

# Economics of Roundup Ready Crops: Farmer Benefits and the Impact of Weed Resistance

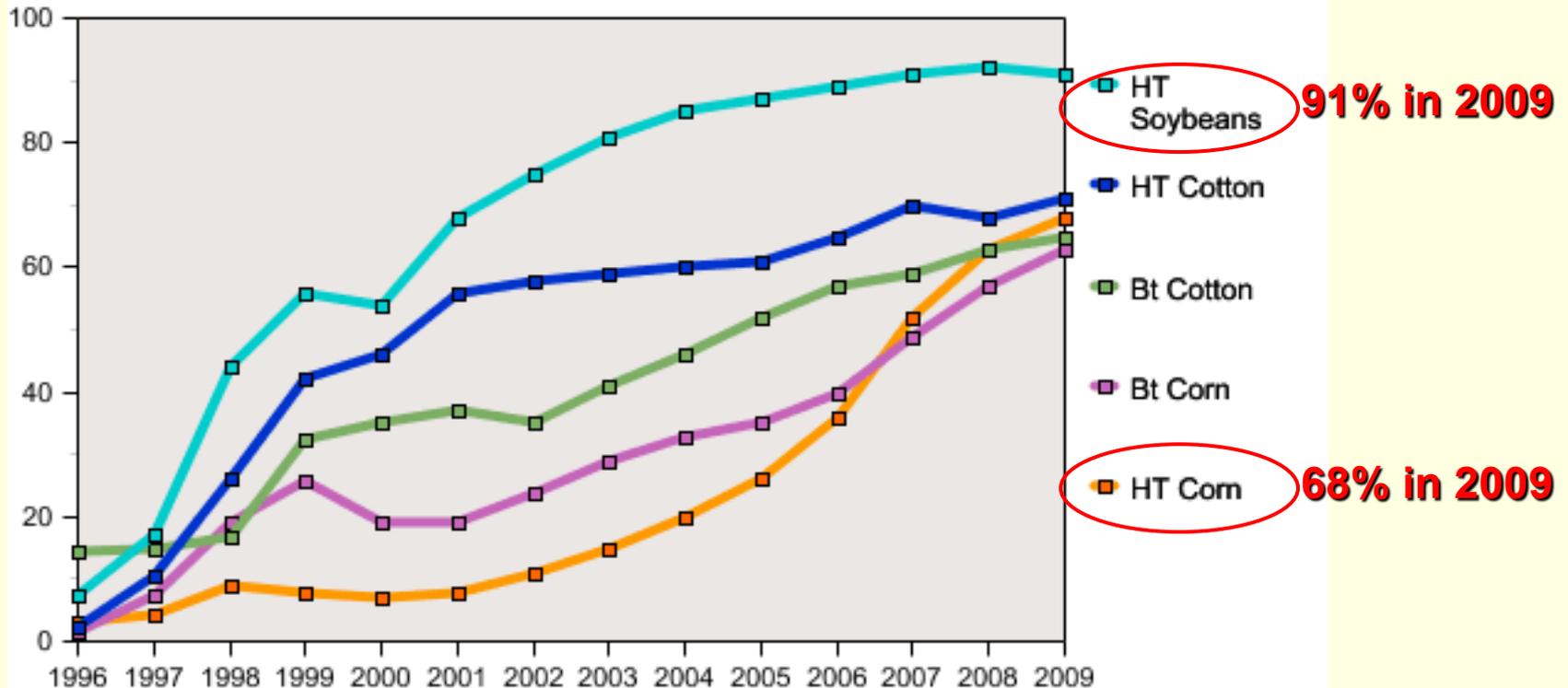
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Ag & Applied Economics, UW-Madison  
Wisconsin Crop Management Conference  
January 12-14, 2010

# Herbicide Tolerant Crops Have Become Very Popular

Rapid growth in adoption of genetically engineered crops continues in the U.S.

Percent of acres



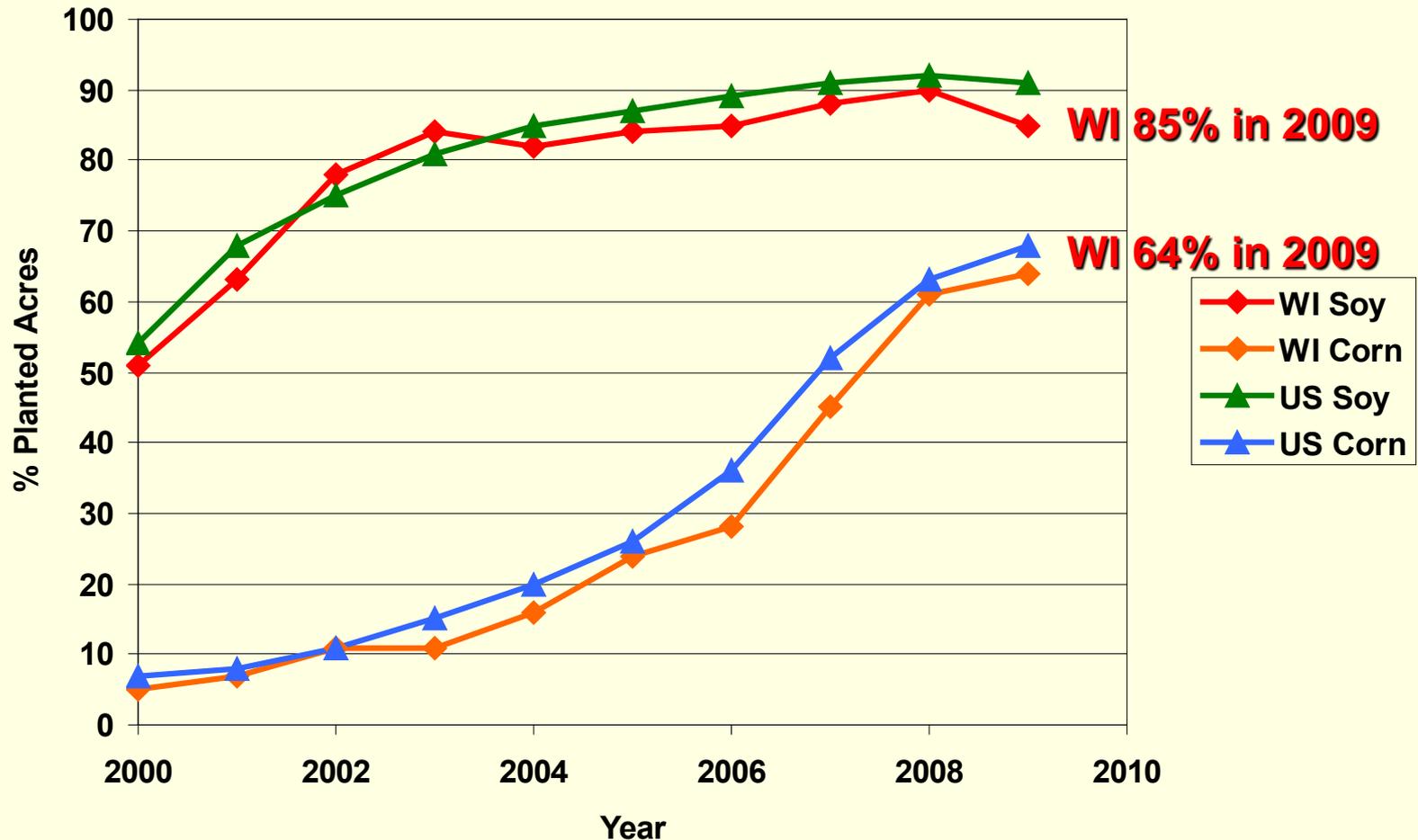
Data for each crop category include varieties with both HT and Bt (stacked) traits.

