Soybean aphid resistance to pyrethorid insecticides: Rethinking how we manage soybean aphid

Robert Koch
Department of Entomology

Outline

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

Resistance

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


precision tillage.com

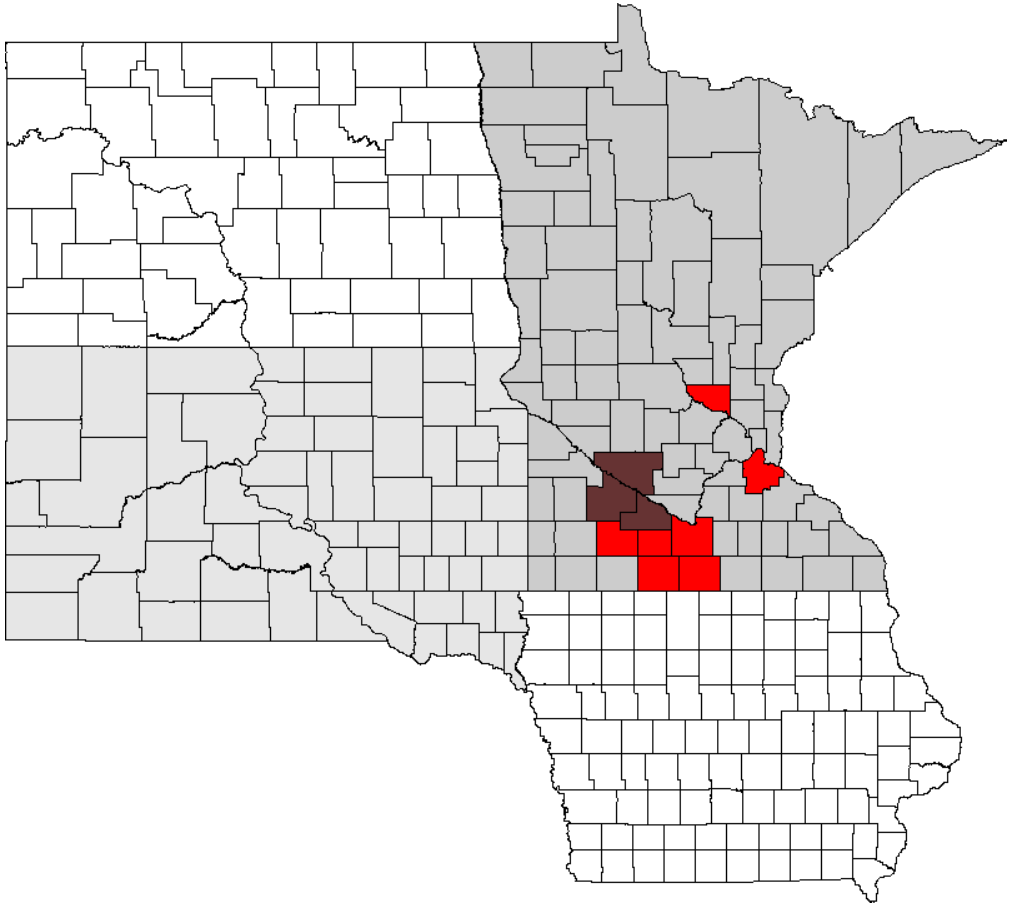
Foliar insecticides for soybean aphid

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

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)



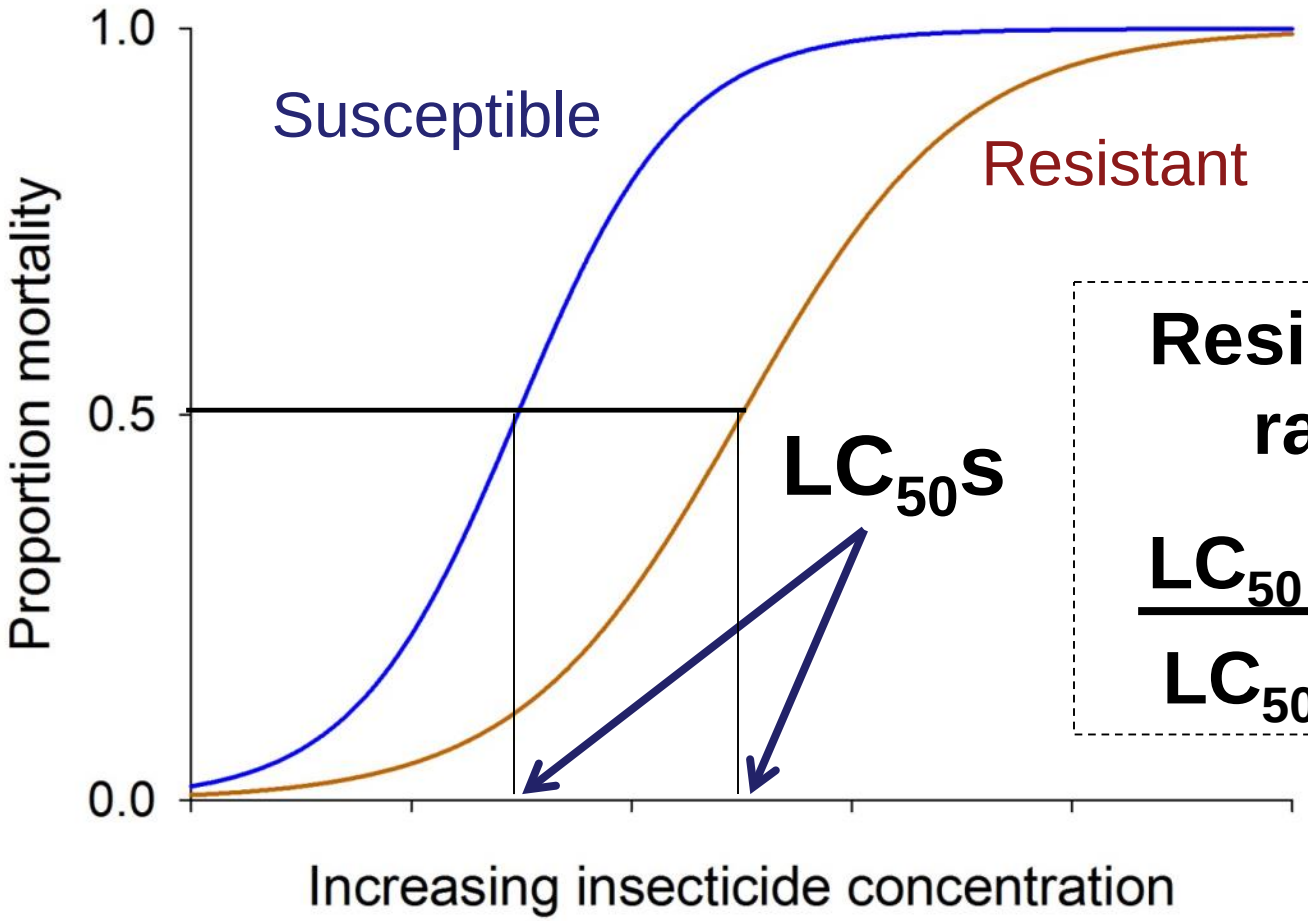
- University of Minnesota
  - Koch, Potter, MacRae, Glogoza

