be held responsible in any manner for any personal injury or property damage or other type of loss resulting from the handling, storage or use of this material. The buyer assumes all risk and liability therefrom and accepts and uses this material on these conditions.

Manufactured by  
**CALIFORNIA SPRAY-CHEMICAL CORP.**  
Richmond, Calif. • Orlando, Fla. • St. Petersburg, Fla. • St. Louis, Mo.  
Form W-4227-A  
Product No. 2290

**ORTHO**  
MADE IN U.S.A.

**TREATS 2000 SQUARE FEET**  
NET CONTENTS ONE PINT

# ORTHO<sup>®</sup> 95 DIELDRIN SPRAY

**KILLS**  
ANTS, LAWN BEETLES (and Webworms), WHITE GRUBS, GRASSHOPPERS and other Lawn and Ornamental Soil Insects

**ANT**      **LAWN BEETLE**      **GRUB**

100%      100%      100%

**A SOIL INSECTICIDE**

**READ ENTIRE LABEL. USE STRICTLY IN ACCORDANCE WITH LABEL CAUTIONS, WARNINGS AND DIRECTIONS.**

**DIRECT**

Apply with an ORTHO Lawn & Garden Sprayer for easy, uniform distribution.

**HOME LAWNS:** Ants, Lawn Moth (and Webworm), Cutworms, Sawflies, Pillbugs, Wireworms, White Grubs, Snails, Slugs, June Beetle Grubs, Armyworms, Mole Crickets, Crickets, Grasshoppers—8 Tablespoons in 15 gallons water per 500 sq. ft. of lawn area (1 1/4 teaspoons per gal. water for 33 sq. ft.). Also spray under ornamental plantings. Sprinkle lightly after treatment. Do not permit children and pets to go on treated lawn until the insecticide has been washed off the grass and into soil, and grass has completely dried.

**NURSERY, GREENHOUSE AND GARDEN SOILS** (where ornamentals are grown): Bacchylirus Weevils and pests listed under Home Lawns—8 Tablespoons in 15 gallons water per 500 square feet (1 1/4 teaspoons per gal. water for 33 sq. ft.). In open soil, mix into top 3 or 4 inches of soil. Do not treat when soil is wet. Apply before rain or sprinkling.

**EARWIGS:** Apply at above dosage to daytime hiding places, such as lawns, around base of trees, shrubs, along walks, fences and building foundations.

...cash by the bushel for Orland Manternach!

# HEPTACHLOR

soil insecticide  
increases corn yield  
35 bushels  
per acre!



**HEPTACHLOR YIELD CHECK NO. 761**

Orland Manternach feeds 700 to 800 hogs a year on his 200 acre farm, near Cascade, Iowa. Last season, he planted 110 acres of corn, and gained 55.4 bonus bushels per acre by using Heptachlor soil insecticide.

	SEED SOYBEAN PER ACRE	TOTAL BUSHELS ACRE CORRECTED TO 15.5% MOISTURE
HEPTACHLOR	12,300	138.0
CHECK	11,800	103.0
DIFFERENCE WITH HEPTACHLOR	500	35.0



**HEPTACHLOR PAYS**—If cash returns were measured as corn yields are, you'd find that Heptachlor soil insecticide would give you bushel after bushel of "money in the bank." Heptachlor protection often makes 4 acres produce as much as 5 untreated acres. And most of the yield increase is profit, because the cost of treatment is often as low as \$1.00 per acre.

**SOIL INSECT CONTROL**—Soil insect damage causes root injury, reduced stands, poor ear development, and lodging. Heptachlor prevents this damage. Treated corn grows well and stands straight. You can pick it at maximum safe speeds. Heptachlor kills all major soil insect pests of corn. You can apply it broadcast or in the row, in granular or liquid form, or in liquid or dry fertilizer mixtures. To save time and work, application can be combined with other operations.

**BUSHEL BETTER**—Heptachlor gives corn more protection per pound. It's easier to handle, too, and has no unpleasant odor. For further information, request folder 503-30.

**VELSICOL CHEMICAL CORPORATION**  
330 East Grand Avenue • Chicago 11, Illinois  
EXCLUSIVE SOLE MANUFACTURERS OF TECHNICAL HEPTACHLOR

ask for  
**HEPTACHLOR**  
SOIL INSECTICIDE

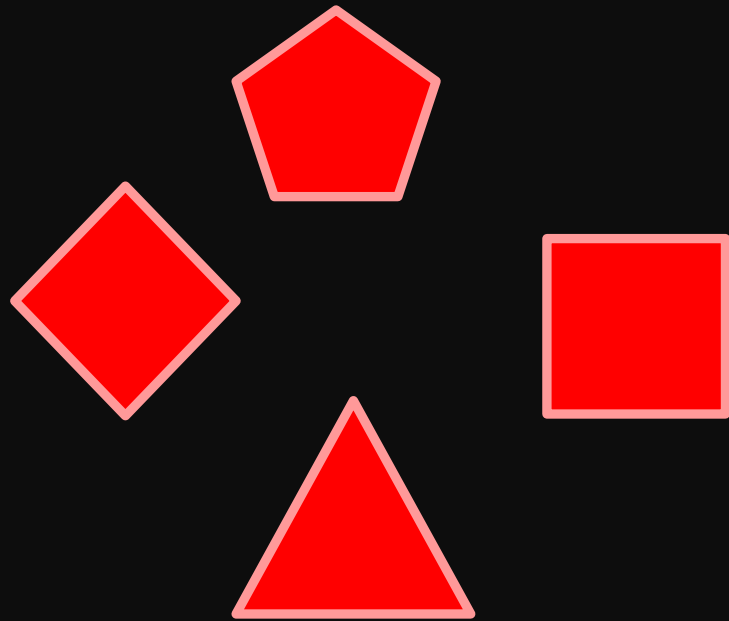
**SEED TREATERS** . . . for extra protection during germination.  
Just mix HEPTACHLOR with seed in planter box!

**SOLE PROTECTION FOR CORN**



# Problem: Limited modes of actions

Pyrethroids (3A)



Oxadiazines – Indoxacarb (22A)