Sources: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-09 are available in tables 1-3.

Source: <http://www.ers.usda.gov/data/biotechcrops/>

# Wisconsin Farmers Following the National Trend

## % Acres Planted in Transgenic Varieties



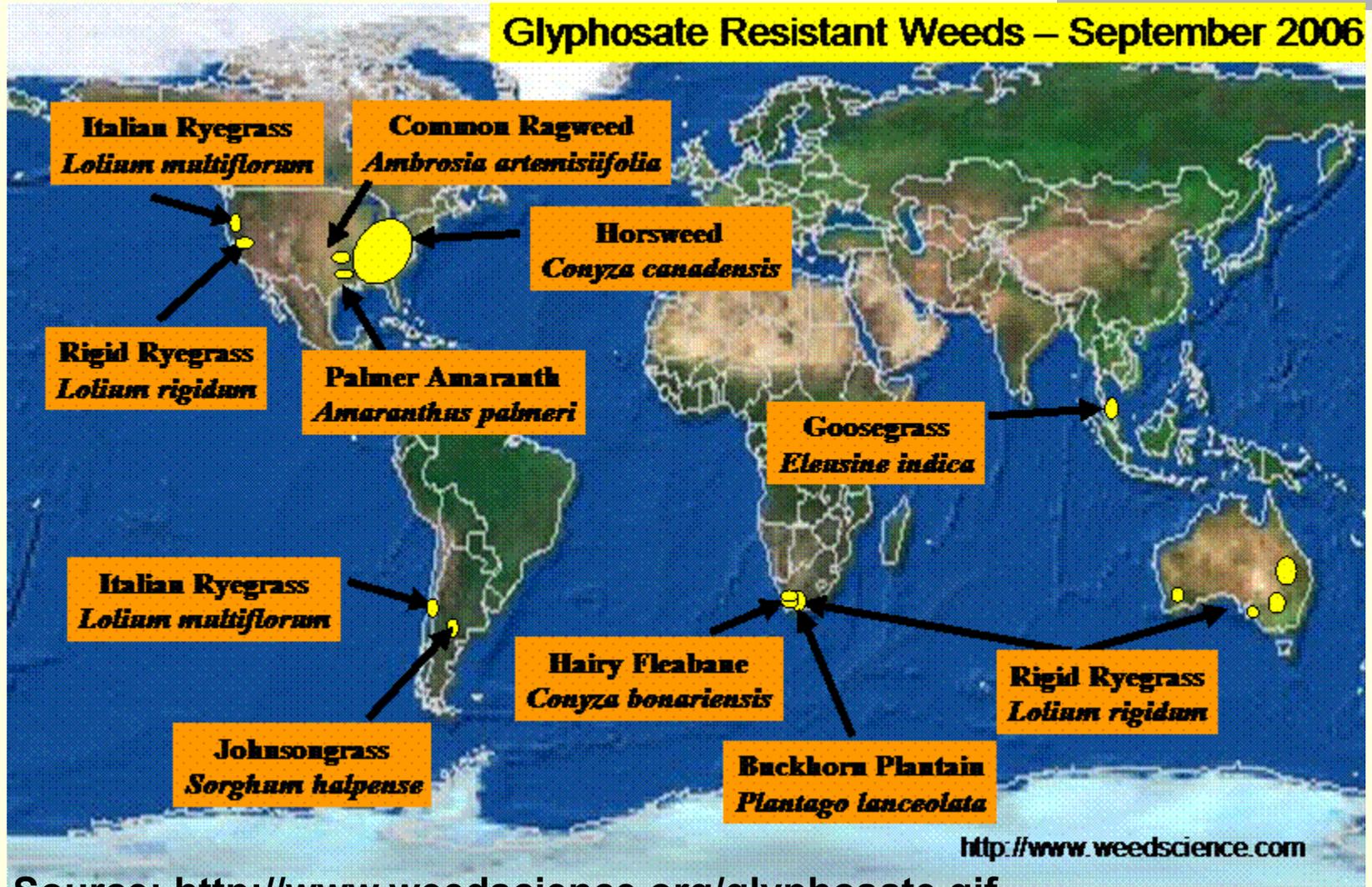
Source: <http://www.ers.usda.gov/data/biotechcrops/>

