

# A Game Changer: Pyrethroid-Resistant Soybean Aphids

**Robert Koch**

Department of Entomology



UNIVERSITY OF MINNESOTA

**Driven to Discover**<sup>SM</sup>

# Outline

- Soybean aphid management
- Documentation of resistance
- Managing resistant populations



# Resistance

- Genetically-based decrease in susceptibility to a pesticide (Tabashnik et al. 2014)





precisiontillage.com



UNIVERSITY OF MINNESOTA  
**Driven to Discover<sup>SM</sup>**

# Foliar insecticides for soybean aphid

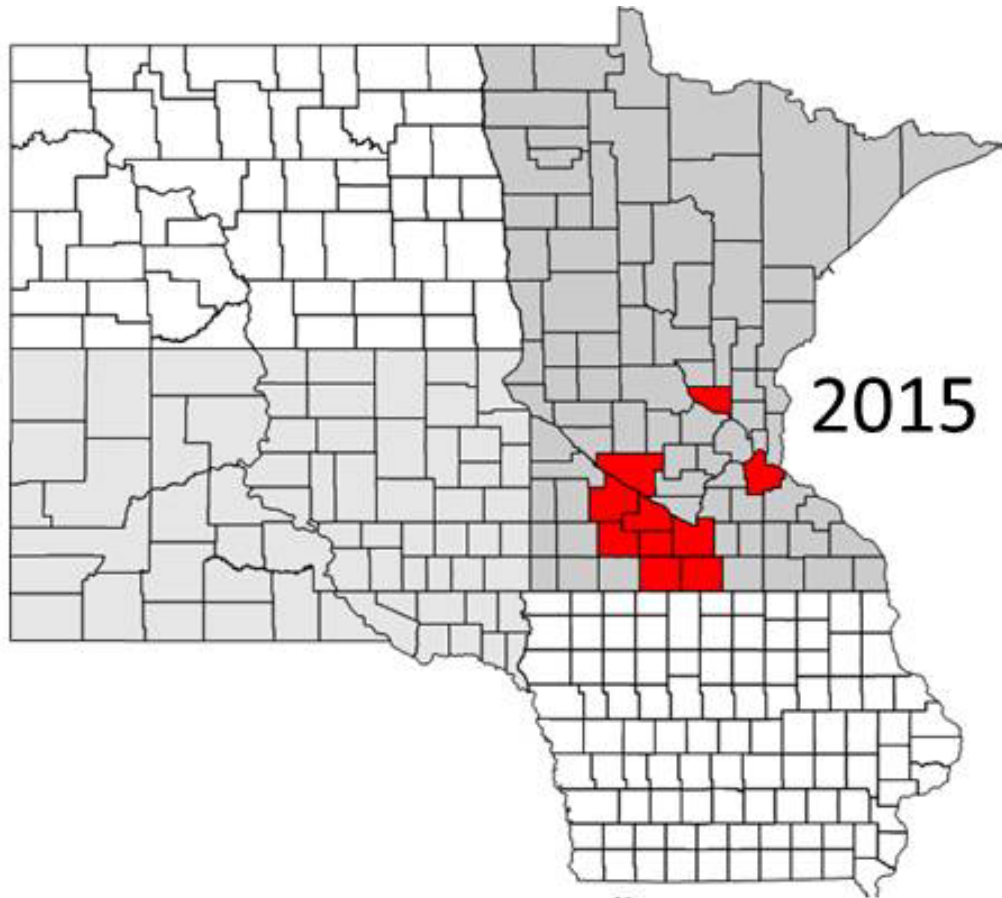
<b>Group 1 AChE inhibitors</b>	<b>Group 3 Na channel modulators</b>	<b>Group 4 nAChR agonists</b>
1A methomyl  1B acephate chlorpyrifos dimethoate	3A alpha-cypermethrin beta-cyfluthrin bifenthrin cyfluthrin deltamethrin esfenvalerate gamma-cyhalothrin lambda-cyhalothrin permethrin zeta-cypermethrin pyrethrins	4A acetamiprid chlothianadin imidacloprid thiamethoxam  4D flupyradifurone

# Soybean aphid & resistance?

- “Light resistance” to organophosphates in China (Quin et al. 2011)
- No evidence of resistance in MI (Chandrasena et al. 2011)
- First records of resistance in North America (Hanson et al. 2017)



# Counties with pyrethroid performance issues (2015)



University of Minnesota

Map by B. Potter



UNIVERSITY OF MINNESOTA

Driven to Discover<sup>SM</sup>

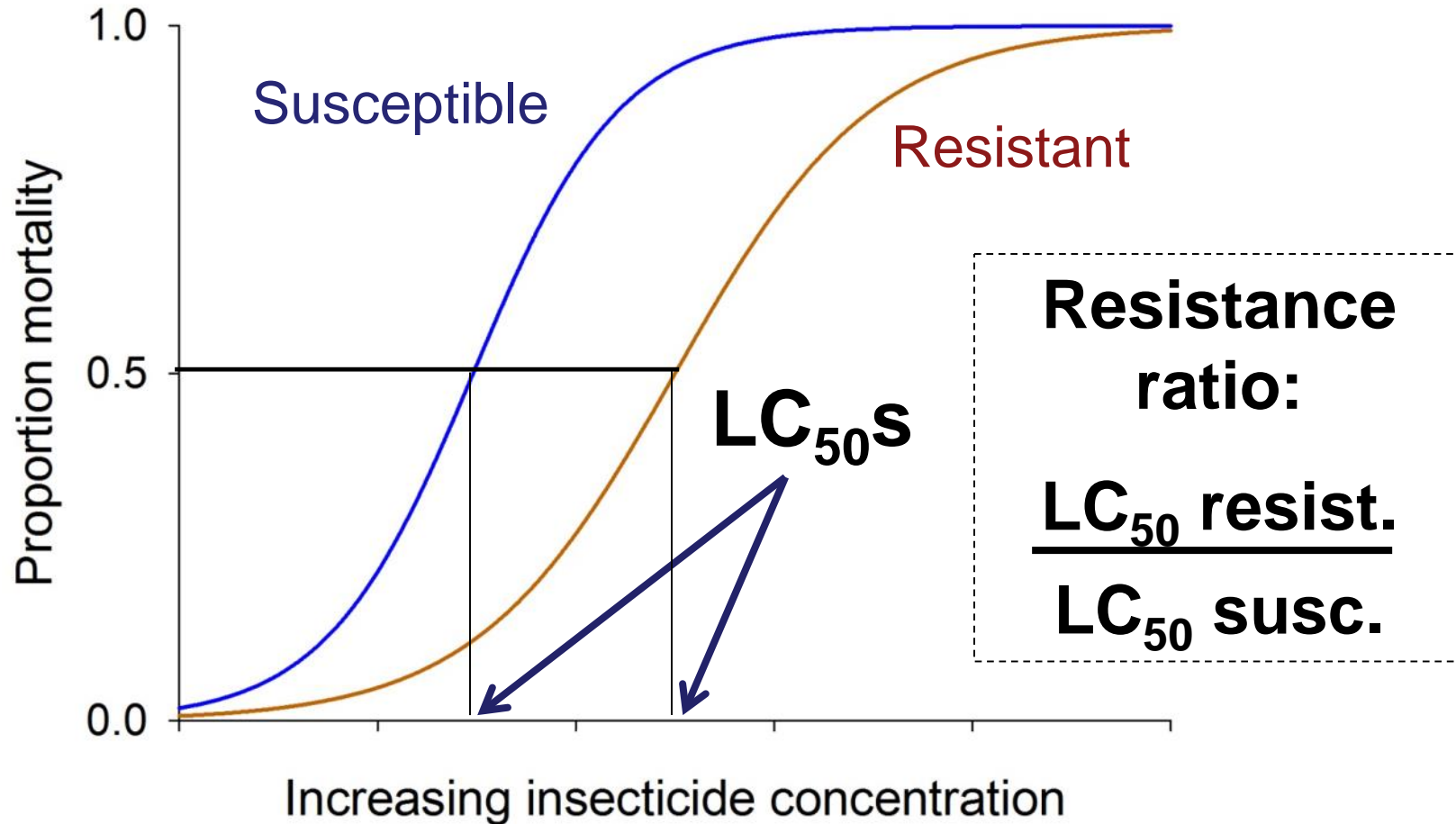
# Soybean aphid resistance monitoring, 2015

- Aphids from field with bifenthrin failure
- Glass-vial assays
  - Bifenthrin or  $\lambda$ -cyhalothrin
  - 10 concentrations of insecticide & untreated
  - 10 adults per vial
  - Mortality assessed after 4 h