Map by B. Potter

Soybean aphid resistance monitoring, 2015

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

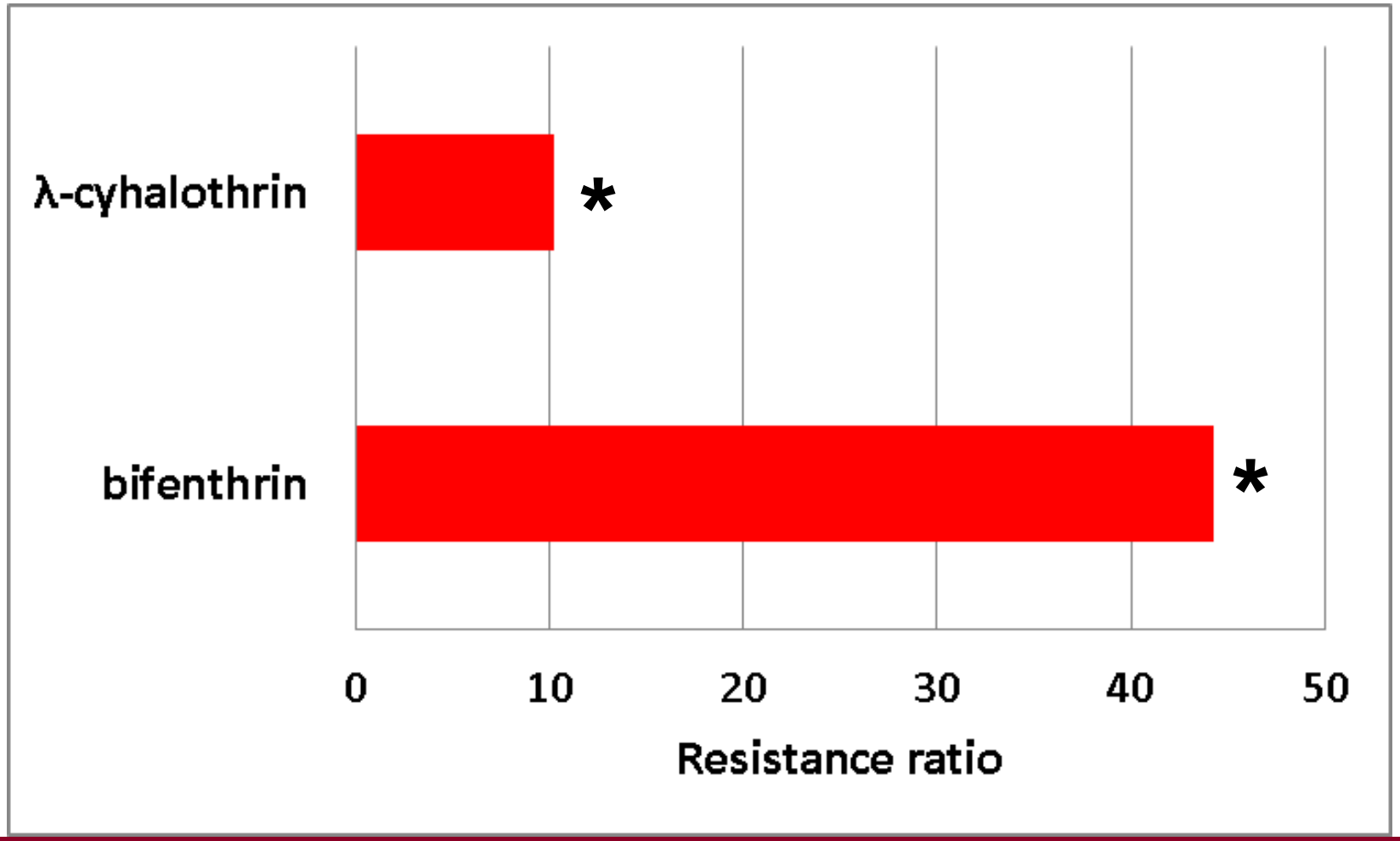
LC_{50} & resistance ratio



Resistance ratio:

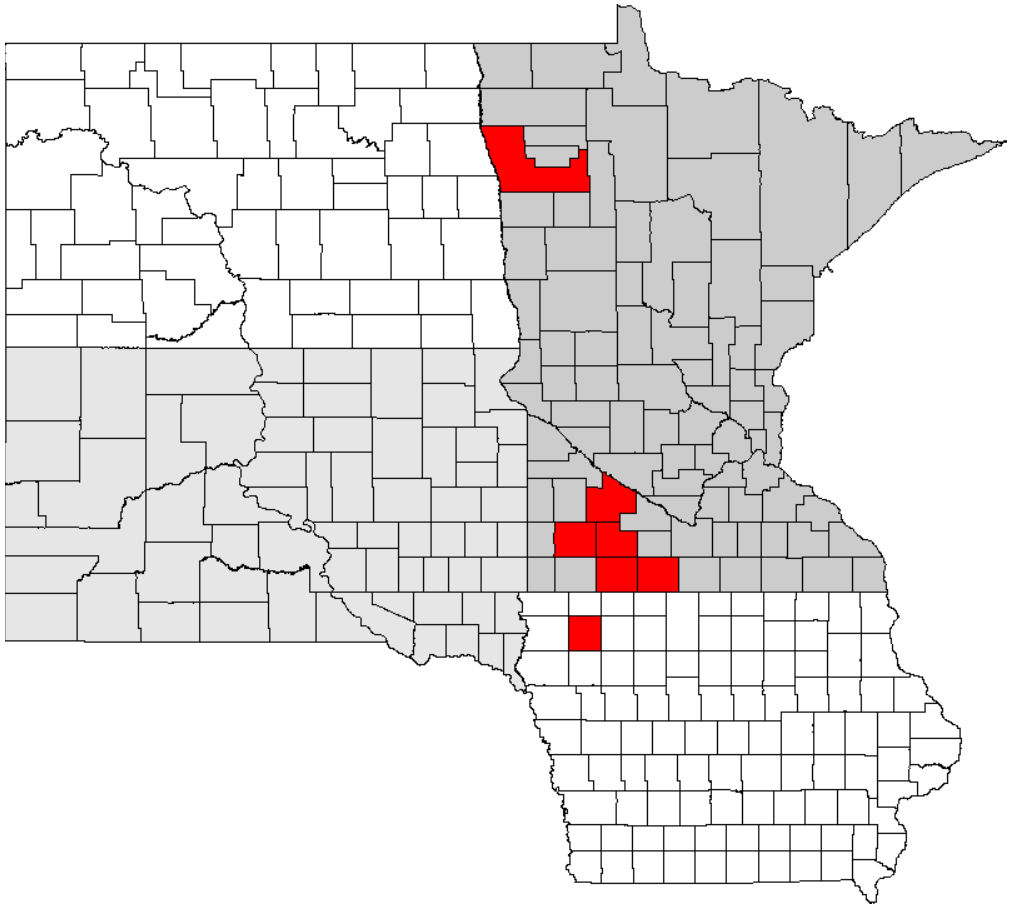
$$\frac{LC_{50}\ \text{resist.}}{LC_{50}\ \text{susc.}}$$

2015: Lamberton, MN



Hanson et al. 2017

Counties with pyrethroid performance issues (2016)



