



# Resisting resistance: Strategies for maintaining chemical control efficacy

Devon Carroll, Ph.D.



Herbicide resistance

=

herbicide DOES NOT work anymore

# Key Definitions

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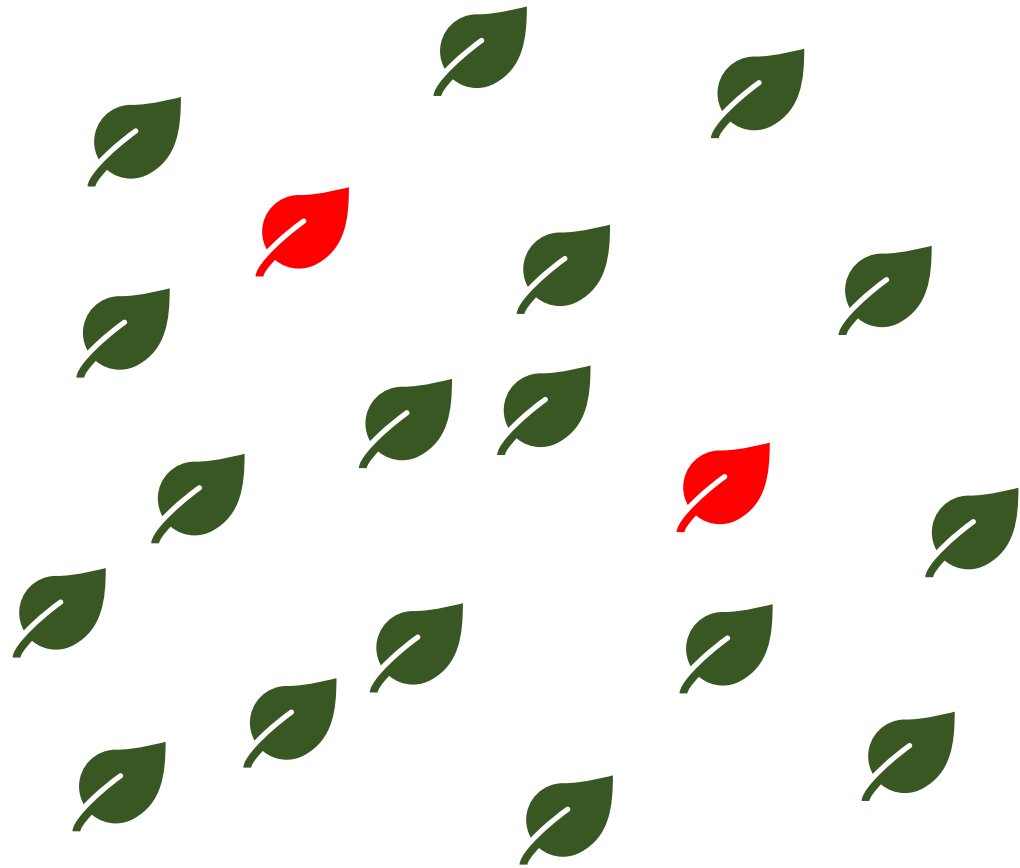
