



# Herbicide Resistance: Causes, Consequences and Mitigation

Charlie Reinhardt  
Villa Academy  
[www.villaacademy.co.za](http://www.villaacademy.co.za)



IPPS 2017, Tzaneen,  
2 March 2017

## **Weed impacts are multi-faceted, and affect:**

- **Crop yield, which impacts on grower income**
- **Crop quality, which impacts on crop price**
- **Problem plants reduce carrying capacity of livestock and game farms**
- **Alien invasive plants threaten natural vegetation**
- **Recreational activities**
- **Environmental aesthetics**
- **Land value**

**Why should nurseries care about weeds?**





















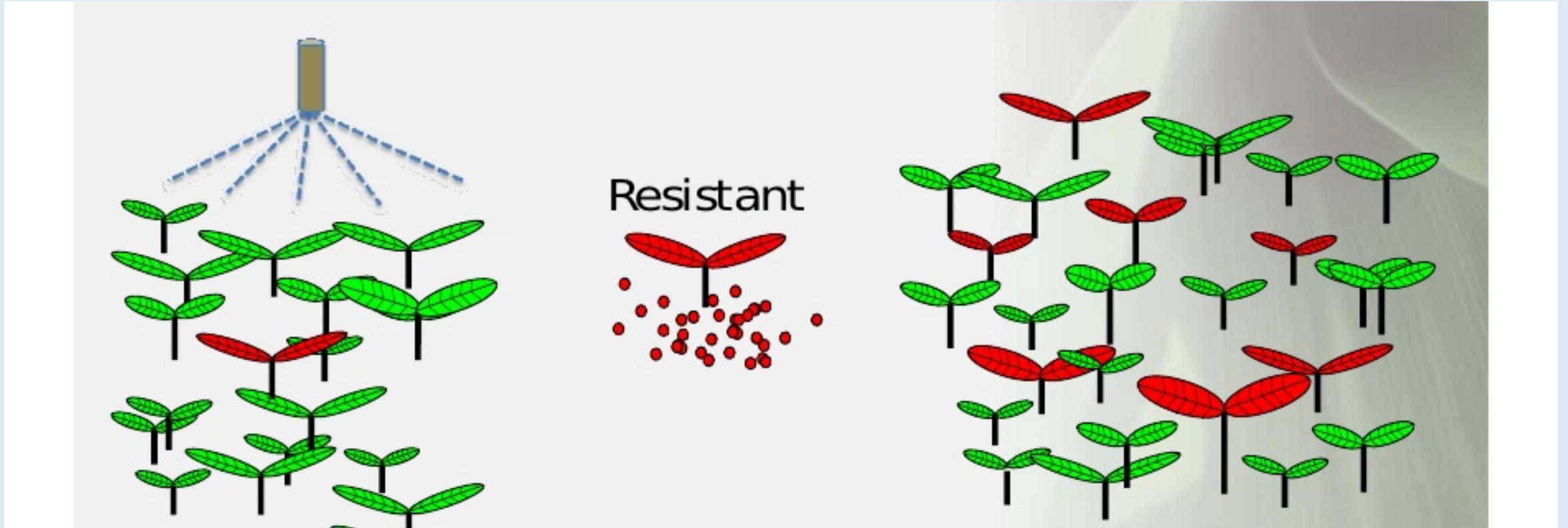




## **Other aspects of weed management where nurseries ought to vigilant:**

- **Import and distribution of alien invasive weed species.**
- **Distribution of weeds to areas where they did not occur before.**
- **Control methods that cause shifts in weed species.**
- **Herbicide use that promotes evolution of herbicide-resistant weeds.**

