

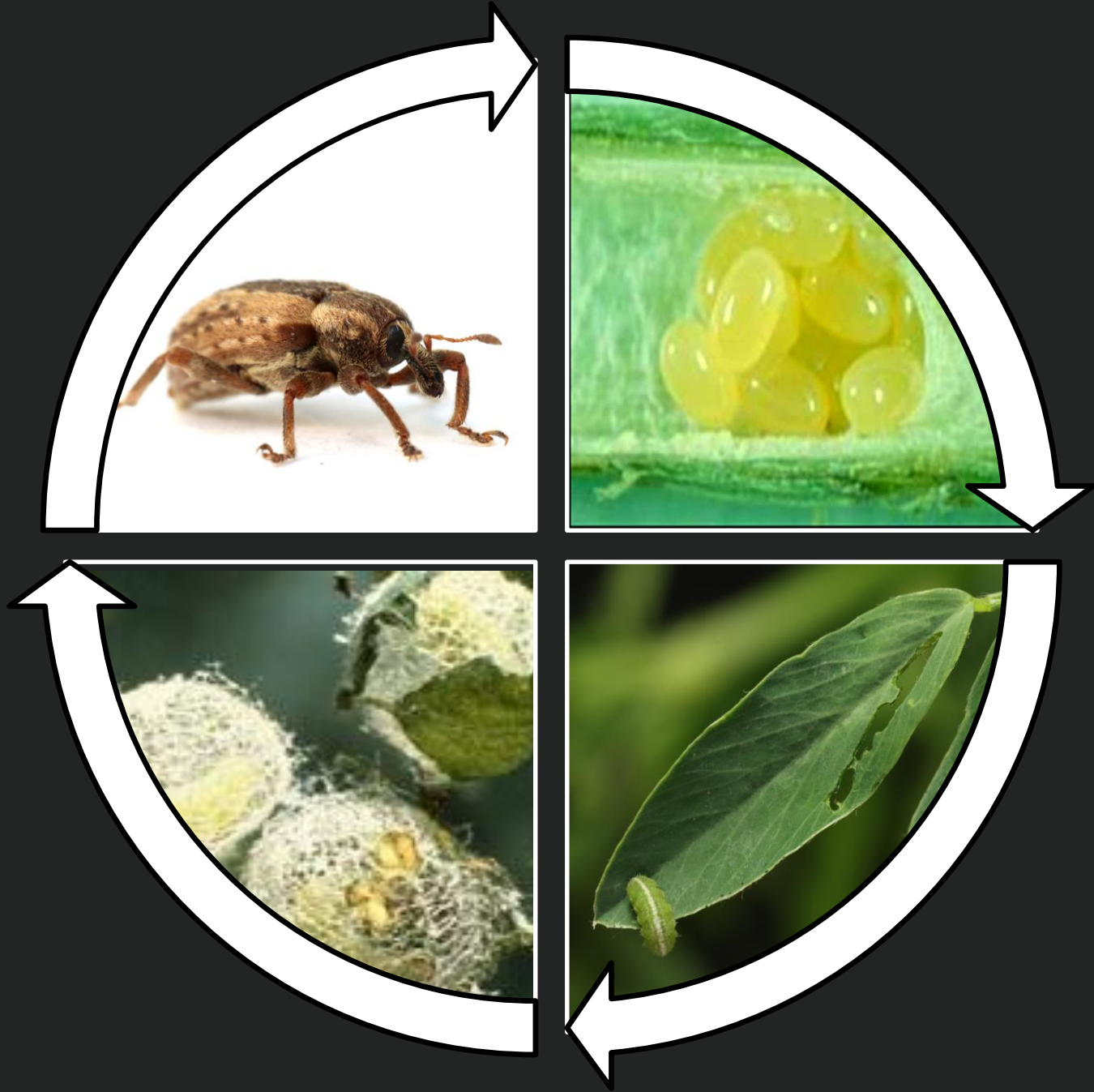
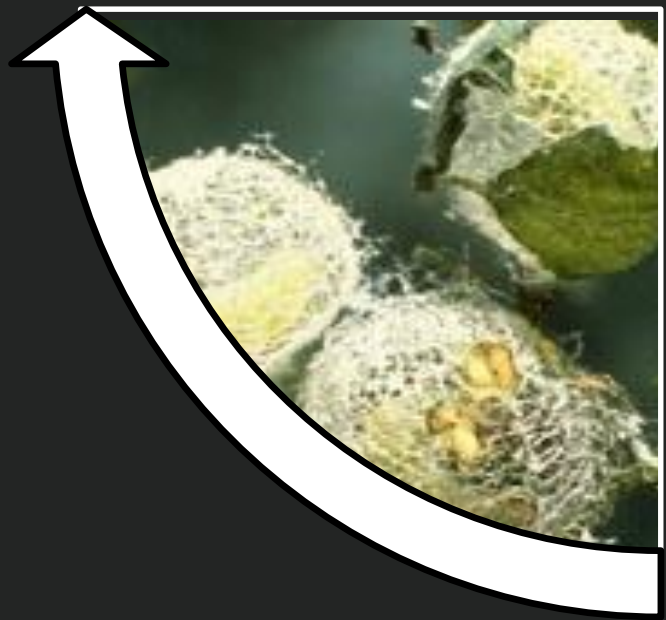
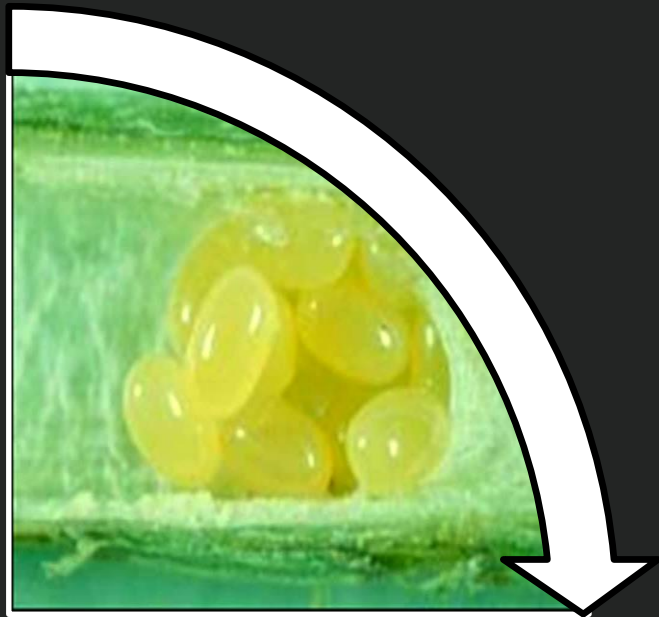
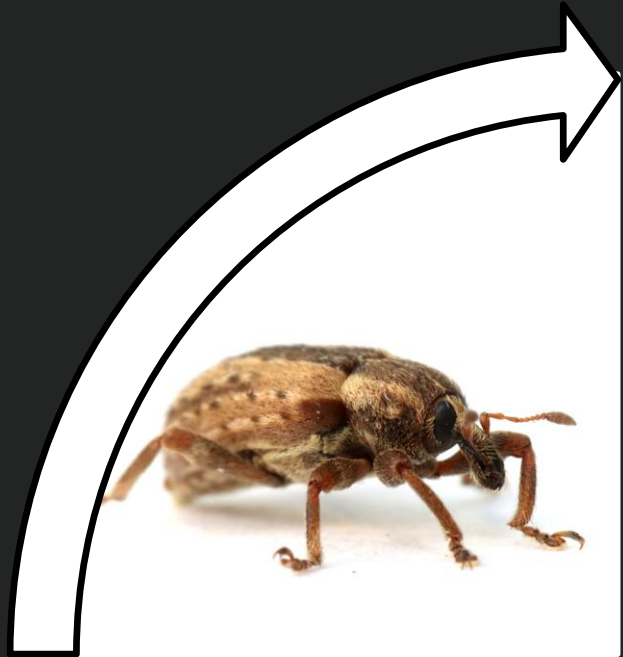
# The problem of insecticide resistance with alfalfa weevil

Ian Grettenberger – UC Davis/UCANR

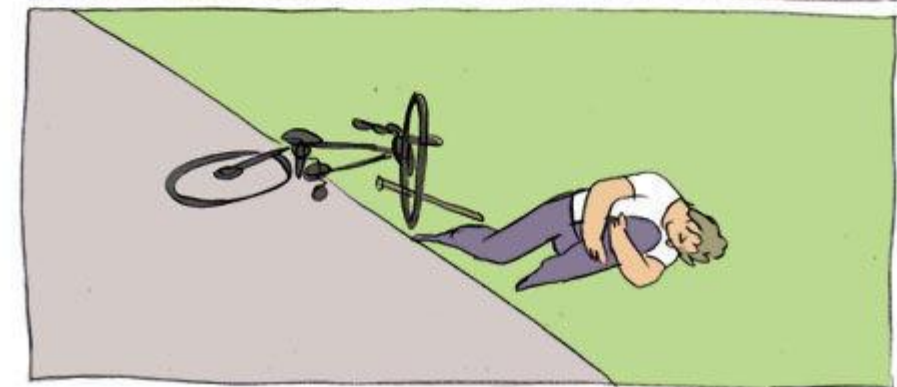
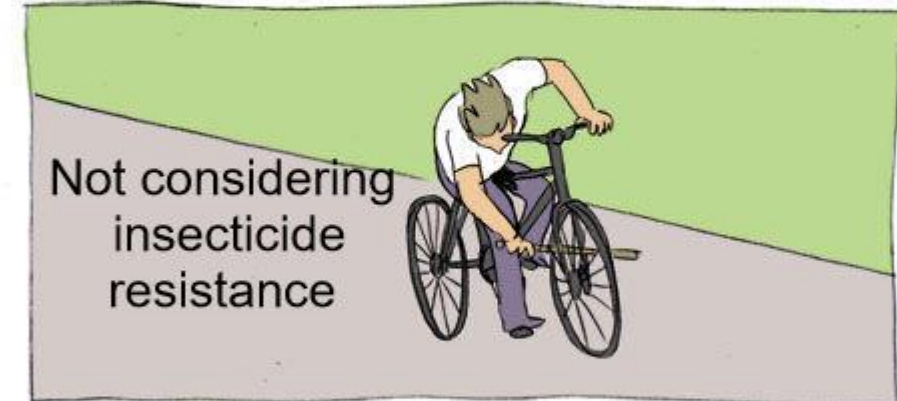








# Why care about resistance?



How does insecticide  
resistance develop?