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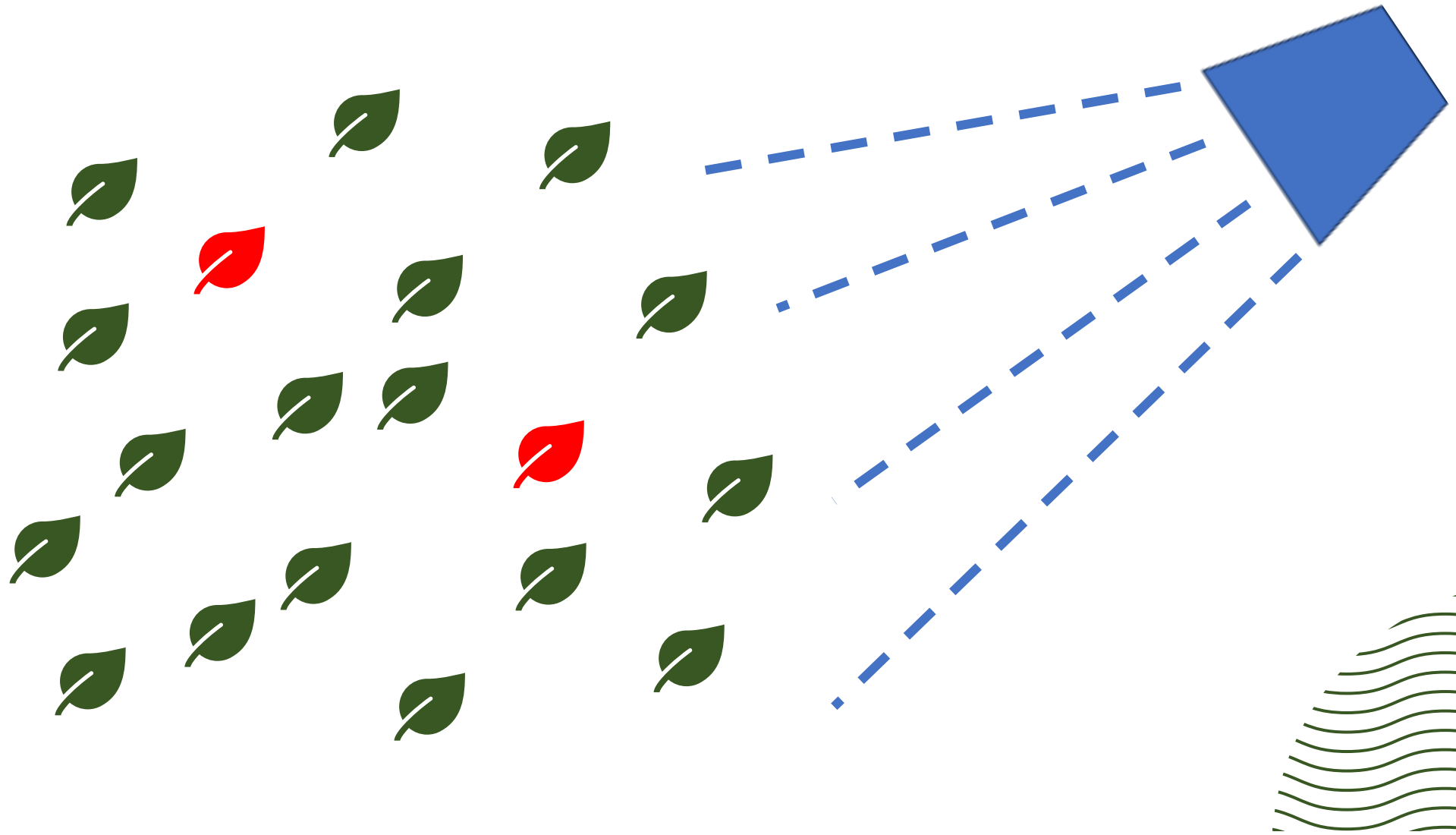
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- No change in herbicide response
- No selection or genetic manipulation
- Plant was never susceptible