**RESISTANT ALFALFA WEEVIL**



Kevin Wanner



Erika Rodbell



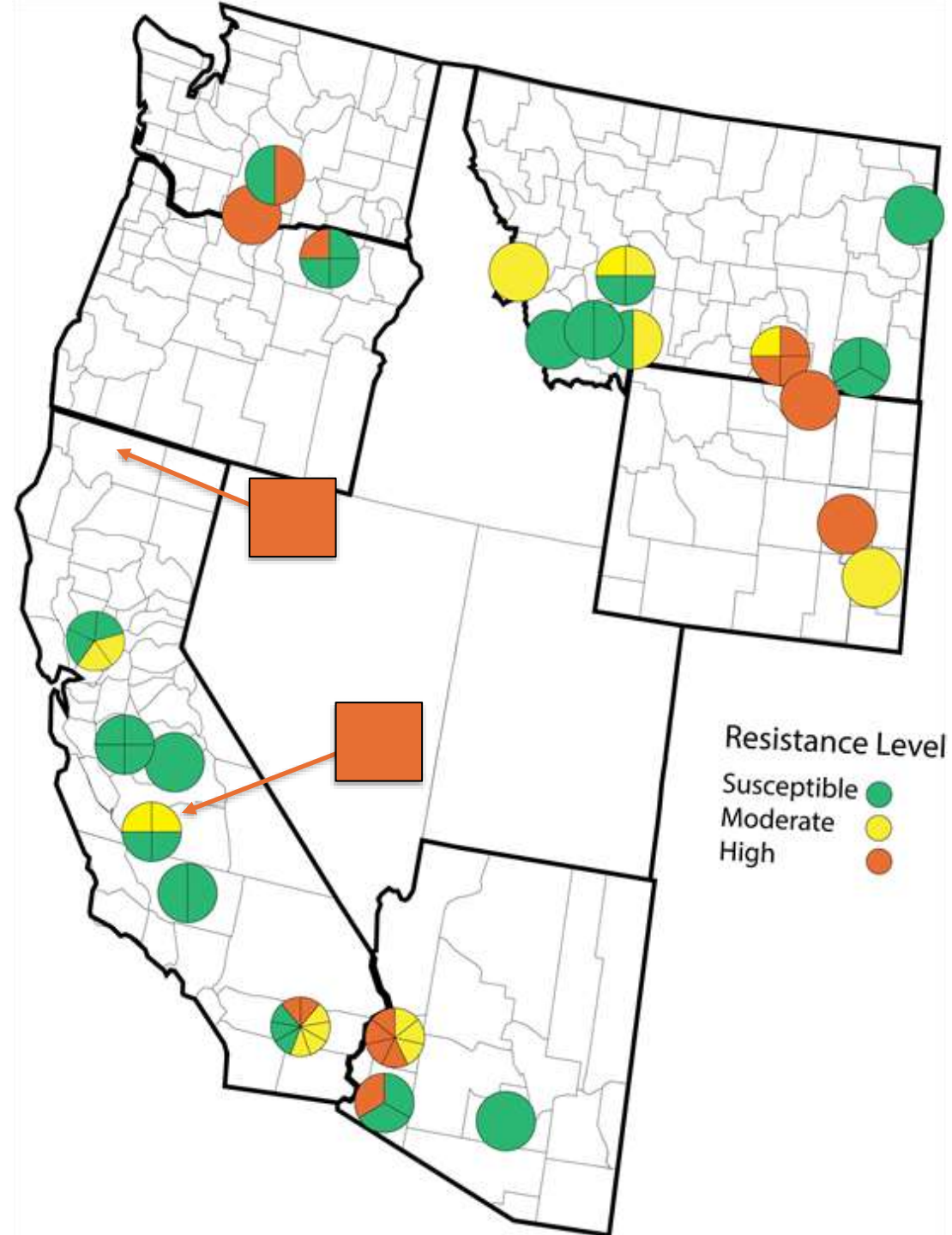
Madi Hendrick

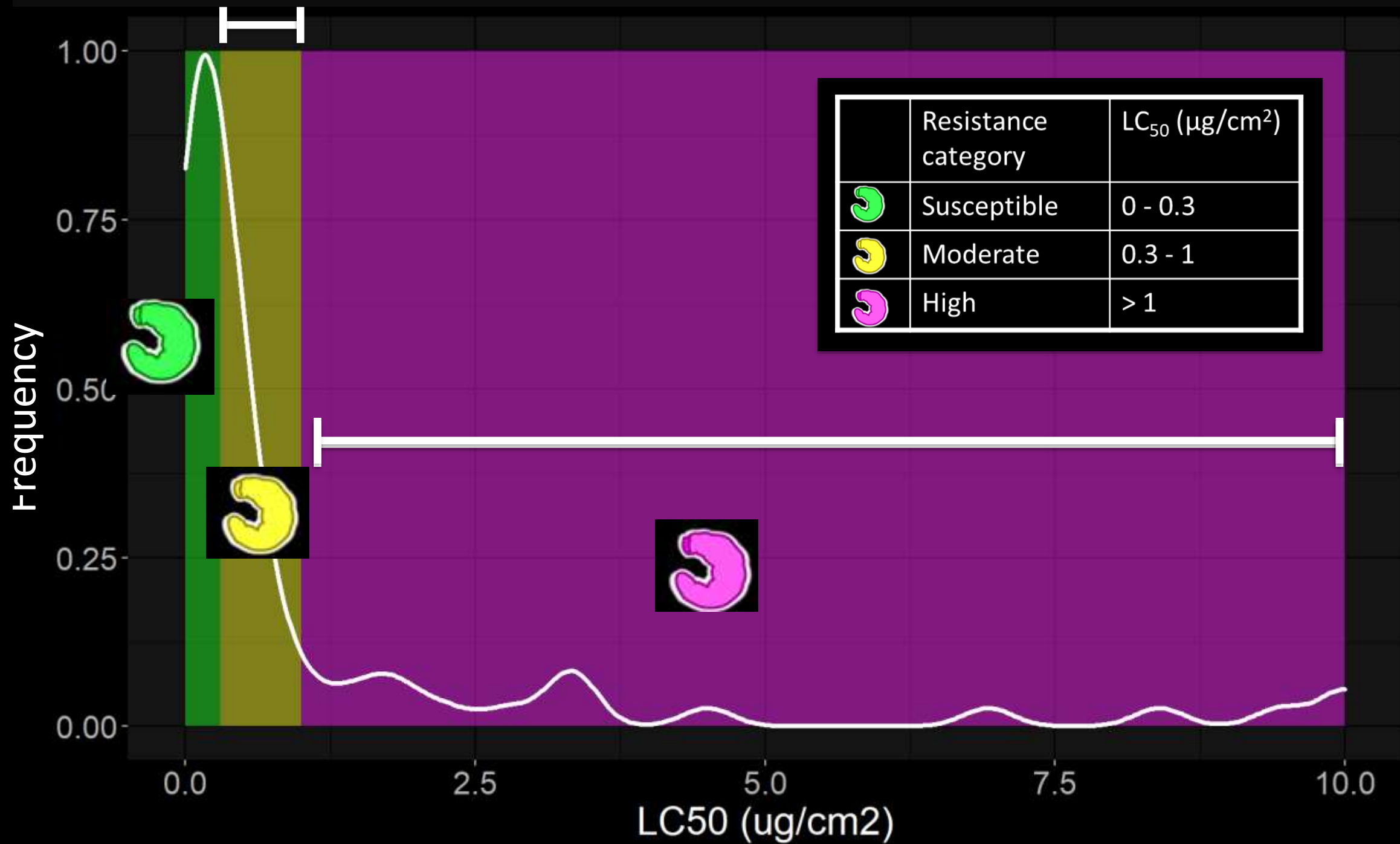




# Lambda-cyhalothrin bioassays