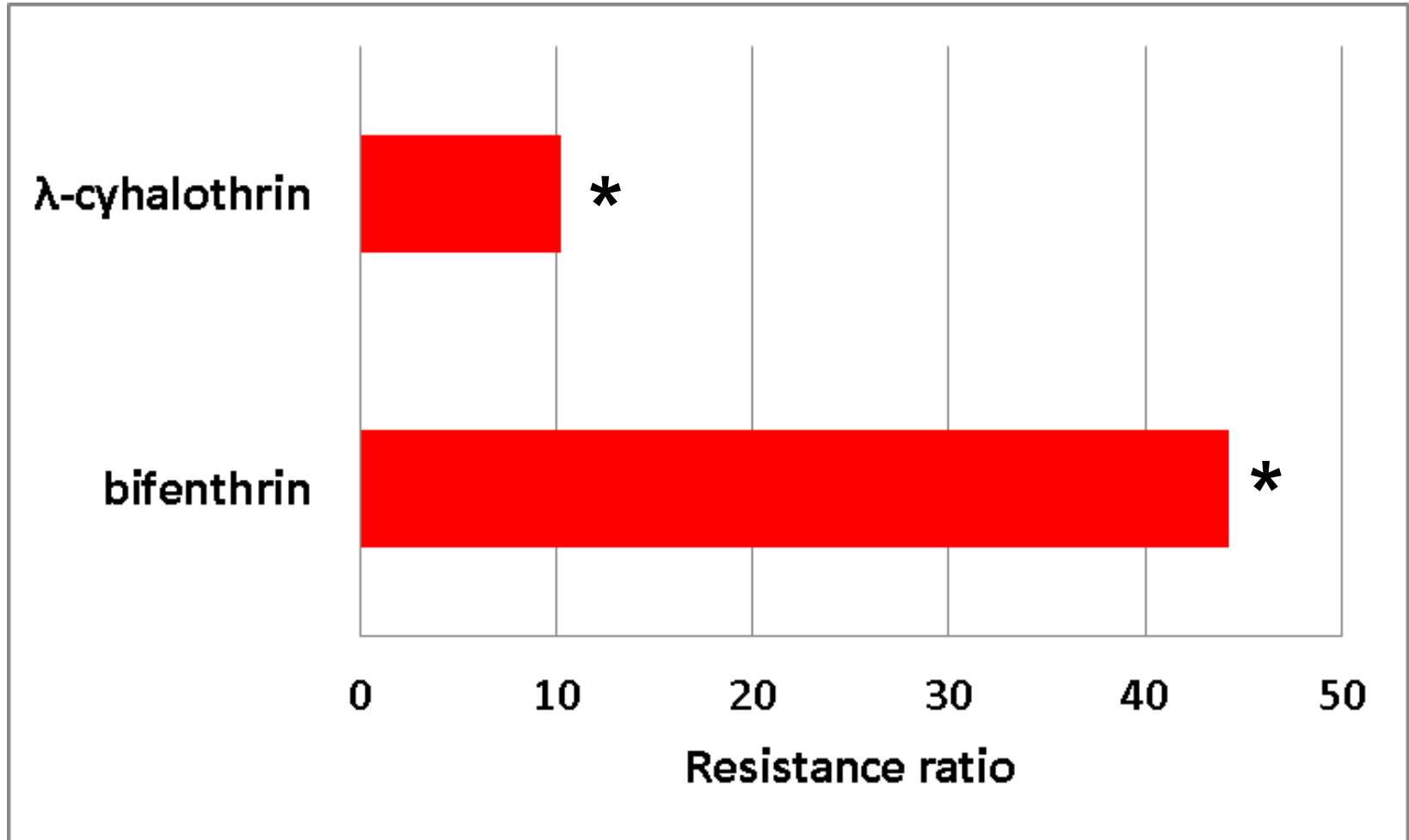




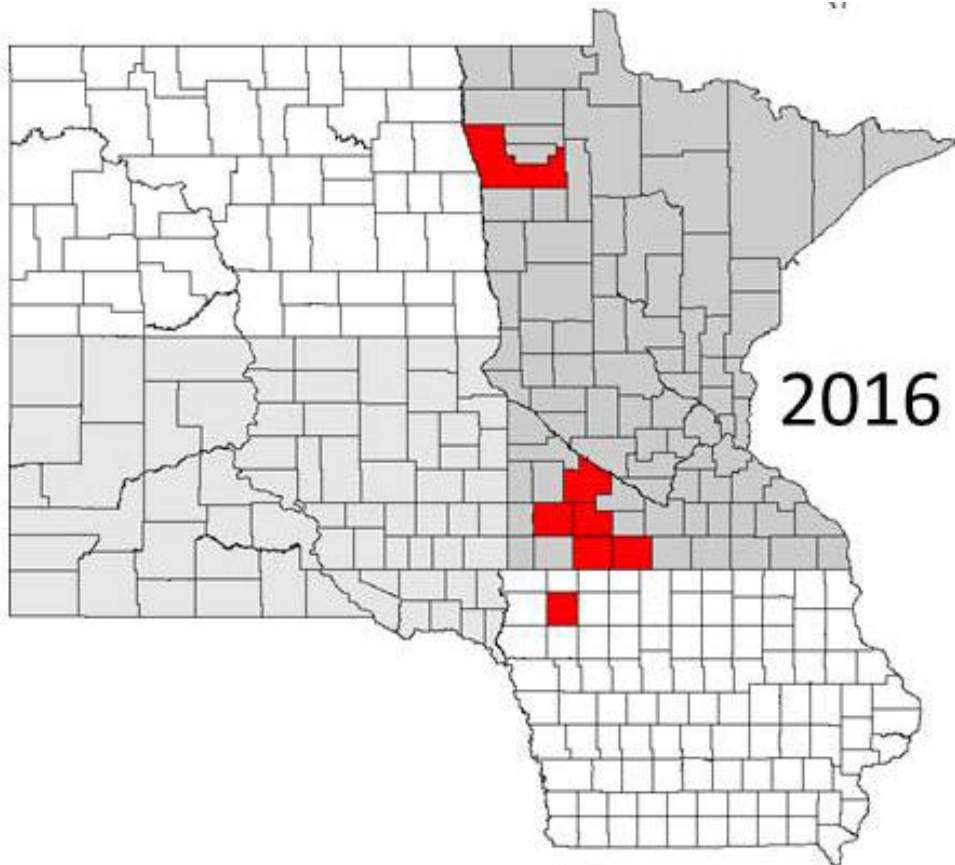
# LC<sub>50</sub> & resistance ratio



# 2015: Lamberton, MN



# Counties with pyrethroid performance issues (2016)



University of Minnesota  
Iowa State University

Map by B. Potter



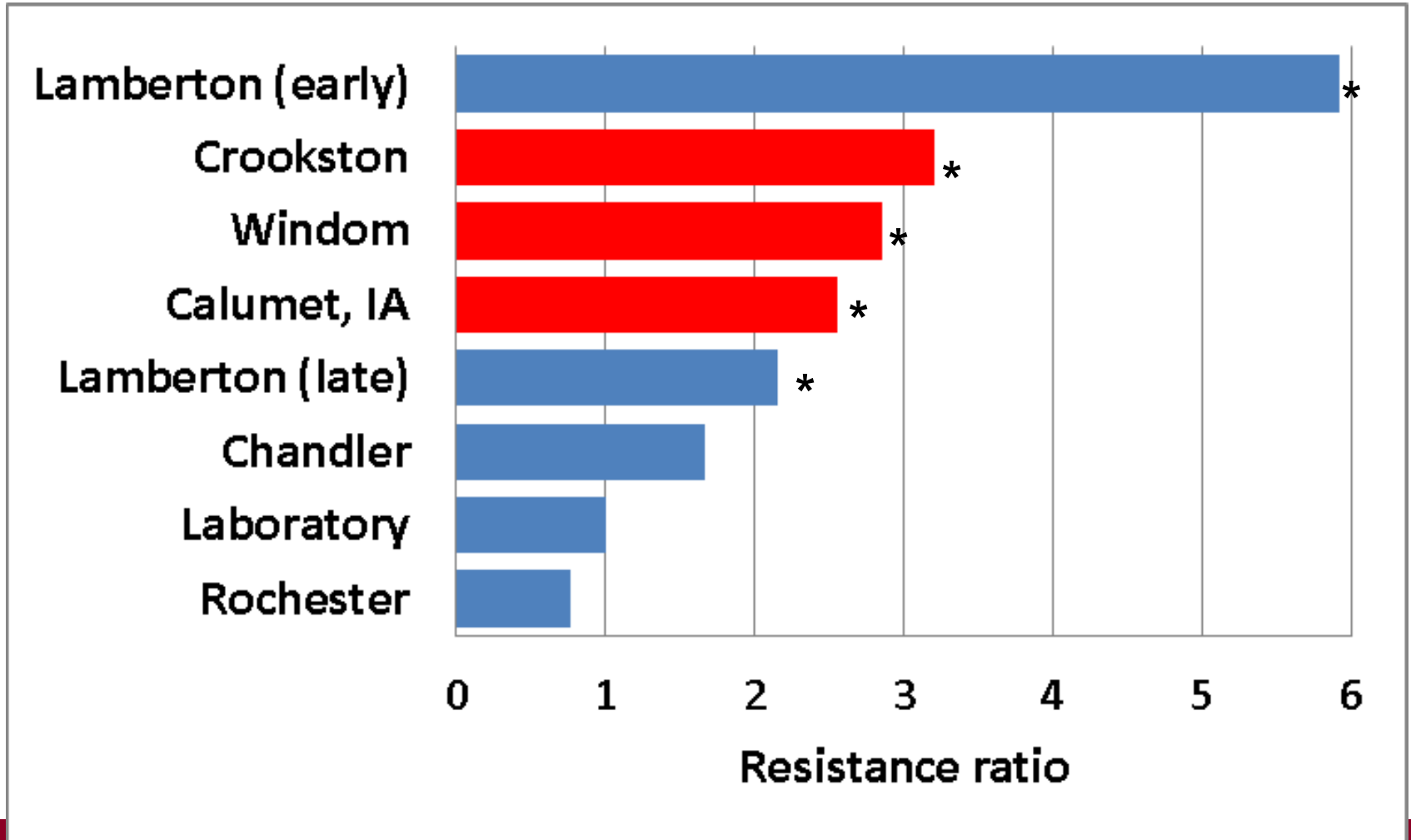
UNIVERSITY OF MINNESOTA  
Driven to Discover<sup>SM</sup>

