

# **Weed Resistance to Herbicides: An Economic Threat to U.S. Agriculture**

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# Weed Resistance

**Definition: “Inherited ability of a weed population to survive and reproduce after exposure to an herbicide dose (rate) that would control an unselected population”**

***--- Weed Science Society of America***



Susceptible



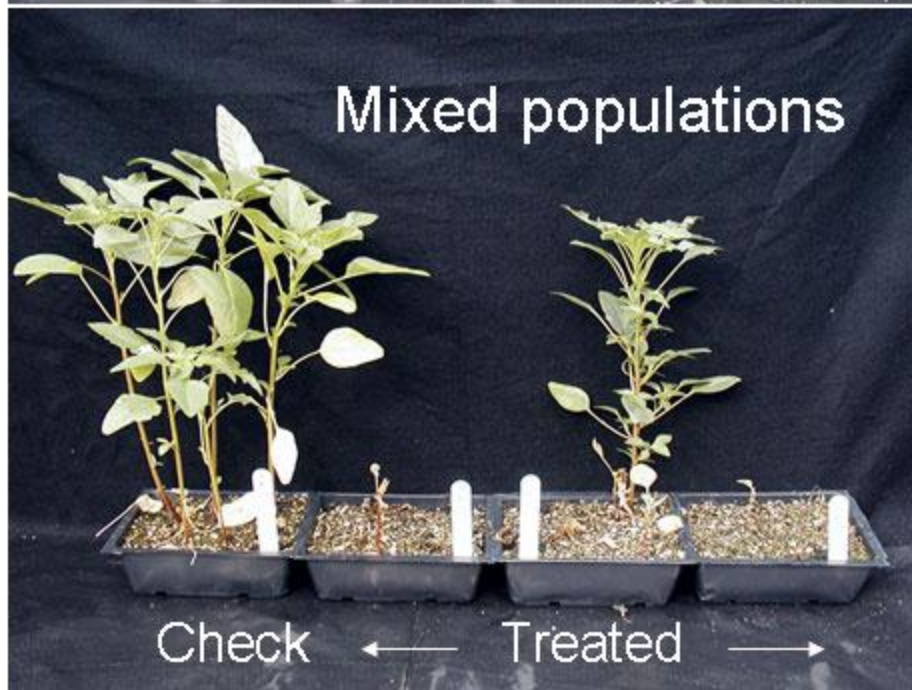
Low resistance



High resistance



Mixed populations



# Herbicide Mechanisms of Action (MOAs)

## Definition:

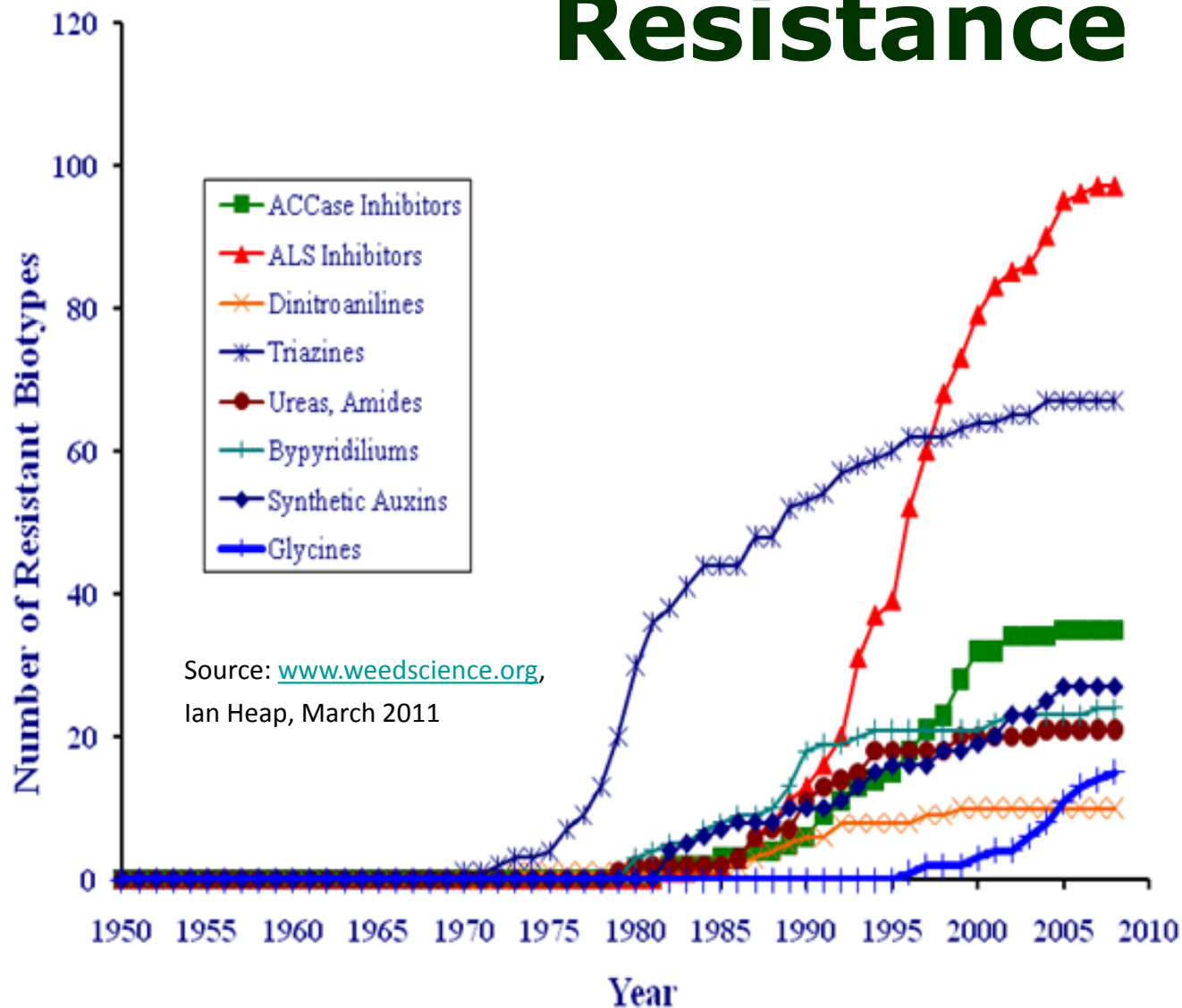
The MOA is the means by which the herbicide controls the weed.