# How Resistance Occurs



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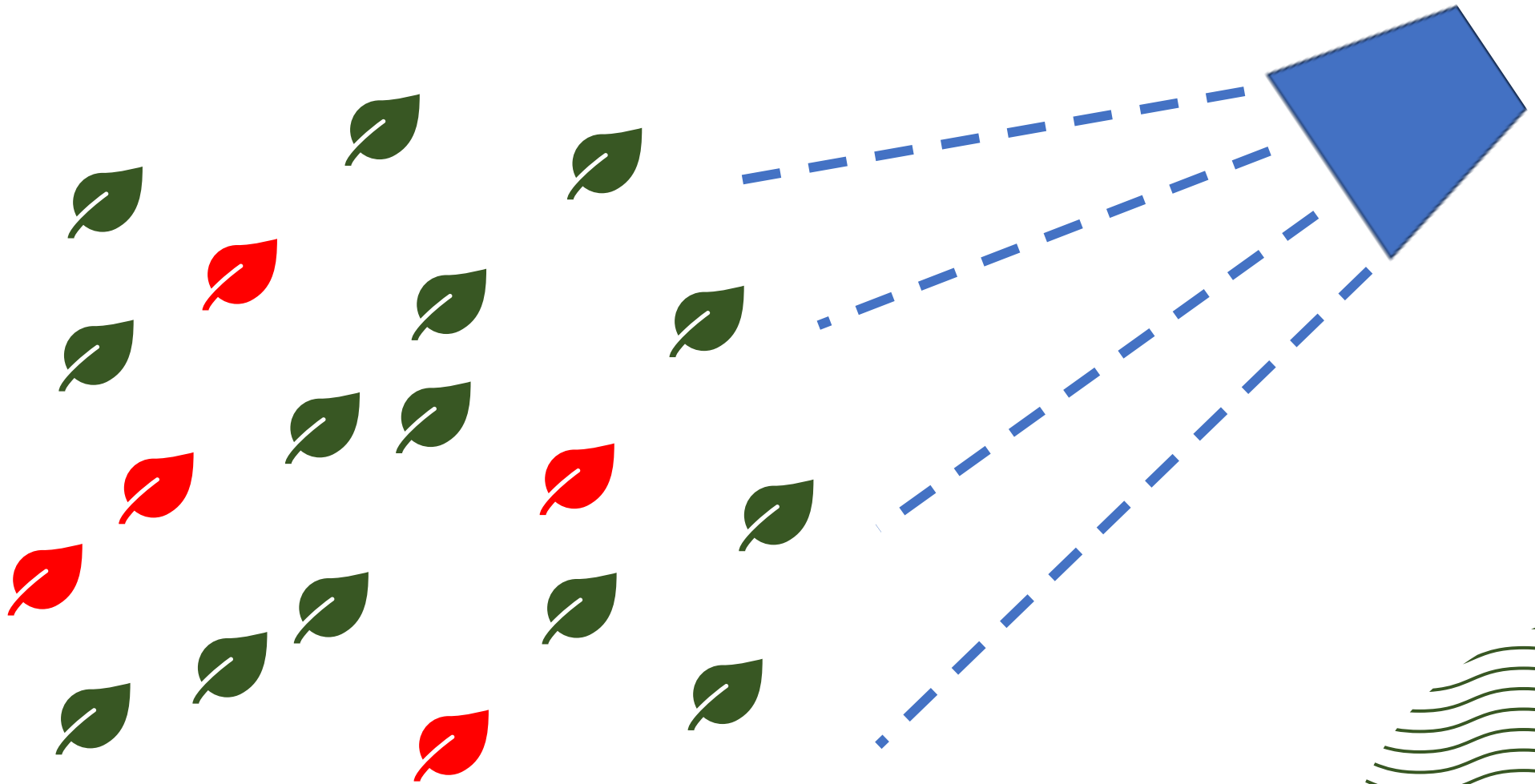


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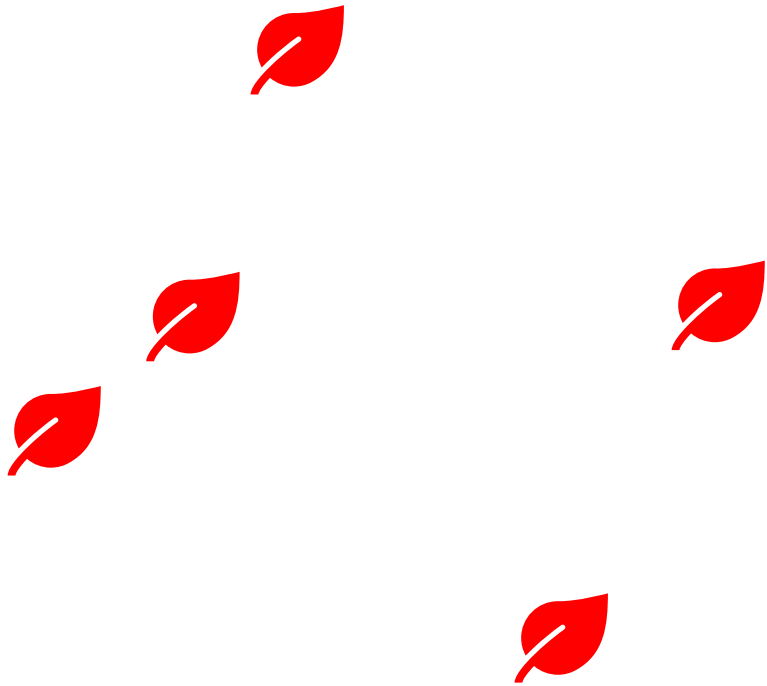