# Evolution of herbicide-resistant weeds

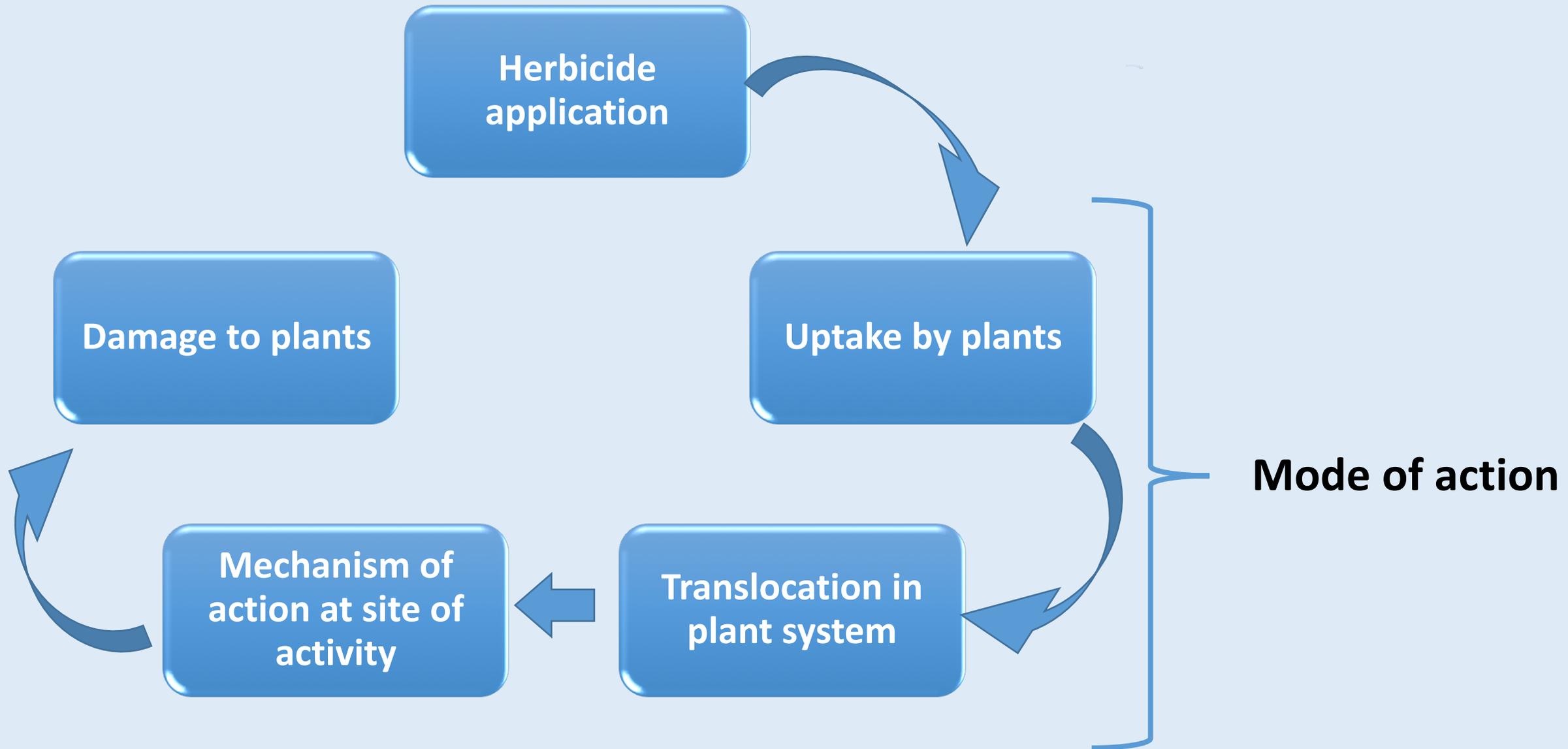


The natural frequency of herbicide resistant individuals: **“one in a million”**

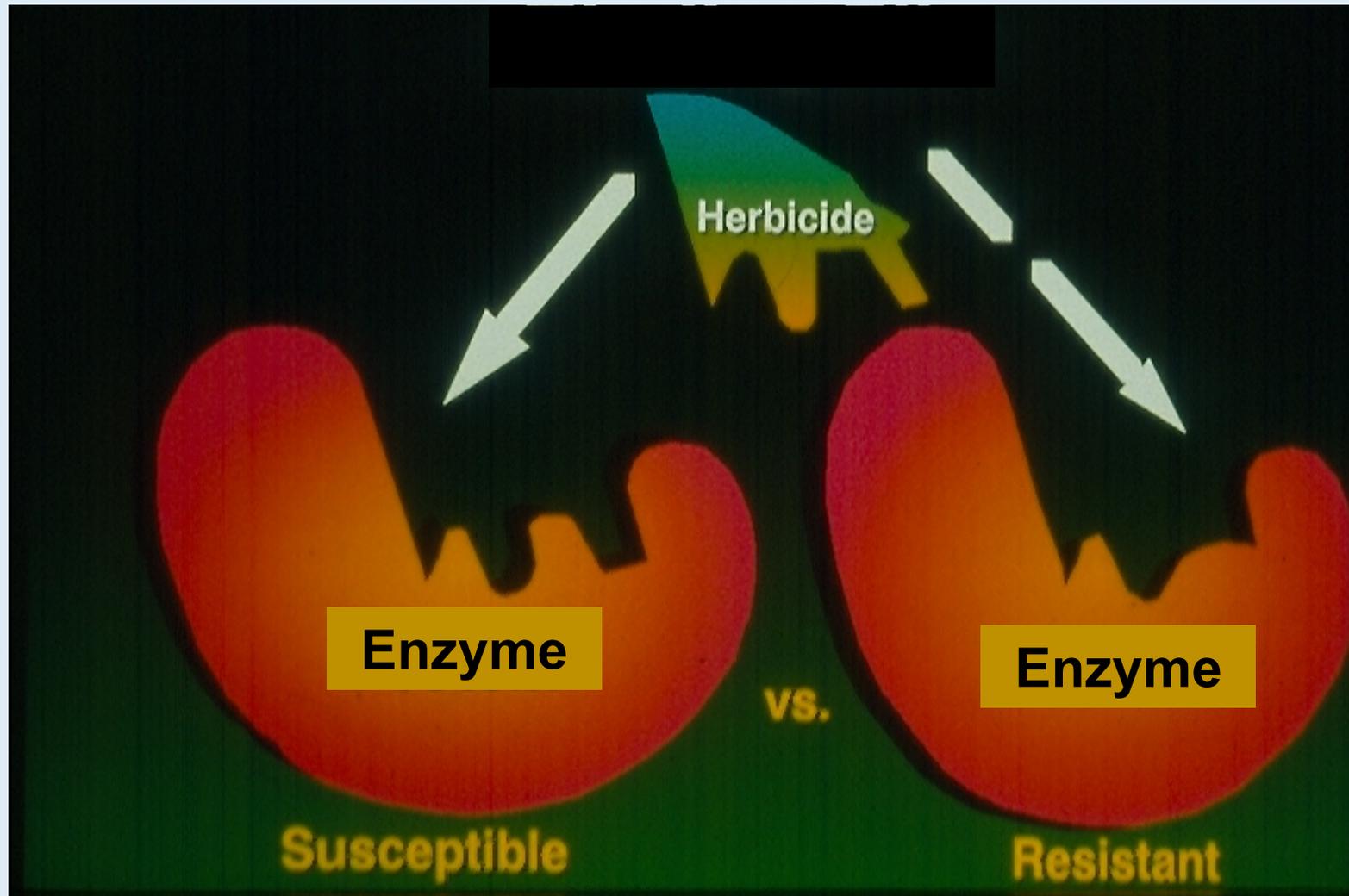
## **Definition of herbicide resistance (Heap 2017)**