## Importance for Resistance:

Weeds will generally be resistant to all herbicides with the same MOA.

**There are only 16 MOAs**

# Current Status of Resistance



← ALS-inhibitors

← Triazines

← ACCase-inhibitors

← Glycines

# 2011 Cotton Producer Survey

## - Key Research Issues -

**% of Respondents Who Ranked Issue in Their Top 5**

	SE	Mid	SW	FW	US
Input Costs	66	64	73	70	69
Resistant Weeds	76	73	34	23	54
Variety Selection	41	36	44	53	42
Resistant Insects	< 6	12	< 9	< 10	< 10



# **Herbicide-Resistant Weeds**

## **Loss of Options**

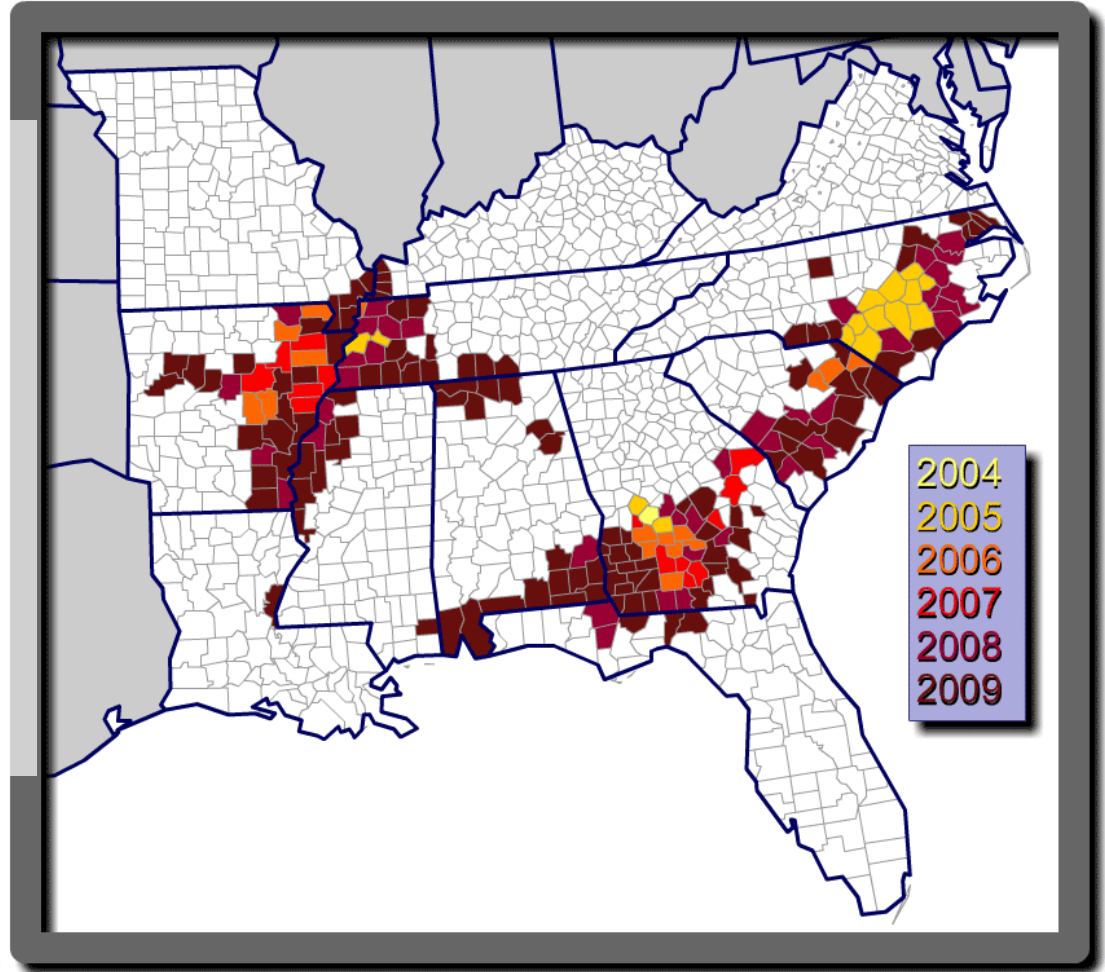
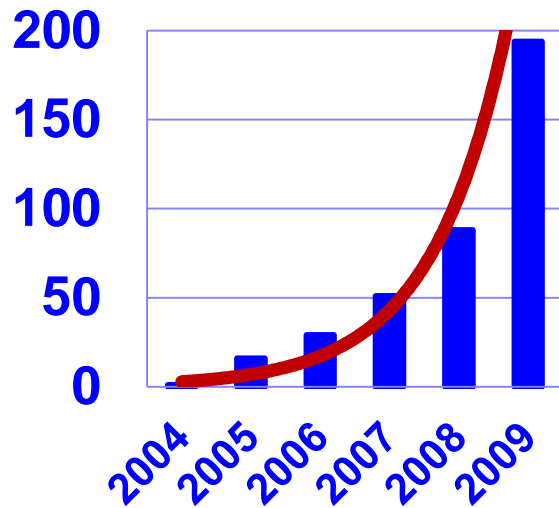
<b>Herbicide MOAs</b>	<b>Trade Name</b>	<b>Est. Loss of Efficacy</b>
ALS (in soybeans)	Pursuit, Staple	95 %
ALS (in cotton)	Staple	60 %
ACCase	Assure, Fusilade	30 %
Glycine	Roundup and others	30 %
Photosystem II	Cotoran, Diuron	5 %
PPO	Valor, Reflex	3 %
Auxin Analogs	2,4-D, Clarity (dicamba)	1 %
Glufosinate	Liberty (Ignite)	< 1 %