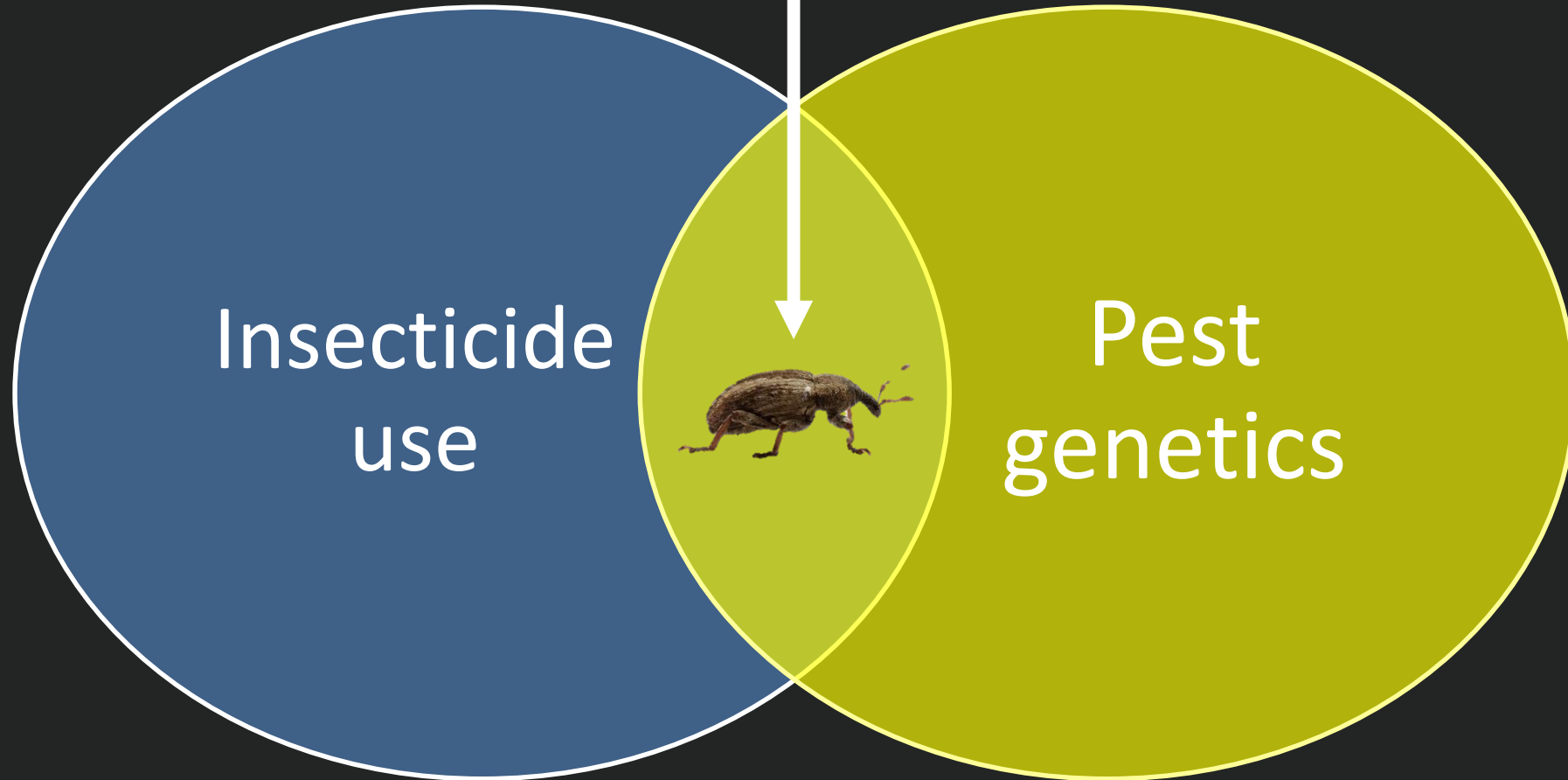
# Pest genetics



Insecticide use



# Insecticide resistance



# Resistance is Genetic



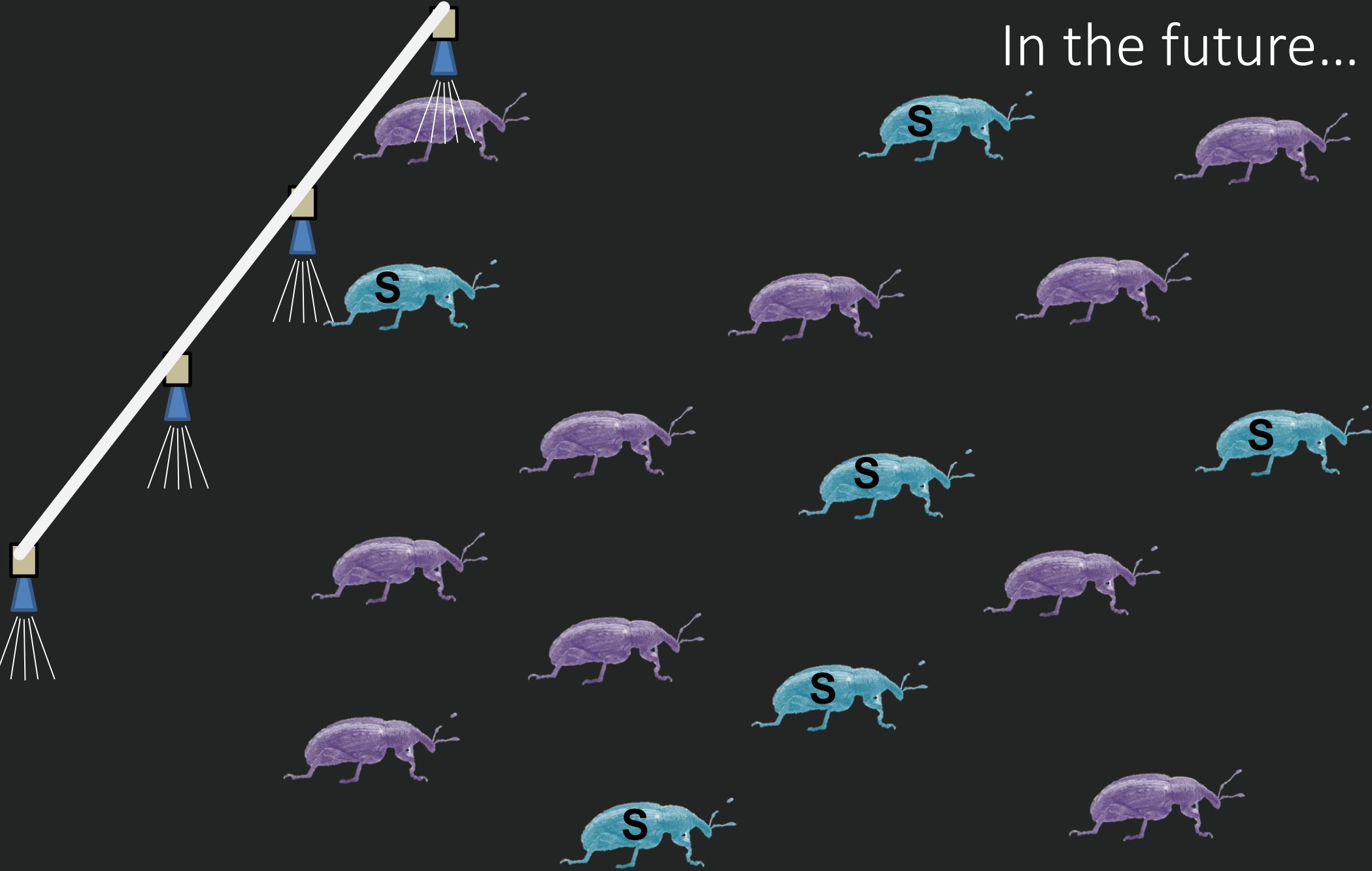
S is Susceptible



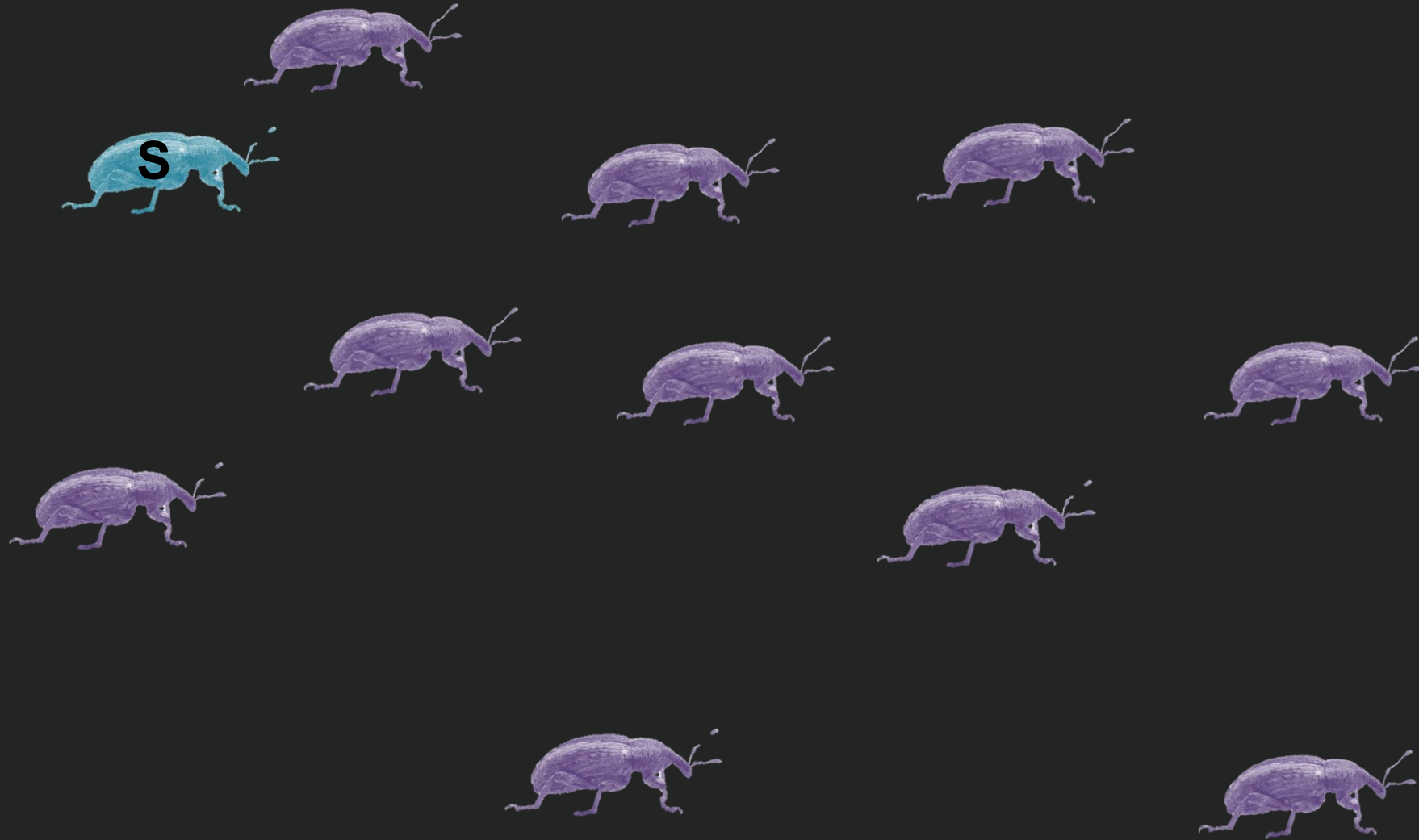
Mating



In the future...



# Resistance is Now Common



# Problem: Pyrethroid-resistant alfalfa weevils

“We’ve had to learn to live with higher levels”

“Once it’s here, it’s basically like a new pest ... really we effectively don’t have anything to control it ...”