**“The evolved capacity of a previously herbicide-susceptible weed population to withstand the herbicide, and to complete its life cycle, when the herbicide is used at its normal rate in an agricultural situation”.**

# HOW HERBICIDES WORK



# Mutation at site-of-action (enzyme) confers herbicide resistance



# International Survey of Herbicide-Resistant Weeds

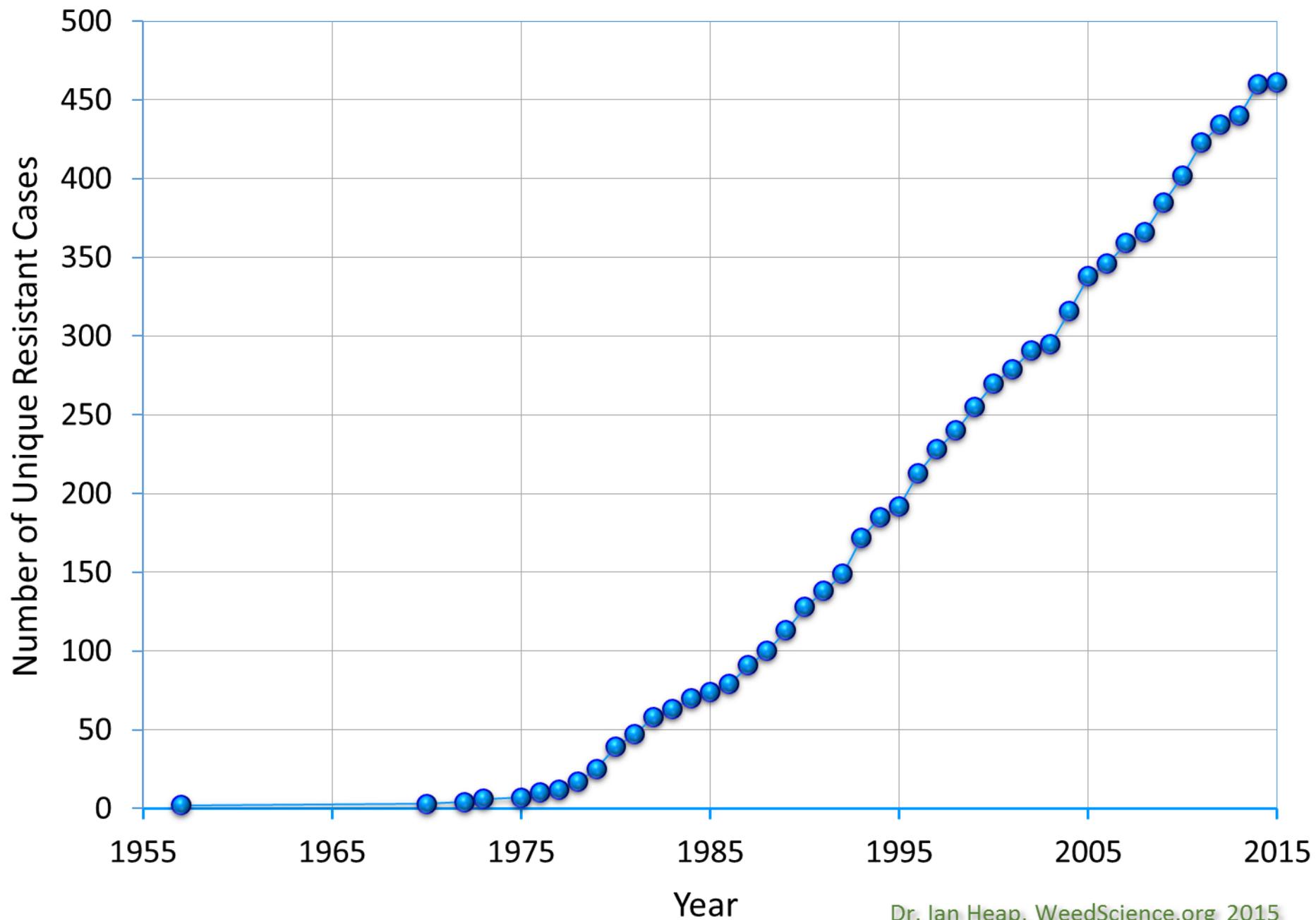
[www.weedscience.org/](http://www.weedscience.org/)