# **Poster Child of Herbicide Resistance..... Glyphosate-Resistant Palmer Amaranth in Georgia**

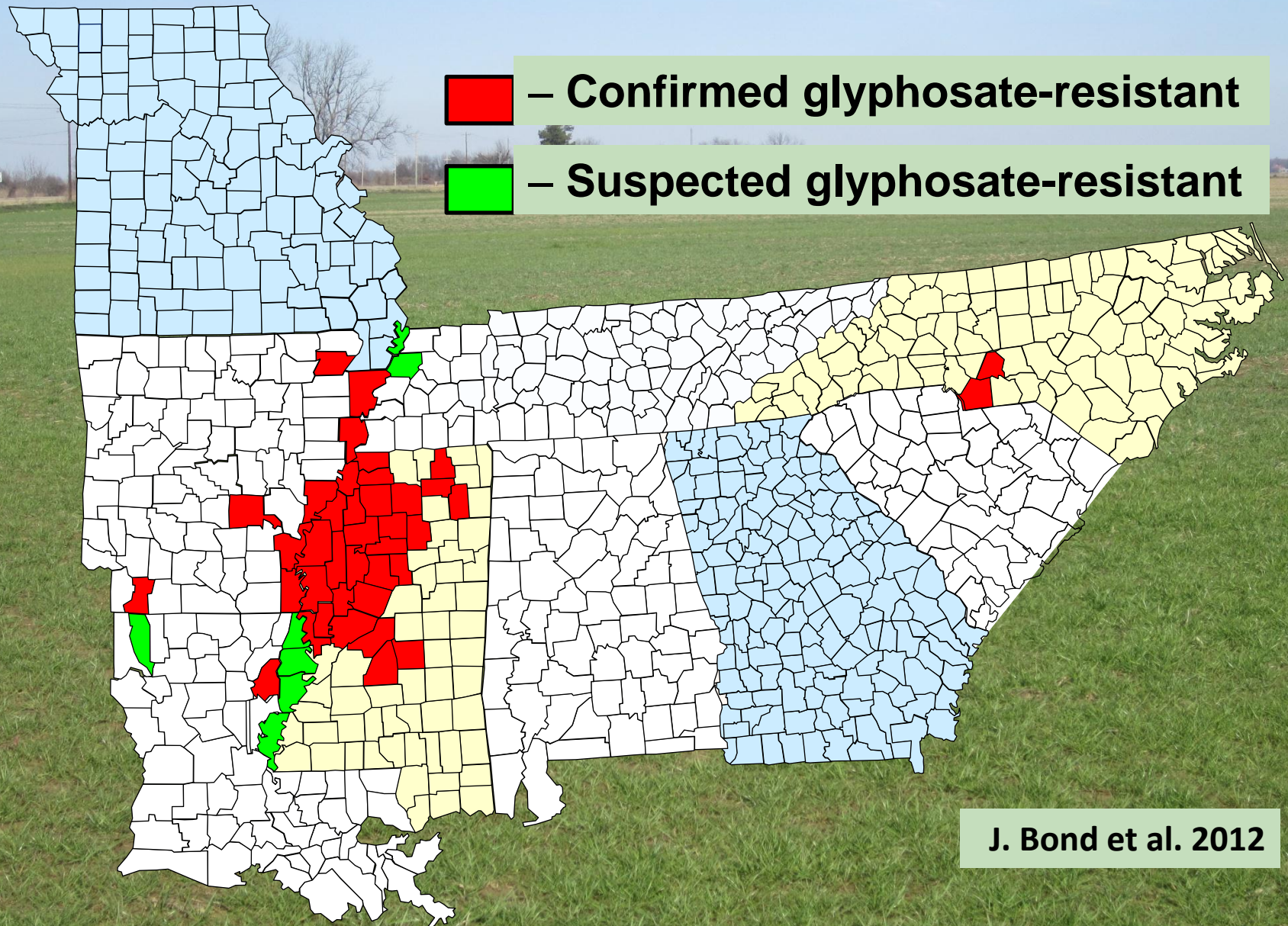




# Counties with Glyphosate-Resistant Palmer Amaranth



# Glyphosate-Resistant Italian Ryegrass



J. Bond et al. 2012

# The Challenge of Glyphosate Resistance

Early predictions were that glyphosate resistance would not occur:

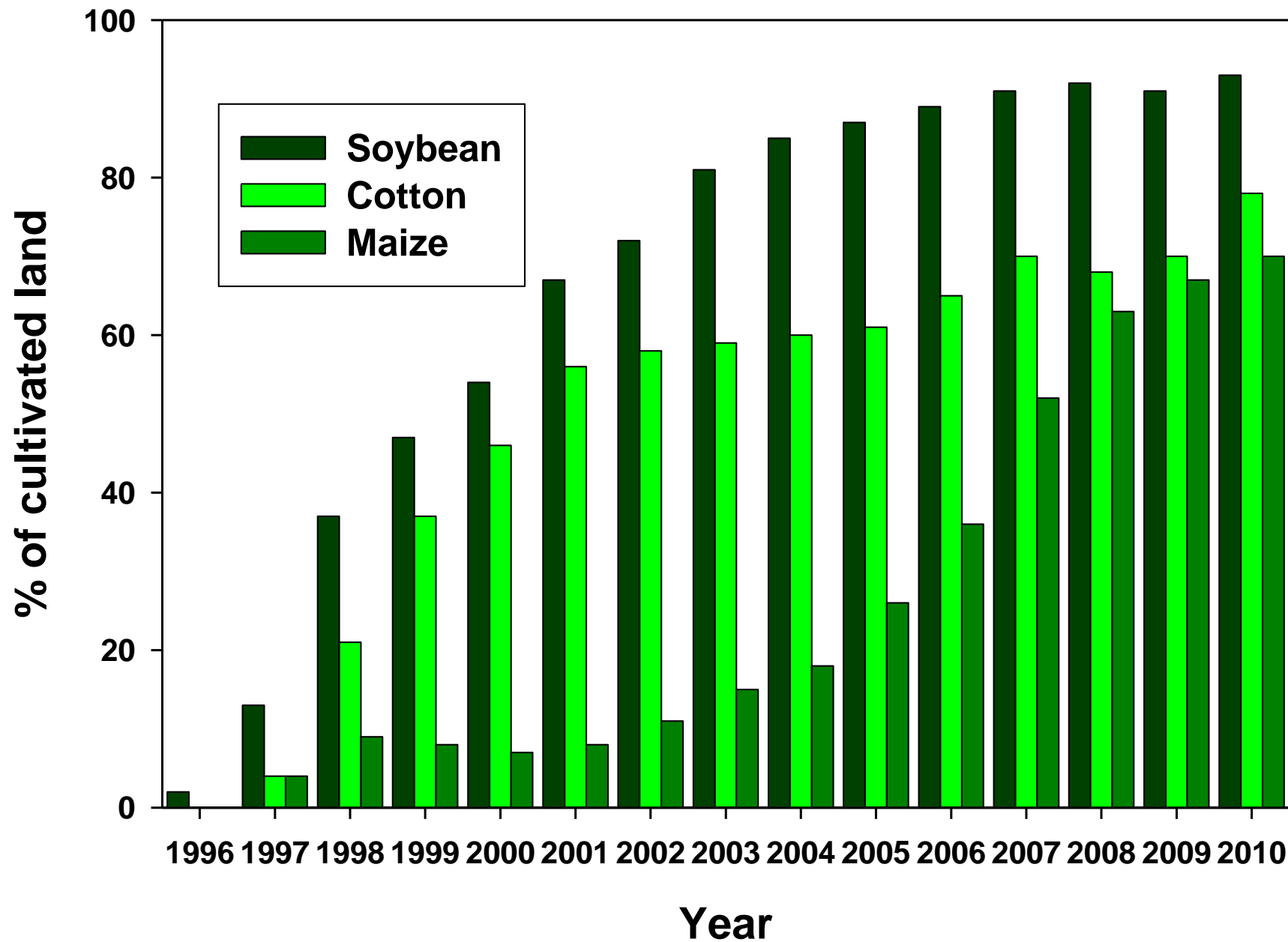
- Unique mode of action
- Minimal tolerance in plants
- Difficulty in selecting resistance for GR crops
- Target site alterations lead to less fit plants