# Insecticide resistance is 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; Bissell 1969) 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. Plainfield, N. J.  
St. Louis, Mo.  
Form W-4617-A  
Product No. 2290

**ORTHO**

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

**ORTHO<sup>®</sup> 95  
DIELDRIN  
SPRAY**

**KILLS  
ANTS, LAWN EGGS (Sod Webworms), WHITE GRUBS,  
GRASSHOPPERS and Other Lawn and Ornamental Soil Insects**

**ANT**      **LAWN MOTH**      **EARWIG**

Active ingredients      by wt.  
Heptachlor-epoxy-octahydro-dimethane  
methane (from Dieldrin)      15.5%  
Related Compounds (from Dieldrin)      2.8%  
Aromatic Petroleum Derivative Solvent      73.4%  
Inert Ingredients      8.3%

**A SOIL INSECTICIDE**

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

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

**HOME LAWN:** Ants, Lawn Moth (Sod Webworm), Cutworms, Sowbugs, Pillbugs, Wireworms, White Grubs, Snails, Slugs, June Beetle Grubs, Armyworms, Mole Crickets, Crickets, Grasshoppers—8 Teaspoonfuls in 15 gals. water per 500 sq. ft. of lawn area (1½ teaspoonful 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): Brachyrhinus Weevils and pests listed under Home Lawns—8 teaspoonfuls in 15 gallons water per 500 square feet (1½ teaspoonfuls 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 400 acre farm near Cascade, Iowa. Last season, he planted 110 acres of corn, and gained 35.4 bonus bushels per acre by using Heptachlor soil insecticide.

Orland Manternach farm, Cascade, Ia. Ten pounds of 20% granular Heptachlor per acre, applied broadcast with a fertilizer sprayer. Test on third year corn land not treated previously.

	STRAND COUNT PER ACRE	YIELD BUSHELS/ACRE CORRECTED TO 15.5% MOISTURE
HEPTACHLOR	14,300	138.0
CHECK	17,800	102.6
INCREASE WITH HEPTACHLOR	1,500	35.4



**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 BASIC MANUFACTURERS OF TECHNICAL HEPTACHLOR

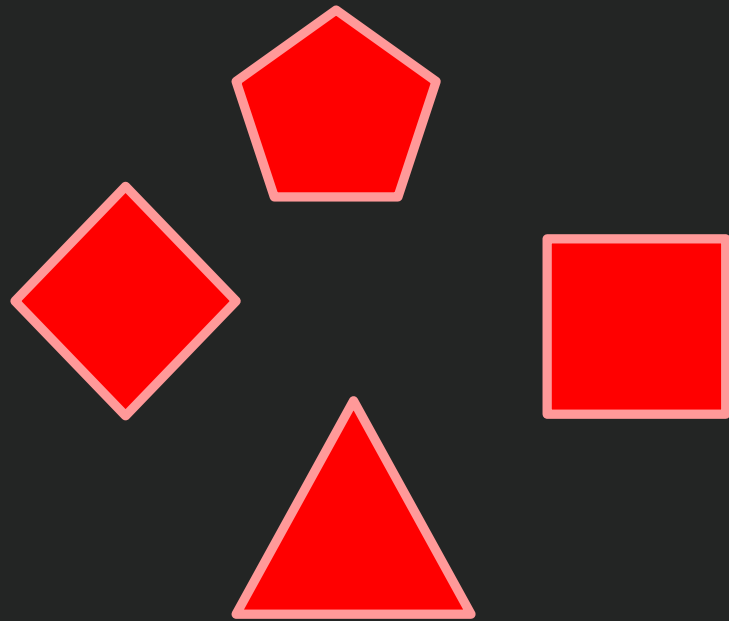
ask for  
**HEPTACHLOR**  
SOIL INSECTICIDE

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



# Problem: Limited modes of actions

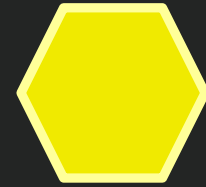
Pyrethroids (3A)



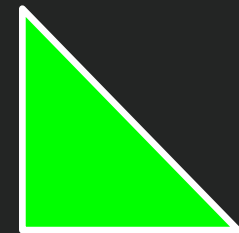
Oxadiazines – Indoxacarb (22A)



Spinosyns-Spinosad (5)



Organophosphates – malathion (1B)







# Warrior II

with Zeon Technology<sup>®</sup>

GROUP 3 INSECTICIDE

## Insecticide

Active Ingredient:

Lambda-cyhalothrin<sup>1,2</sup> ..... 22.8%

Other Ingredients: ..... 77.2%

Total: ..... 100.0%

Warrior II with Zeon Technology contains 2.08 lbs. of active ingredient per gal. and is a capsule suspension.

<sup>1</sup>CAS No. 91465-08-6    <sup>2</sup>Synthetic pyrethroid

Contains petroleum distillate.

## KEEP OUT OF REACH OF CHILDREN. WARNING / AVISO

*Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)*

See additional precautionary statements and directions for use in booklet.

EPA Reg. No. 100-1295    EPA Est. 39578-TX-1

Product of the United Kingdom

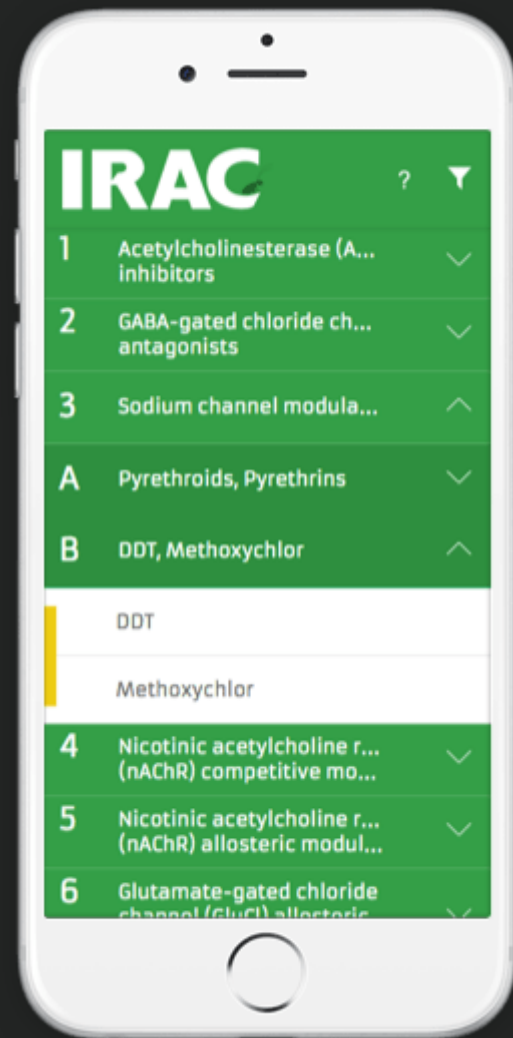
Formulated in the USA

SCP 1295A-L2B 0709

304012

# 1 gallon

Net Contents



3

SODIUM CHANNEL MODULATORS



A

PYRETHROIDS, PYRETHRINS



B

DDT, METHOXYCHLOR



4

NICOTINIC ACETYLCHOLINE RECEPTOR (NACHR) COMPETITIVE MODULATORS



A

NEONICOTINOIDS



*Acetamiprid, Clothianidin, Dinotefuran, Imidacloprid, Nitenpyram, Thiacloprid, Thiamethoxam*

B

NICOTINE



C

SULFOXIMINES



*Sulfoxaflor*

D

BUTENOLIDES



E

MESOIONICS

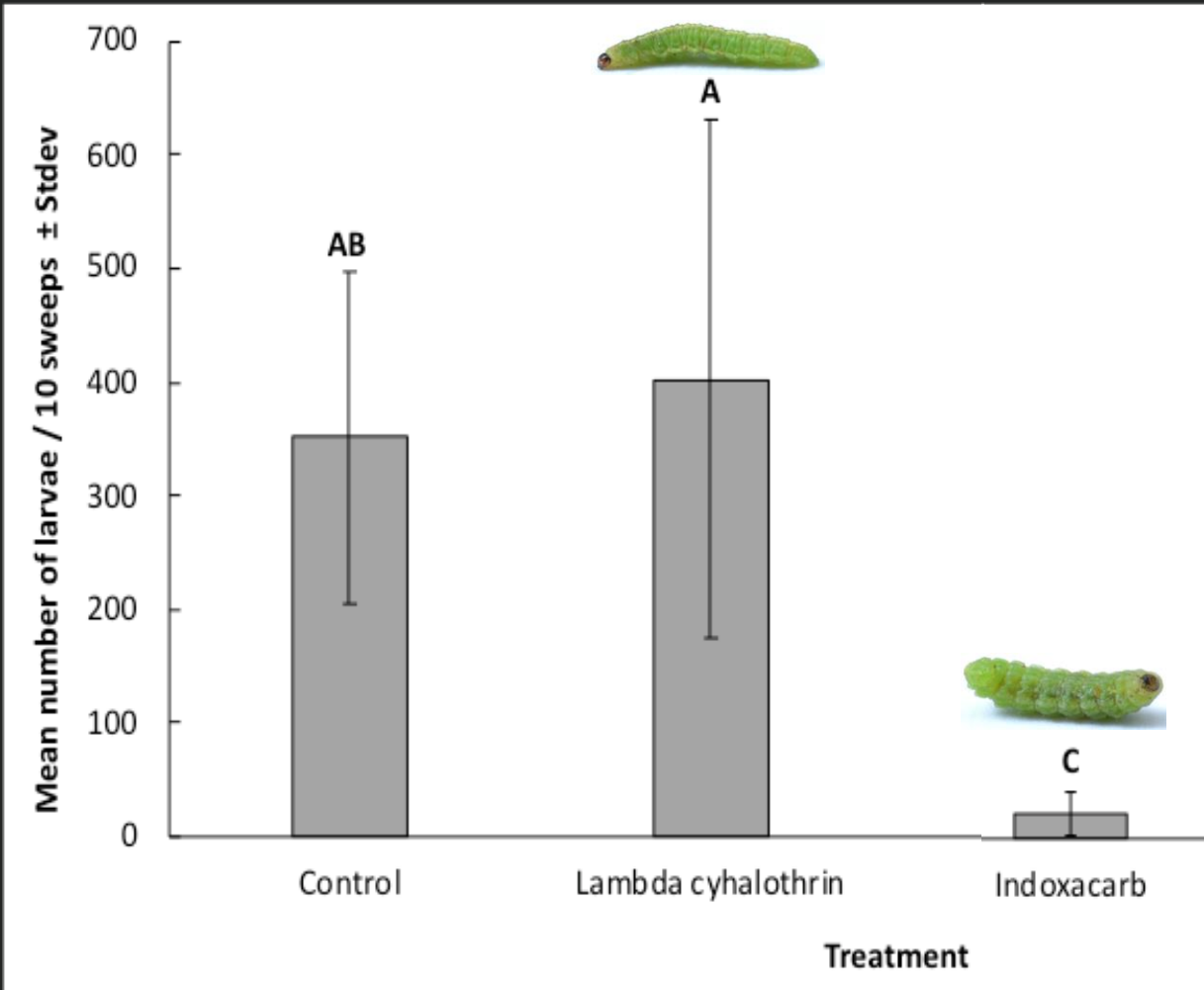


Cross resistance



# Field Results – Resistant Population

- Warrior II (lambda-cyhalothrin, MoA 3A) useless against resistant population
- Steward (indoxacarb, MoA 22A) worked well