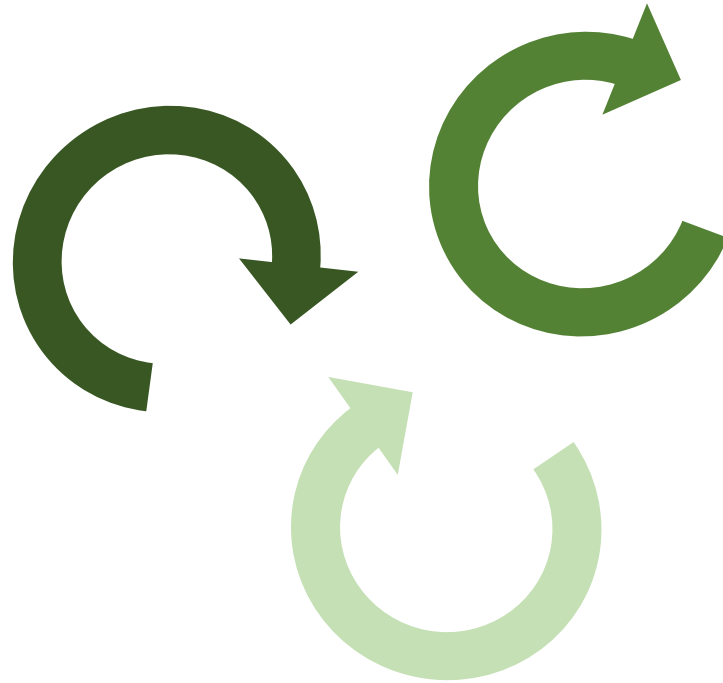
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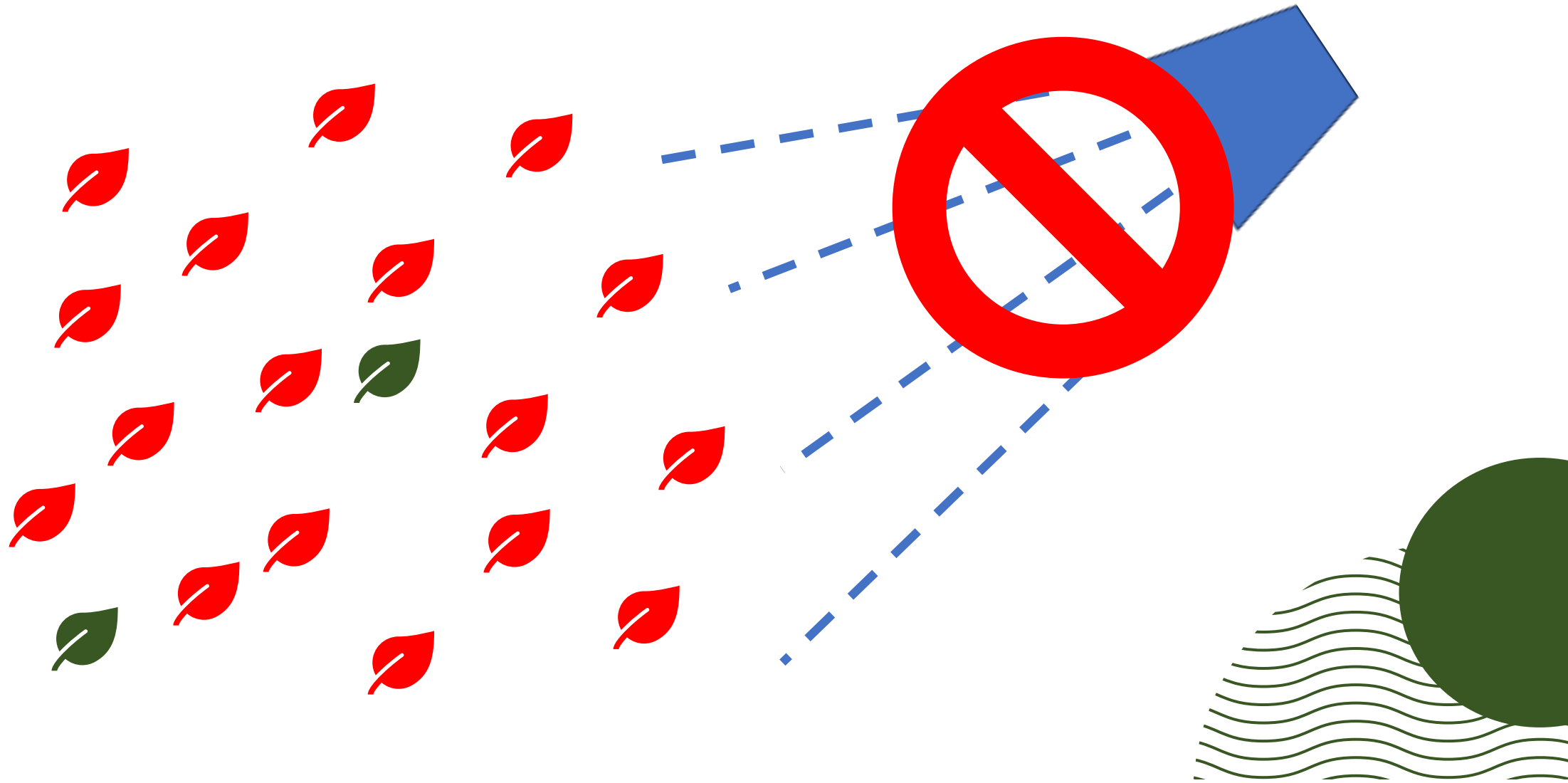
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Now what?