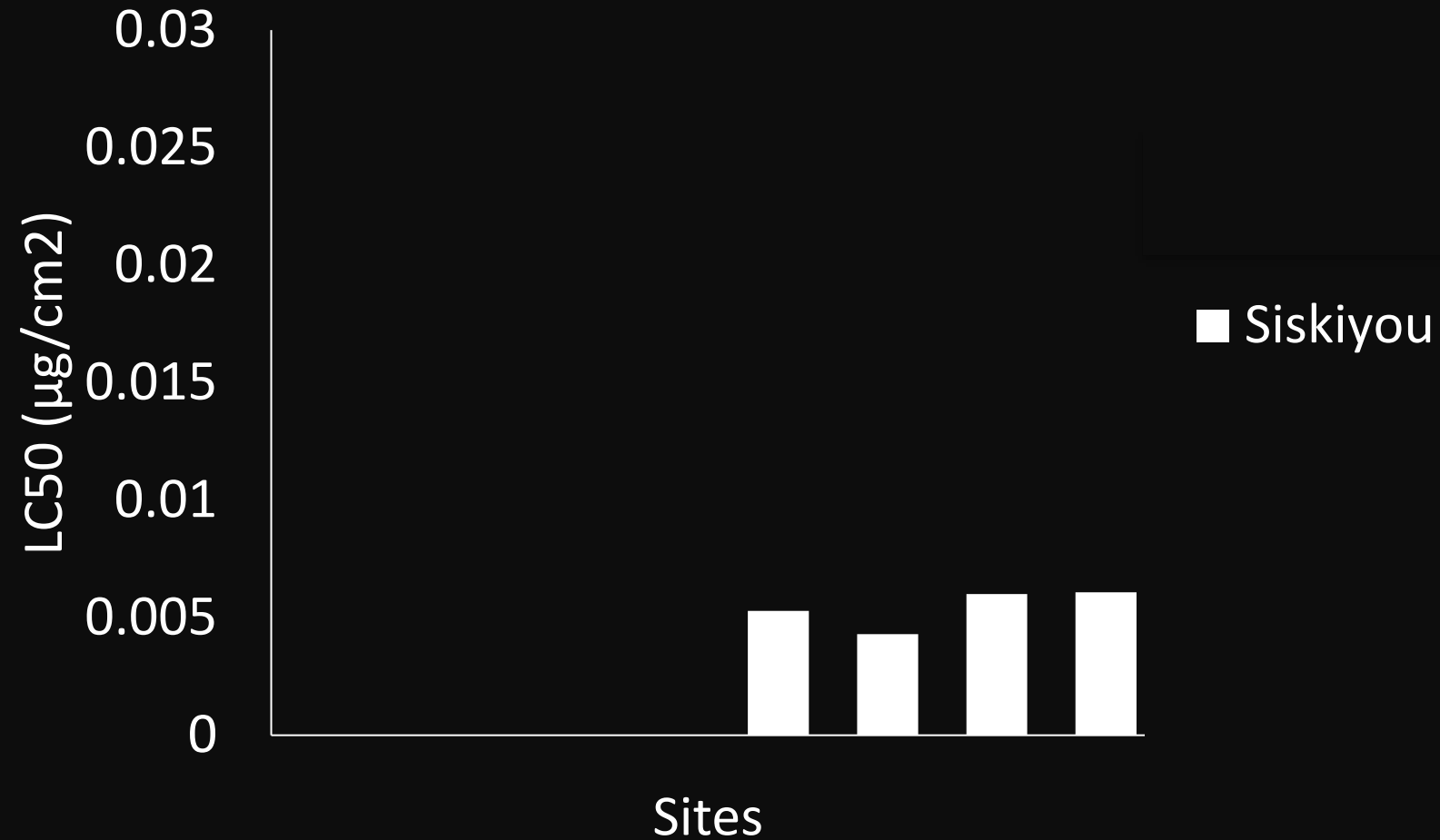




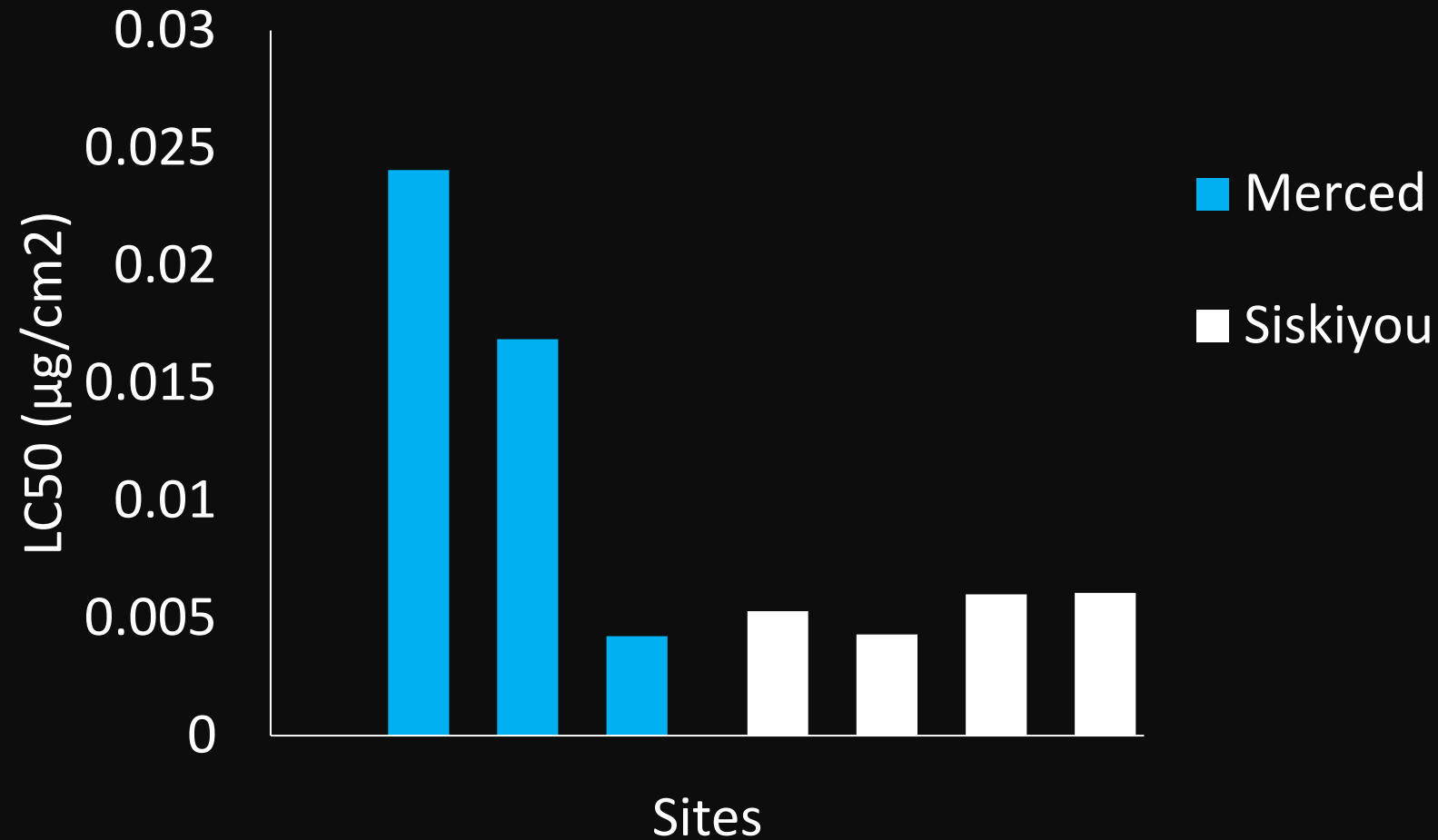




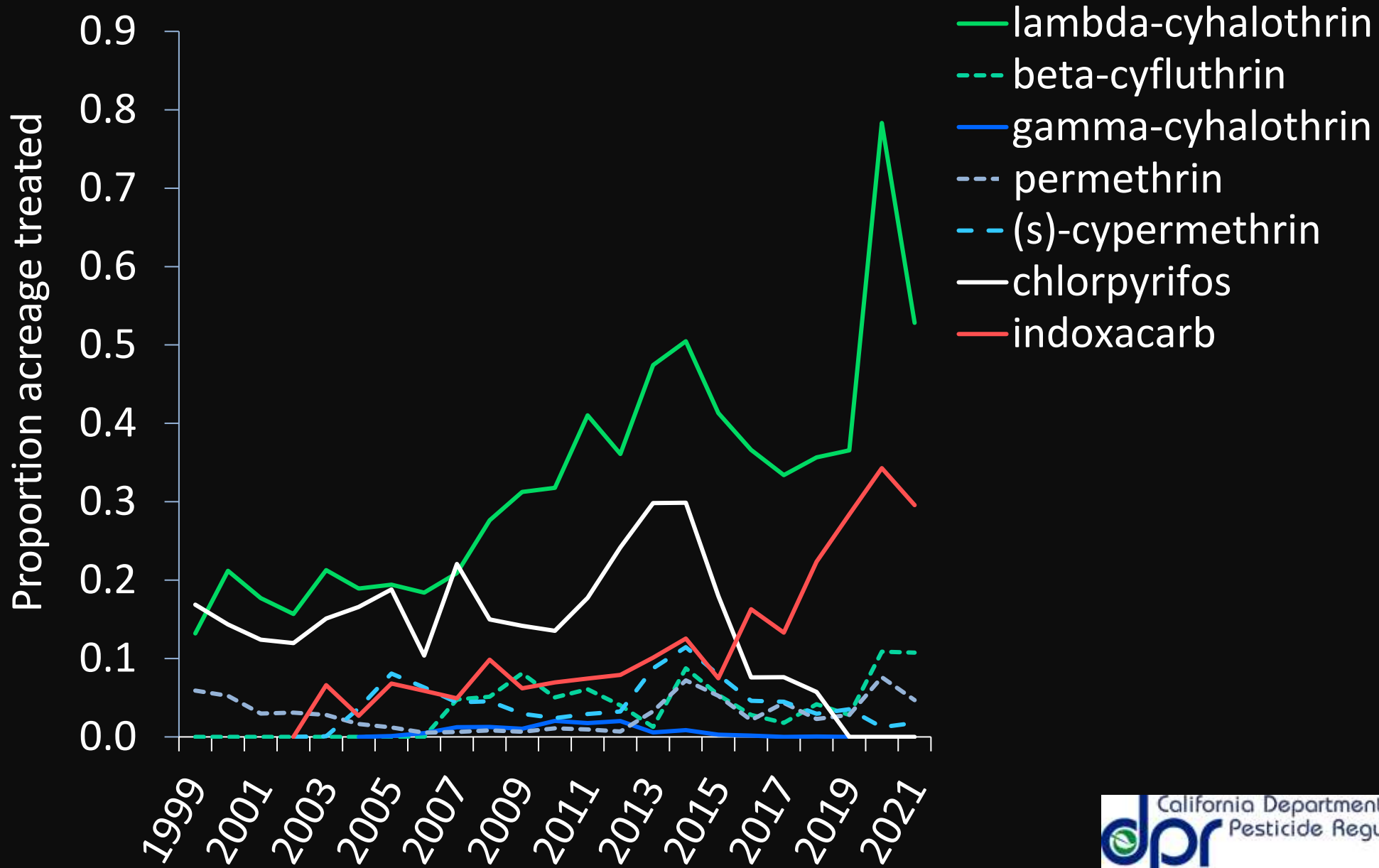
# There can be opportunities to be proactive: Steward/indoxacarb