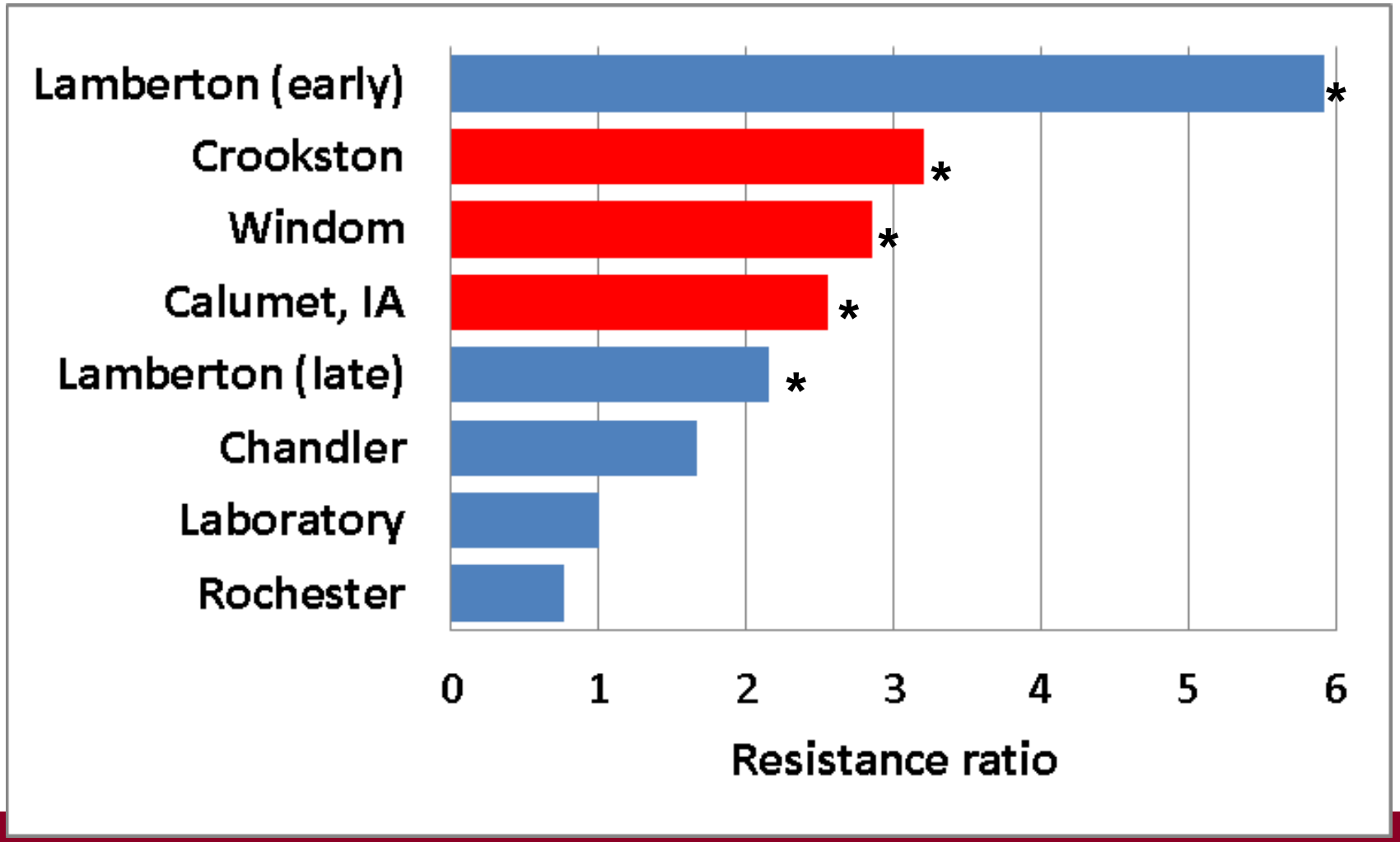
- University of Minnesota
  - Koch, Potter, MacRae, Glogoza
- Iowa State University
  - Hodgson

Map by B. Potter

Soybean aphid resistance monitoring, 2016

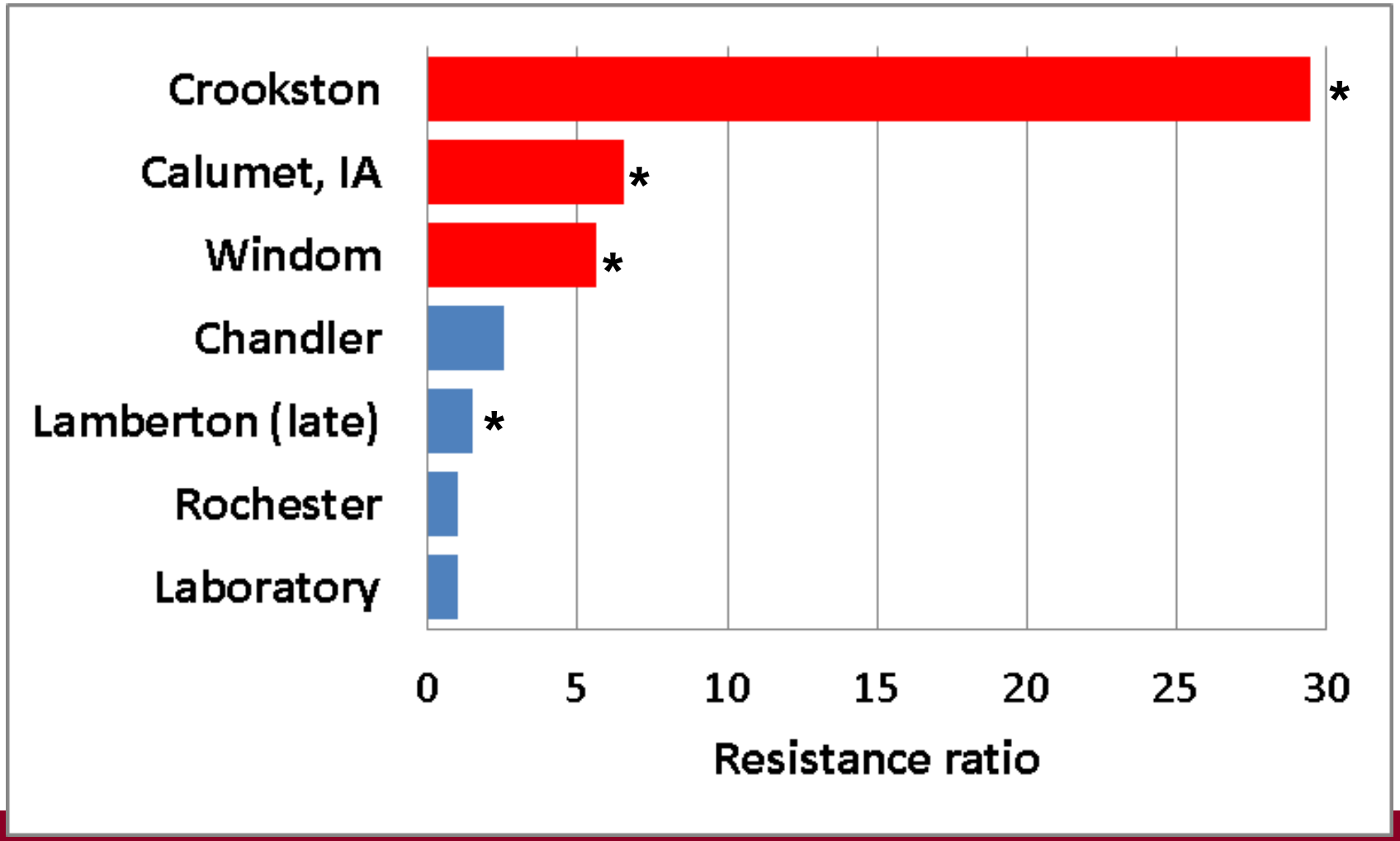
- Aphids throughout state
- Glass-vial assays
  - Bifenthrin or λ-cyhalothrin
  - 10 concentrations of insecticide & untreated
  - 10 adults per vial
  - Mortality assessed after 4 h