# Weed Resistance: Clouds on the Horizon?

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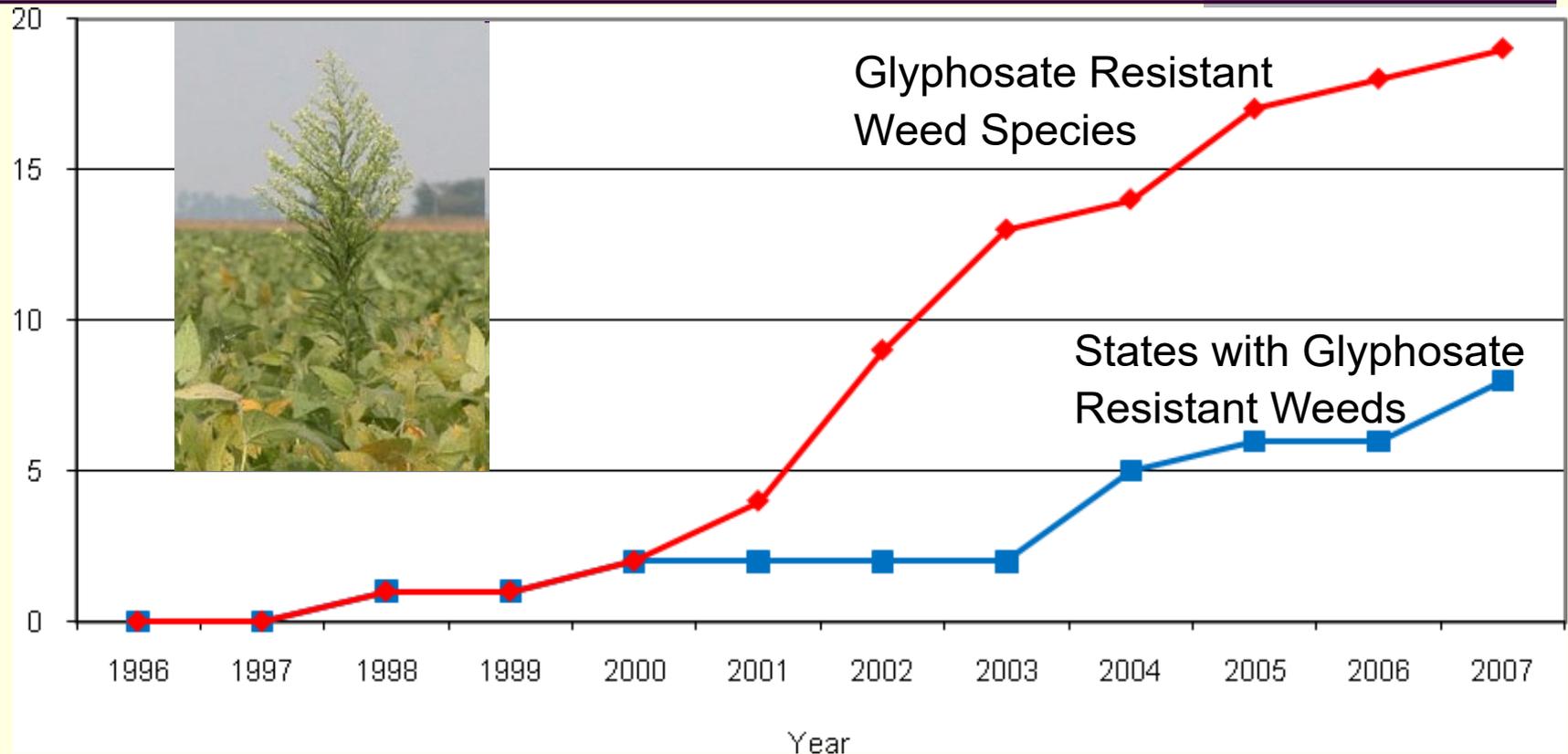
- Most of these herbicide tolerant crops are Roundup Ready
- Over reliance on a single herbicide/mode of action can lead to weed resistance/tolerance
- It's happened for other herbicides and has happened for Roundup/glyphosate

# Global Distribution of Glyphosate Resistance



Source: <http://www.weedscience.org/glyphosate.gif>

# Glyphosate Resistance is a Growing Problem in the US.



Number of weed species with glyphosate resistant populations and number of states with glyphosate-resistant weed populations (Source: Hurley, Mitchell & Frisvold 2009; Heap 2009).

# Weed Resistance is a Problem in Wisconsin, but not for Glyphosate

## HERBICIDE RESISTANT WEEDS IN WISCONSIN

Weed	Situation	Herbicide Mode of Action	Year
<b><u>Lambsquarters</u></b> ( <i>Chenopodium album</i> )	corn	C1/5 - Photosystem II inhibitors (atrazine)	1979
<b><u>Smooth Pigweed</u></b> ( <i>Amaranthus hybridus</i> )	corn	C1/5 - Photosystem II inhibitors (atrazine)	1985
<b><u>Kochia</u></b> ( <i>Kochia scoparia</i> )	corn, railways	C1/5 - Photosystem II inhibitors (atrazine)	1987
<b><u>Velvetleaf</u></b> ( <i>Abutilon theophrasti</i> )	corn	C1/5 - Photosystem II inhibitors (atrazine)	1990
<b><u>Giant Foxtail</u></b> ( <i>Setaria faberi</i> )	carrot, corn, onion, sweet corn	A/1 - ACCase inhibitors (fluazifop-P-butyl, sethoxydim)	1991
<b><u>Large Crabgrass</u></b> ( <i>Digitaria sanguinalis</i> )	carrot, onion	A/1 - ACCase inhibitors (fluazifop-P-butyl, sethoxydim)	1992
<b><u>Kochia</u></b> ( <i>Kochia scoparia</i> )	roadsides	B/2 - ALS inhibitors (sulfometuron-methyl)	1995
<b><u>Common Waterhemp</u></b> ( <i>Amaranthus rudis</i> )	soybean	B/2 - ALS inhibitors (imazethapyr)	1999
<b><u>Giant Foxtail</u></b> ( <i>Setaria faberi</i> )	corn, soybean	B/2 - ALS inhibitors (imazethapyr, nicosulfuron)	1999
<b><u>Green Foxtail</u></b> ( <i>Setaria viridis</i> )	corn, soybean	B/2 - ALS inhibitors (imazamox)	1999
<b><u>Eastern Black Nightshade</u></b> ( <i>Solanum ptycanthum</i> )	soybean	B/2 - ALS inhibitors (imazamox, imazethapyr)	1999

Source: Heap 2009

# In Wisconsin, Glyphosate Resistance is not a Problem—At Least Not Yet!

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- Chris Boerboom in summer 2009 started investigating giant ragweed in WI with suspected resistance to glyphosate
  - WI Crop Manager June 18, 2009  
(<http://ipcm.wisc.edu/Default.aspx?tabid=53>)
- David Stoltenberg continuing the research
  - Seeds from plants surviving glyphosate applications being prepped (cleaned and cold treated) for greenhouse experiments taking place late this winter
  - Stay tuned for details