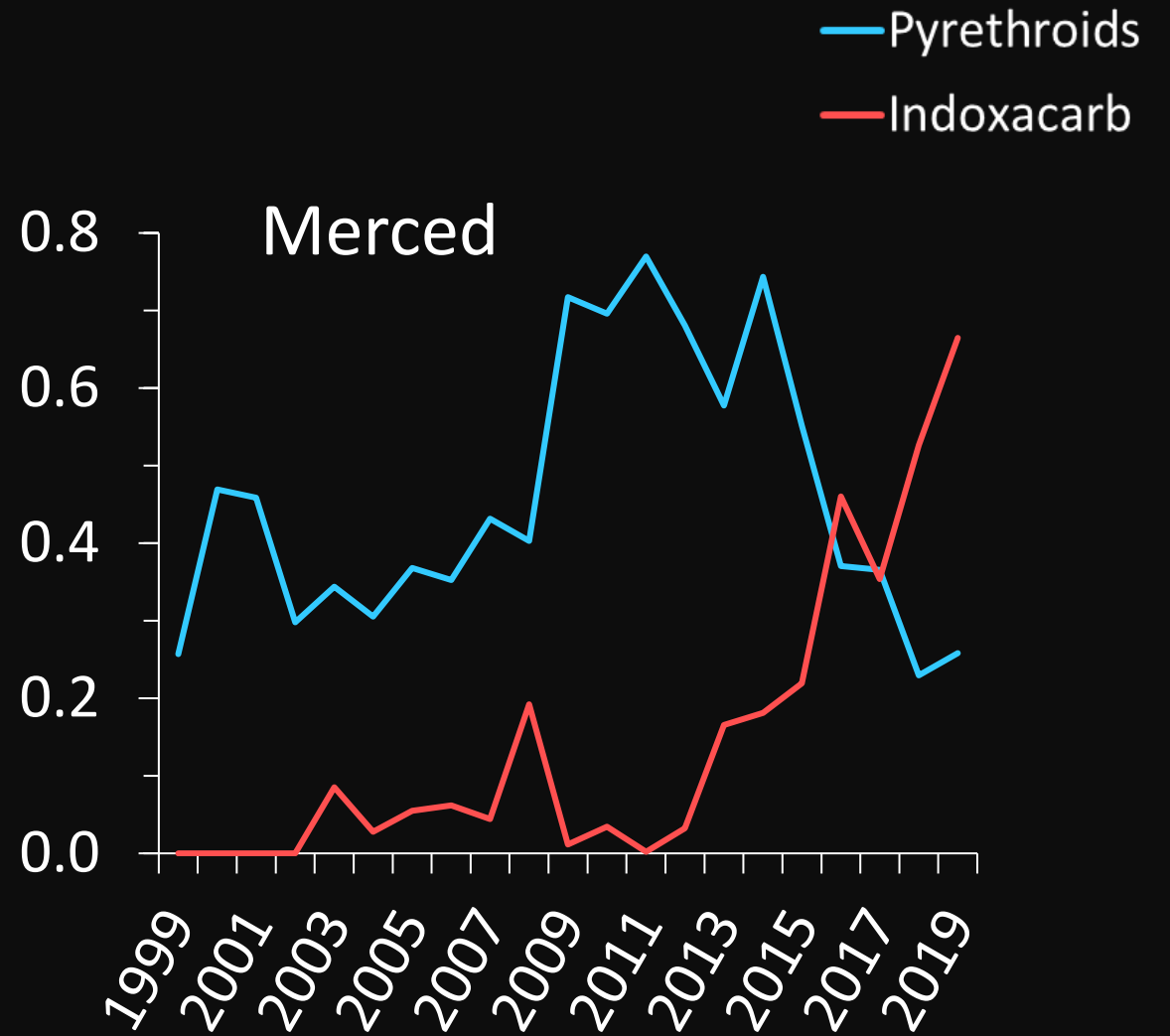
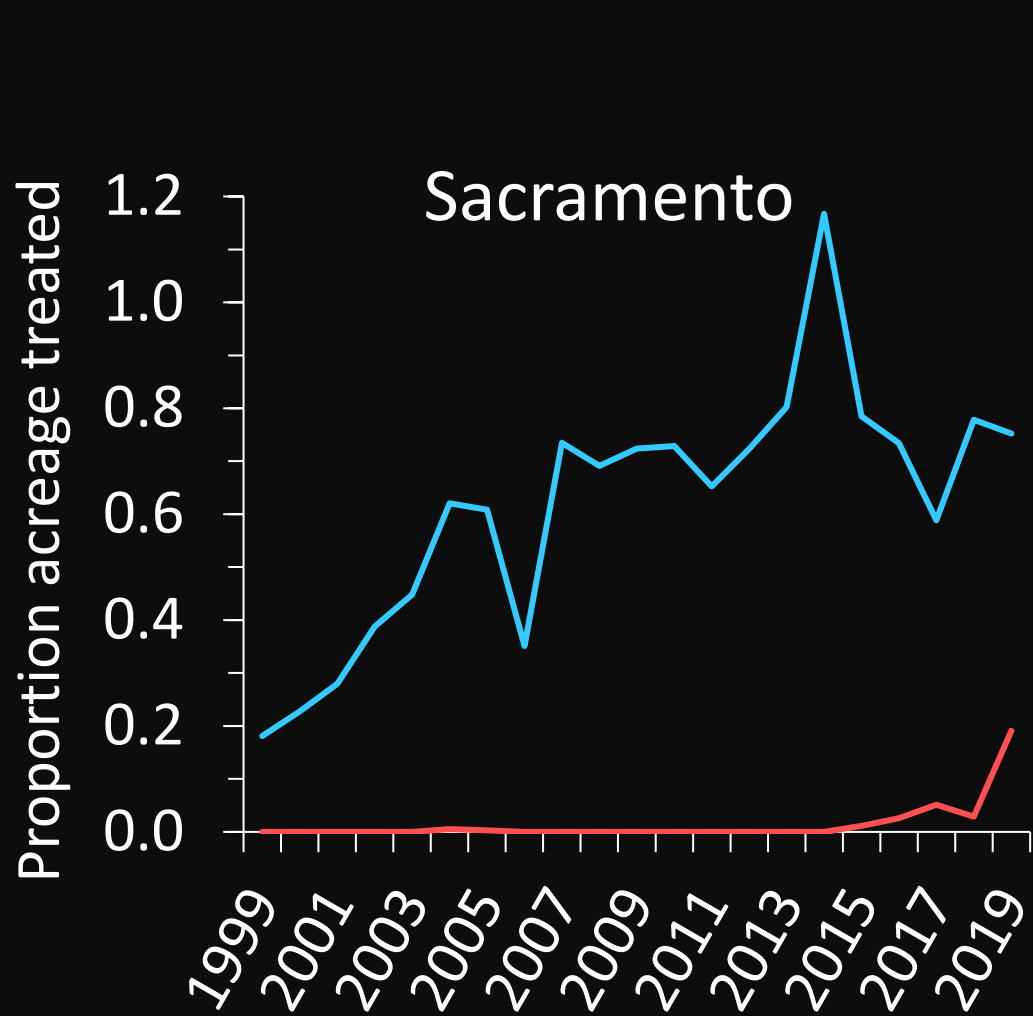


# There can be opportunities to be proactive: Steward/indoxacarb



# What have we seen in CA?







How does resistance  
spread...  
how far,  
how quickly?







Bowles Farming

# What do we have to look forward to?

- Resistance across the landscape for a key chemistry
- Likely not a lot of Few future chemicals
- DO have susceptibility
- Need to make BEST use of current tools