2016: bifenthrin



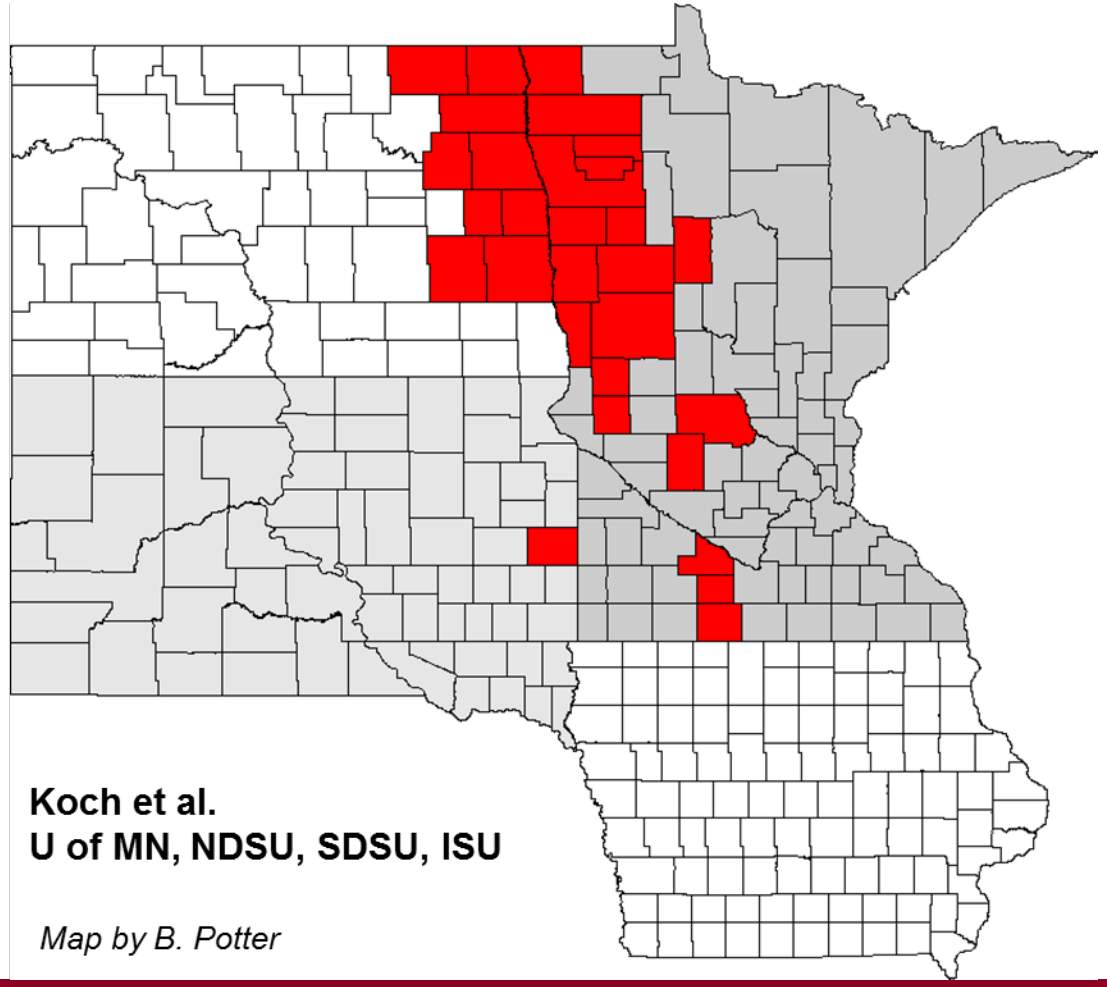
Hanson et al. 2017

2016: λ-cyhalothrin

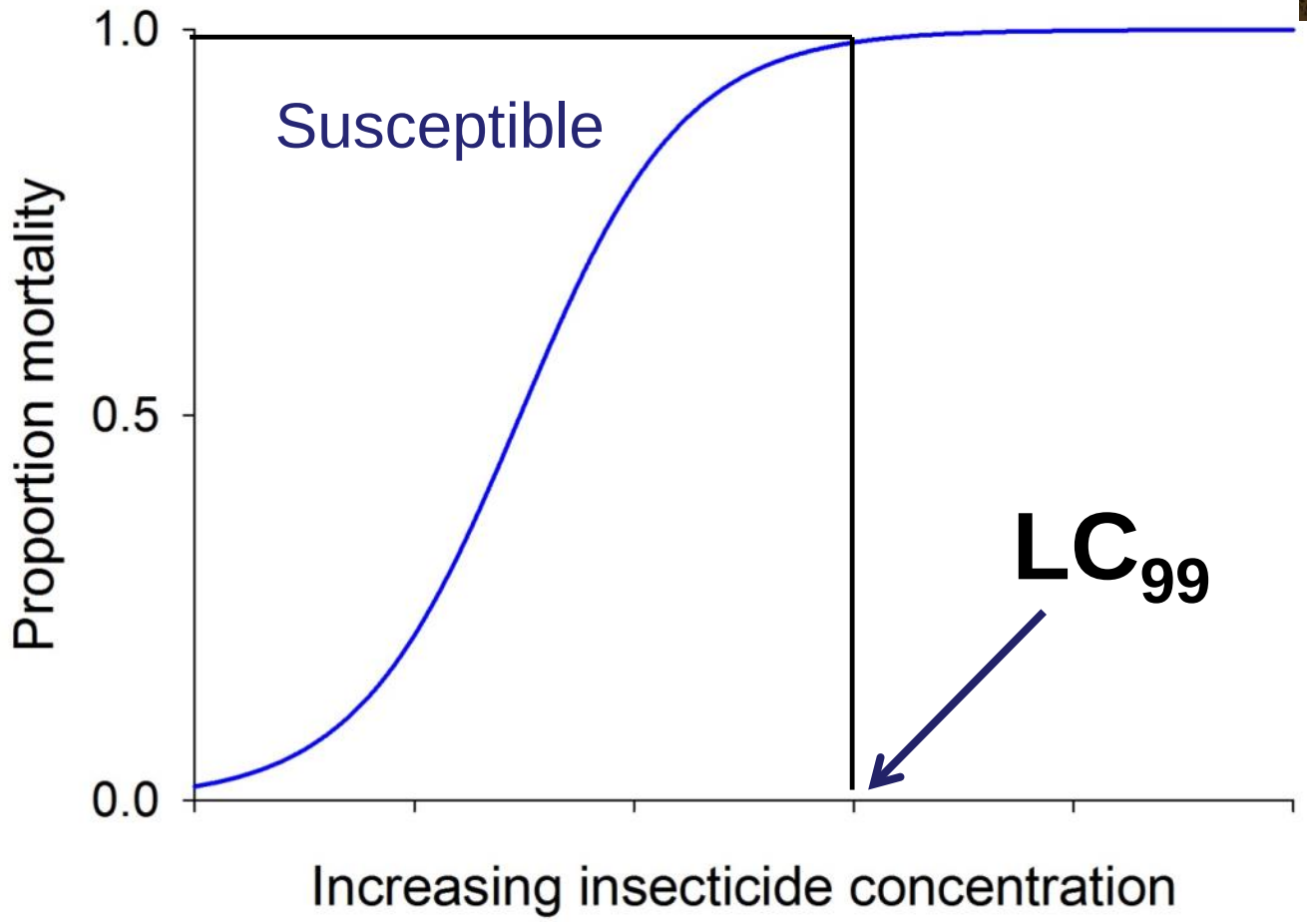


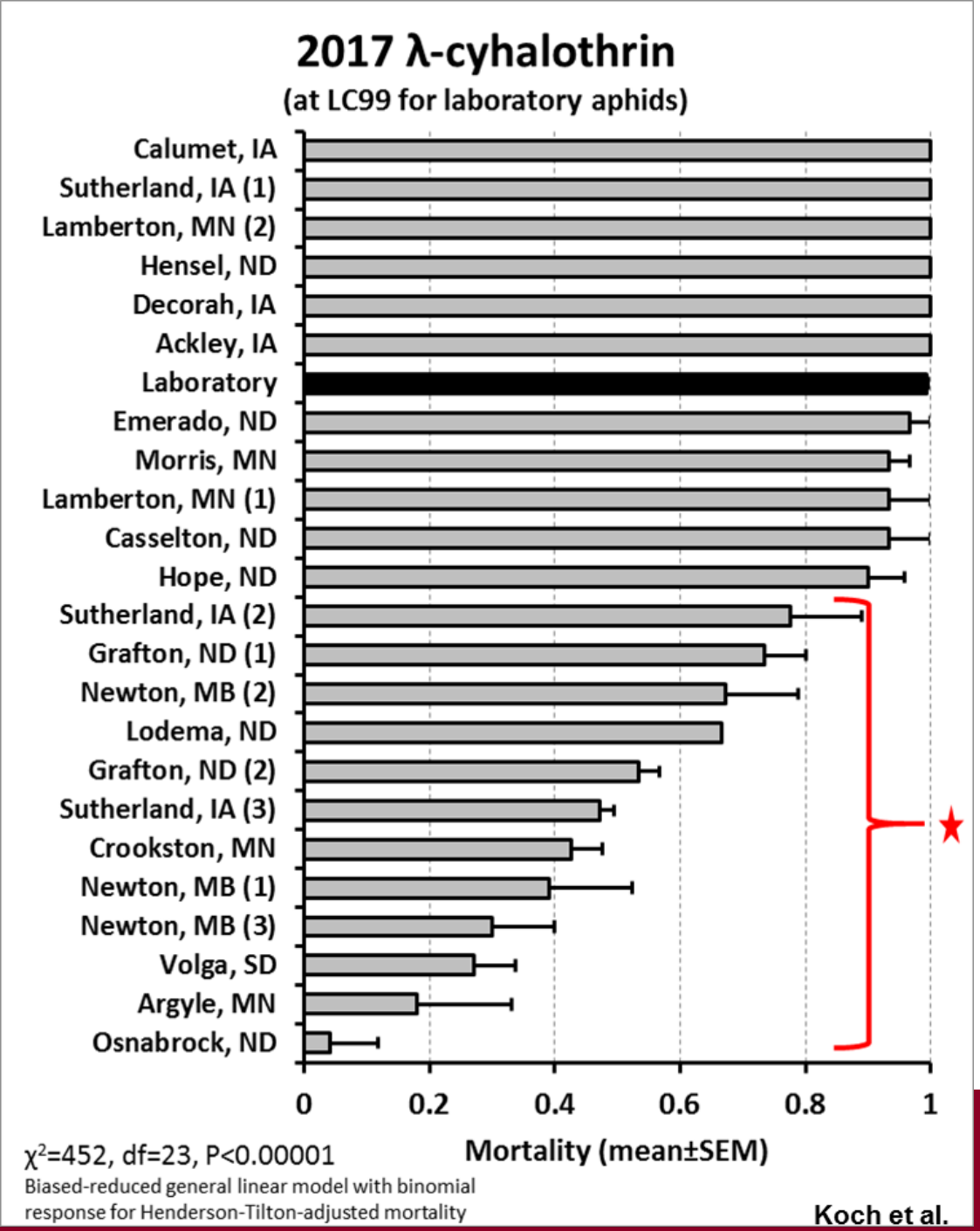
Hanson et al. 2017

Counties with pyrethroid performance issues (2017)



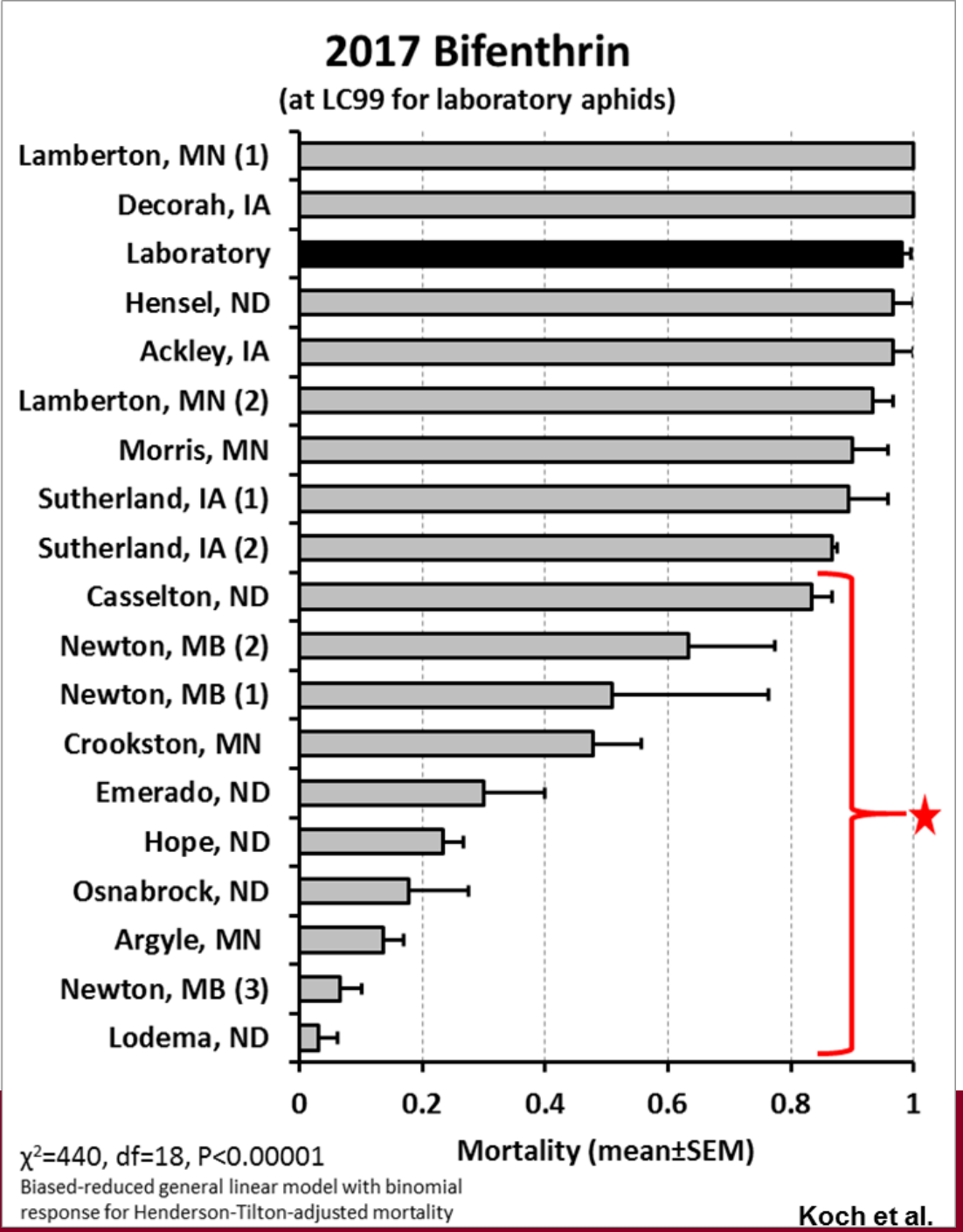
Discriminating dose: LC_{99}





Glass-vial bioassays (2017)

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



Glass-vial bioassays (2017)

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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

Species	Insecticides resisted
Green peach aphid	BPU, C, Nic, OC, OP, Py
Cotton/melon aphid	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
Cowpea aphid	Nic, C, OP, Py
Bean aphid	C, OP
Buckthorn aphid	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

Now what?