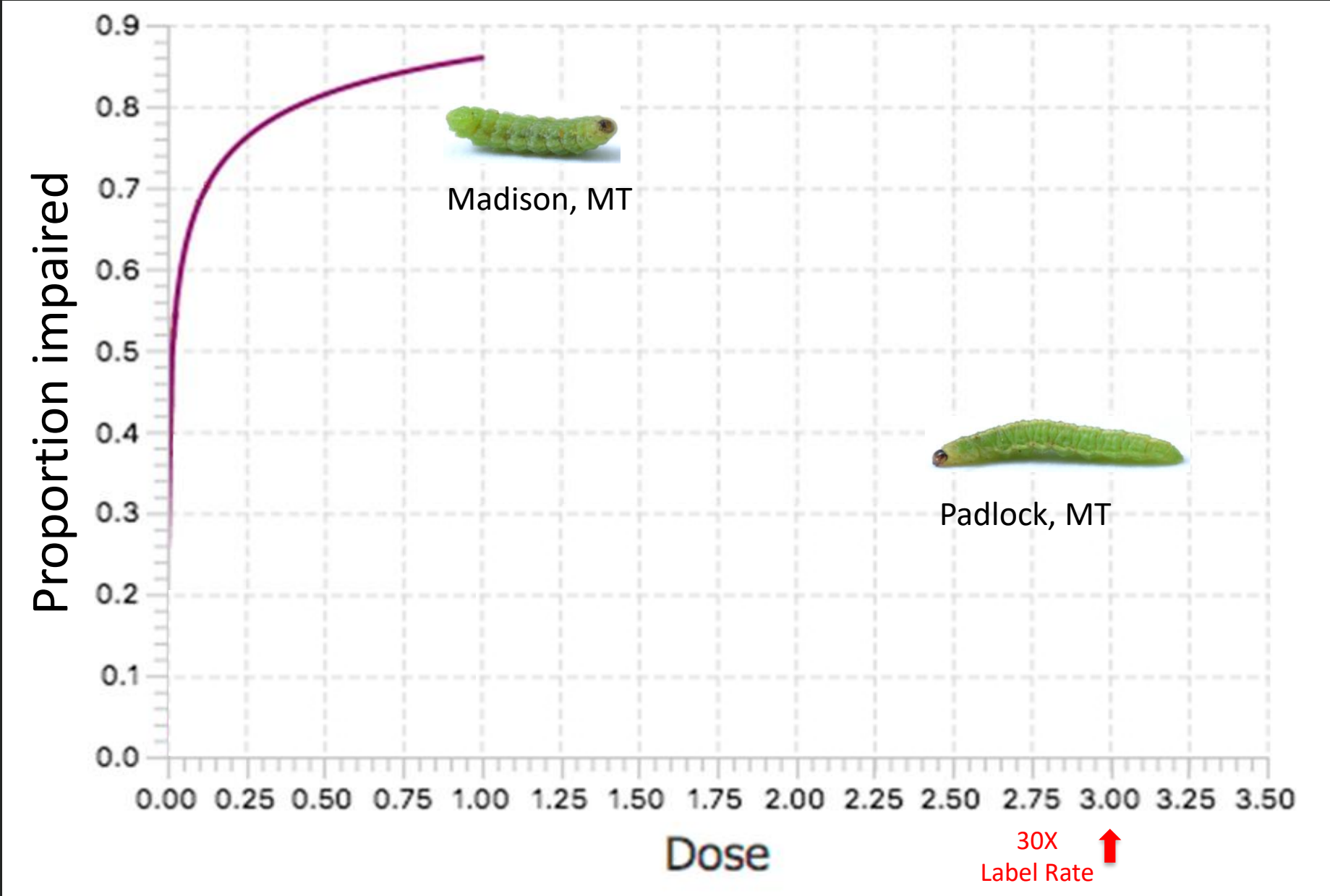
Ten 3<sup>rd</sup> to 4<sup>th</sup> instar larvae placed in treated glass vials

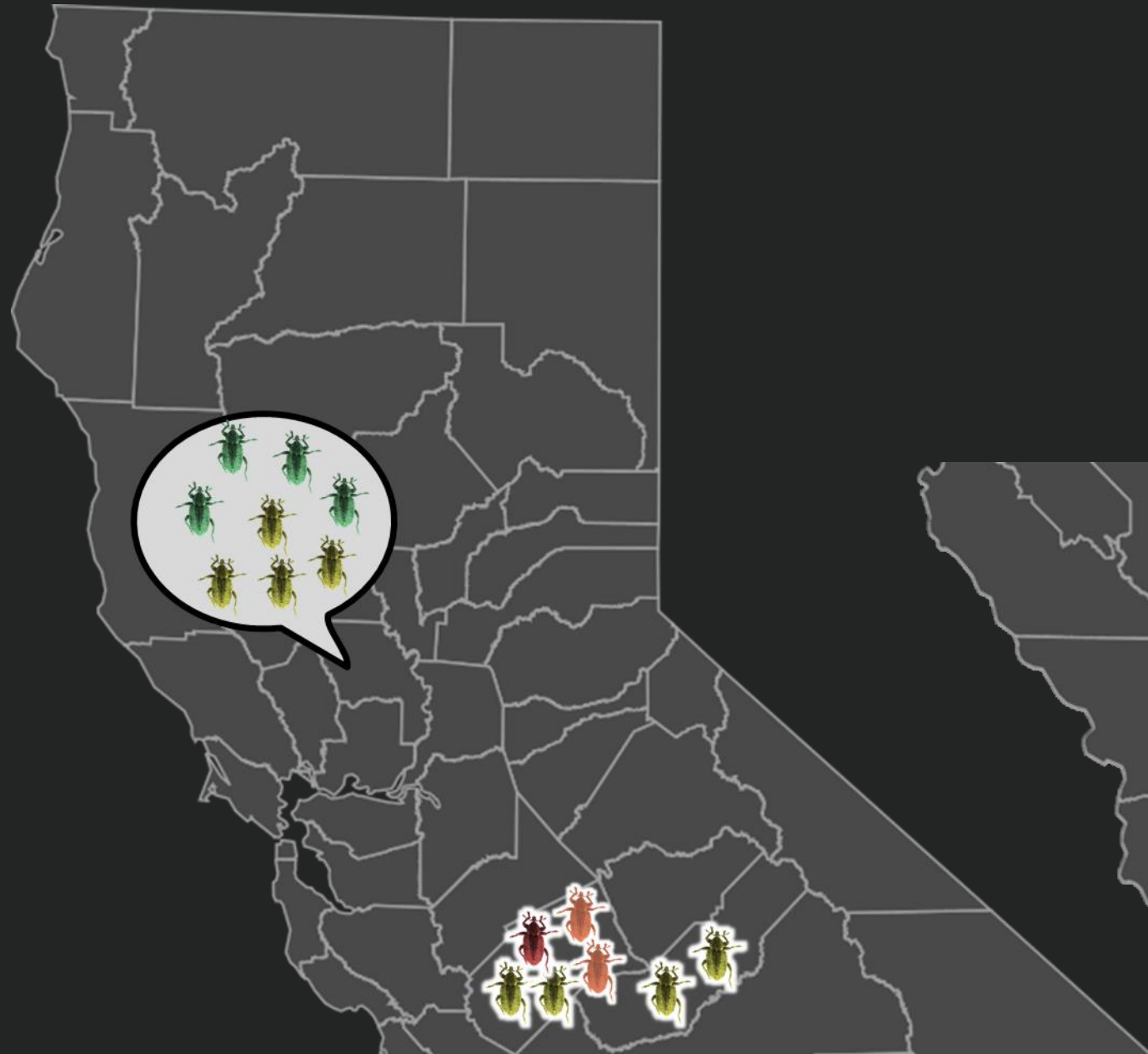
Five vials per dose maintained at 21°C for 24 hours