# Questions Addressed in This Study

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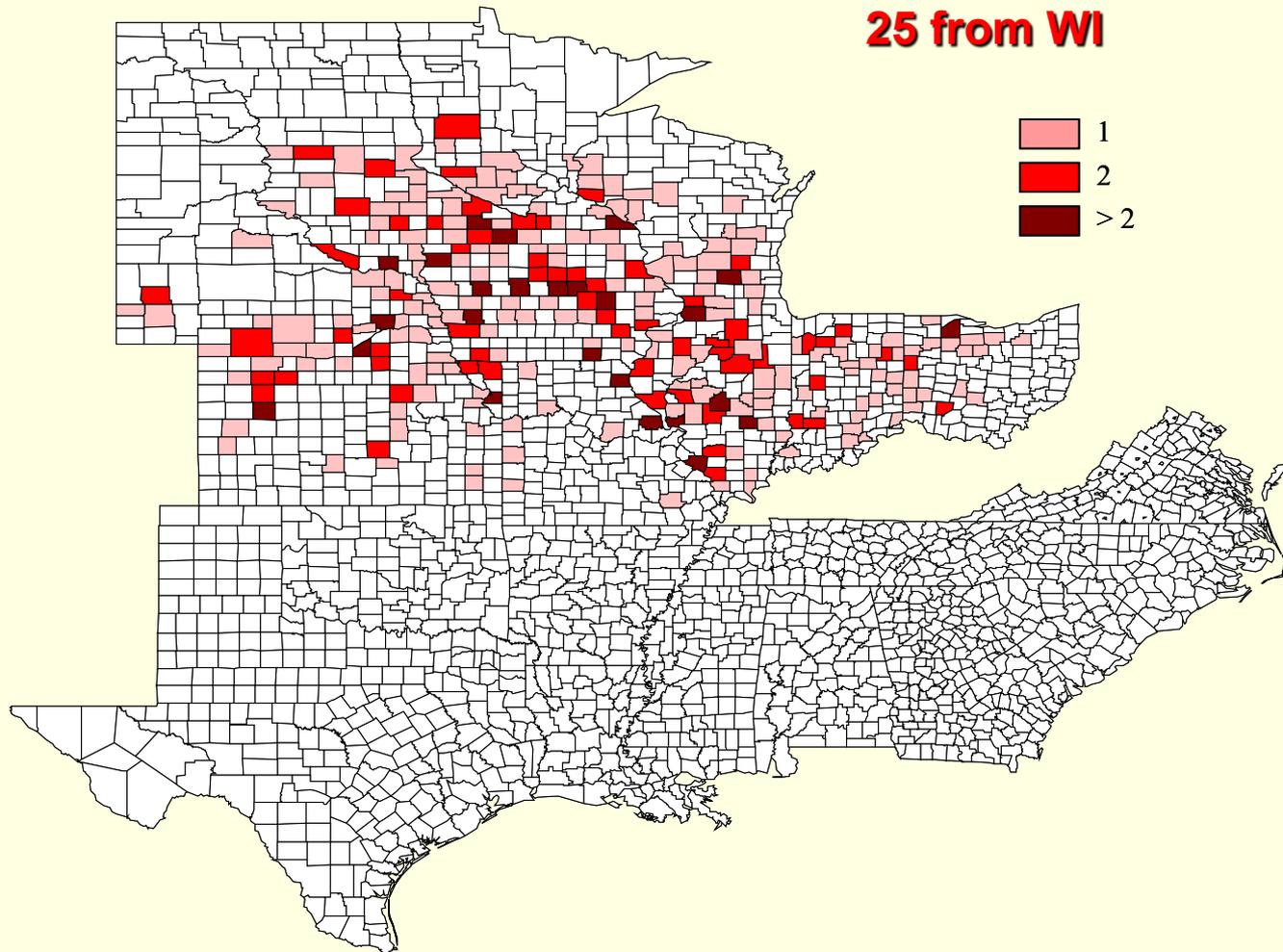
- What is the value of the benefits to farmers from RR Soybeans & RR corn?
- Do farmers think weed resistance is a problem?
- How does weed resistance affect the value of RR soybeans & RR corn?
- Overview the Study and Summarize Results

# Study of RR Benefits and Resistance

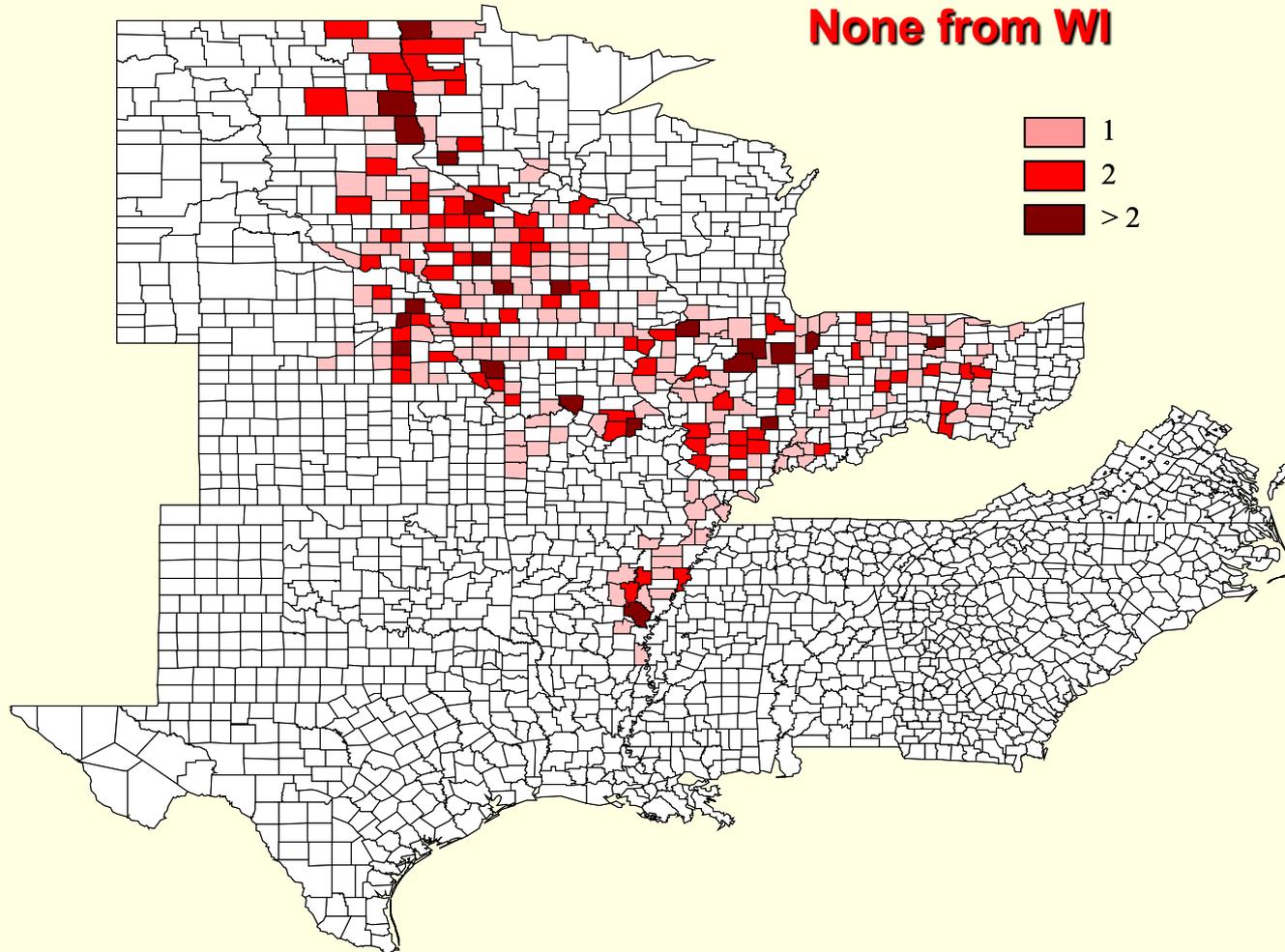
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- Terry Hurley (U of MN), Paul Mitchell, and George Frisvold (U of AZ)
- Corn, soybean and cotton growers
- Telephone survey of 400 corn, 400 soybean and 400 cotton farmers from main states
  - At least 250 acres of target crop
  - Surveyed during Nov-Dec 2007
  - Questions on 2007 and plans for 2008
  - Weed management with RR focus
- Funded by Monsanto