# The Challenge of Glyphosate Resistance

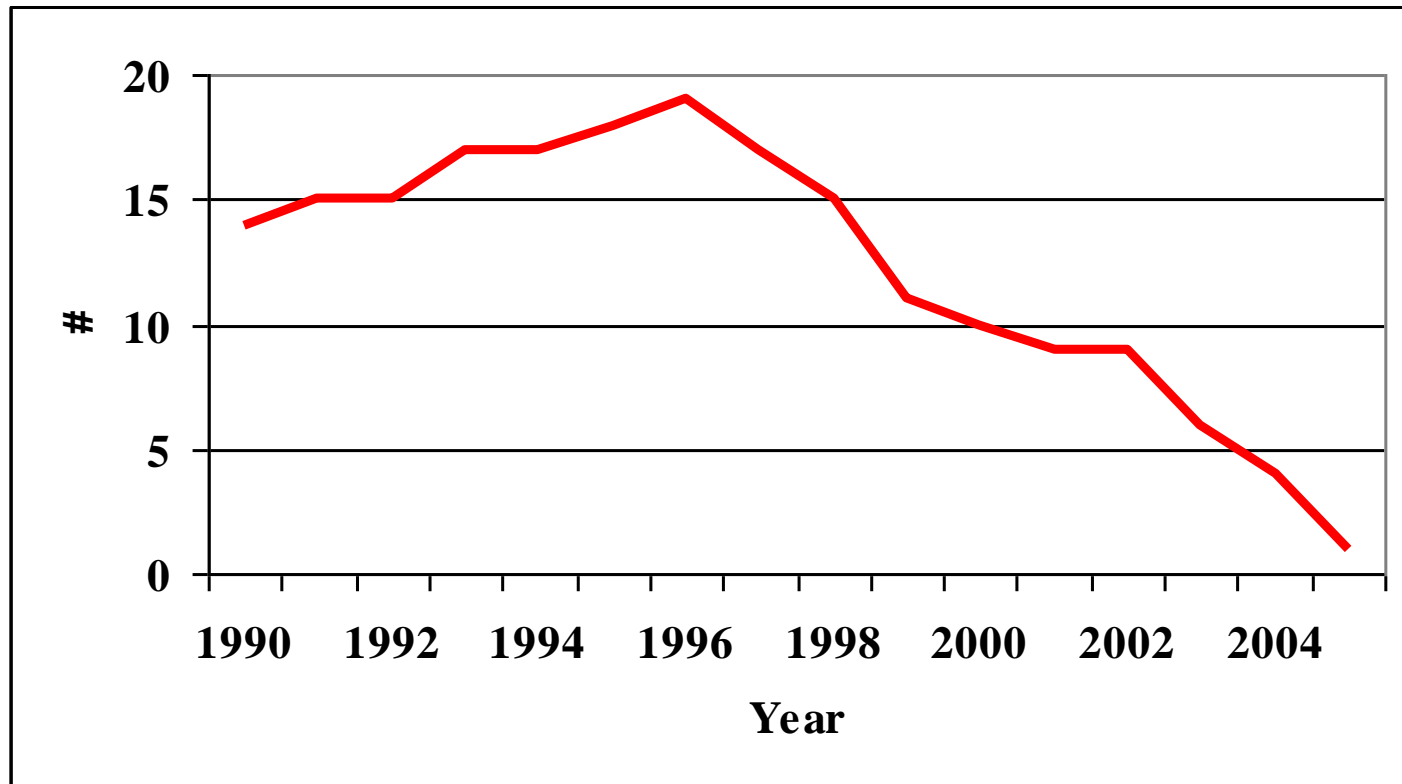
The prediction did not anticipate, the **intense** selection pressure placed on glyphosate in agronomic systems

- >90% of cotton and soybean acreage shifted to glyphosate-resistant crop cultivars
- Price reductions of generic glyphosate made it the herbicide of choice
- Reduced rates of glyphosate (likely) common