Dr Ian Heap – [ianHeap@weedscience.org](mailto:ianHeap@weedscience.org)

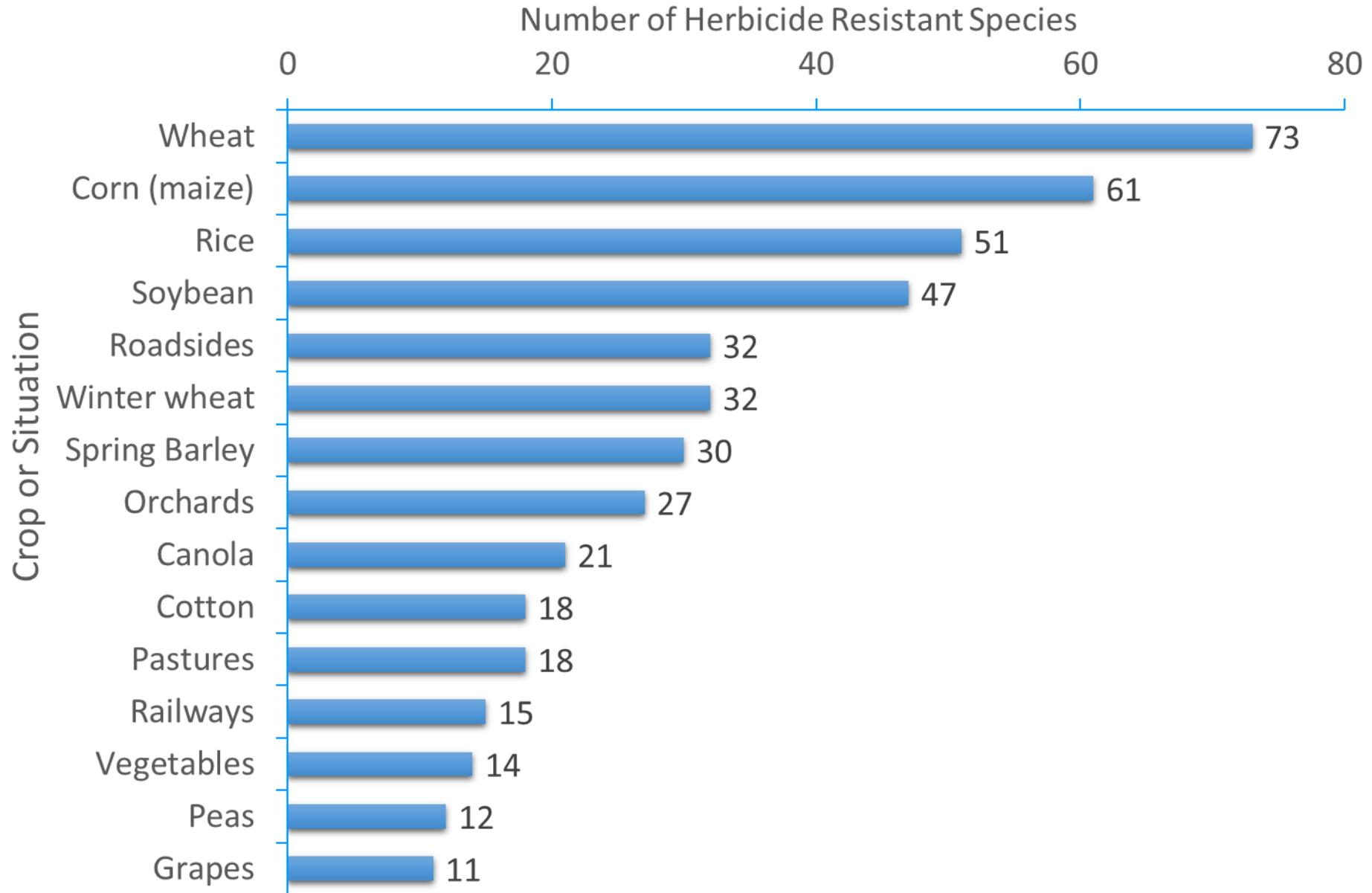
Currently **470 unique cases** of herbicide resistant weeds globally, with **250 species** (145 dicots and 105 monocots). Weeds have evolved resistance to **23 of the 26 known herbicide sites of action** and to **160 different herbicides**. Herbicide resistant weeds have been reported in **86 crops in 66 countries**.