# Where are the Corn farmers from?



# Where are the Soybean farmers from?

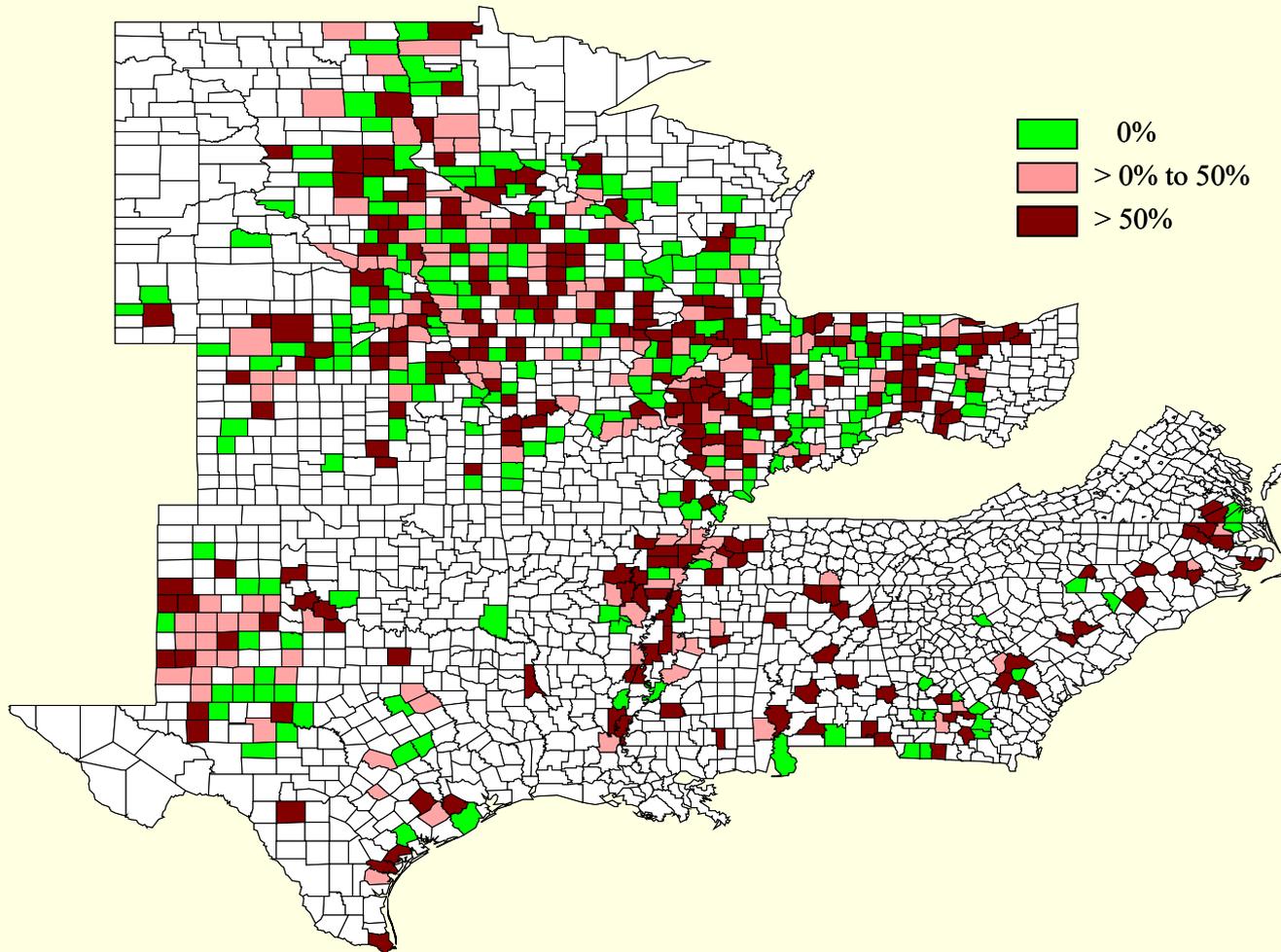


# Farmer Concerns about Resistance

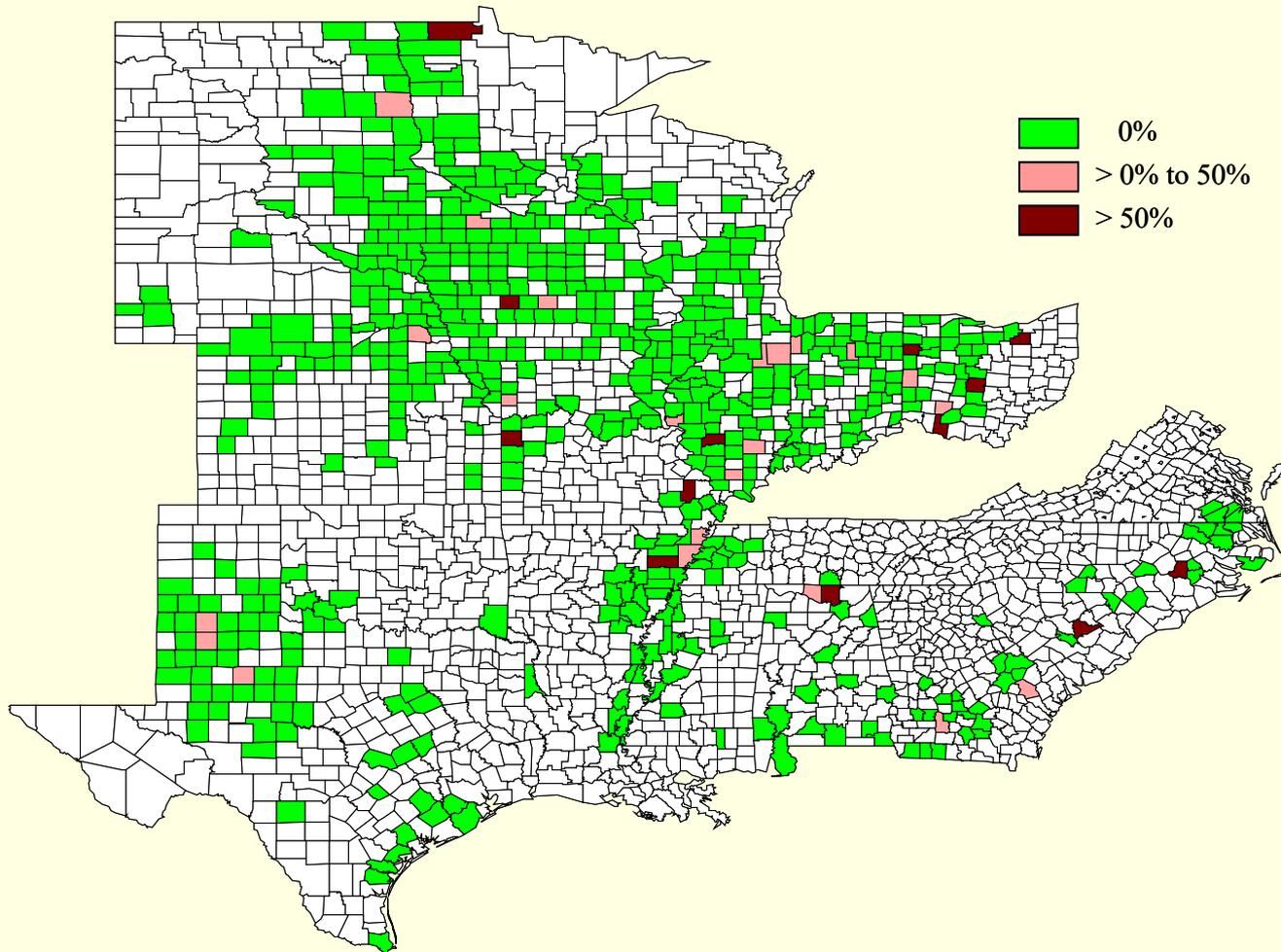
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- No where in the survey was weed resistance ever mentioned
- End of survey asked an opened question  
**“What are your biggest concerns in regards to weed management?”**
- Responses mentioning weed resistance
  - Concerned about weed resistance
    - 47% corn growers, 52% soybean growers
  - Mentioned having weed resistance
    - 3% of all growers (corn, cotton, soybean)