# Soybean aphid resistance monitoring, 2016

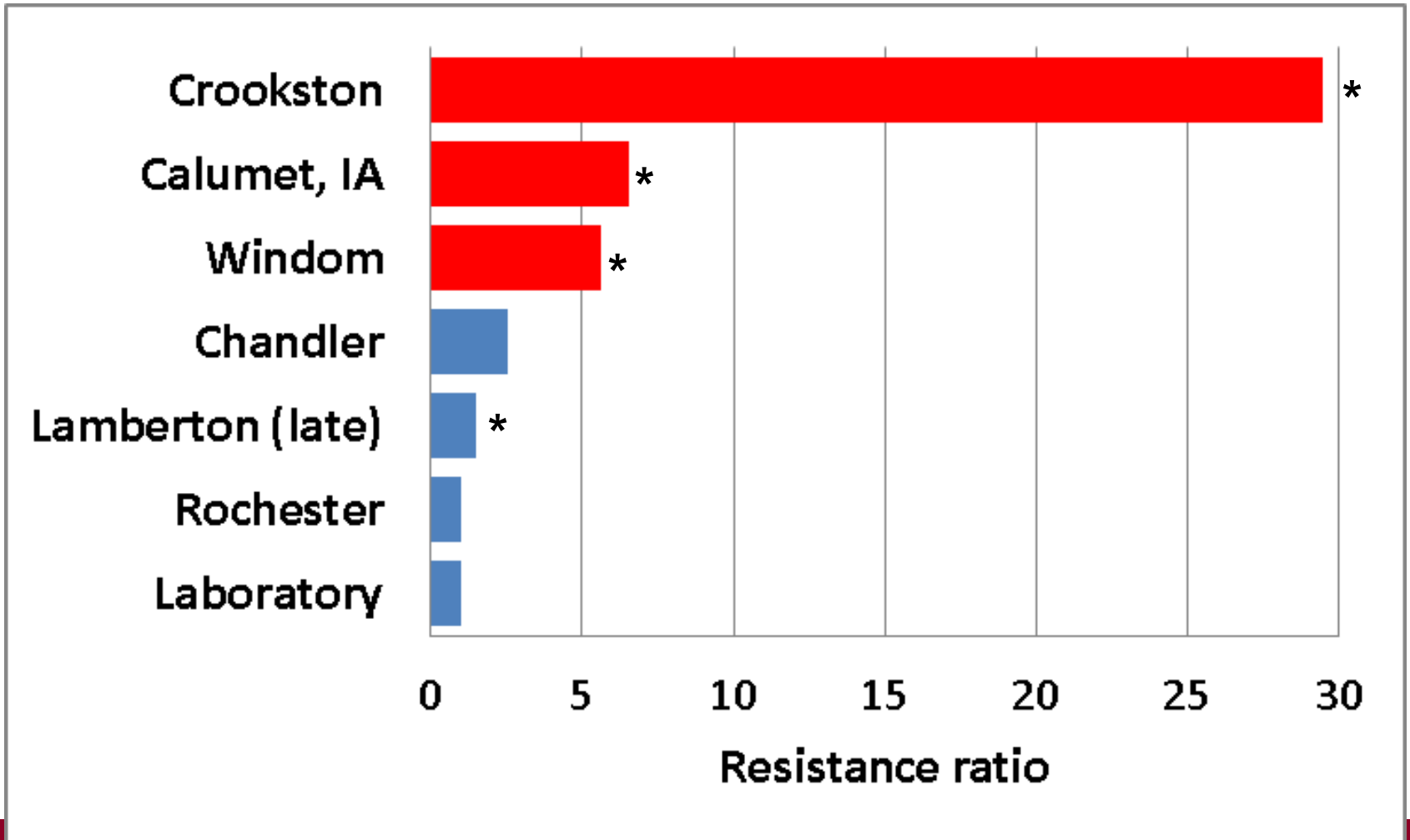
- Aphids throughout state
- Glass-vial assays
  - Bifenthrin or  $\lambda$ -cyhalothrin
  - 10 concentrations of insecticide & untreated
  - 10 adults per vial
  - Mortality assessed after 4 h



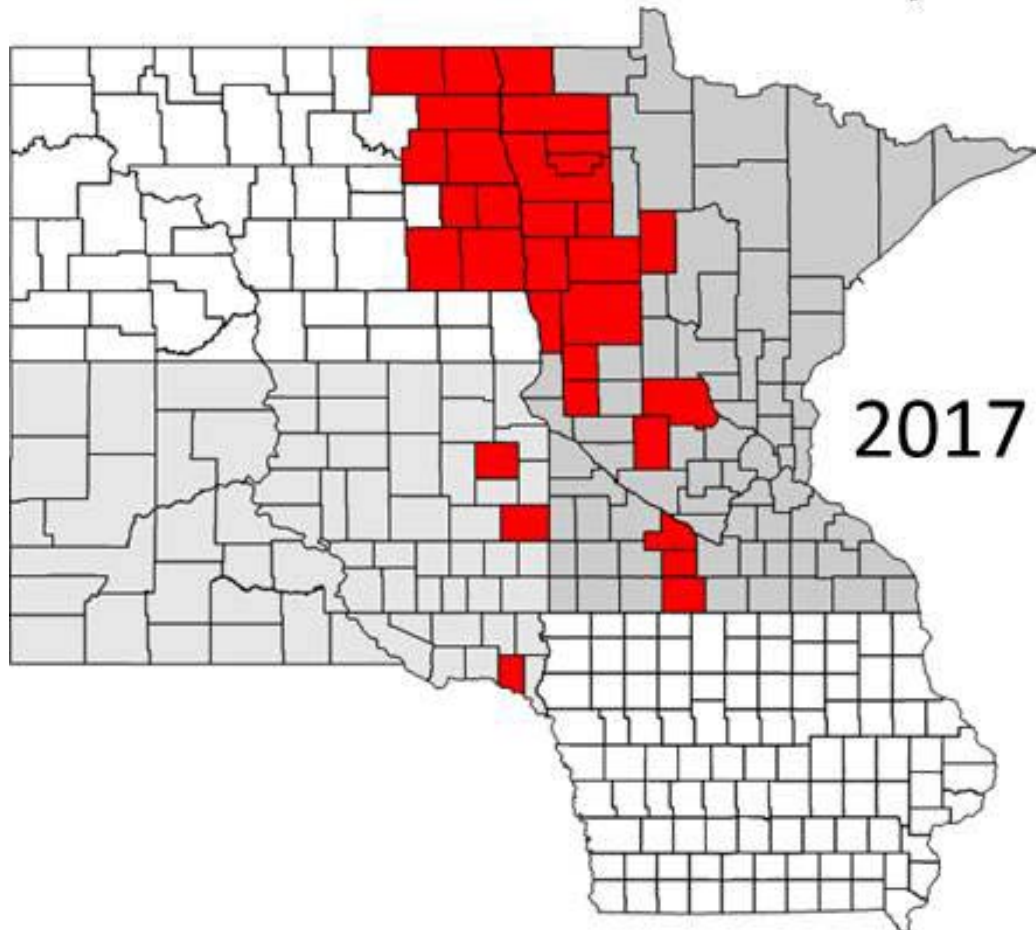
# 2016: bifenthrin



# 2016: $\lambda$ -cyhalothrin



# Counties with pyrethroid performance issues (2017)



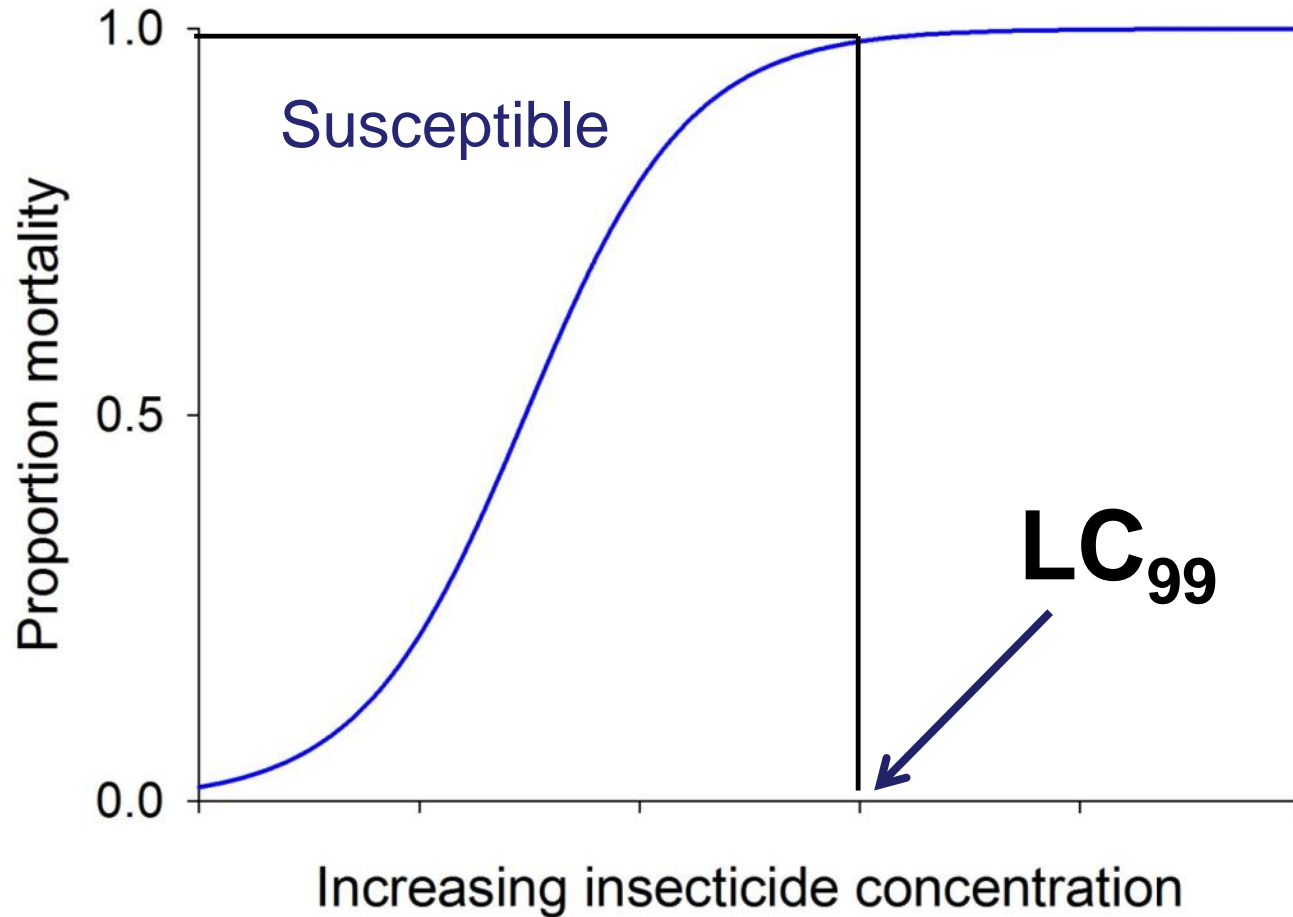
- University of Minnesota
- North Dakota State University
- Iowa State University
- South Dakota State University