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

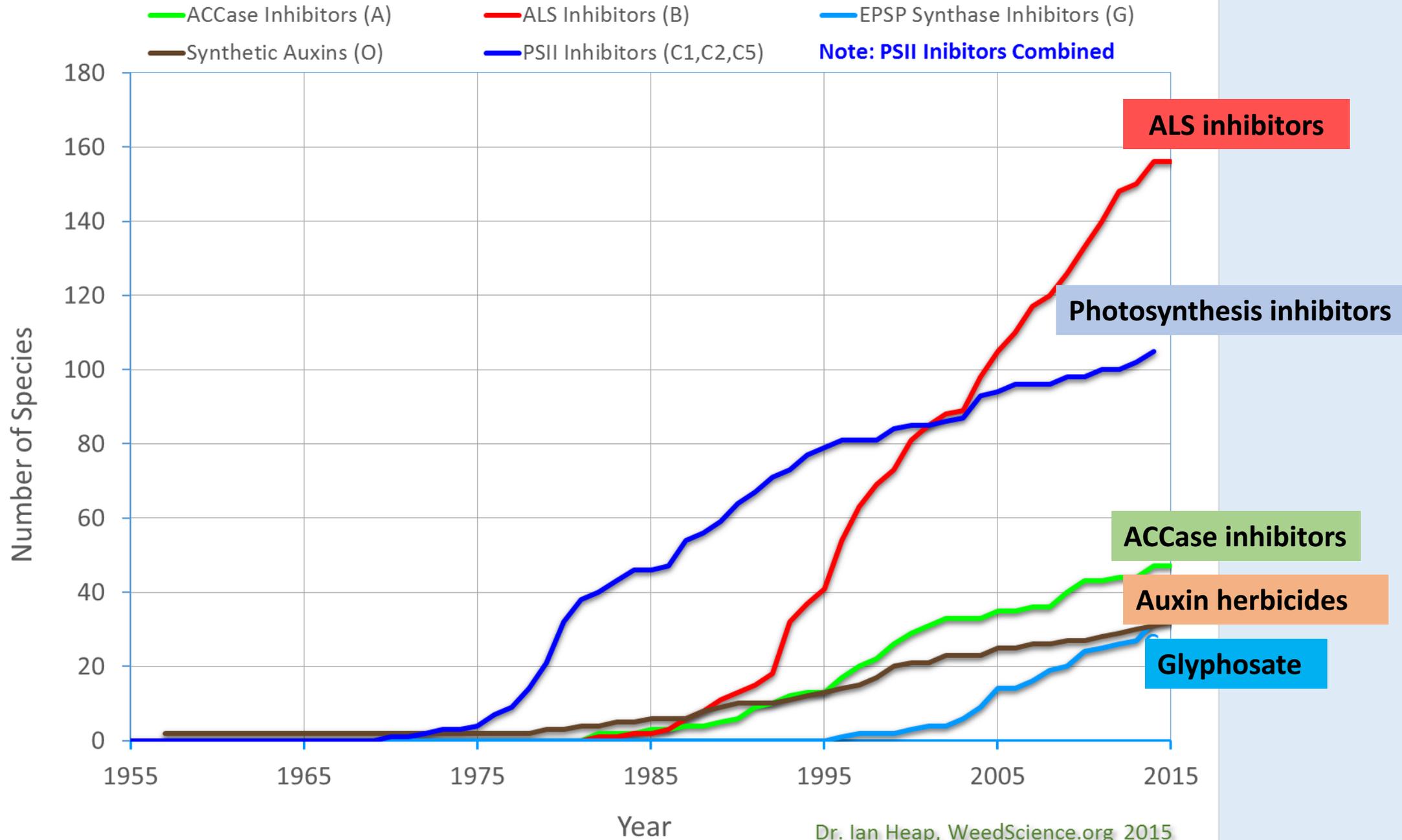
## Global Increase in Unique Resistant Cases