# Number of different herbicides used on $\geq$ 5% of U.S. soybeans

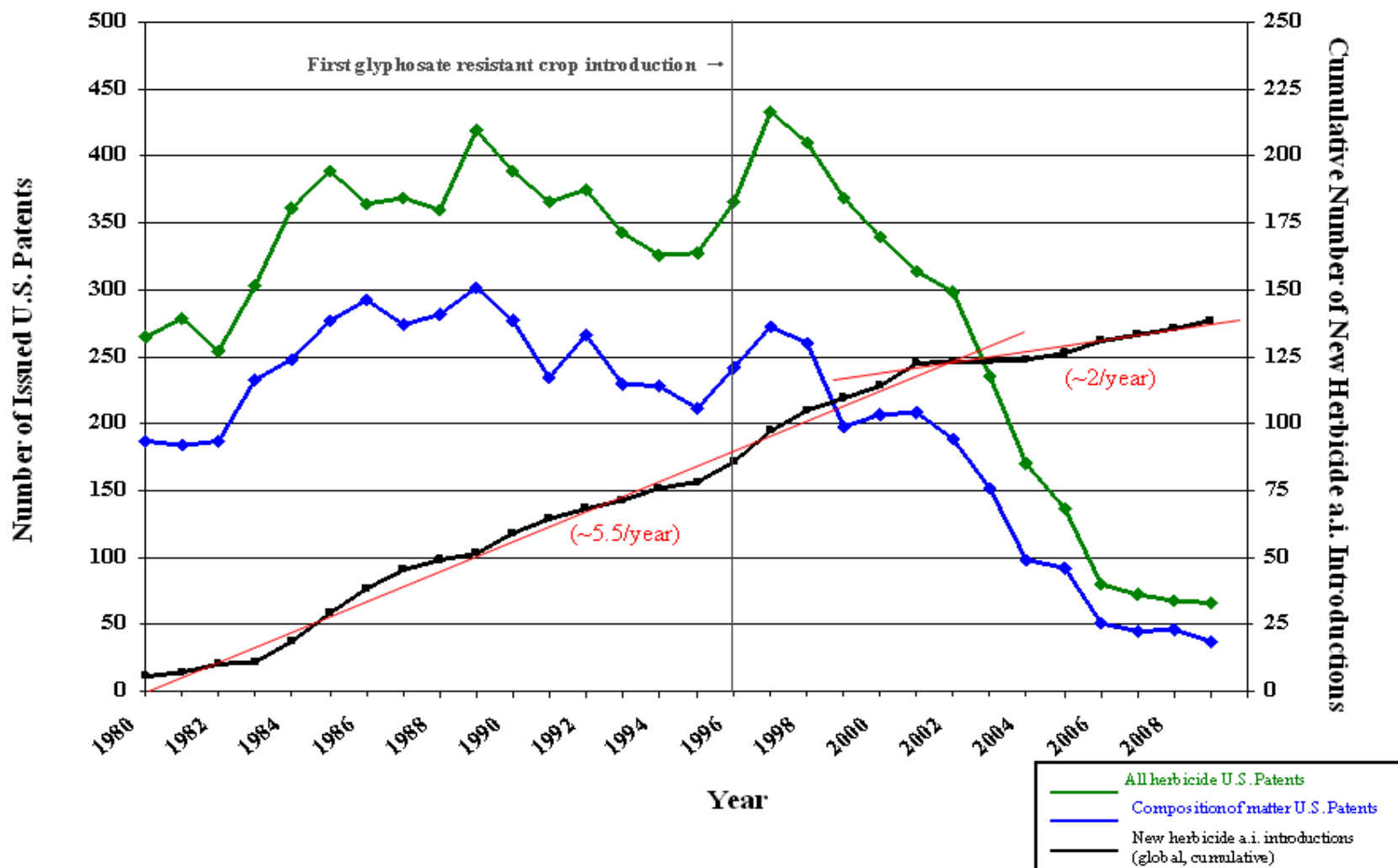


Source: USDA, Young

# **% of cotton acres applying weed management practice**

Practice	1996	2000	2007
Genetically modified herbicide resistant seed	not reported	58	90
Field scouted for weeds	71	82	92
Burndown herbicide used	6	23	41
Pre-emergence weed control	90	79	73
Post-emergence weed control	62	76	89
Cultivated for weed control	89	63	38

# Herbicide Innovation: A 30 Year Look at U.S. Patents and New Active Ingredient Introductions<sup>1</sup>



From Gerwick, Sept., 2010, Agrow



# Current Status of Resistance

No herbicides with new mechanisms of action are in advanced development trials. **The last new mechanism of action was introduced over 20 years ago;** therefore, we will have to rely on currently available herbicides for the foreseeable future.