Map by B. Potter



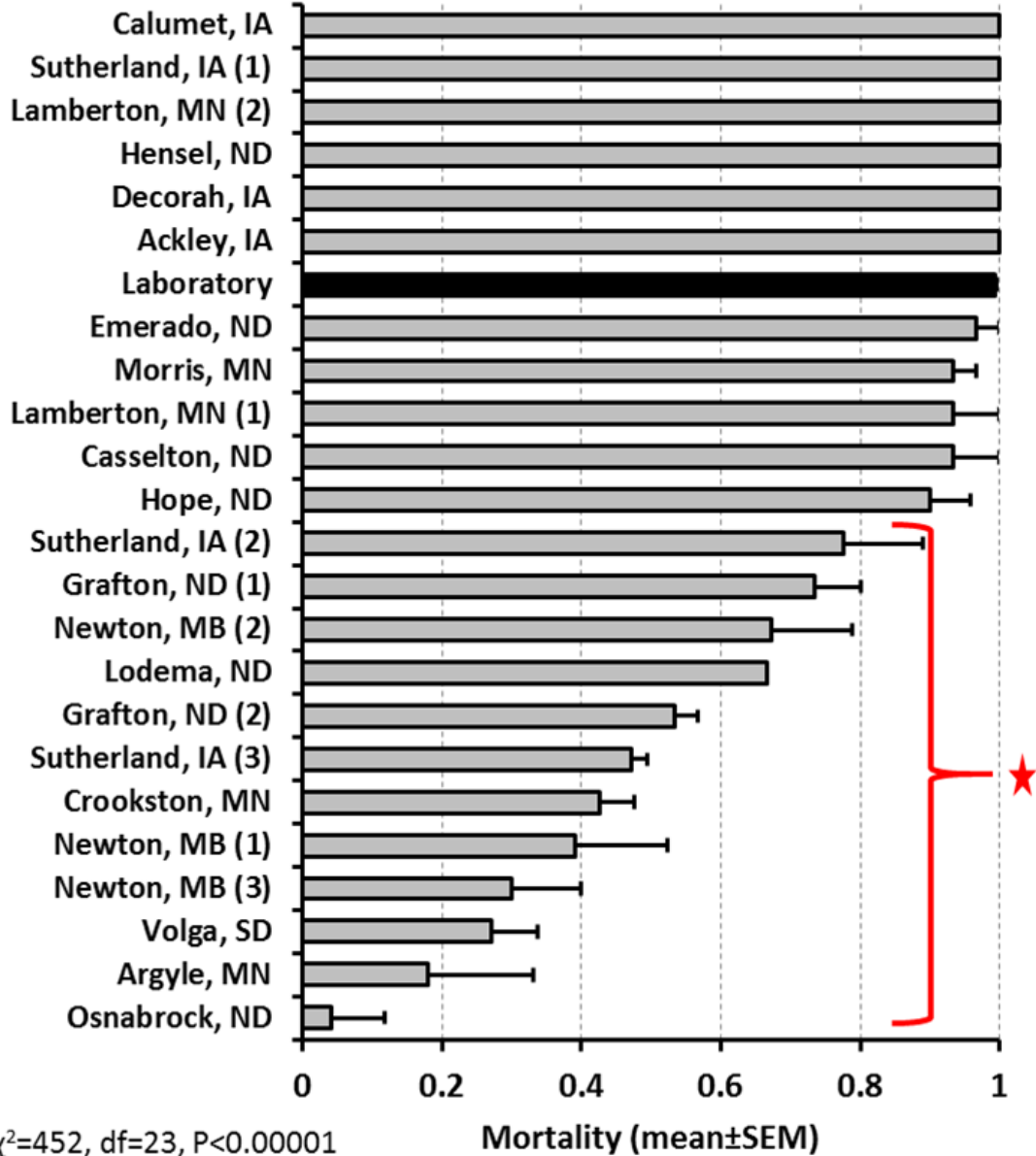
UNIVERSITY OF MINNESOTA  
Driven to Discover<sup>SM</sup>

# Discriminating dose: $LC_{99}$





## 2017 $\lambda$ -cyhalothrin (at LC99 for laboratory aphids)



$\chi^2=452$ ,  $df=23$ ,  $P<0.00001$

Mortality (mean ± SEM)

Biased-reduced general linear model with binomial response for Henderson-Tilton-adjusted mortality

Koch et al.

# Glass-vial bioassays (2017)



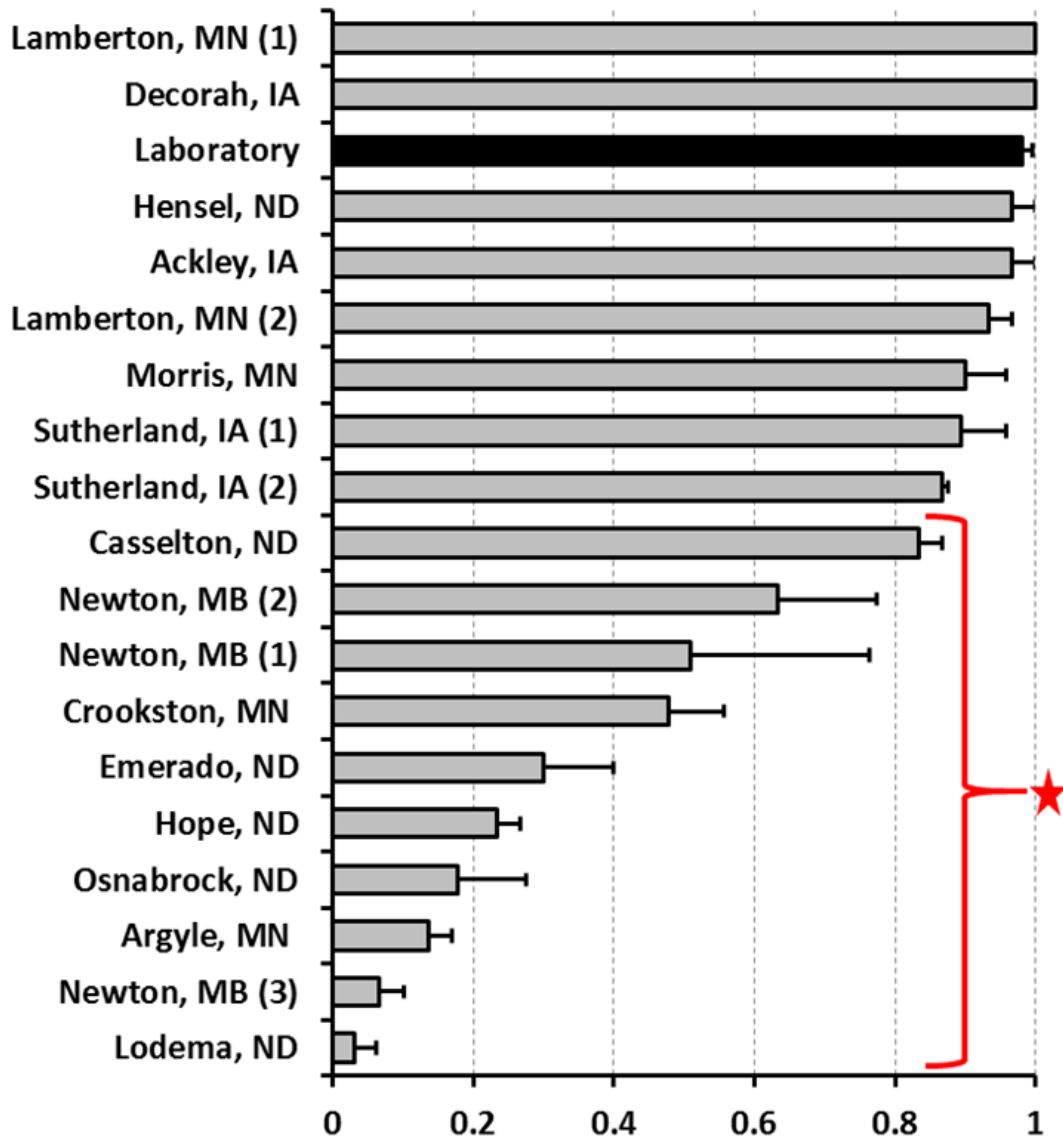
Univ. of Minnesota,  
North Dakota State Univ.,  
South Dakota State Univ.,  
Iowa State Univ., &  
Manitoba Agriculture



UNIVERSITY OF MINNESOTA

Driven to Discover<sup>SM</sup>

## 2017 Bifenthrin (at LC99 for laboratory aphids)



$\chi^2=440$ ,  $df=18$ ,  $P<0.00001$

Mortality (mean ± SEM)

Biased-reduced general linear model with binomial response for Henderson-Tilton-adjusted mortality

Koch et al.