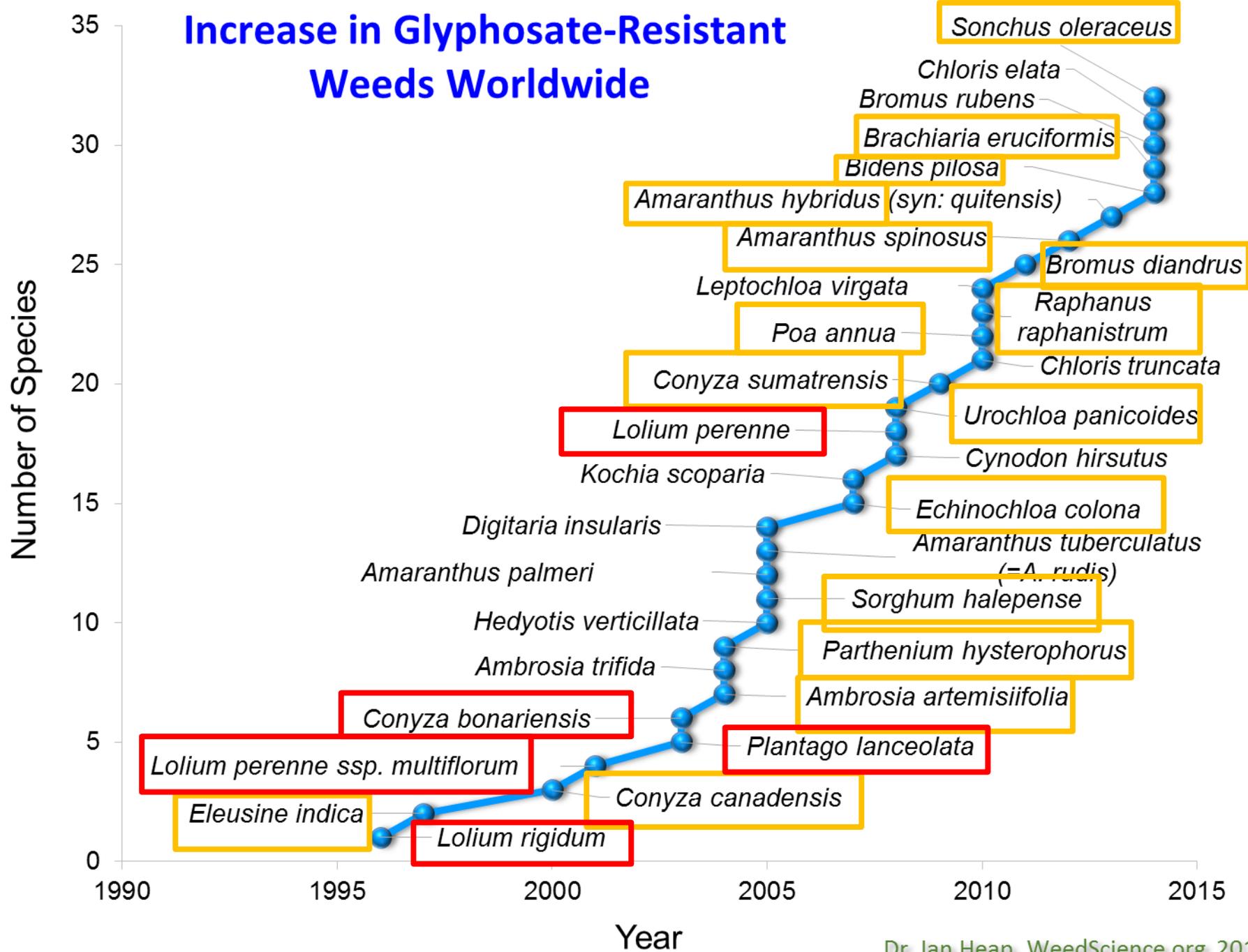
# Number of Herbicide-Resistant Species by Crop



# Number of Resistant Species for Several Herbicide Sites of Action (HRAC Codes)



# Increase in Glyphosate-Resistant Weeds Worldwide



# Herbicide resistance cases relevant for nurseries

Global situation: [www.weedscience.org/](http://www.weedscience.org/)

Situation	Global no. of species	How many of those species also occur in RSA?
Nurseries	10	7
Gardens	1	0
Golf courses	4	2 ( <i>P. annua</i> ; <i>E. indica</i> )
Built-up areas	1	1 ( <i>Lolium</i> )
Fruit	6	6
Forests	7 (All in Israel)	1
Turf	7	3
Vegetables	20	9

## **Common weeds of nurseries (under controlled conditions)**

**Note: The following list of weeds is not complete, and entrants will vary from location to location**

***Amaranthus hybridus*** (Pigweed)  
Herbicide resistance: 29 cases



***Amaranthus viridus***  
Herbicide resistance: 1 case



***Capsella bursa-pastoris***  
(Shepherd's purse)  
Herbicide resistance: 7 cases



13/07/2015

***Cardamine hirsuta*** (Bitter cress)  
Herbicide resistance: 0 cases





***Senecio vulgaris*** (Common groundsel)  
Herbicide resistance: 16 cases



***Sonchus oleraceus*** (Common sowthistle)

Herbicide resistance: 6 cases



***Oxalis corniculata*** (Yellow sorrel)  
Herbicide resistance: 0 cases



***Phyllanthus spp***  
Herbicide resistance: 0 cases



***Stellaria media*** (Common chickweed)  
Herbicide resistance: 22 cases



31/07/2015

***Drymaria cordata*** (Tropical chickweed)  
Herbicide resistance: 0 cases



***Euphorbia inaequilatera*** (Smooth creeping milkweed)  
Herbicide resistance: 0 cases



***Euphorbia hirta*** (Red milkweed)  
Herbicide resistance: 0 cases



USA

*Chamaesyce (=Euphorbia) maculata* (Spotted spurge)