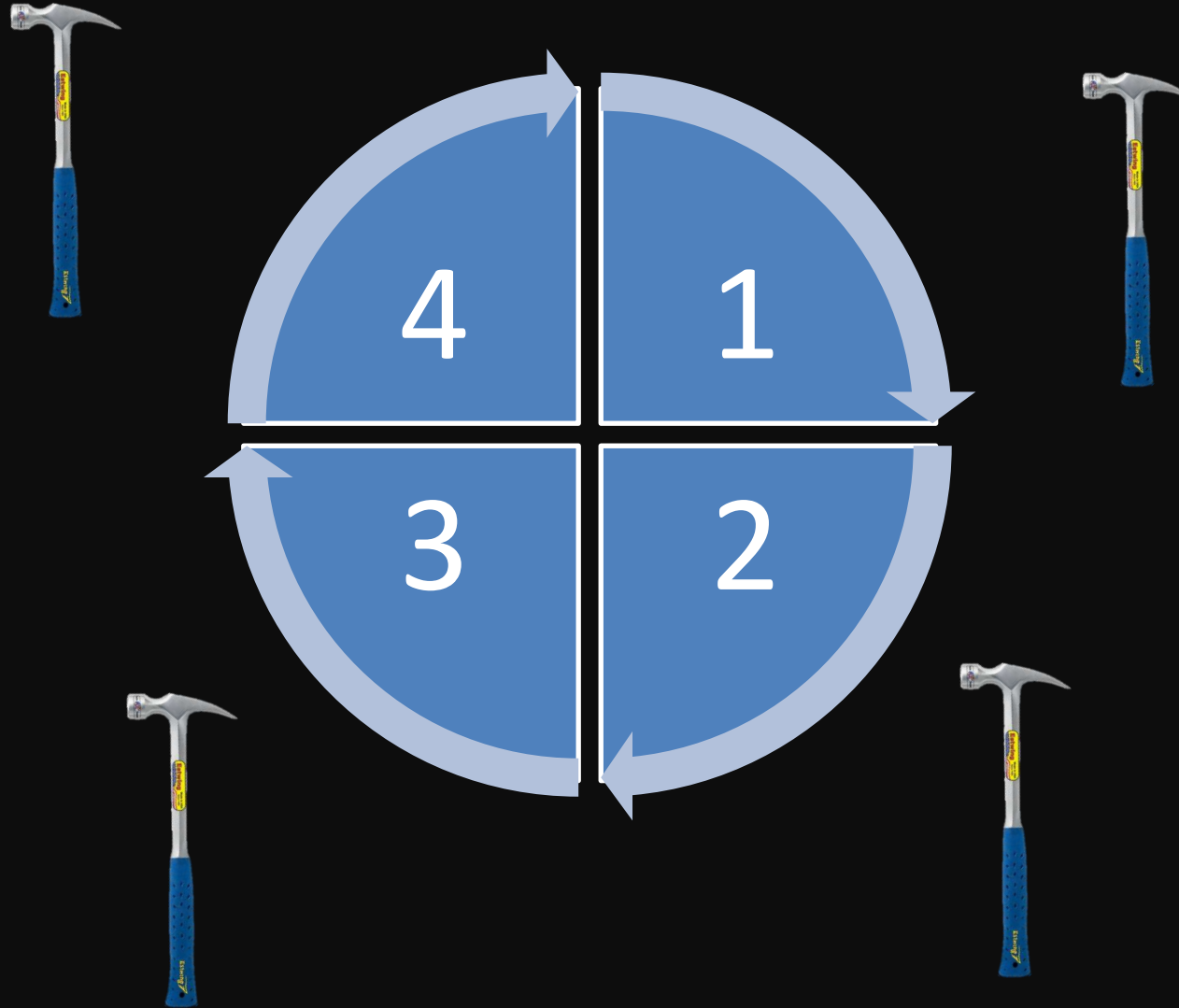


# What can we do?

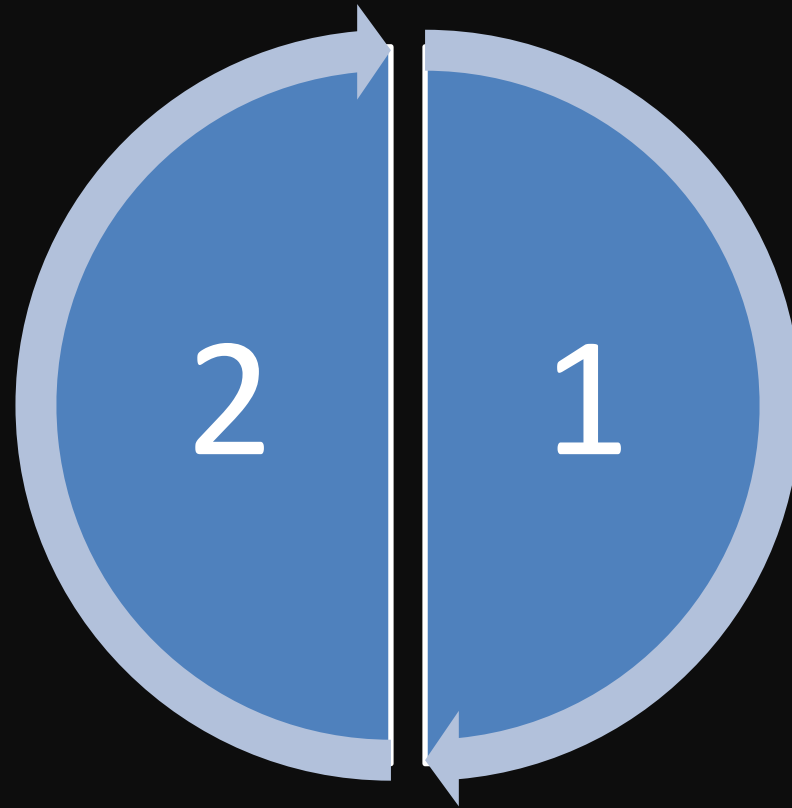
- Vigorous crop
- Cultural controls
- Monitoring/thresholds
  - No spray, no selection
- Best practices for applications
- Rotate modes of actions