# Glass-vial bioassays (2017)



Univ. of Minnesota,  
North Dakota State Univ.,  
South Dakota State Univ.,  
Iowa State Univ., &  
Manitoba Agriculture



UNIVERSITY OF MINNESOTA

Driven to Discover<sup>SM</sup>

# How did we get here?

- Reliance on few insecticide groups for aphid management
- Persistent infestations in/near MN
- Treating more than needed
  - Treating fields below threshold
  - Adding insecticide when targeting weeds or pathogens (“...just in case”)
  - Using low rates of insecticide



# Insecticide-resistant aphids

<b>Species</b>	<b>Insecticides resisted</b>
Green peach aphid	BPU, C, Nic, OC, OP, Py
<u>Cotton/melon aphid</u>	C, OC, OP, Py
Greenbug	OP
Hop aphid	C, OP, Py
Currant-lettuce aphid	C, OC, OP
Rosy apple aphid	C, OP, Py
Potato aphid	C, OP, Py
<u>Cowpea aphid</u>	Nic, C, OP, Py
<u>Bean aphid</u>	C, OP
<u>Buckthorn aphid</u>	C
Turnip aphid	OP, Py
Bird cherry-oat aphid	OP
Spotted alfalfa aphid	C, OP

**BPU: benzoylphenyl ureas;**  
**C: carbamates;**  
**Nic: nicotine/neonics;**  
**OC: organochlorines;**  
**OP: organophosphates;**  
**Py: pyrethroids**

Foster et al. 2007

# Pyrethroid resistance

- General mechanisms
  - Metabolic
    - monooxygenases (cytochrome P450)
    - esterases
    - glutathione S-transferases
  - Target site insensitivity
    - knock down resistance (kdr; super-kdr)
  - Reduced cuticular penetration

# Soybean aphid resistance to $\lambda$ -cyhalothrin in China

- 76-fold resistance after 40 generations of laboratory selection with  $\lambda$ -cyhalothrin
- Increased esterase & cytochrome P450 expression
- Cross resistance to: chlorpyrifos, acephate, cypermethrin, esfenvalerate, cyfluthrin, carbofuran, and bifenthrin

# Now what?

- Don't waste your bullets



# 1. Don't spray when not needed

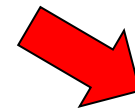
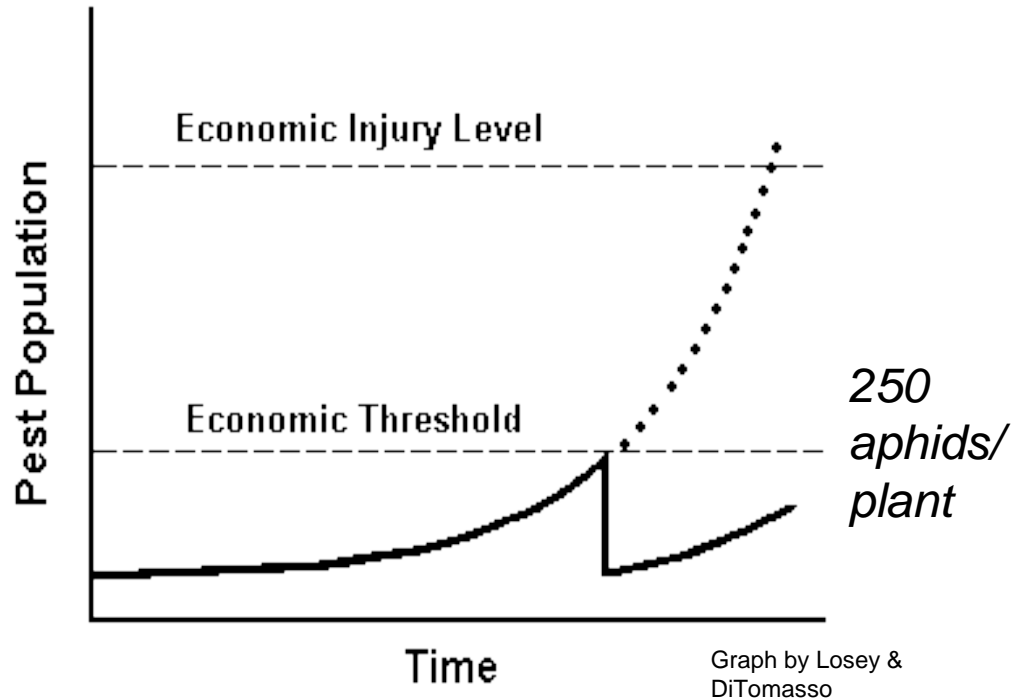