- Don’t waste your bullets

1. Don’t spray when not needed

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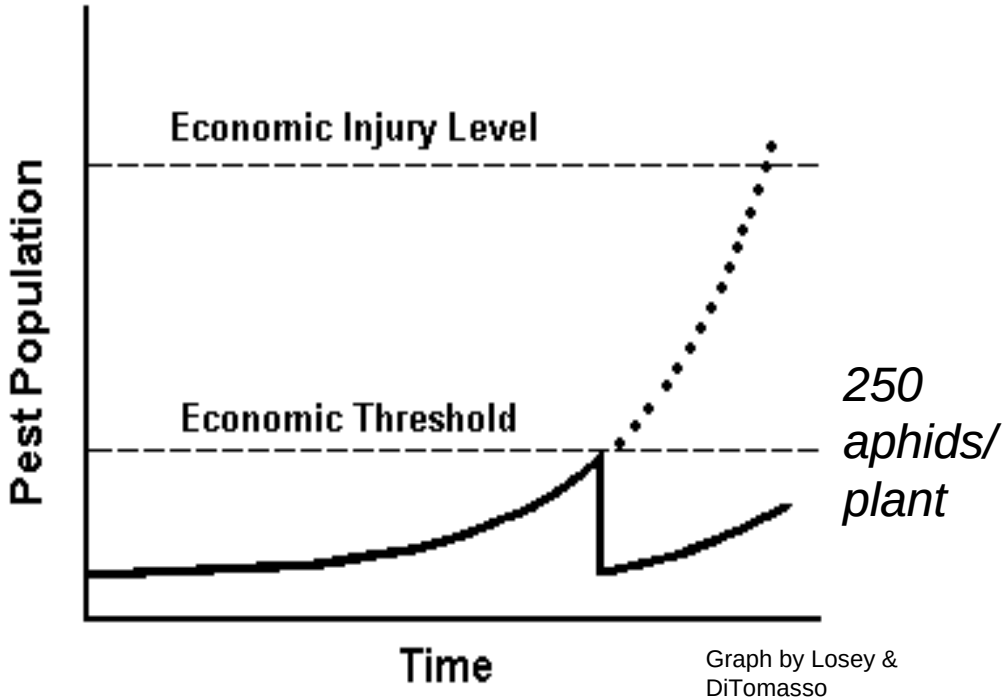
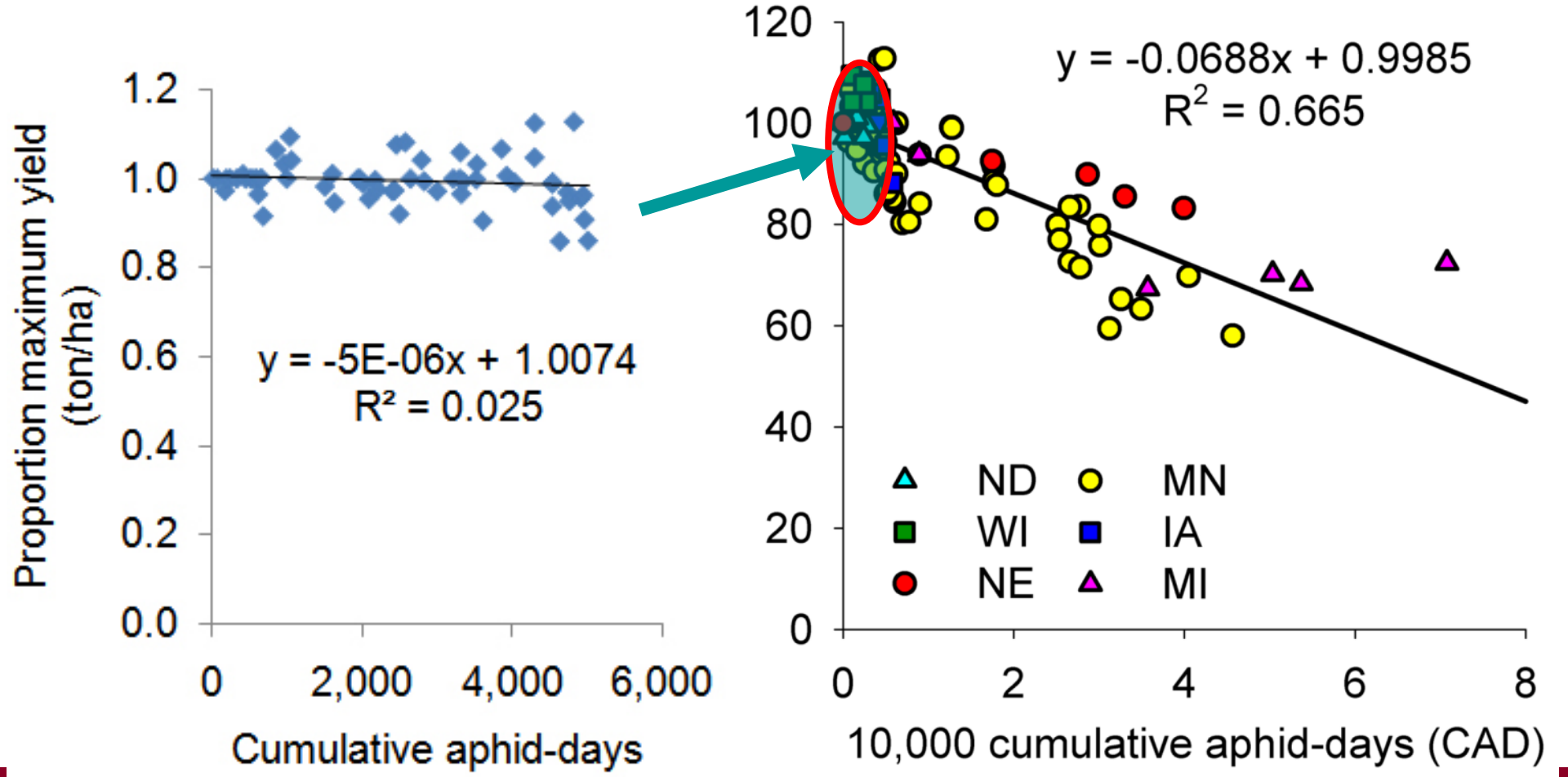