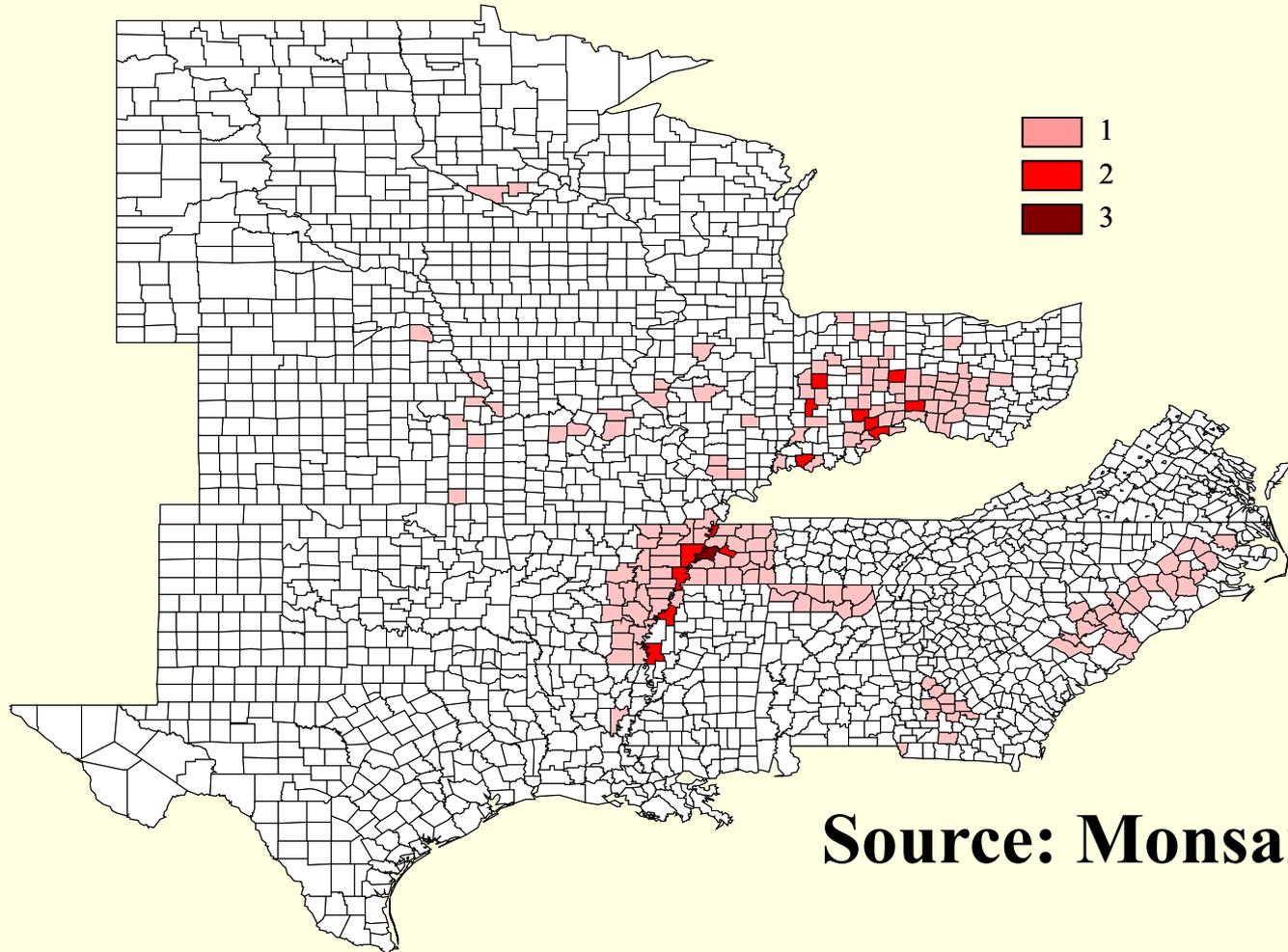
# Concerned about weed resistance



# Mentioned having weed resistance



# Number of weed species with suspected or confirmed resistance to glyphosate in 2006



**Source: Monsanto**

# Estimating Farmer Benefits

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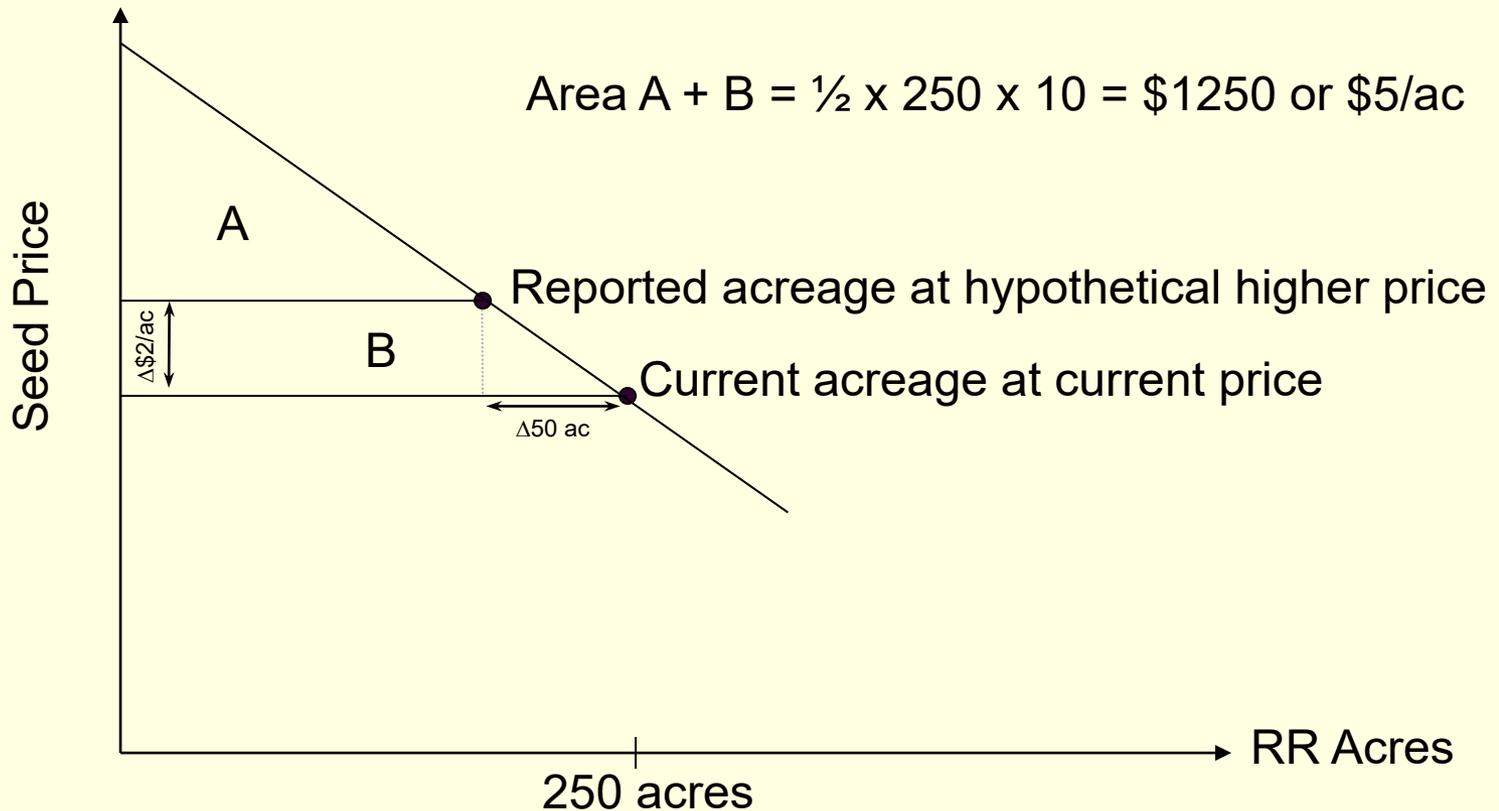
- Farmers asked their planned 2008 RR and conventional corn/soybean acres and RR corn/soybean acres with a residual herbicide
- How will these acreages change if the price of RR seed changed or the price of residual herbicide changed a few dollars per acre
- From acreage shifts to (hypothetical) price changes, derive value of RR crop using “consumer surplus”
- “Contextually stated preferences”
  - Farmers give more reasonable results than just asking them directly: “What’s RR corn/soybeans worth to you?”

# Telephone Survey Script

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- For the next few questions, please think about how your current plans for the 2008 season might change if your cost for Roundup Ready [**crop**] seed increased by [**\$**] per acre.
- 22a. If the cost for Roundup Ready [**crop**] seed increased by [**\$**] per acre, would you plan to plant Roundup Ready [**crop**] next year in 2008?
- 22b. **[If “yes” in Q.22a >> ask:]** How many acres of Roundup Ready [**crop**] would you plan to plant next year? Remember, you earlier indicated that you currently plan to plant [**Q.17**] acres of Roundup Ready [**crop**] in 2008.