UNIVERSITY OF MINNESOTA

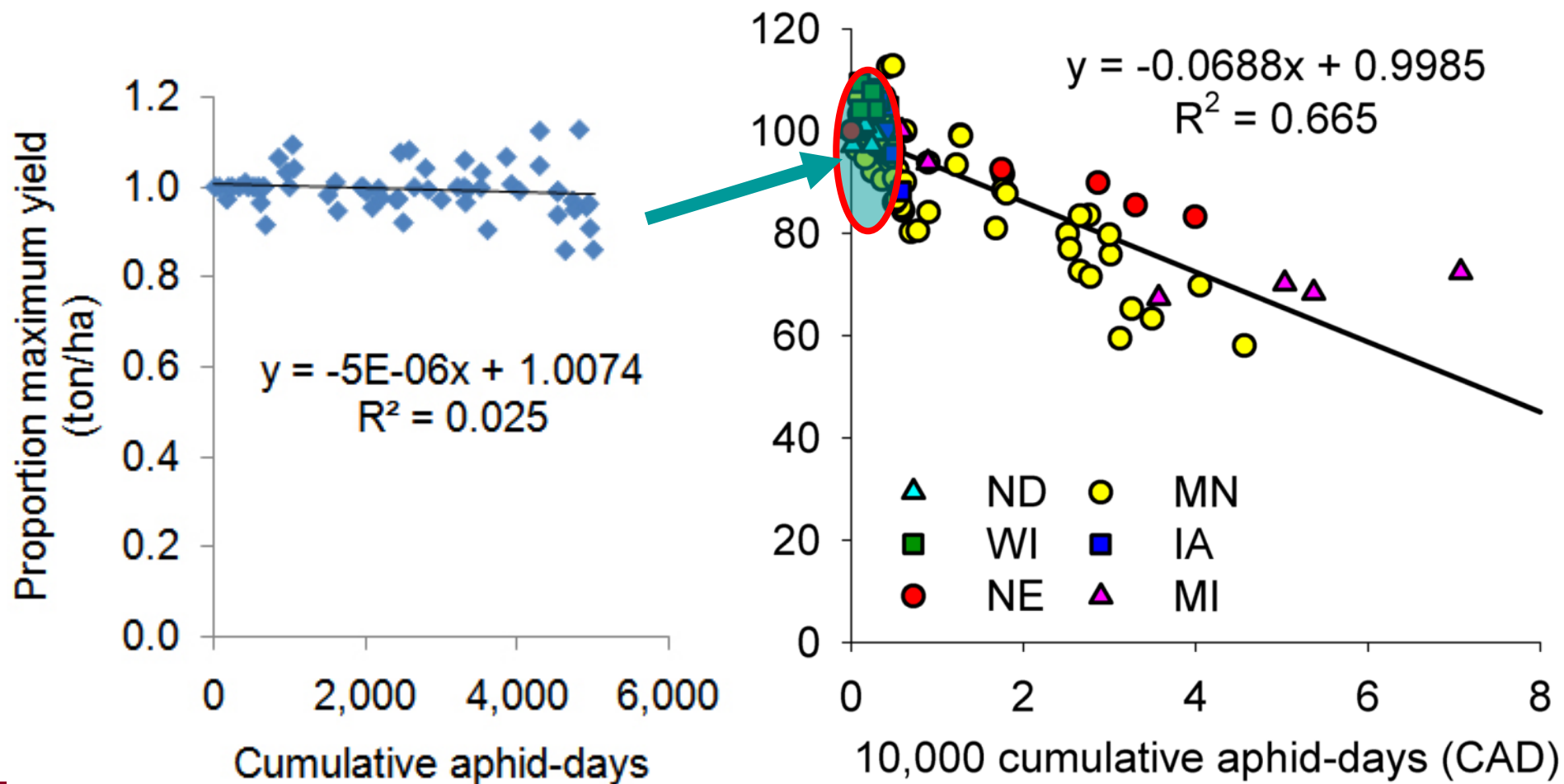
**Driven to Discover**<sup>SM</sup>



# 1. Don't spray when not needed



# Soybean aphid yield loss relationship

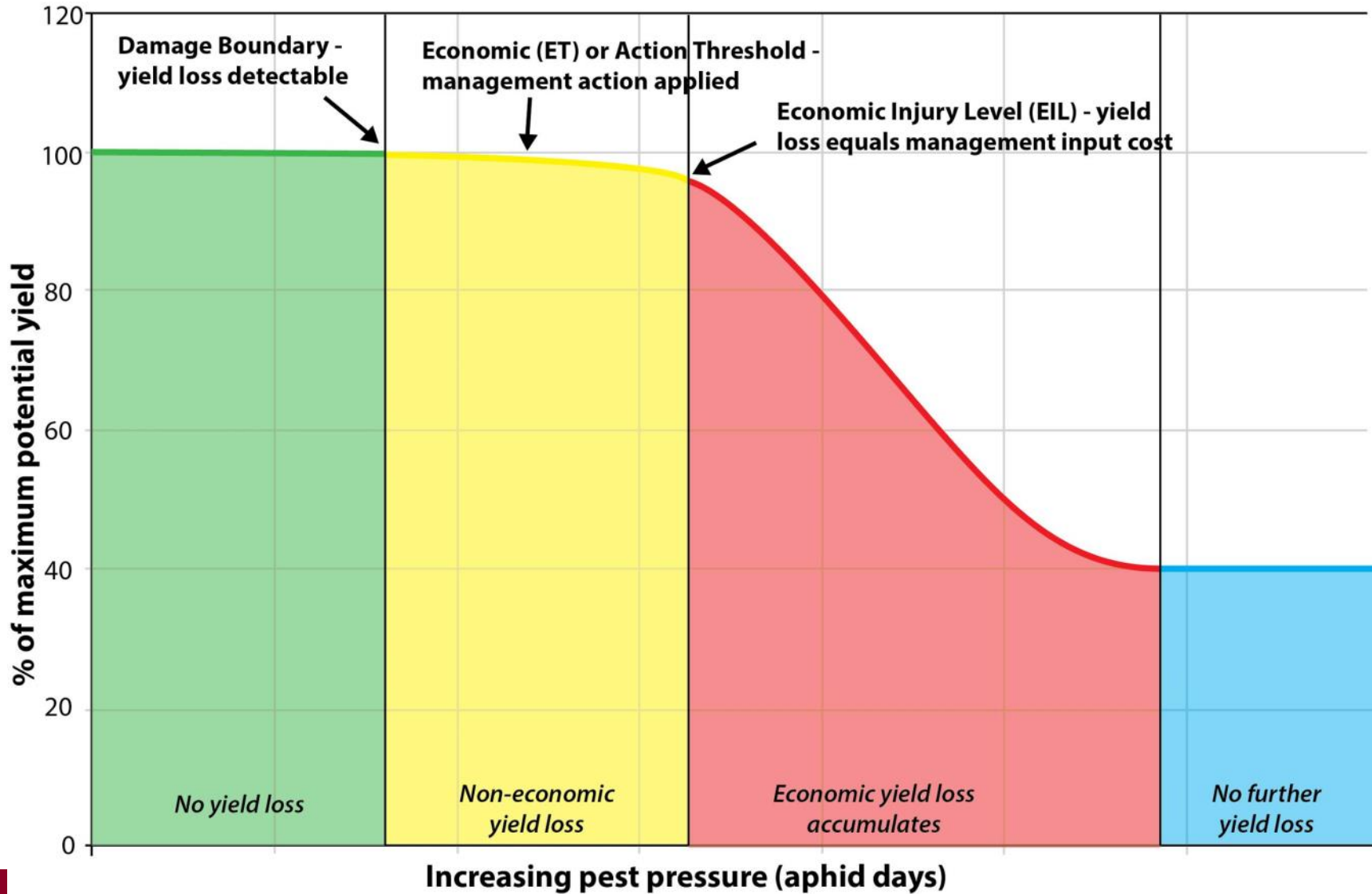


Data from Ragsdale et al. 2007. JEE 100(4): 1258-1267

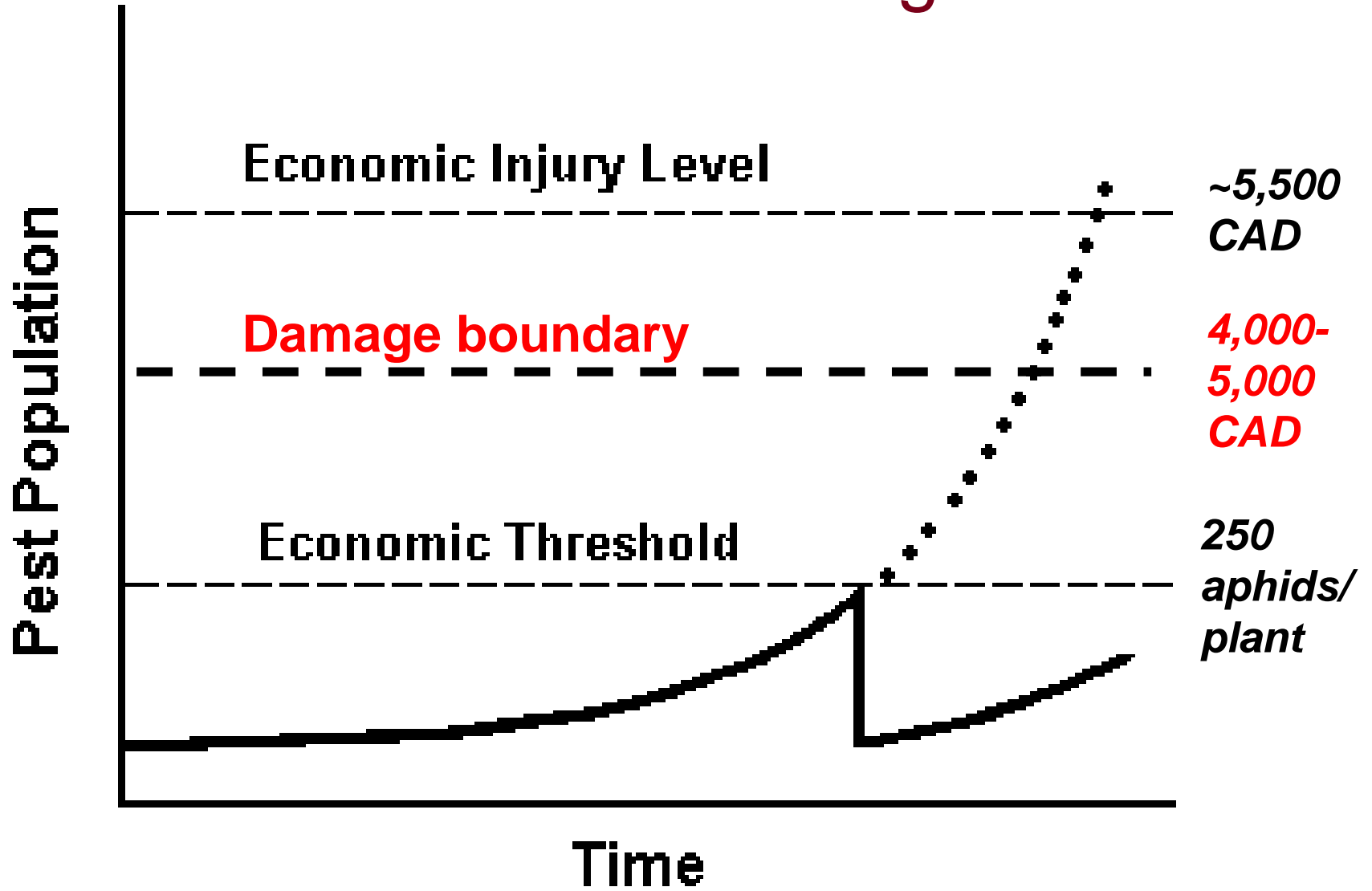
UNIVERSITY OF MINNESOTA

graphs from K. Tilmon

# Damage curve: pest population & yield



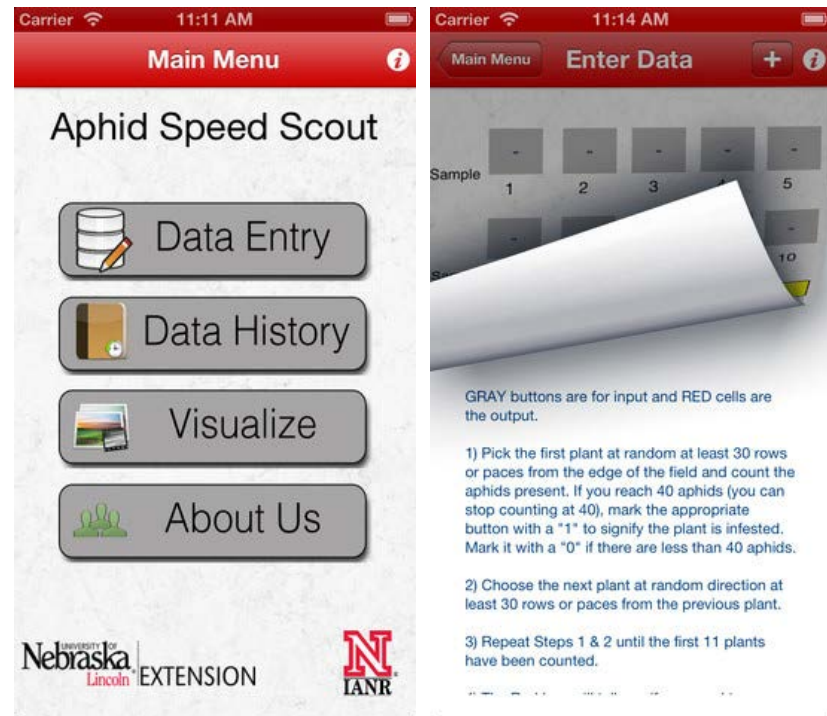
# Decision making



# “Speed scouting”

- Tally threshold
- Pros:
  - Saves time
  - Easy to use
- Cons:
  - Less detailed
  - Over-recommends treatment

## Aphid Speed Scout App (Android & Iphone/Ipad)



### Blank, hard-copy worksheets:

[http://www.ent.iastate.edu/dept/faculty/hodgson/files/ul/2009 Speed Scouting blank form.pdf](http://www.ent.iastate.edu/dept/faculty/hodgson/files/ul/2009%20Speed%20Scouting%20blank%20form.pdf)



## 2. If you spray, do it right



UNIVERSITY OF MINNESOTA

**Driven to Discover<sup>SM</sup>**

## 2. If you spray, do it right

- Rates
  - Use only labeled rates of insecticides
  - High labeled rates may be preferred



## 2. If you spray, do it right

- Rates
- Nozzles, volume & pressure
  - Small droplets
  - Ground: >15 gal/ac at >30 psi
  - Air: 3-5 gal/ac





## 2. If you spray, do it right

- Rates
- Nozzles, volume & pressure
- Environmental conditions
  - Avoid spraying under conditions that promote droplet or vapor drift
  - Windy, temperature inversion, etc.