# U.S. Species with Confirmed Glyphosate Resistance

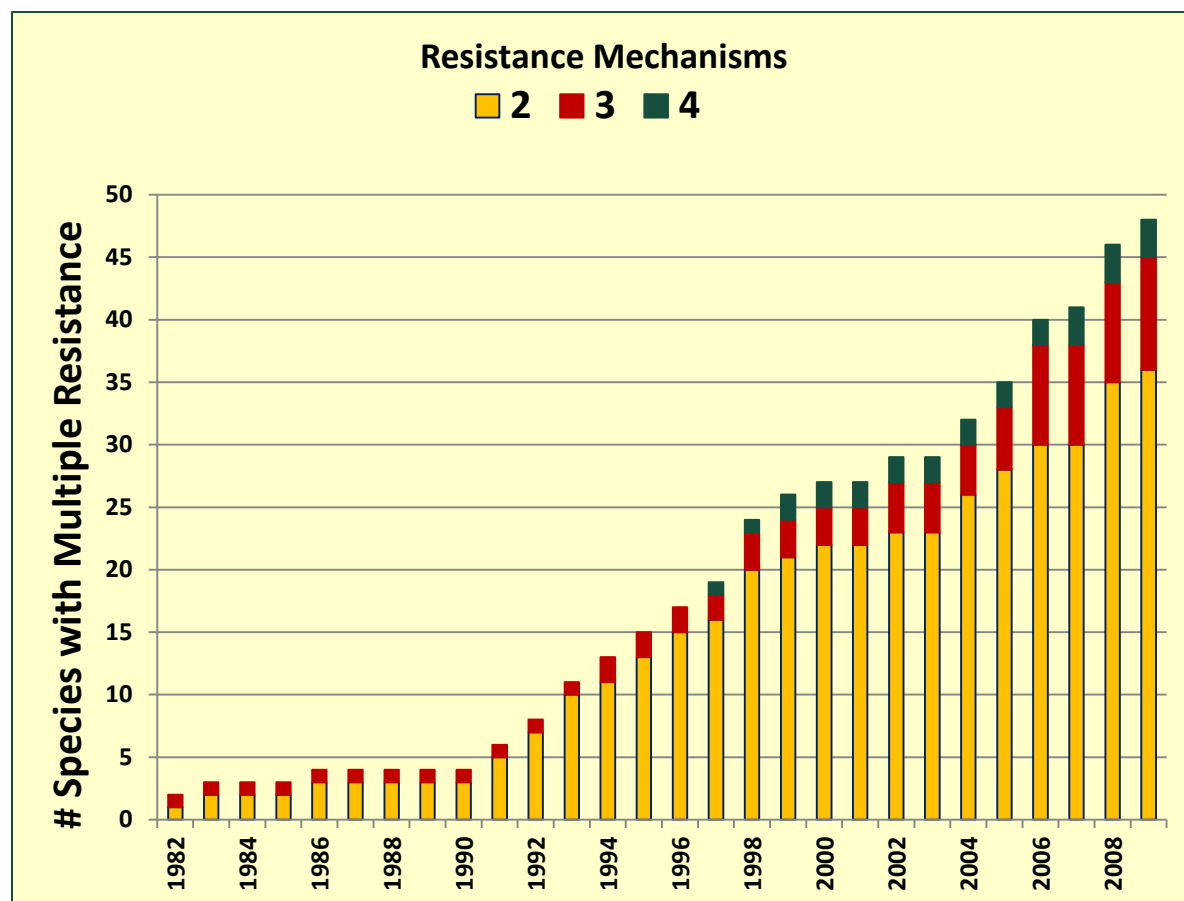
- Palmer amaranth (*Amaranthus palmeri*)
- Common waterhemp (*Amaranthus rudis*)
- Common ragweed (*Ambrosia artemisiifolia*)
- Giant ragweed (*Ambrosia trifida*)
- Hairy fleabane (*Conyza bonariensis*)
- Horseweed (*Conyza canadensis*)
- Italian ryegrass (*Lolium multiflorum*)
- Rigid ryegrass (*Lolium rigidum*)
- Johnsongrass (*Sorghum halepense*)

***Thirteen species in other countries, but not U.S.***

# Weeds with Resistance to More than one Mechanism of Action

The number of weed species with resistance to more than one herbicide mechanism of action has increased drastically since 1990. Currently, 50 weed species with multiple forms of resistance have been confirmed.

Source: [www.weedscience.org](http://www.weedscience.org),  
Ian Heap, March 2011





**Palmer amaranth in GA with  
resistance to both the ALS and  