# How herbicides work

To be effective, an herbicide must **BIND** to its site of action

- 1) Get in the plant (penetration/uptake)
- 2) Move to site of action (translocation)
- 3) **BIND** to site of action

Lock = binding site  
Key = herbicide

Must match for efficacy!





# Types of Resistance

## Target Site (TSR)

Genetic mutation that **alters the binding site**

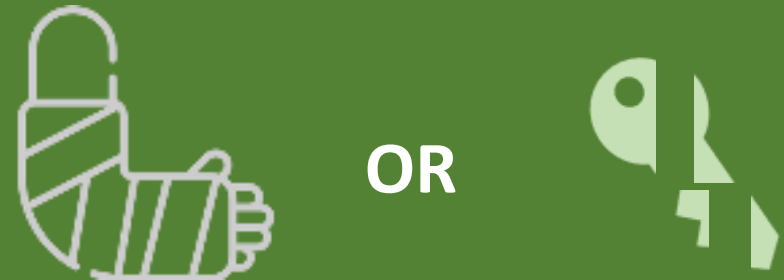
Confers high level of resistance



## Non-Target Site (NTSR)

Blocks **reaching binding site**  
(e.g., uptake, translocation, *metabolism*)

Can cause multiple/cross resistance



# Metabolic (NTSR) Resistance

- Plant gets good at clearing an herbicide with repeated use
- Metabolism becomes strong enough to clear other compounds
- Resistance to multiple chemistries



# Types of Resistance

Multiple = more than 1 mode of action

Greater loss of tools

Cross = across chemical classes

Loss of a single MOA

# Why does this matter?

## Cost

- More applications = more \$ in labor
- Effective program/chemistry likely more expensive

## Convenience

- Mechanical control is not easy
- Weeds impact playing conditions

## Stewardship

- Seed can spread
- Public perception of improper pesticide use



# *Poa annua* as a case study

- Ranked by Weed Science Society of America as **#1 most troublesome** turfgrass weed
- Resistant to **10 MOAs** totaling **20 active ingredients** in turf
  - Single population resistant to **9 chemistries!**
- Single plant can produce > 2,000 seeds per year (Mitich 1998)
- Resistance can sometimes confer a fitness enhancement (longer roots)