Exposed treated larvae to 43-50°C to determine # dead

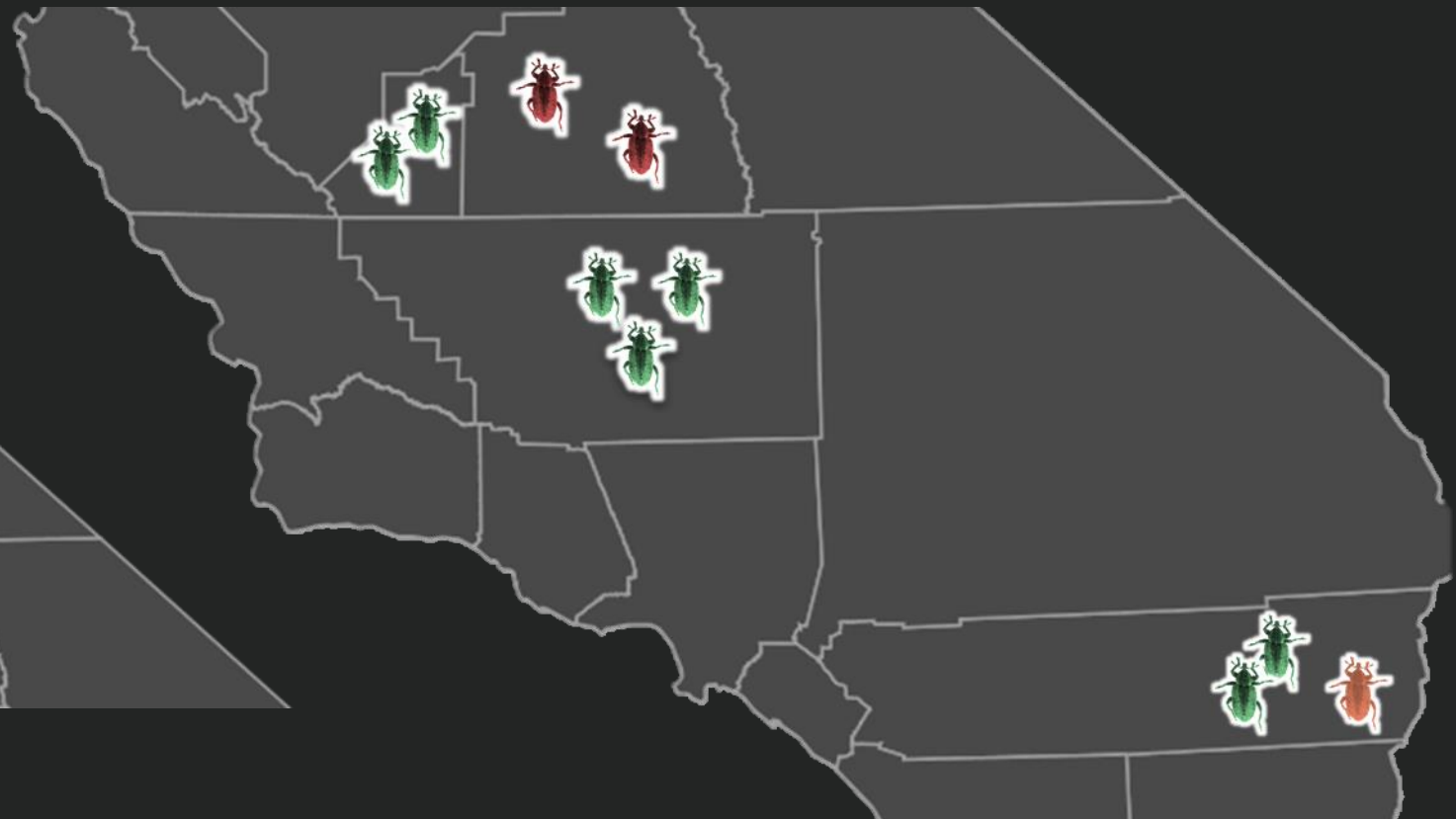


# Resistant vs. susceptible populations



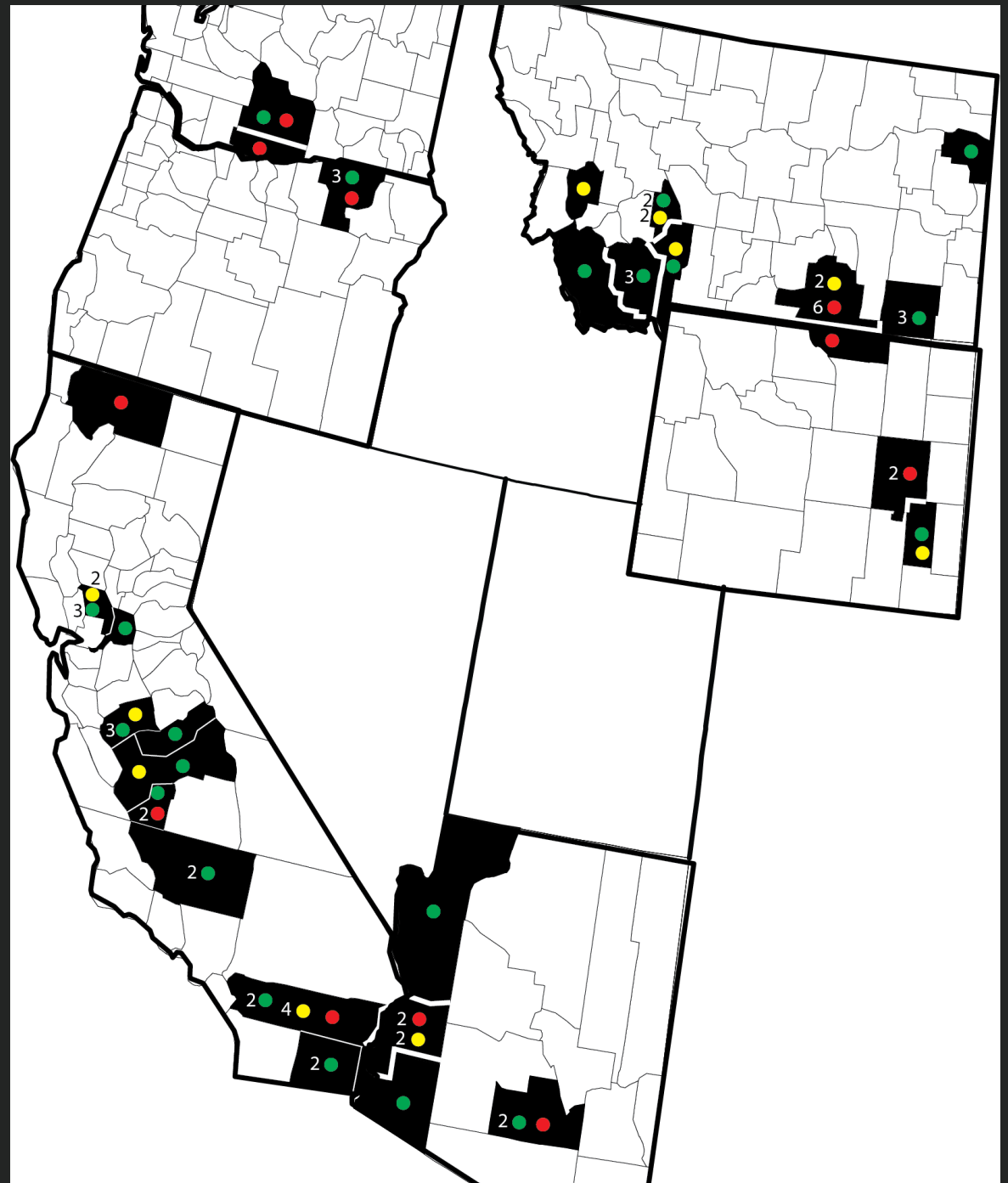


	LC50 (ug/cm <sup>2</sup> )
	< 0.3 Susceptible
	0.3 - 0.59 Resistance Risk (Low)
	0.6 - 0.99 Resistance Risk (High)
	> 1.00 Resistant

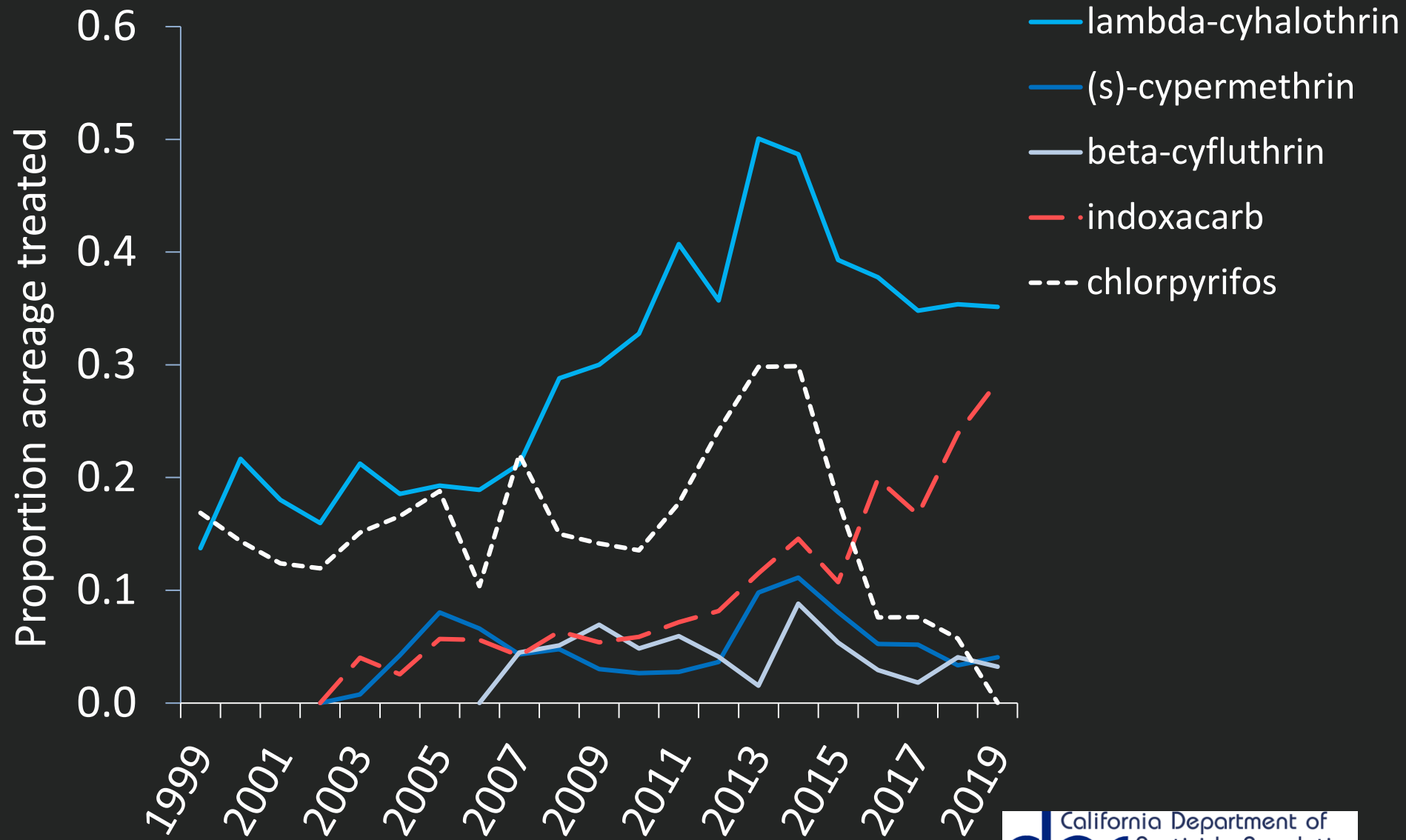


- Susceptible
- Moderately Resistant
- Highly Resistant

- Every western state tested has a highly resistant population of alfalfa weevil
- Cross-resistance between pyrethroid active ingredients (MoA 3A)
- Every state has susceptible populations; an opportunity to mitigate resistance and extend the use of pyrethroids



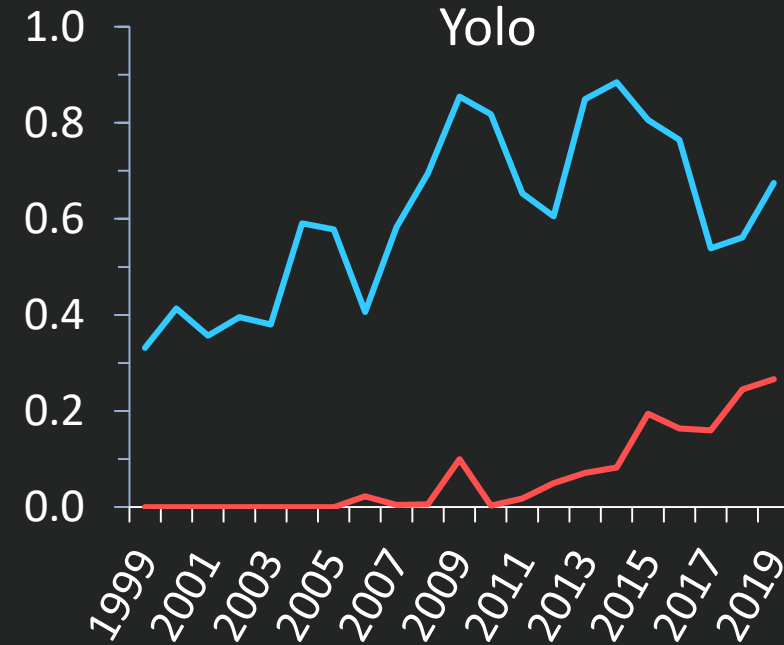
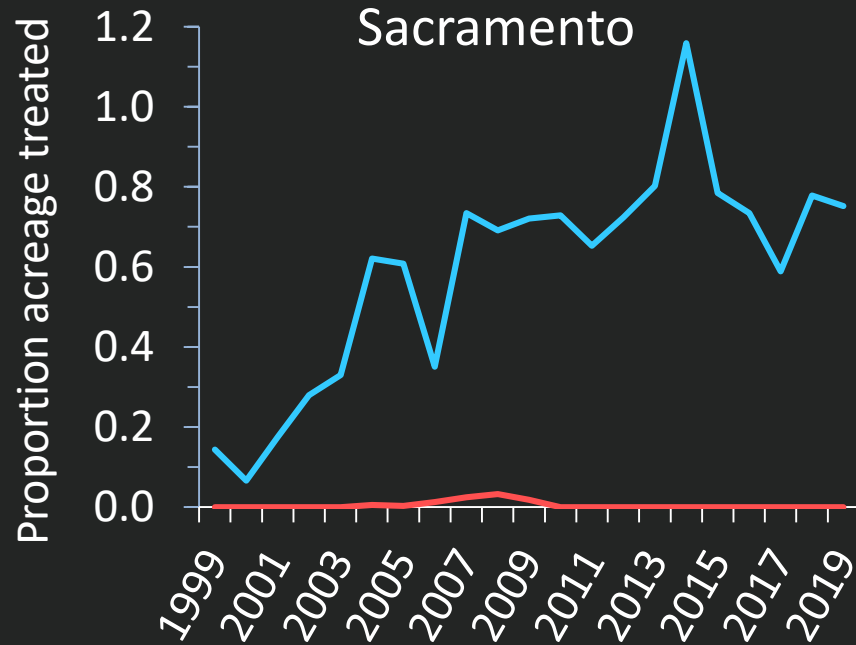
# What have we seen in CA?