250 aphids/ plant

Graph by Losey & DiTomasso

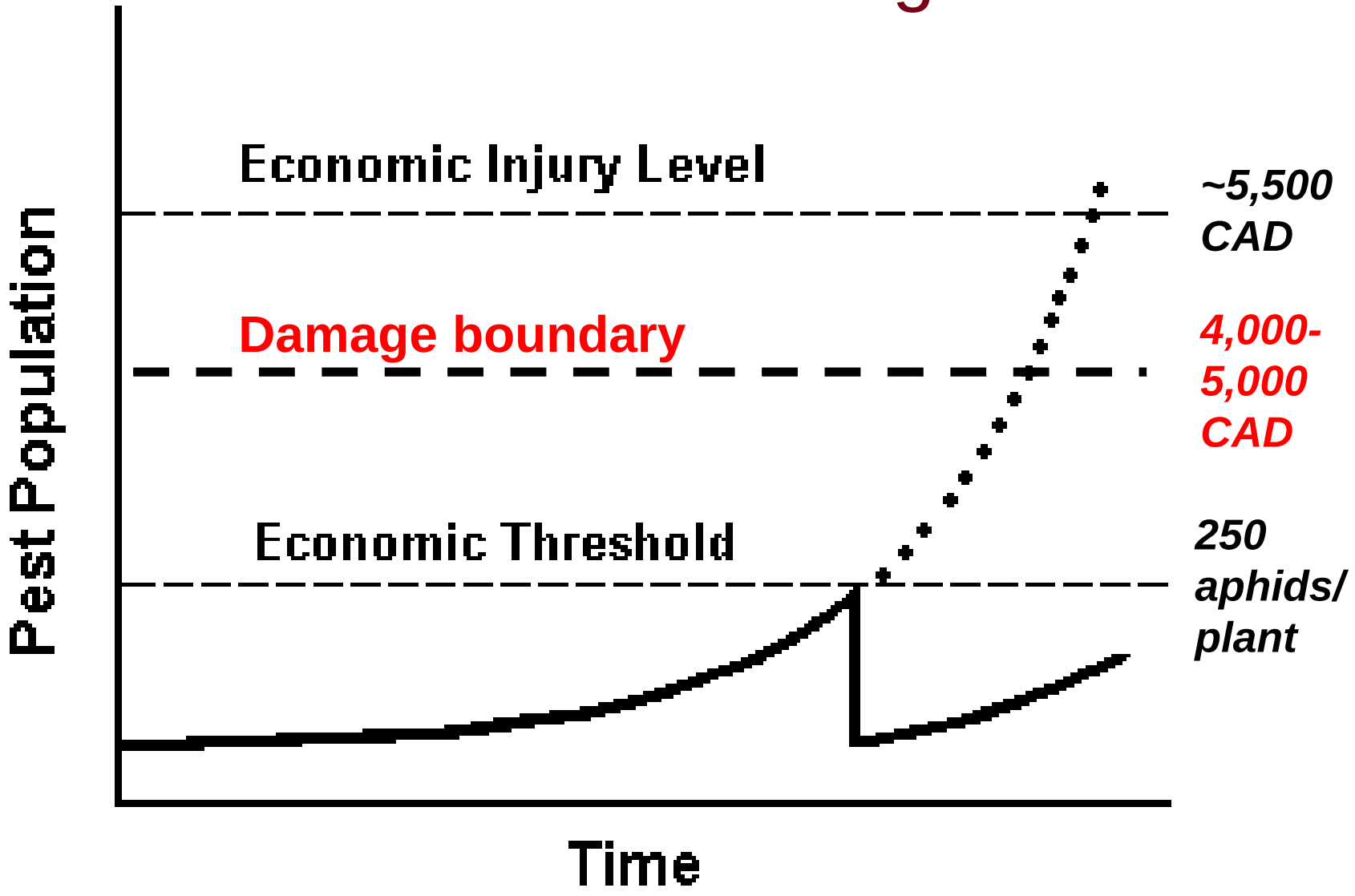
Soybean aphid yield loss relationship



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

graphs from K. Tilmon

Decision making



2. If you spray, do it right

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- 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…

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- 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

Foliar insecticides for soybean aphid

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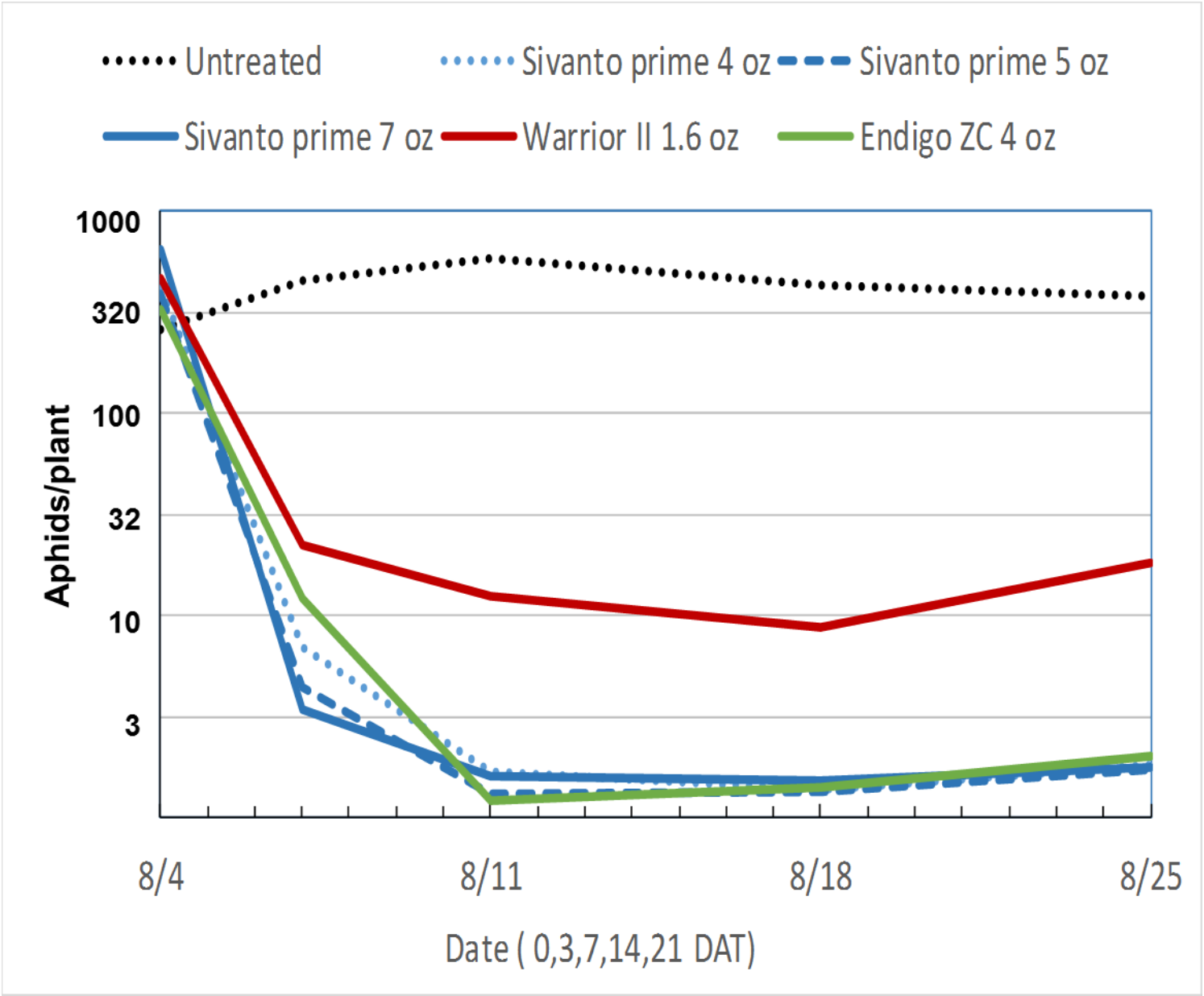
			pyrethrins		



Lamberton, MN 2017

Bruce Potter (U of MN)

Example insecticide rotations

	Initial treatment	Re-treatment
Aphids below ET		
Aphids at or above ET		
• ***Pyrethroid resistance not expected***		
• ***Pyrethroid resistance suspected***		

Example insecticide rotations

	Initial treatment	Re-treatment
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Example insecticide rotations

	Initial treatment	Re-treatment
Aphids below ET	**Don't spray**	**---**
Aphids at or above ET		
• ***Pyrethroid resistance not expected***	**chlorpyrifos**	**Py, Py+NN**
	Py	**chlorpyrifos, Py+NN, Py+OP**
	Py+NN	**chlorpyrifos**
• ***Pyrethroid resistance suspected***		

Example insecticide rotations

	Initial treatment	Re-treatment
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Aphids at or above ET		
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	Py	chlorpyrifos, Py+NN, Py+OP
	Py+NN	chlorpyrifos
• ***Pyrethroid resistance suspected***	**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

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

Carbamates (1A)
(e.g., Lannate, Nudrin)

- Potential benefits:
  - Rapid knockdown
  - Some translocation
  - Broad spectrum
- Potential issues:
  - Short residual
  - Variable toxicity to mammals
  - Toxic to beneficials

Organophosphates (1B)
(e.g., Lorsban, Dimethoate)

- Potential benefits:
  - Rapid knockdown
  - Inexpensive generics
  - Some translocation
  - Broad spectrum
  - Effective against spider mites
- Potential issues:
  - Variable toxicity to mammals
  - Toxic to beneficials
  - Resistant 2-spotted spider mites
  - Dimethoate less effective against soybean aphid

Pyrethroids (3A)
(e.g., Warrior, Tundra, Asana, Hero)

- Potential benefits:
  - Rapid knockdown
  - Some residual activity
  - Inexpensive generics
  - Low mammalian toxicity
  - Broad spectrum
- Potential issues:
  - Resistance is developing
  - Sensitive to application technology
  - Toxic to beneficials
  - Most have potential to flare spider mites