glycine mechanisms of action**

**Weathermax 88 oz.**

**Staple LX 10 oz.**



# Federal Agency Responses

- **Environmental Protection Agency** – pressure to “do something” has led to questions regarding regulations, or alternatives thereof
- **USDA Animal Plant Health Inspection Service** – role of resistance management in approving new biotech crops
- **USDA Natural Resources Conservation Service** – impact of herbicide resistance on conservation systems

# **Strategic Solution**

- **National Leadership by the Weed Science Society of America**
- **Recommendations to Conserve Herbicide Mechanisms of Action**
  - **Presented at the ‘Weed Resistance Summit’ sponsored by the National Research Council at Washington, D. C., May 10, 2012**

# Recommendations Impacting Grower Practices

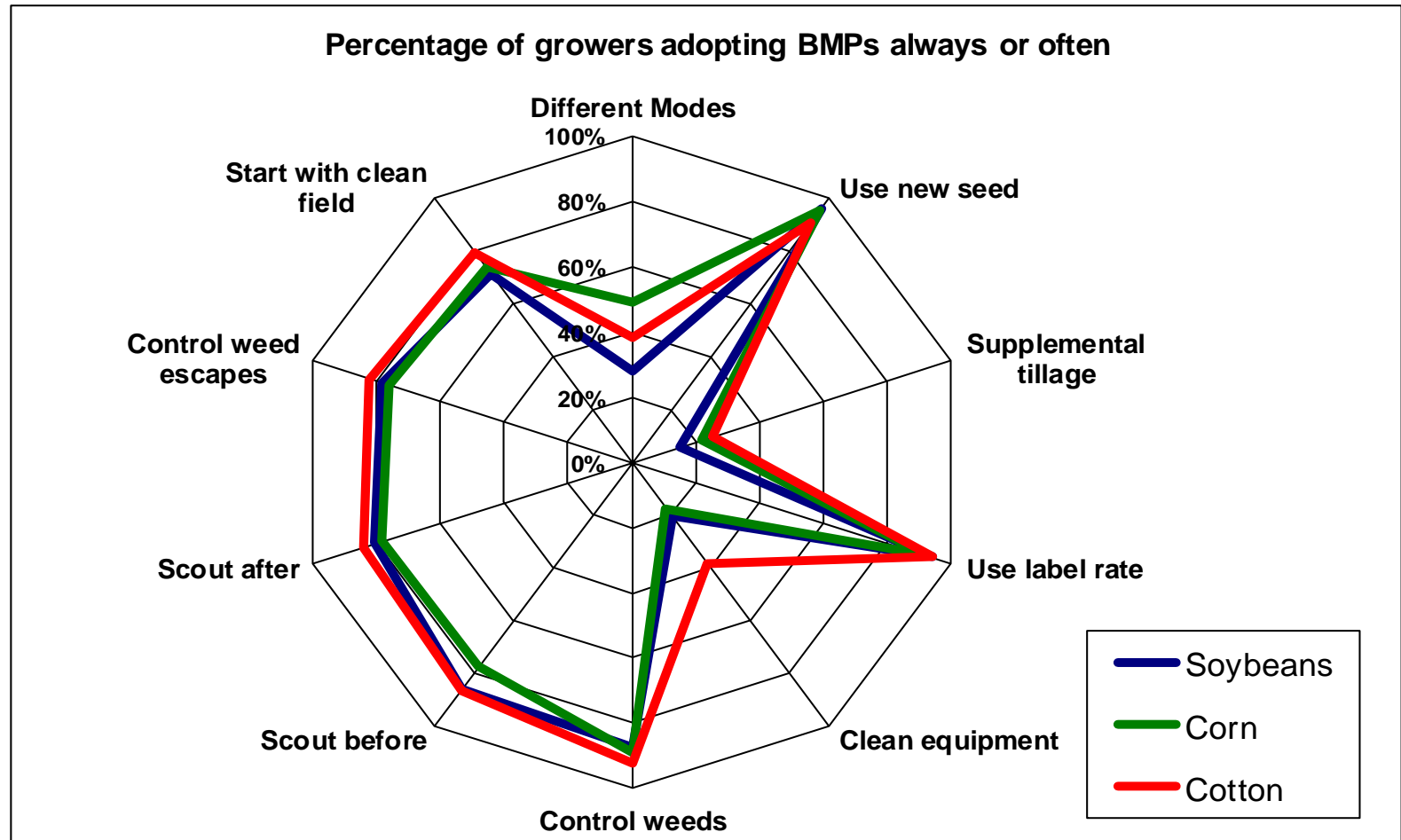
## Manage Herbicides to Retard Resistance