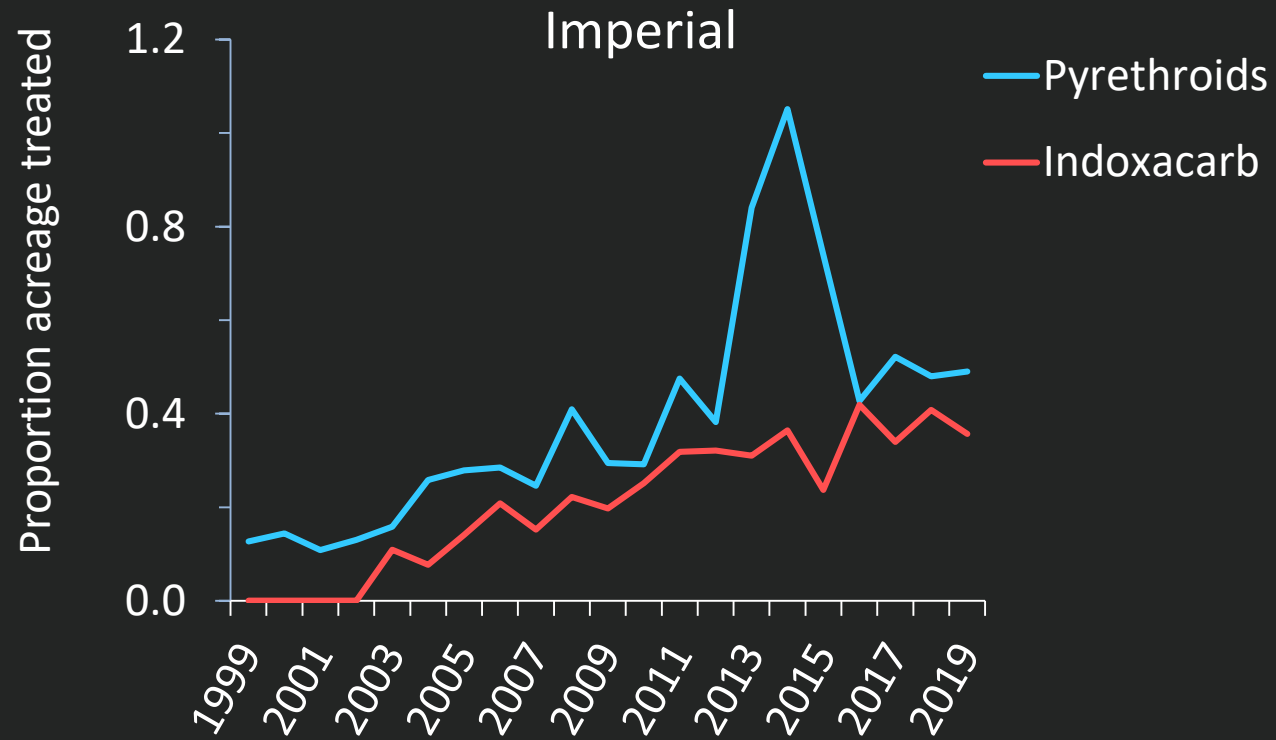


# Generally sustained pyrethroid use

— Pyrethroids  
— Indoxacarb

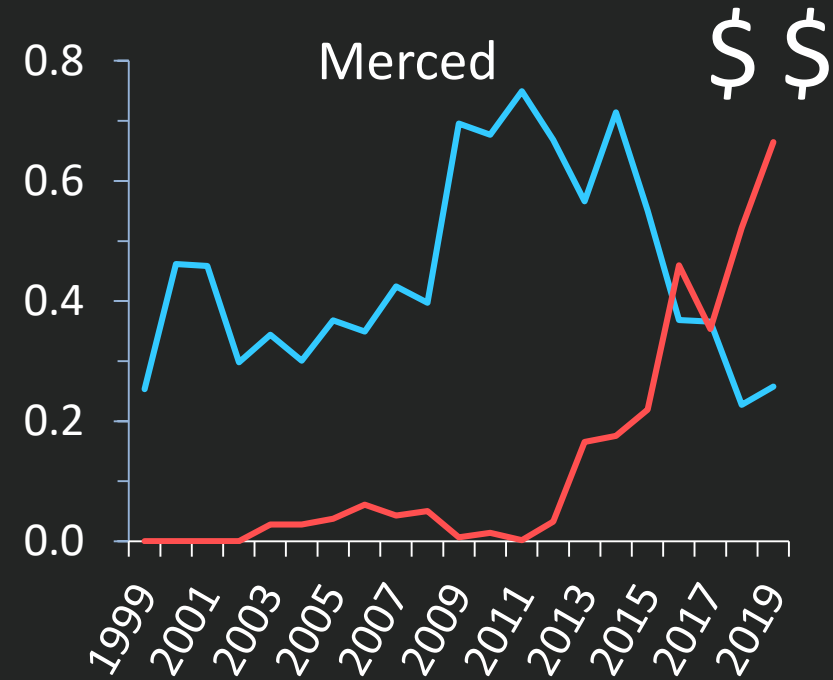
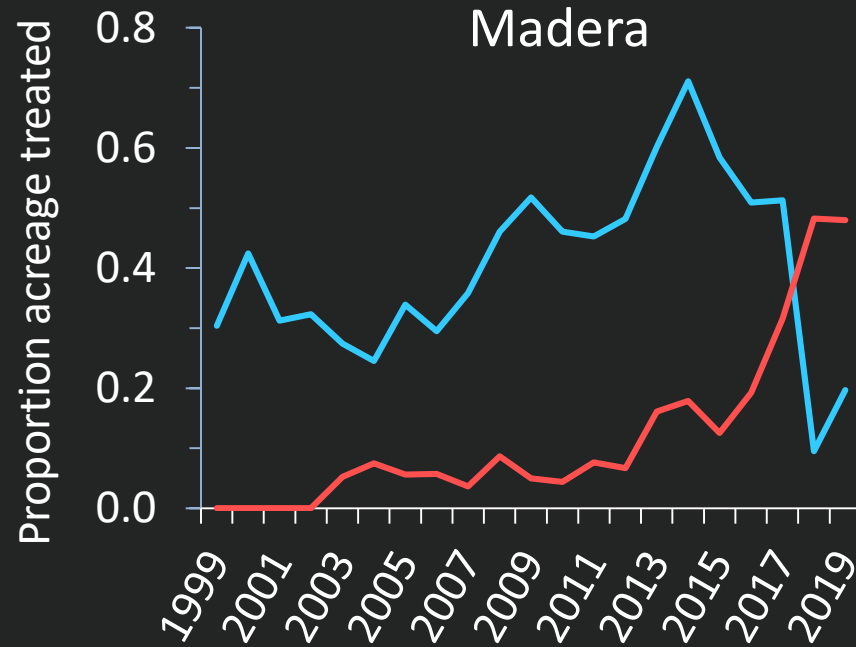