# Rotation is necessary

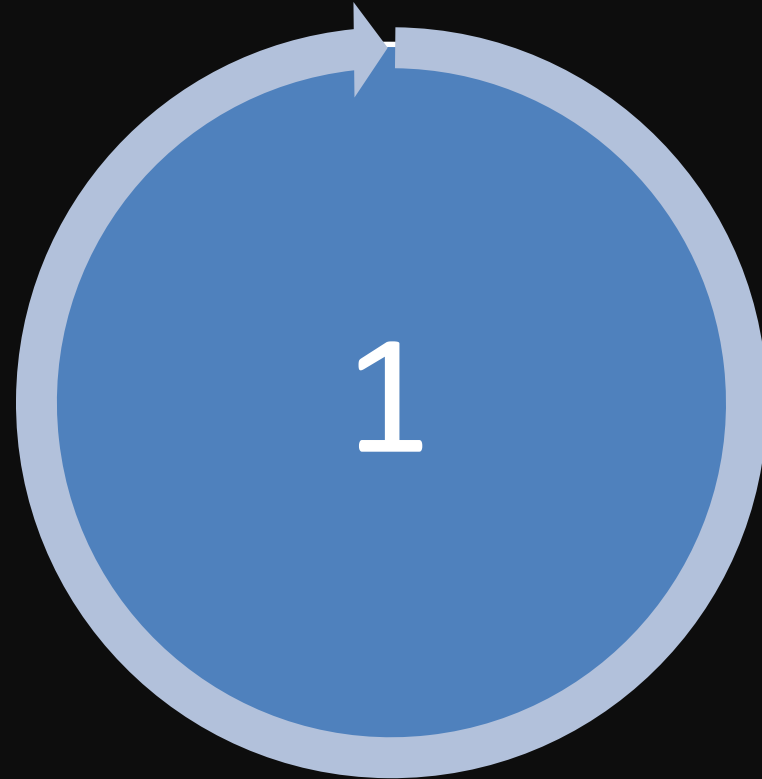


Rotation is necessary

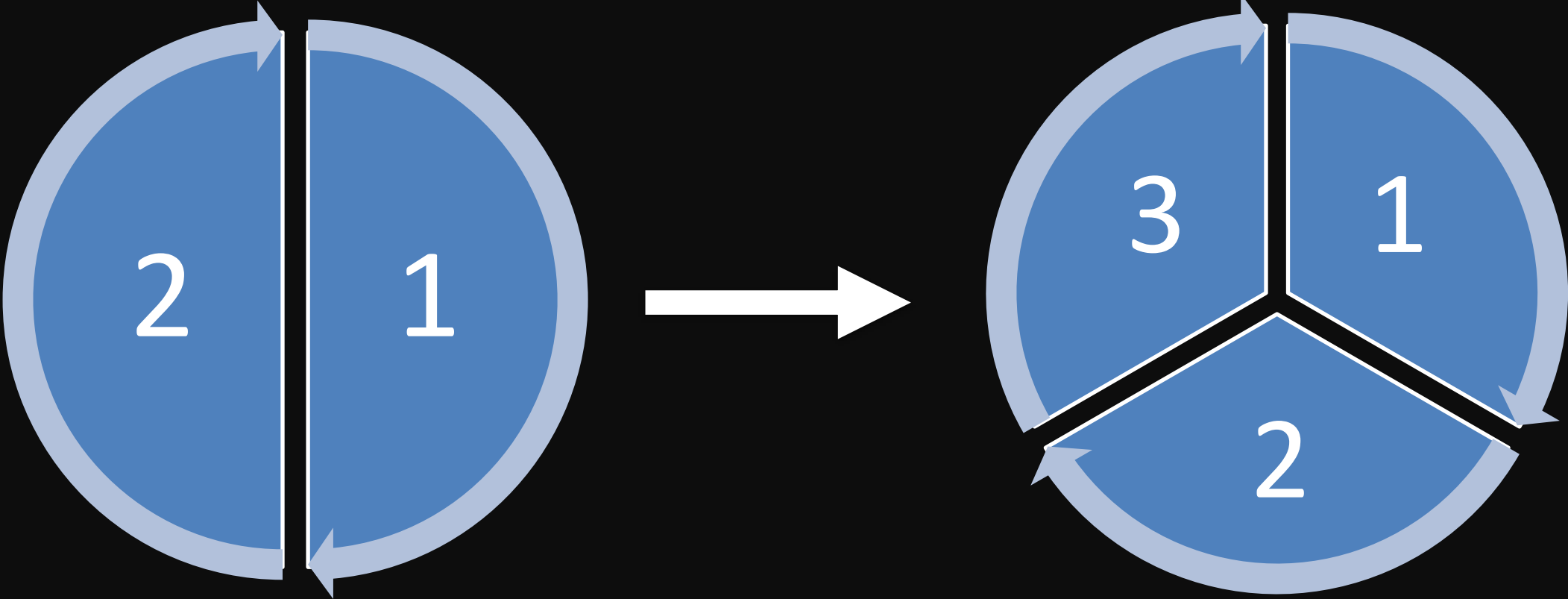




Rotation is necessary...but how?????