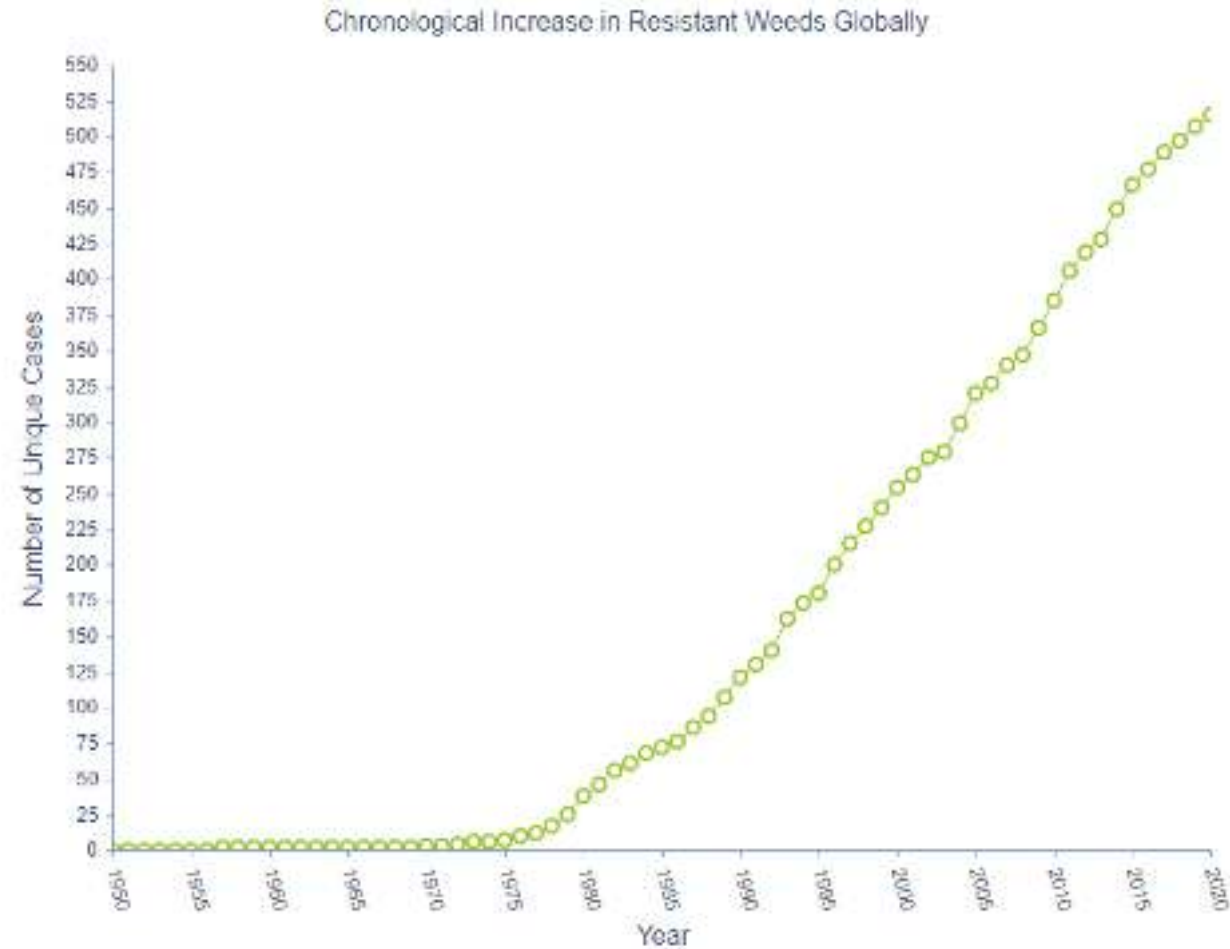
# Management cost comparison

Before Resistance		After Resistance	
HERBICIDE	COST	HERBICIDE	COST
ROUNDUP (64 FL OZ/A)	\$2,000	PRINCEP (2 QT/A) 100 ACRES	\$1,000
BARRICADE (48 FL OZ/A)	\$7,988	RONSTAR FLO (0.78 GAL/A) 190 ACRES	\$23,712
***APPLIED ACROSS 200*** ACRES		FINALE (1.5 GAL/A) 35 ACRES	\$2,152
		ROUNDUP (64 FL OZ/A) 155 ACRES	\$1,550
\$9,988 = \$50 /acre		\$28,614 = \$143 /acre	