# Use of both pyrethroids and indoxacarb

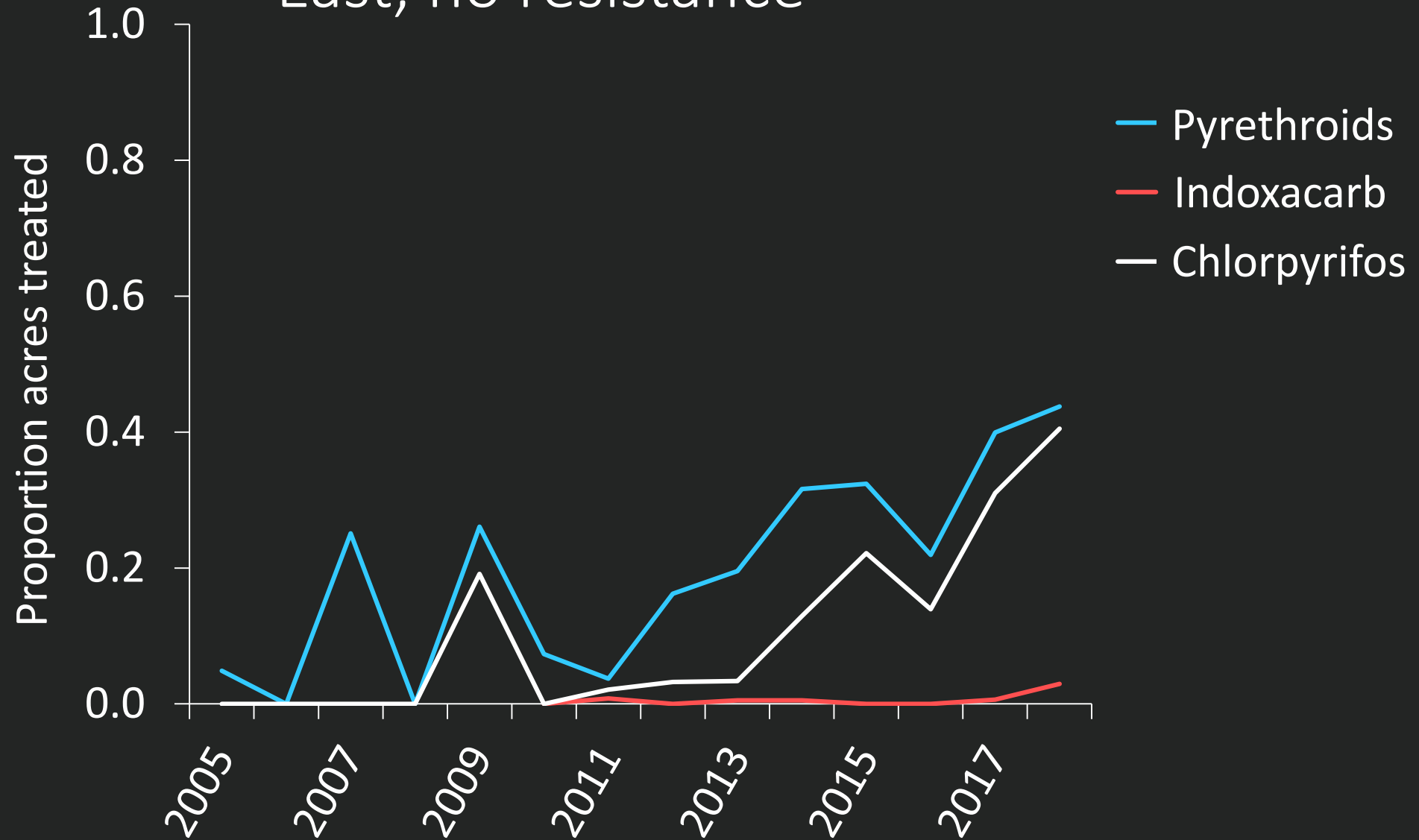


# “Swapping” – proactive or reactive

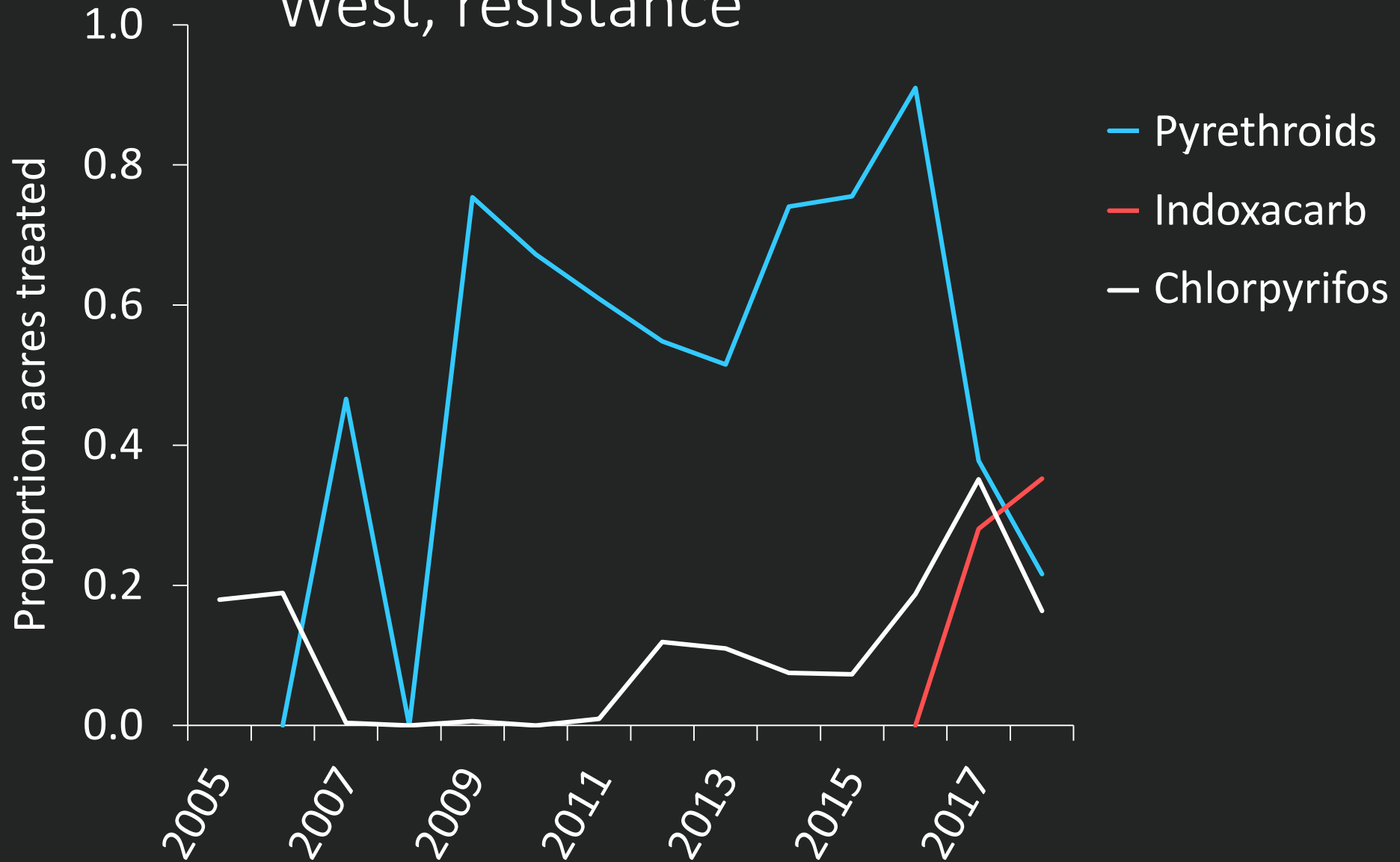
— Pyrethroids  
— Indoxacarb



# Siskiyou: a tale of two regions: East, no resistance



# Siskiyou: a tale of two regions: West, resistance



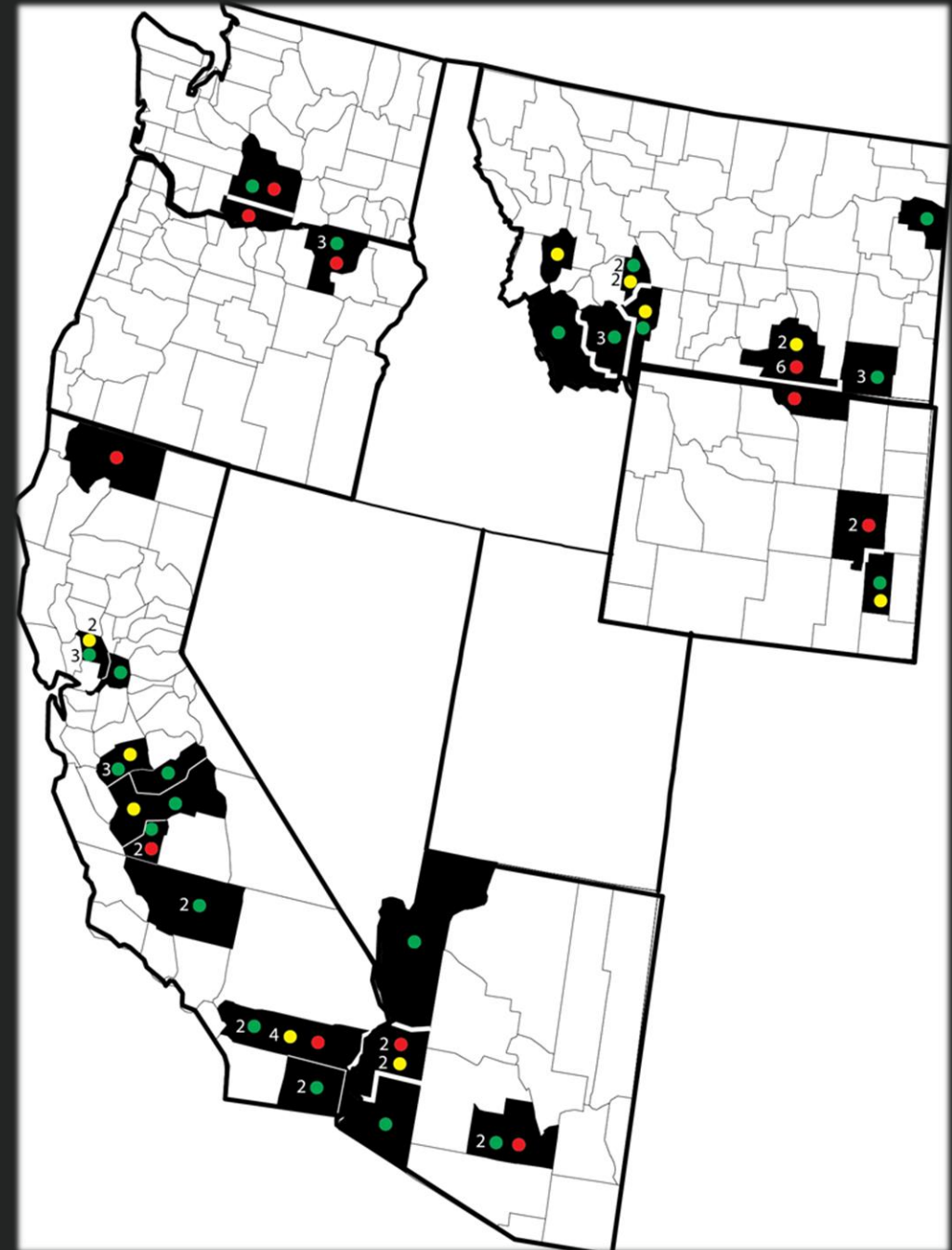
# How does resistance spread... how far, how quickly?

- Plenty of uncertainty
- In intensive alfalfa areas + smaller scales: rapidly
- Otherwise, appear to be strong local effects...initially



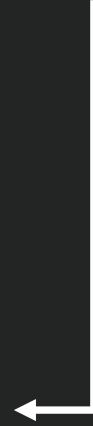
# What do we have to look forward to?

- Clearly have resistance across the landscape
- Likely not a lot of future chemicals
- Still DO have susceptibility in the landscape
- 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