- 22c. **[If RR less than 100% of crop acres >> ask:]** And, given this price change, how many acres of conventional herbicide [**crop**] would you plan to plant in 2008? That is, [**crop**] that is not Roundup Ready or LibertyLink or AgriSure?

# Consumer Surplus



**Area A + B is “Consumer Surplus”**

**Dollar value a farmer gets from RR crop**

# What is the value (\$/ac) of the benefits to farmers from RR Soybeans & RR corn?

	Corn	w/ residual	Soybean	w/ residual
Median Benefit	<b>\$16.74</b>	<b>\$11.93</b>	<b>\$8.44</b>	<b>\$5.29</b>
90% Conf. Interval	\$11.44 to \$32.34	\$8.97 to \$17.39	\$7.47 to \$9.77	\$4.02 to \$7.41
Effect of Residual Herbicide	<b>-\$4.81 (-29%)</b>		<b>-\$3.15 (-37%)</b>	

**Farmers find RR crops valuable, even if used with a residual**

**Using a residual decreases value of RR crops about 30%-40%**

# How does weed resistance affect the value of RR soybeans & RR corn?

- Used growers' responses to open ended questions to code whether they are concerned about resistance
- Used Monsanto data to see if farmed in a county or a crop reporting district (CRD) with confirmed resistance

## % Change in Value of RR Crop

<u>Resistance</u>	Corn	w/ residual	Soybean	w/ residual
Concerned	3.1%	0.3%	<b>3.9%</b>	<b>25.2%</b>
In County	-0.4%	-0.4%	-0.7%	4.8%
In CRD	-0.5%	0.5%	1.8%	<b>-9.1%</b>