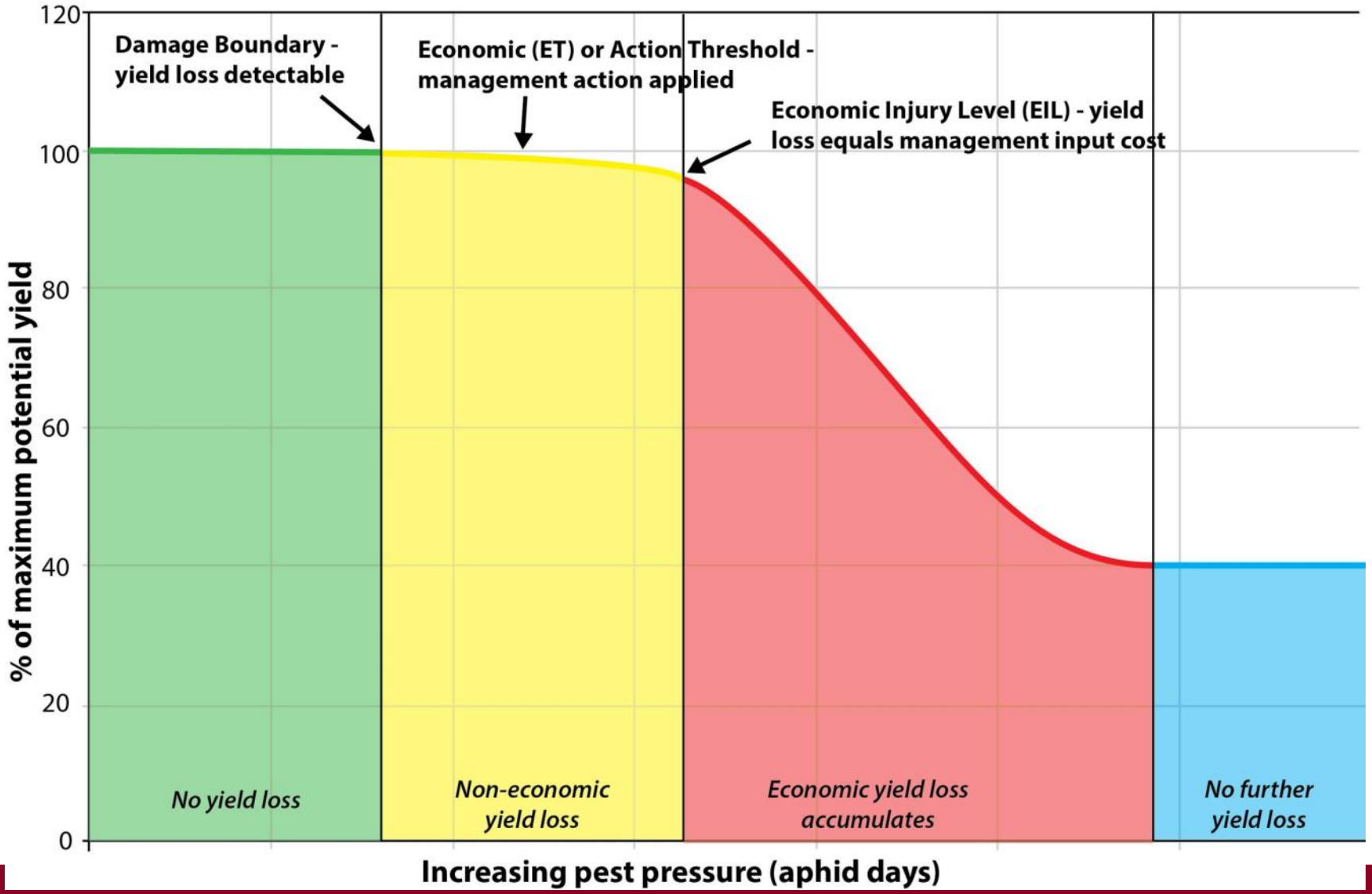
Neonicotinoids (4A)
(e.g., Belay, Admire)

- Potential benefits:
  - Some translocation upward
  - Some residual activity
  - Very low mammalian toxicity
- Potential issues:
  - Selection pressure following seed treatment
  - Slow acting when alone
  - Potential to flare spider mites
  - Toxic to bees & some beneficials

Butenolides (4D)
(e.g., Sivanto)

- Potential benefits:
  - Some residual activity
  - Low mammalian toxicity
  - Less impact on beneficial insects
- Potential issues:
  - Cost $$$
  - Lack of efficacy data against soybean aphid

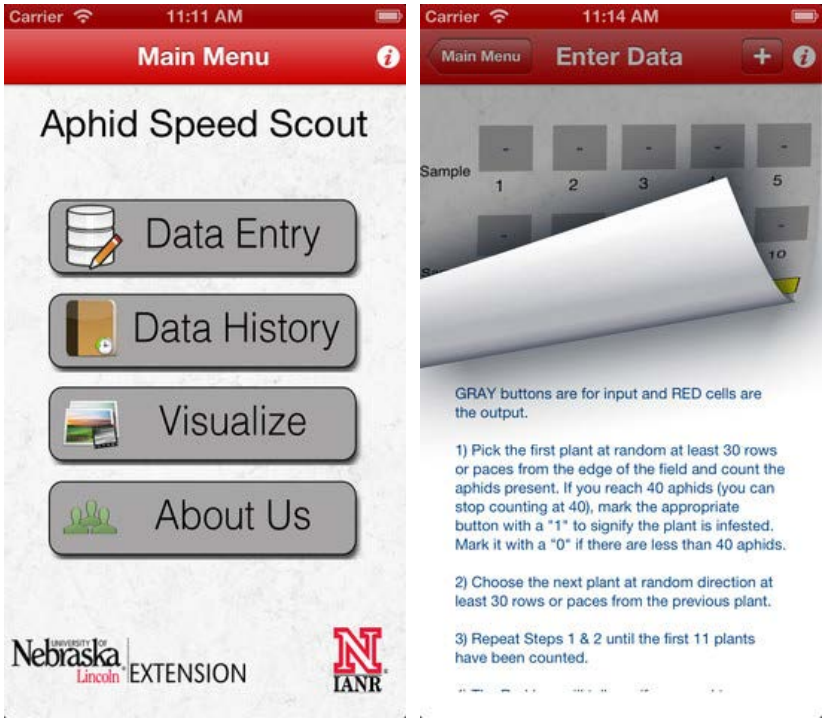
Damage curve: pest population & yield



“Speed scouting”

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

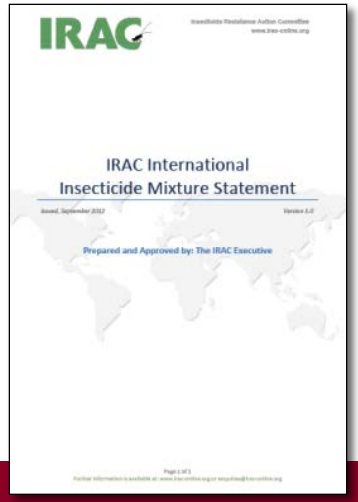
Aphid Speed Scout App (Android & Iphone/Ipad)



Blank, hard-copy worksheets:
http://www.ent.iastate.edu/dept/faculty/hodgson/files/ul/2009 Speed Scouting blank form.pdf

3. If you have a failure…

- Rule out other causes
- Alternate insecticide group for next spray
  - Mixtures: Generally less effective for resistance management
    - Pest susceptibility
    - Registered rates
    - Duration of residual activity
    - Cross-resistance



Pyrethroid resistance

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

Liu 2012

Soybean aphid resistance to λ-cyhalotrhin in China

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

Xi et al. 2015