Rotation is necessary



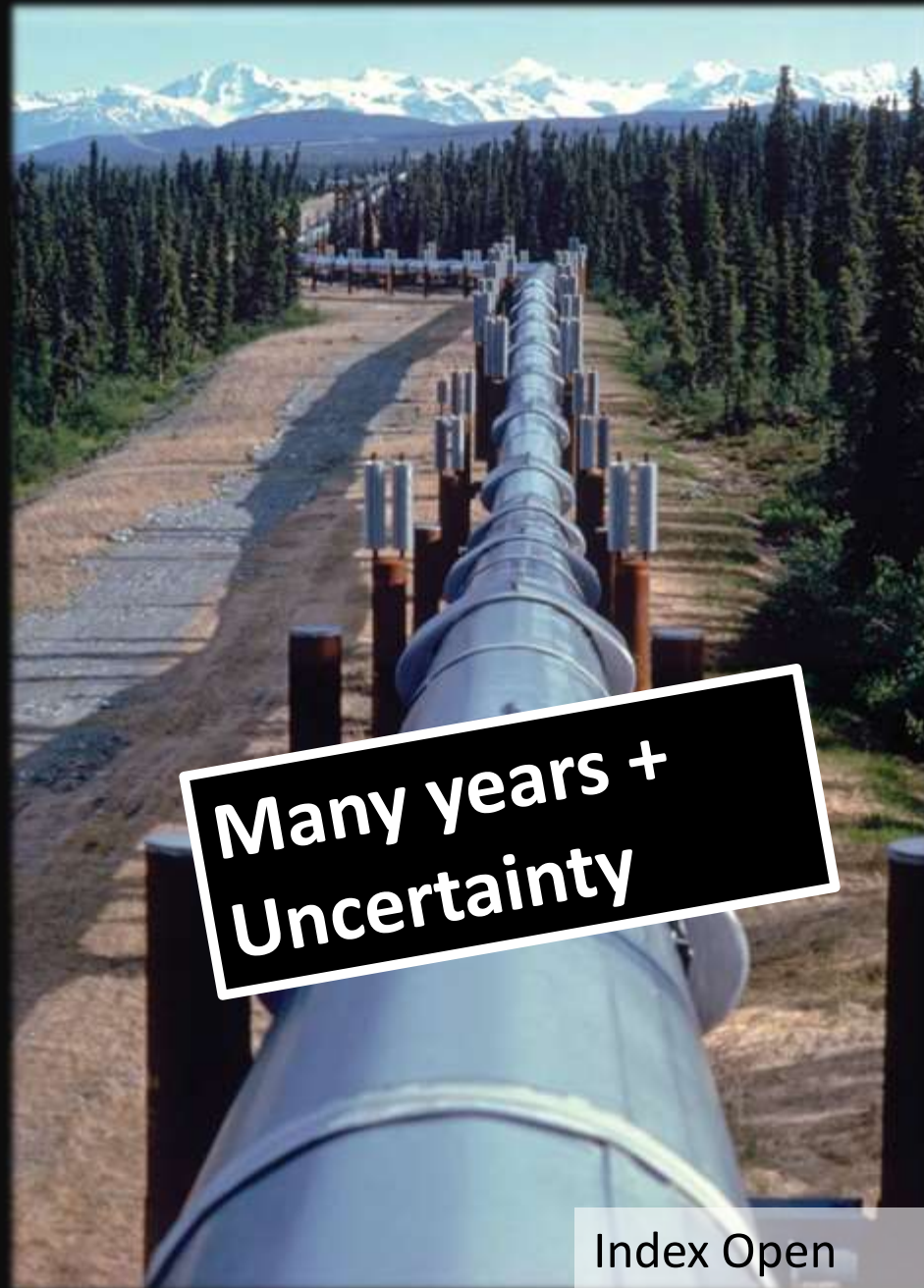
# Rotation is necessary







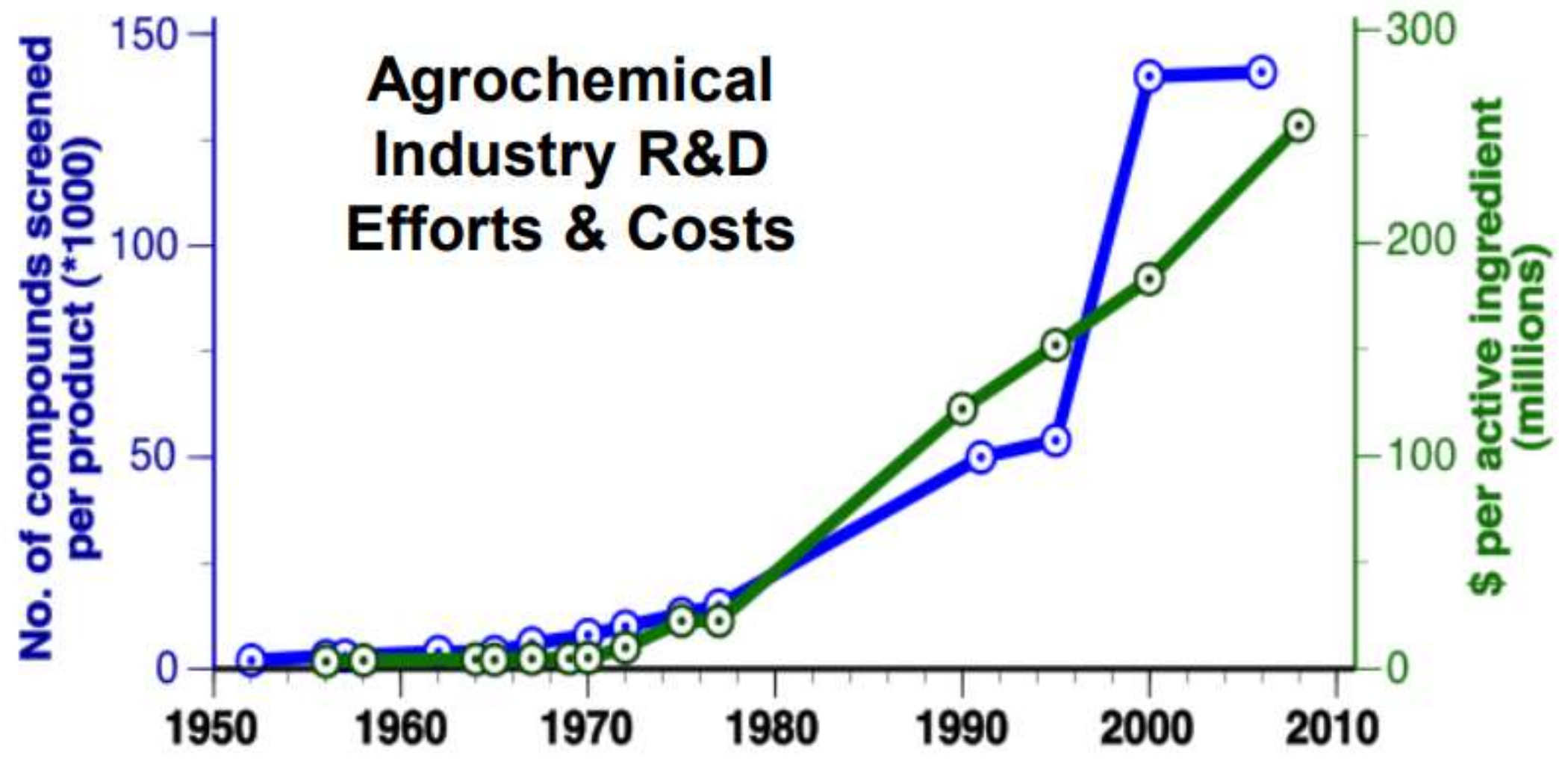




**Many years +  
Uncertainty**

Index Open

# Agrochemical Industry R&D Efforts & Costs









Can this be you?





# Acknowledgements



**RESISTANT ALFALFA WEEVIL**



- Rachael Long (Yolo, Solano, Sacramento)
- Nick Clark (Kings, Tulare, Fresno)
- Rob Wilson (Intermountain REC, Siskiyou)
- Giuliano Galdi (Siskiyou)
- Tom Getts (Lassen, Modoc, Plumas-Sierra)