Applications: Use Full Label Rates

Within-Season: Diversify Mechanisms of Action

Between-Seasons: Rotate Traits and Herbicides

# Adoption of Best Management Practices Varies More Across Practices than Crops





# Current Status of Herbicide Resistance in Weeds

## Lesson 1

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# Objectives

By the end of this lesson, you will:

Understand the need for managing herbicide resistance in weeds.



Know the current status of herbicide resistance in weeds.



*Above: Seedling stage of kochia, a weed that is known to be resistant to several herbicides.*

*Image number 5361300 at [www.invasive.org](http://www.invasive.org).*

# How Herbicides Work

## Lesson 2

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# Objectives

By the end of this lesson, you will:

Know the terminology associated with herbicide use, including tolerance, chemistry, efficacy, timing, and placement of applications.



Understand how herbicides are categorized according to their mechanism of action.



*Above: Inflorescence of wild oat, a weed that is known to be resistant to several herbicides.*

*Image number 5404825 at [www.invasive.org](http://www.invasive.org).*

# What is Herbicide Resistance?

## Lesson 3

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# Objectives

By the end of this lesson, you will:

Understand what herbicide resistance is and how it evolves in the field.



*Above: Redroot pigweed in an onion field. Redroot pigweed is a weed that is known to be resistant to several herbicides.*

*Image number 5362588 at [www.invasive.org](http://www.invasive.org).*

Recognize the factors that influence selection for herbicide resistance.

Define the different types of herbicide resistance.

# Scouting After a Herbicide Application and Confirming Herbicide Resistance

## Lesson 4

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# Objectives

By the end of this lesson, you will:

Understand the importance of scouting for herbicide-resistant weeds.



Know the factors that can contribute to weeds being present after a herbicide application.



Know how to identify herbicide resistance in the field.



Understand when to suspect and test for herbicide resistance in the field.



Know procedures for confirming herbicide resistance.



*Above: Italian ryegrass is a weed that is known to be resistant to several herbicides.*

*Image number 5387406 at [www.invasive.org](http://www.invasive.org).*

# Principles of Managing Herbicide Resistance

## Lesson 5

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# Objectives

By the end of this lesson, you will:

Understand that diversity is an important concept in the management of herbicide-resistant weeds.



Identify the broad strategies and specific tactics for managing herbicide-resistant weeds.



Compare the value of proactive versus reactive management for herbicide-resistant weeds.



*Above: Seedling stage of waterhemp, a weed that is known to be resistant to several herbicides.*

*Image number K8040-1 at the USDA-ARS online image gallery.*



# Collaborations/Initiatives

## With EPA

Development of Herbicide Product Label Language

- Mechanism of Action Group number display
- Text associated with Mechanism of Action Group
- Resistance Management Plans

## With USDA-APHIS

Reports:

- I Summarizing current state of resistance
- II Best management practices and obstacles to adoption

## With USDA National Resources Conservation Service (NRCS)

Concerns about impact of Herbicide Resistance on conservation

- Collaborative meetings leading to
- Adoption of best management practices

## With Industry, Commodity Groups

Resistance Education/Training Modules

# The Path Forward....

Continue and increase:

- Emphasis on education and training (deliver a consistent message)
- Emphasis on research (basic and best method)
- Development of new weed control options

**Cooperation between all parties is critical for  
.....SUCCESS**