South Africa



***Euphorbia heterophylla*** (Wild pointsettia)  
Herbicide resistance: 4 cases



***Conyza bonariensis*** (Hairy fleabane)  
Herbicide resistance: 19 cases



***Commelina benghalensis*** (Wandering jew)

Herbicide resistance: 0 cases



***Cyperus esculentus*** (Yellow nutsedge)  
Herbicide resistance: 1 case



***Lolium spp*** (Ryegrass)  
Herbicide resistance: 45 cases



***Poa annua*** (Wintergrass)  
Herbicide resistance: 28 cases



***Cuscuta campestris*** (Dodder)  
Herbicide resistance: 1 case



**SAHRI (SA Herbicide Resistance Initiative)  
at  
University of Pretoria**

website address:

<http://www.up.ac.za/sahri>

- **Screening of weeds in glasshouse for sensitivity/tolerance/resistance towards glyphosate.**
- **Elucidating mechanisms of resistance.**
- **Advocacy on “Best Weed Management Practices”.**

**The project is supported by Monsanto**



# Glyphosate dose-response screening

Recommended rate: 900 g a.e. ha<sup>-1</sup>

Population "A"



0

225

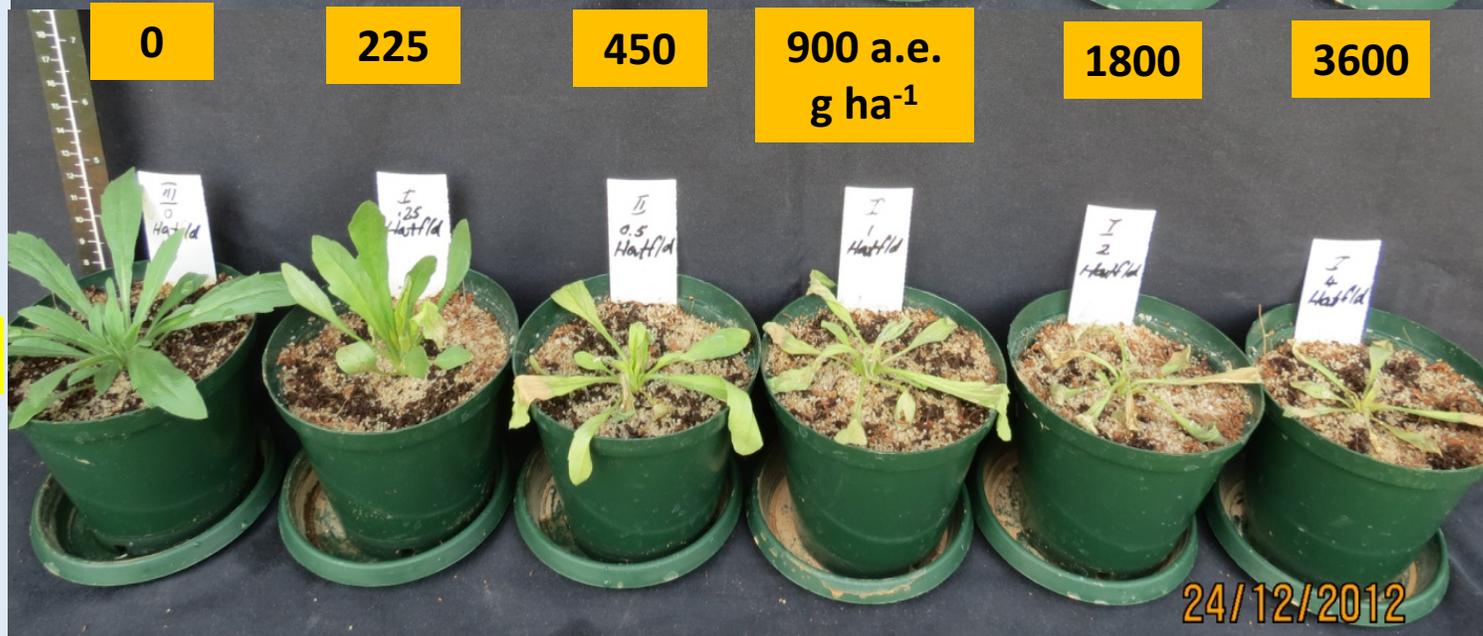
450

900 a.e.  
g ha<sup>-1</sup>

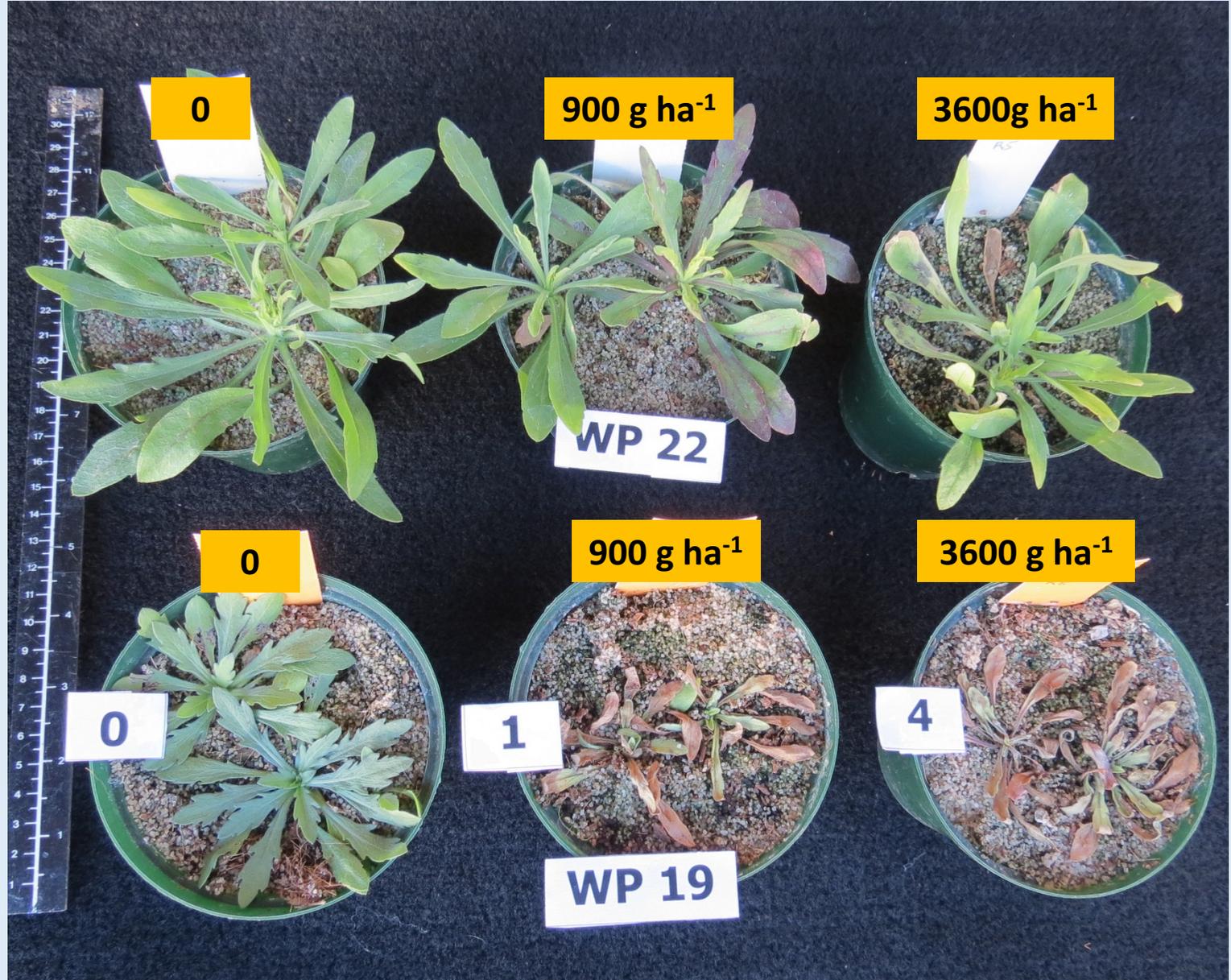
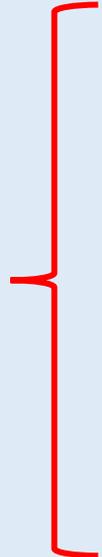
1800

3600

Population "B"



Glyphosate-resistant



Glyphosate-sensitive





24/12/2012



30/10/2013



25/03/2013

## **Golden rules for managing herbicide resistance**

- 1. Keep weed numbers low – reduce the “1 in 1,000,000” chance that an individual weed plant in a population could, in a natural way, evolve herbicide resistance;**
- 2. Prevent weed seed production because resistance is genetically inherited and is spread through seed;**
- 3. Do not rely on a single herbicide, or a single mechanism-of-action; Employ more than one herbicide mechanism-of-action – formulated herbicide mixtures and tank-mixtures;**
- 4. Avoid under- and over-dosing since both promote resistance;**
- 5. Integrate different weed control methods where applicable.**

# Conclusion

“Sociologists define a *wicked problem* as one without clear causes or solutions, and thus difficult or impossible to solve.” – Prof David E. Ervin, Portland State University (2016)

Herbicide resistance is a **wicked problem** – the causes are obscured by a complex mix of biological and technological factors, and are fundamentally driven by the whims of human decision-making.

“Doing something different” is key to successful resistance management.

“Insanity: Doing the same thing over and over again and expecting different results” – Albert Einstein