- Michelle Leinfelder-Miles (Delta)
- Michael Rethwisch (Imperial)
  
- Kevin Goding (UCD)
- Treanna Pierce (UCD)
- Omir Livneh (UCD)
- Ben Lee (UCD)
  
- Growers/PCAs



# Questions

Ian Grettenberger  
imgrettenberger@ucdavis.edu



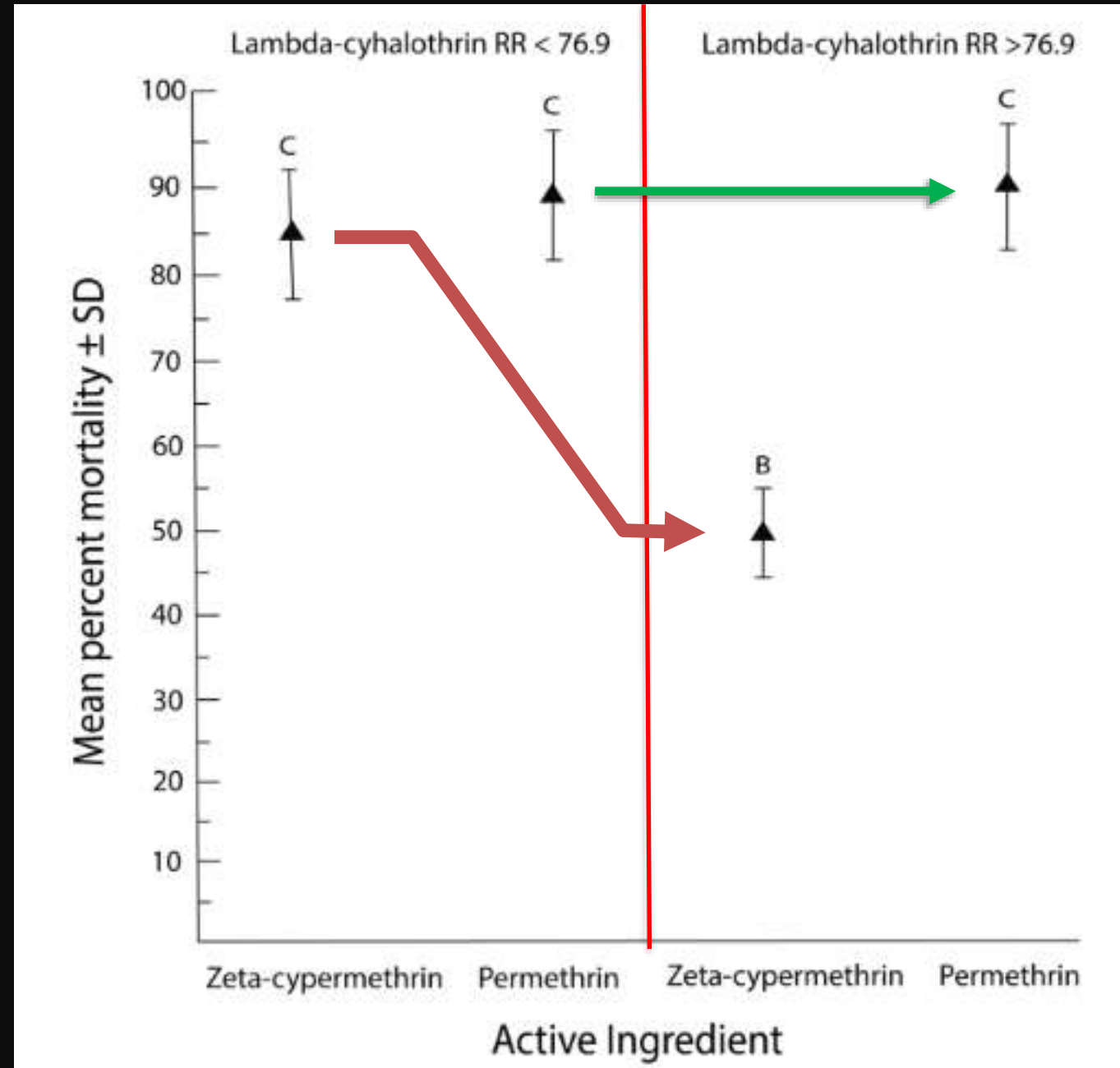


# What about cross resistance?



- Cross resistance between lambda-cyhalothrin and zeta-cypermethrin
- Limited cross resistance between lambda-cyhalothrin and permethrin

“Not resistant”  $\longrightarrow$  Resistant



~~Reactive~~  
Proactive