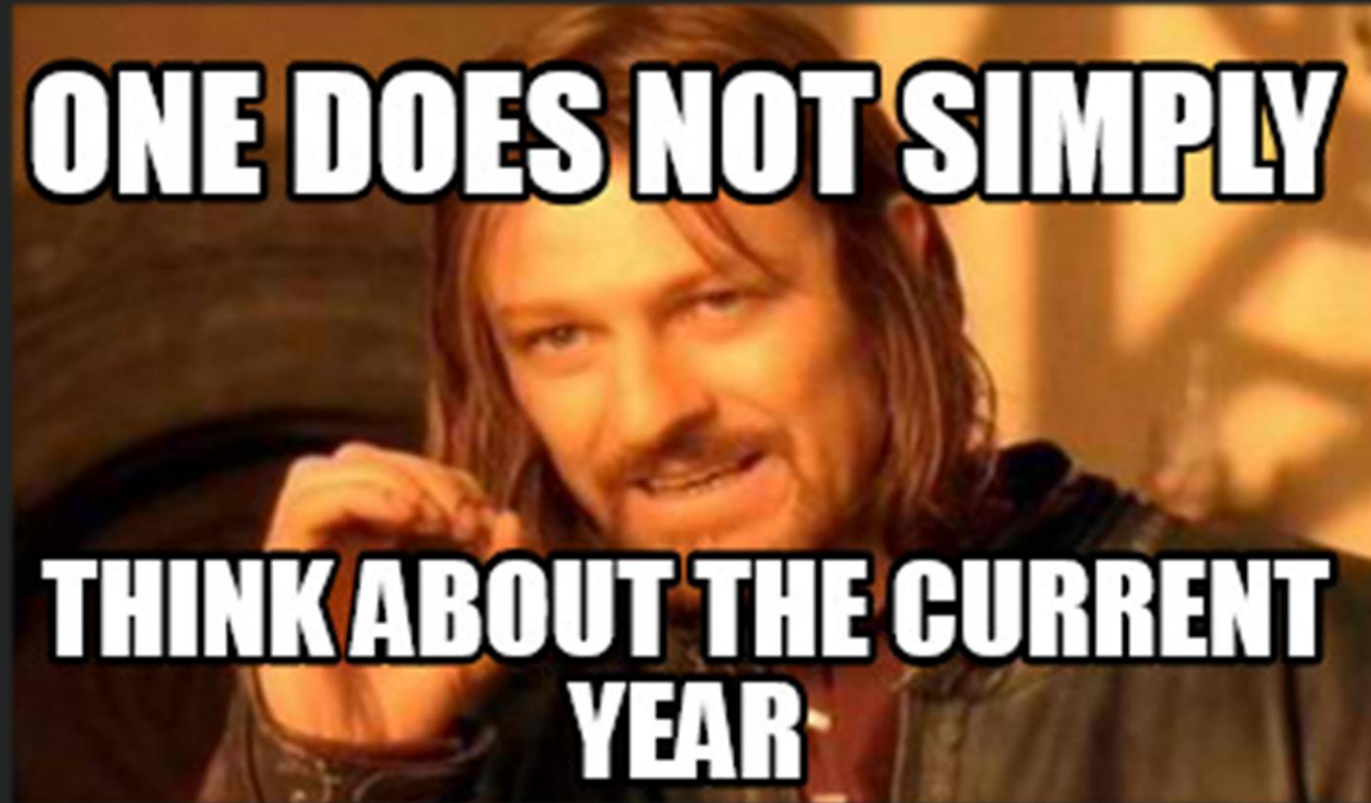




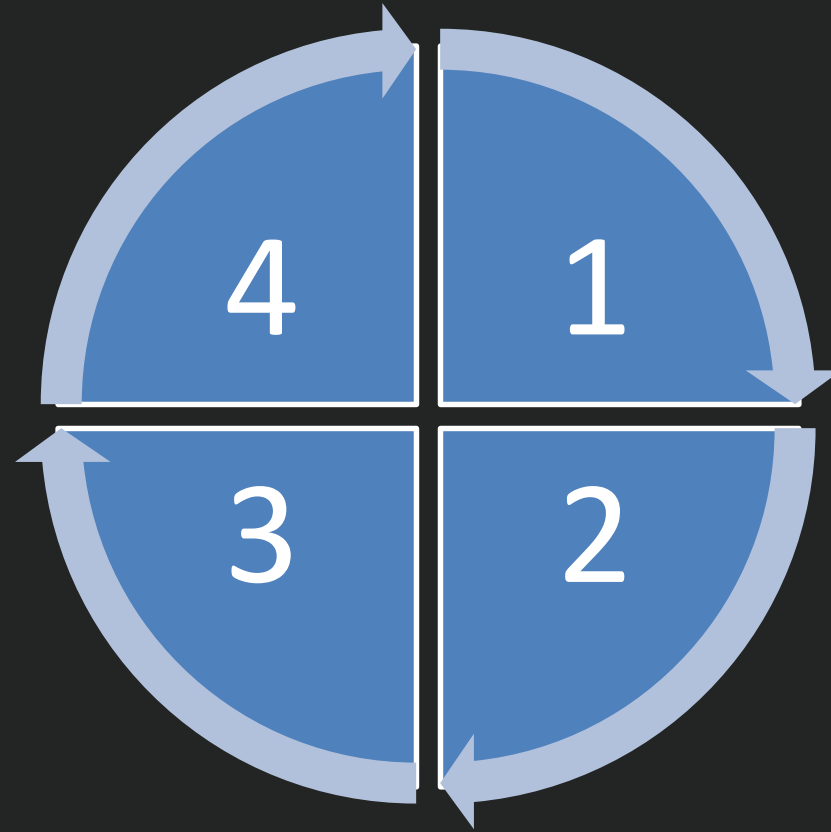




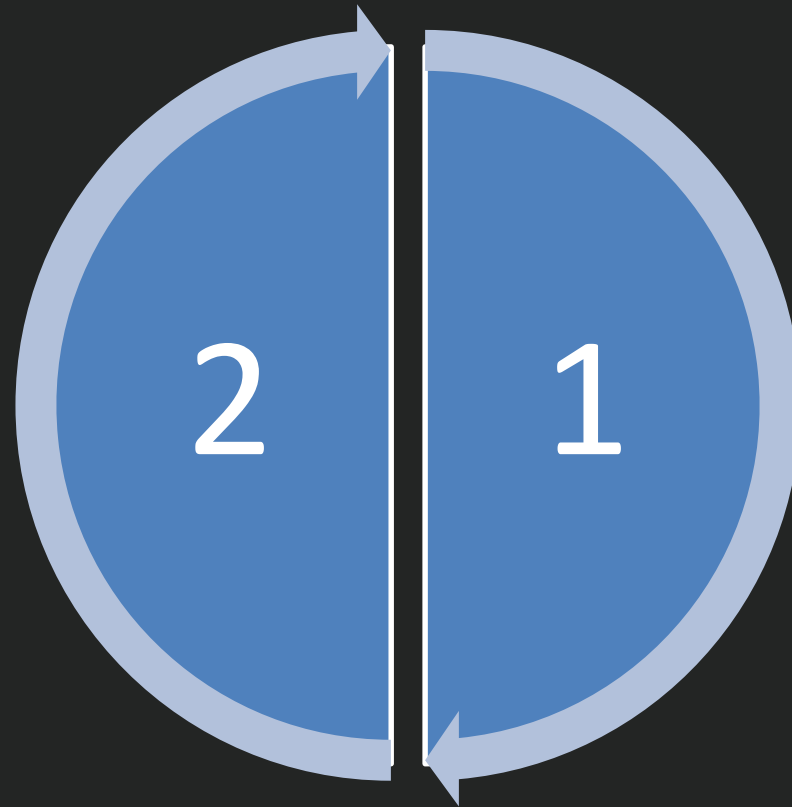
What can we do?



Rotation is necessary

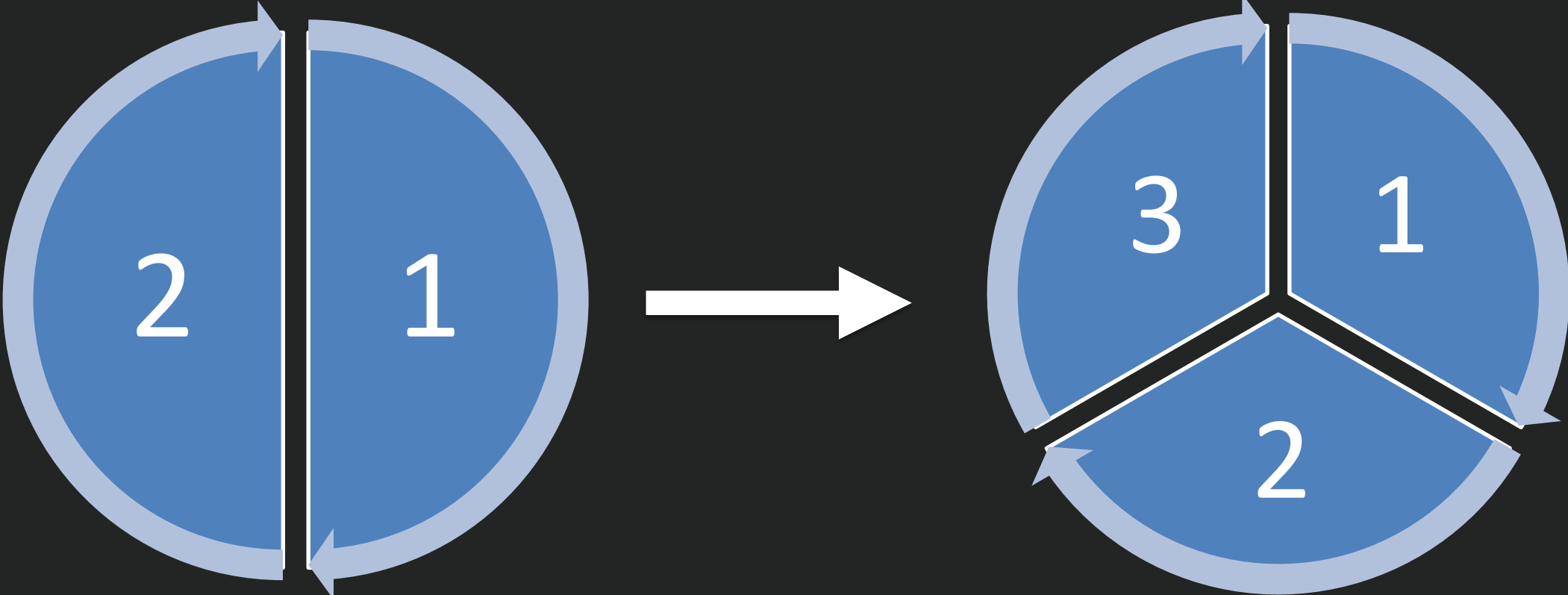


Rotation is necessary

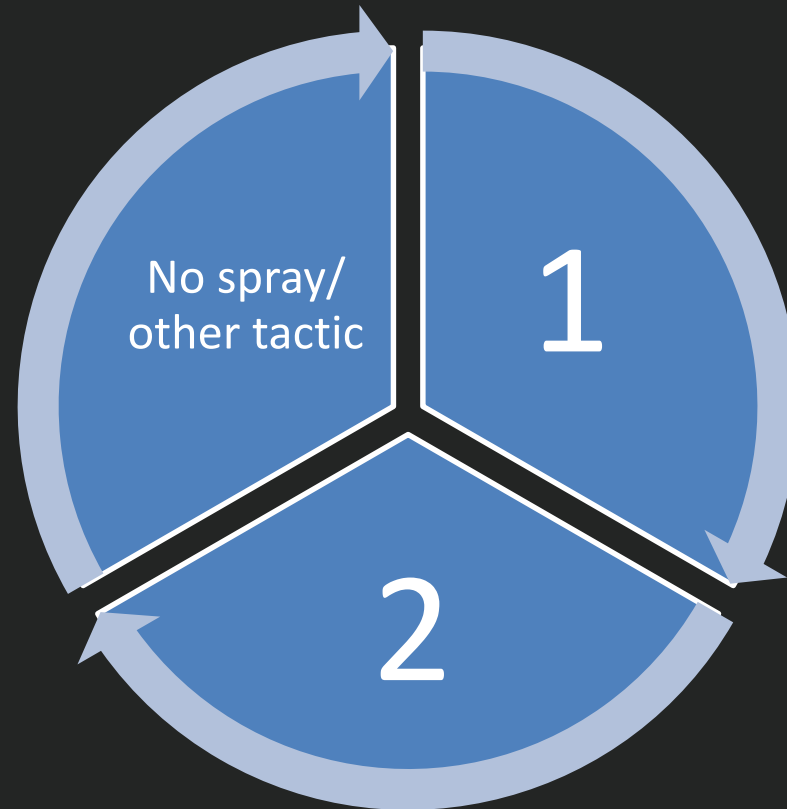




# Rotation is necessary



# Rotation is necessary







Rotation is necessary



~~Reactive~~  
Proactive



# Acknowledgements



- Madi Hendrick (UCD)
- Kevin Wanner (Montana State)
- Erika Rodbell (Montana State)
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- Giuliano Galdi (Siskiyou)
- Tom Getts (Lassen, Modoc, Plumas-Sierra)
- Michelle Leinfelder-Miles (Delta)
- Michael Rethwisch (Imperial)
- Kevin Goding (UCD)
- Treanna Pierce (UCD)
- Growers/PCAs



Questions?