## 2. If you spray, do it right

- Rates
- Nozzles, volume & pressure
- Environmental conditions
- Scout field 3-5 days after spraying to check effectiveness



# 3. If you have a failure...



UNIVERSITY OF MINNESOTA

**Driven to Discover<sup>SM</sup>**

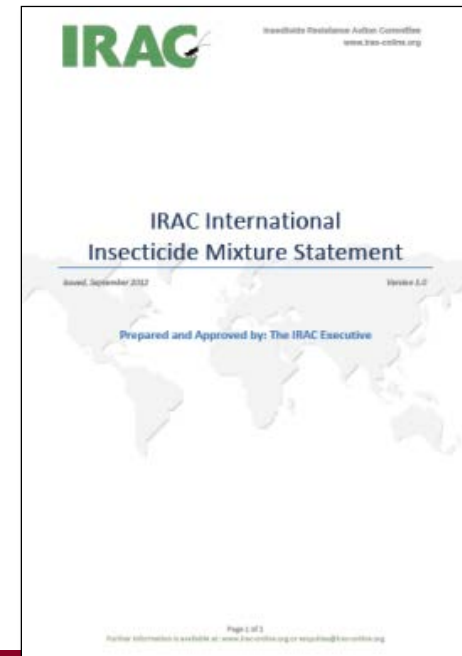
# 3. If you have a failure...

- Rule out other causes
  - Incorrect pesticide or rate, poor coverage
  - Unfavorable conditions during application
  - Re-colonization by pest



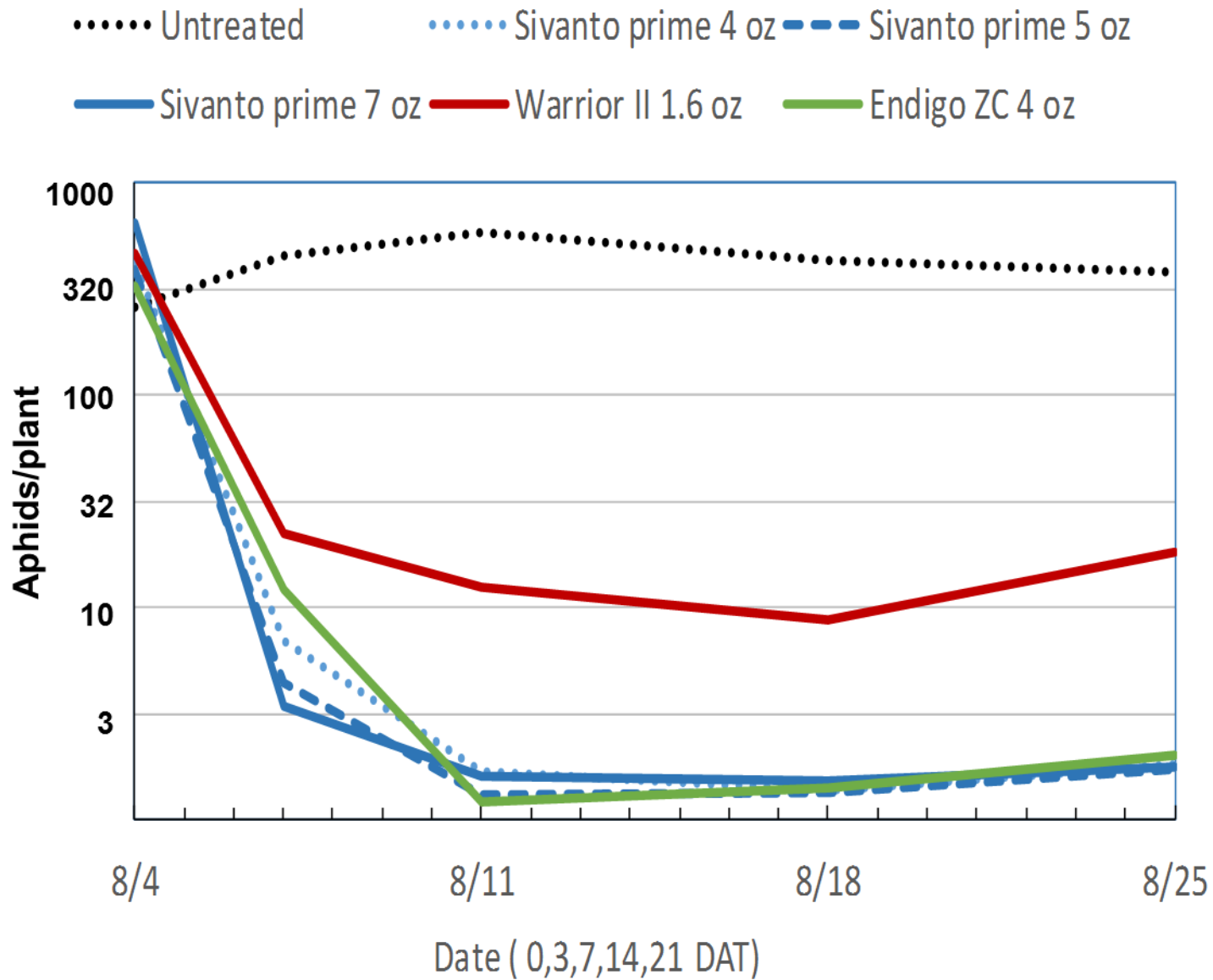
# 3. If you have a failure...

- Rule out other causes
- Alternate insecticide group for next spray
  - Group numbers are on labels
  - Mixtures are generally less effective for resistance management



# Foliar insecticides for soybean aphid

<b>Group 1</b> <b>AChE inhibitors</b>	<b>Group 3</b> <b>Na channel modulators</b>	<b>Group 4</b> <b>nAChR agonists</b>
<p>1A methomyl</p> <p>1B acephate chlorpyrifos dimethoate</p>	<p>3A alpha-cypermethrin beta-cyfluthrin bifenthrin cyfluthrin deltamethrin esfenvalerate gamma-cyhalothrin lambda-cyhalothrin permethrin zeta-cypermethrin pyrethrins</p>	<p>4A acetamiprid chlothianadin imidacloprid thiamethoxam</p> <p>4D flupyradifurone</p>



# Example insecticide rotations

	Initial treatment	Re-treatment
<b>Aphids below ET</b>		
<b>Aphids at or above ET</b>		
<ul style="list-style-type: none"><li><i>Pyrethroid resistance not expected</i></li></ul>		
<ul style="list-style-type: none"><li><i>Pyrethroid resistance suspected</i></li></ul>		





# Example insecticide rotations

	Initial treatment	Re-treatment
Aphids below ET	Don't spray	---
Aphids at or above ET		
• <i>Pyrethroid resistance not expected</i>		
• <i>Pyrethroid resistance suspected</i>		



# Example insecticide rotations

	Initial treatment	Re-treatment
Aphids below ET	Don't spray	---
Aphids at or above ET		
<ul style="list-style-type: none"> <li><i>Pyrethroid resistance not expected</i></li> </ul>	chlorpyrifos	Py, Py+NN
	Py	chlorpyrifos, Py+NN, Py+OP
	Py+NN	chlorpyrifos
<ul style="list-style-type: none"> <li><i>Pyrethroid resistance suspected</i></li> </ul>		