# Resorting to extreme measures...

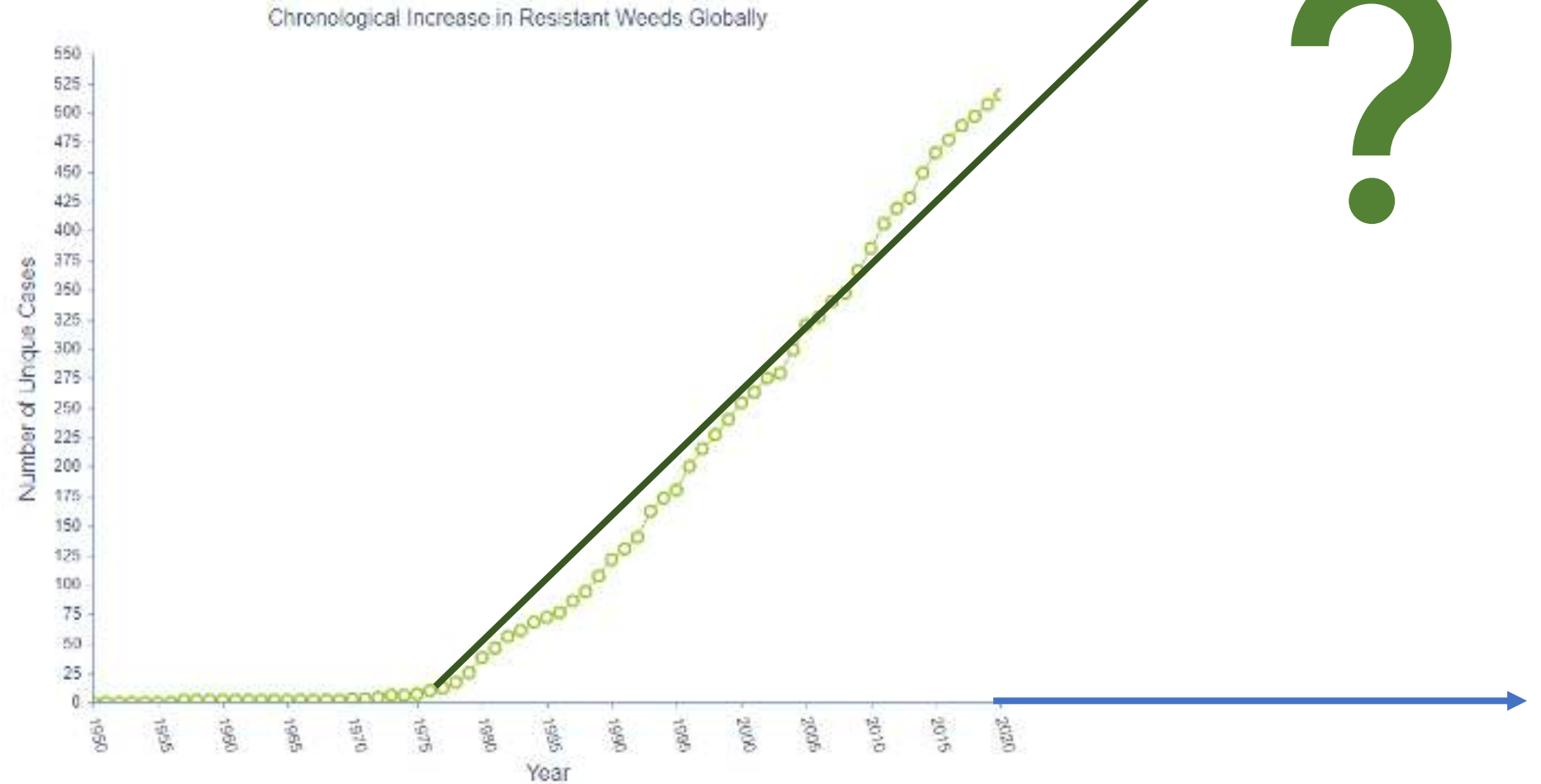


# Resistance Evolution Over Time





# Resistance Evolution Over Time



Assessing  
&  
Preventing (Resisting)  
Resistance

# Influences on speed of development

## Herbicide use

- Available chemistry
- Dosage
- Frequency

## MOA use

- Some occur quicker
- Mixing
- Rotating

## Weed biology

- Seed production
- Frequency in biotypes

# Know Where You Stand

- Do you have any known existing resistance?
- Which weeds species are high risk for resistance development?
- What is the application history on your property?
- Are there instances of failed weed control?