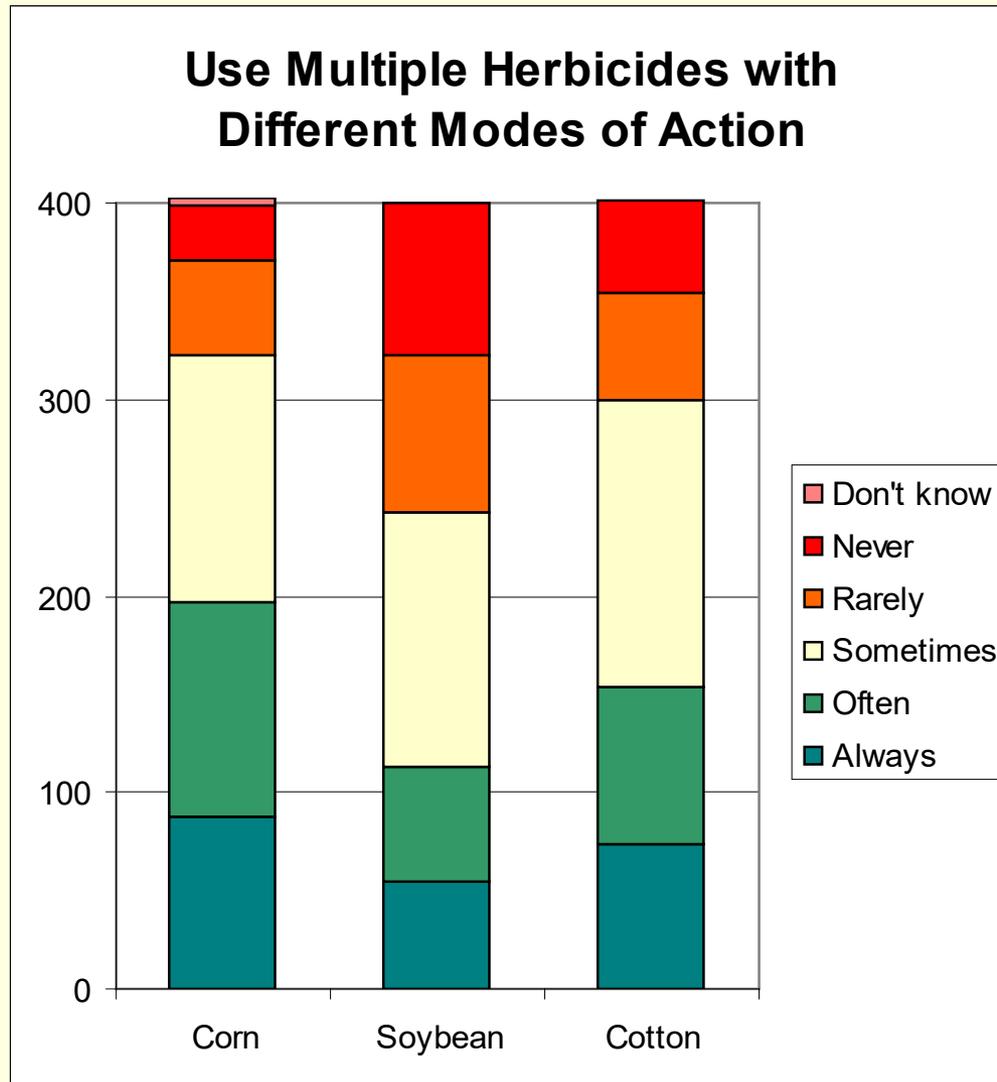
**Red values** significant at the 10% level

# How does weed resistance affect the value of RR soybeans & RR corn?

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- Weed resistance and concerns about weed resistance do not seem to affect the value of RR corn  
Farmers already commonly use multiple herbicides, so they have options they are used to using
- Farmers concerned about weed resistance find RR soybeans more valuable than farmers not concerned about weed resistance, especially if they are using RR soybeans with a residual
  - Proactively managing resistance is easier with RR soybeans, making RR soybeans more valuable
- Soybean farmers in regions with weed resistance find using RR soybeans with a residual less valuable
  - Value of RR crop reduced if “forced” to use a residual because of local development of resistance by others

# Farmer Use of Multiple Herbicides with different MOA by crop



- Corn farmers most likely to follow this practice
- Soybean farmers least likely to follow this practice

# Summary of Findings

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- Farmers are concerned about herbicide resistance: ~ 50%
- RR crops are valuable, even if used with a residual
  - Using a residual decreases value of RR crops about 30%-40%, but still substantial have value (\$8 to &17/ac)
- Weed resistance & concerns about weed resistance
  - Seem not to affect the value of RR corn
  - RR soybeans more valuable if concerned about weed resistance, especially if using a residual
  - In regions with weed resistance, using RR soybeans with a residual is less valuable
- Recommendation: encourage farmers to adopt weed resistance management BMPs

# Weed Resistance BMPs

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Scout fields before a herbicide application

Scout fields after a herbicide application

- Start with a clean field, using a burndown herbicide application or tillage
- Control weeds early when they are relatively small
- Control weed escapes and prevent weeds from setting seeds
- Clean equipment before moving between fields to minimize weed seed spread
- Use new commercial seed that is as free from weed seed as possible
- Use multiple herbicides with different modes of action during cropping season
- Use tillage to supplement weed control provided by herbicide applications
- Use the recommended application rate from the herbicide label

Source: <http://www.weedresistancemanagement.com/stewardship.html> (Monsanto)

# Chris Boerboom's White Paper

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→ Rotate between Roundup Ready and conventional crops or crops with other types of herbicide resistance.

Use Roundup Ready crops in your rotation where they have the greatest economic and management value.

→ Rotate glyphosate with other herbicide modes of action.

→ Rotate non-glyphosate herbicides over time as well.

→ Apply glyphosate at labeled rates at the correct stage of growth.

If glyphosate is used as a burndown treatment and in-crop, tank mix the burndown treatment with another mode of action.

→ Use cultivation after in-crop applications of glyphosate when possible.

Scout fields regularly and identify weeds present.

Respond quickly to changes in weed population.

# Boerboom's examples of crop and herbicide rotations that promote glyphosate stewardship

	<b>Tilled Corn/Soy</b>	<b>No-Till Corn/Soy</b>	<b>Alfalfa/Corn</b>	<b>Continuous Corn</b>
<b>YEAR 1</b>	<u>Conventional Corn</u> Herbicides w/ non-glyphosate MOA	<u>Conventional Corn</u> <i>Burndown</i> : 2,4-D + glyphosate. <i>In-crop</i> : herbicides w/ non-glyphosate MOA	<u>Alfalfa</u> Glyphosate + 2,4-D in early fall	<u>Conventional Corn</u> Herbicides w/ non-glyphosate MOA
<b>YEAR 2</b>	<u>RR Soybean</u> Glyphosate early postemergence	<u>RR Soybean</u> <i>Burndown</i> : 2,4-D + glyphosate. <i>In-crop</i> : glyphosate early postemergence	<u>RR Corn</u> Glyphosate early postemergence* Cultivate	<u>RR Corn</u> Plant only for specific weed problems Glyphosate early postemergence* Cultivate
<b>YEAR 3</b>	Repeat rotation	Repeat rotation	<u>Conventional Corn</u> Herbicides w/ non-glyphosate MOA	Repeat rotation
<b>YEAR 4</b>			<u>Alfalfa</u>	

**Source: Chris Boerboom's White Paper**

# Questions?

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