# Example insecticide rotations

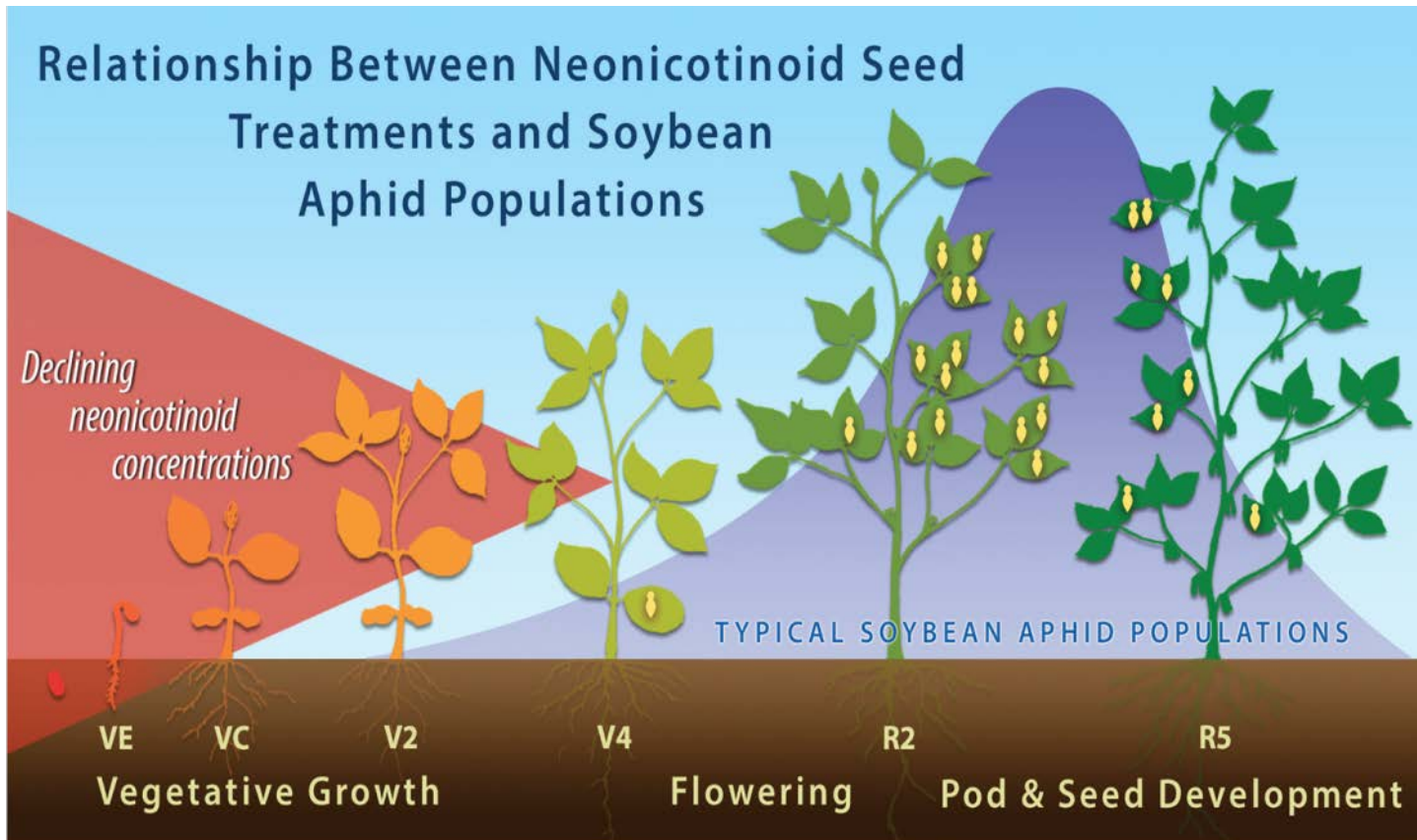
	Initial treatment	Re-treatment
<b>Aphids below ET</b>	<b>Don't spray</b>	<b>---</b>
<b>Aphids at or above ET</b>		
<ul style="list-style-type: none"> <li><i>Pyrethroid resistance not expected</i></li> </ul>	chlorpyrifos	Py, Py+NN
	Py	chlorpyrifos, Py+NN, Py+OP
	Py+NN	chlorpyrifos
<ul style="list-style-type: none"> <li><i>Pyrethroid resistance suspected</i></li> </ul>	chlorpyrifos	Py+NN
	Py+NN	chlorpyrifos
	Py+OP	Py+NN, C

# 3. If you have a failure...

- Rule out other causes
- Alternate insecticide group for next spray
- Report to Extension



# Seed treatments



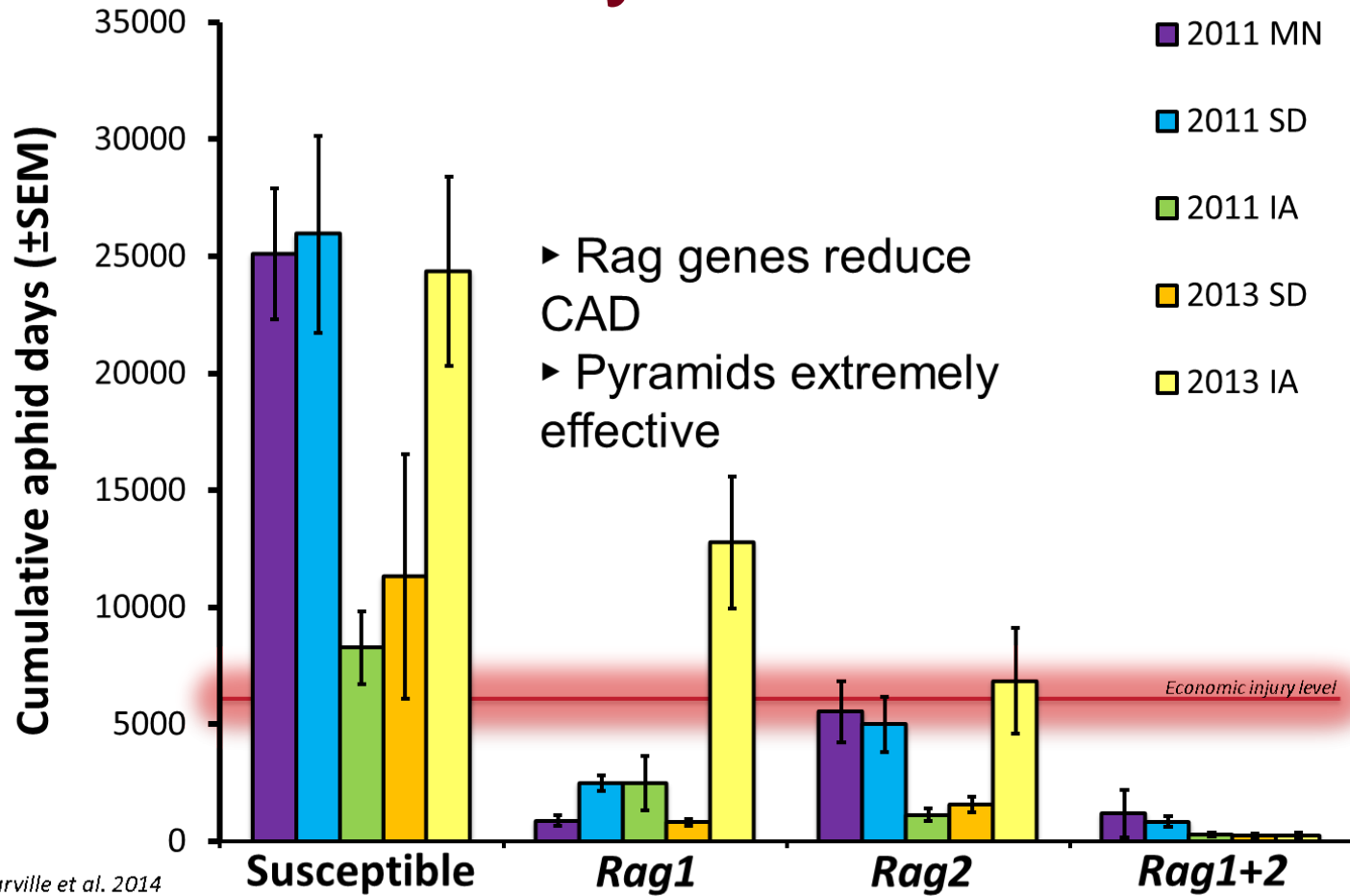
Bailey et al. 2015

Krupke et al. 2017



UNIVERSITY OF MINNESOTA  
Driven to Discover<sup>SM</sup>

# Aphid-resistant soybean



McCarville et al. 2014

McCarville et al. 2014;  
Hesler et al. 2013



UNIVERSITY OF MINNESOTA  
Driven to Discover<sup>SM</sup>

# Limited availability of aphid-resistant soybean

Brand names	Company	Relative maturity	Resistance gene(s)
0543	Gold Country	0.5	<i>Rag1</i>
1114	Seed	1.1	<i>Rag1</i>
LS 10R551N	Legend Seeds	1.0	<i>Rag1</i>
NS1040NR2	NorthStar Genetics	1.1	<i>Rag1</i>
3511 R2YN	Thunder Seed	1.1	<i>Rag1</i>
Viking 0.1544AT	Viking Seeds	1.5	<i>Rag1</i>
Viking 0.1955AT		1.9	<i>Rag1</i>
Viking 2188NAT		2.1	<i>Rag1</i> & <i>Rag2</i>
Viking 0.2188AT12N		2.1	<i>Rag1</i> & <i>Rag2</i>
Viking 0.1A2104RA12		2.3	<i>Rag1</i> & <i>Rag2</i>
Viking 0.2399AT12N		2.4	<i>Rag1</i> & <i>Rag2</i>

# Biological control

- Predators
  - Lady beetles
  - Minute pirate bugs
  - Lacewings
  - Syrphid flies
- Parasitic wasps
- Fungal diseases



Heimpel et al. 2004; Ragsdale et al. 2011; Koch & Costamagna 2017



UNIVERSITY OF MINNESOTA  
Driven to Discover<sup>SM</sup>



# Conclusions

- Few tools (bullets) available to manage soybean aphid
- 3 years of pyrethroid failures & confirmed resistance
- What to do?
  - Don't spray when not needed
  - If you spray, do it right
  - If you have a failure, alternate insecticide groups



# Thank you

Questions???

Robert Koch: [koch0125@umn.edu](mailto:koch0125@umn.edu)



UNIVERSITY OF MINNESOTA

**Driven to Discover**<sup>SM</sup>