# Remember failure $\neq$ resistance

## First consider ...

- Labeling
- Rate
- Timing of application
- Application quality
- Weather



# How do we know if resistance occurs? (Field)

- Chemistry stopped working
- Control differences
- Patches of failure

**Scout, Record, Monitor!**





# How do we know if resistance occurs? (Lab)

- Can scientifically confirm
- Heritable
- Compare to a known susceptible
- Rate response



# Resistance Snapshot in Turf

- 9 species confirmed in turfgrass sites
- Grass weeds biggest issue
  - *Poa annua* (annual bluegrass), *Eleusine indica* (goosegrass), & *Digitaria* spp. (crabgrass)
  - Hard to control grass in grass = fewer chemical options
- Less resistance in BLW, more options... easier to rotate/mix
  - *Chamaesyce maculata* (spurge), *Plantago lanceolata* (buckhorn plantain), *Soliva sessilis* (burrweed)
- Sedge resistance an **increasing problem**



# Preventing Resistance

**Do not** use the same herbicide over and over

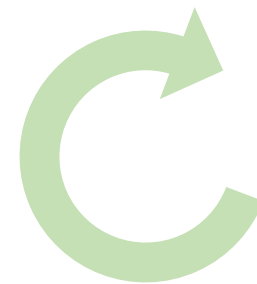
**Mix** (herbicide A + herbicide B in same year)

or

**Rotate** (herbicide A year 1, herbicide B year 2)

**Mixing > rotating**

Don't want escapes!



# Other Methods for Preventing Resistance

- Keep site weed free
- Maintain healthy turf
- Seed quality/bedding
- Prevent escapes... before they set seed!
- Scout
- Integrated pest management (IPM)
- Pesticide stewardship
  - Always apply at labeled rate and weed growth stage
  - Rate on high side when possible
  - Treatment > on young weeds

# Resources

weedsience.org

The screenshot shows the homepage of the International Herbicide-Resistant Weed Database. At the top, there is a navigation bar with icons for Home, About Us, FAQ, Comment, Login, and LogOut. Below this is a banner with the title "INTERNATIONAL HERBICIDE-RESISTANT WEED DATABASE". Underneath the banner is a secondary navigation bar with icons for Quick Stats, Recent Cases, Researchers, Add New Case, Download PowerPoint Graphs, and Show Site Menu.


The main content area is divided into several sections for filtering search results:

- Weed Species:** A dropdown menu on the left lists species like *Echinochloa erecta*, *Echinochloa crusgalli*, *Echinochloa polypogon (2E. 2)*, *Echinochloa polypogon*, and *Echinochloa polypogon*. A search box on the right contains "Echinochloa indica".
- Herbicide Groups:** A dropdown menu on the left lists groups like HRAC 1 (Inhibition of Acetyl CoA Carboxylase), HRAC 2 (Inhibition of Acetolactate Synthase), and HRAC 3 (Inhibition of Microtubule).
- Herbicides:** A dropdown menu on the left lists herbicides like atrazine, glyphosate, and others. "glyphosate" is currently selected and highlighted in yellow.
- Countries:** A dropdown menu on the left lists countries like Argentina, Australia, Austria, and Belgium.
- States:** A dropdown menu on the left lists states like Alabama, Alaska, Arizona, and Arkansas. Above it are buttons for "US", "AU", and "CA".
- Crops:** A dropdown menu on the left lists crops like Rice, Rice Paddy Levee, Roadside, and Rubber. A search box on the right contains "Turf".

At the bottom of the page, there are two buttons: "Search" and "Clear".











# Resources

# weedscience.org

 Export returned data in Excel

#	Year	Species	Country	MOAs	Actives	Situations
1	1992	<a href="#">Eleusine indica</a>	United States (Georgia)	Inhibition of Microtubule Assembly HRAC Group 3 (Legacy K1)	trifluralin	Cotton, Golf courses, Turf
2	2003	<a href="#">Eleusine indica</a>	United States (Hawaii)	PSII inhibitors - Serine 264 Binders HRAC Group 5 (Legacy C1 C2)	metribuzin	Turf
3	1988	<a href="#">Eleusine indica</a>	United States (Tennessee)	Inhibition of Microtubule Assembly HRAC Group 3 (Legacy K1)	prodiamine, pendimethalin, trifluralin	Cotton, Golf courses, Turf

 Overview	 Filter Data	 Charts	 Maps	 Mutations
 Herbicides	 Weeds	 Crops	 Papers	 Resources

# Questions?

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