

Herbicide Resistance

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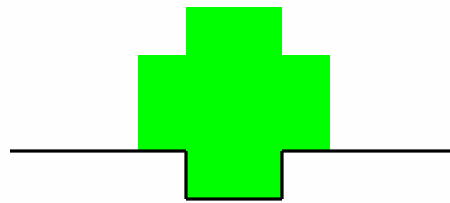
What is Herbicide Resistance?

Herbicide Tolerance :

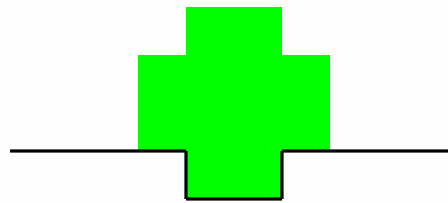
The inherent ability of a species to survive and reproduce after herbicide treatment.

Herbicide Resistance :

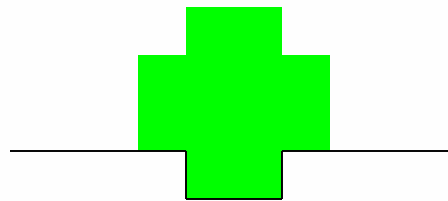
The ability of a plant to survive and reproduce following exposure to a dose of herbicide normally deadly to the wild type.



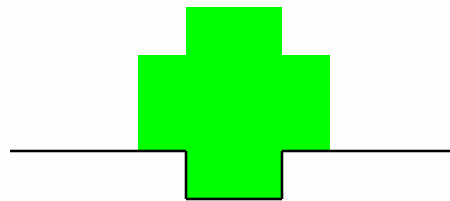
Target Enzyme system



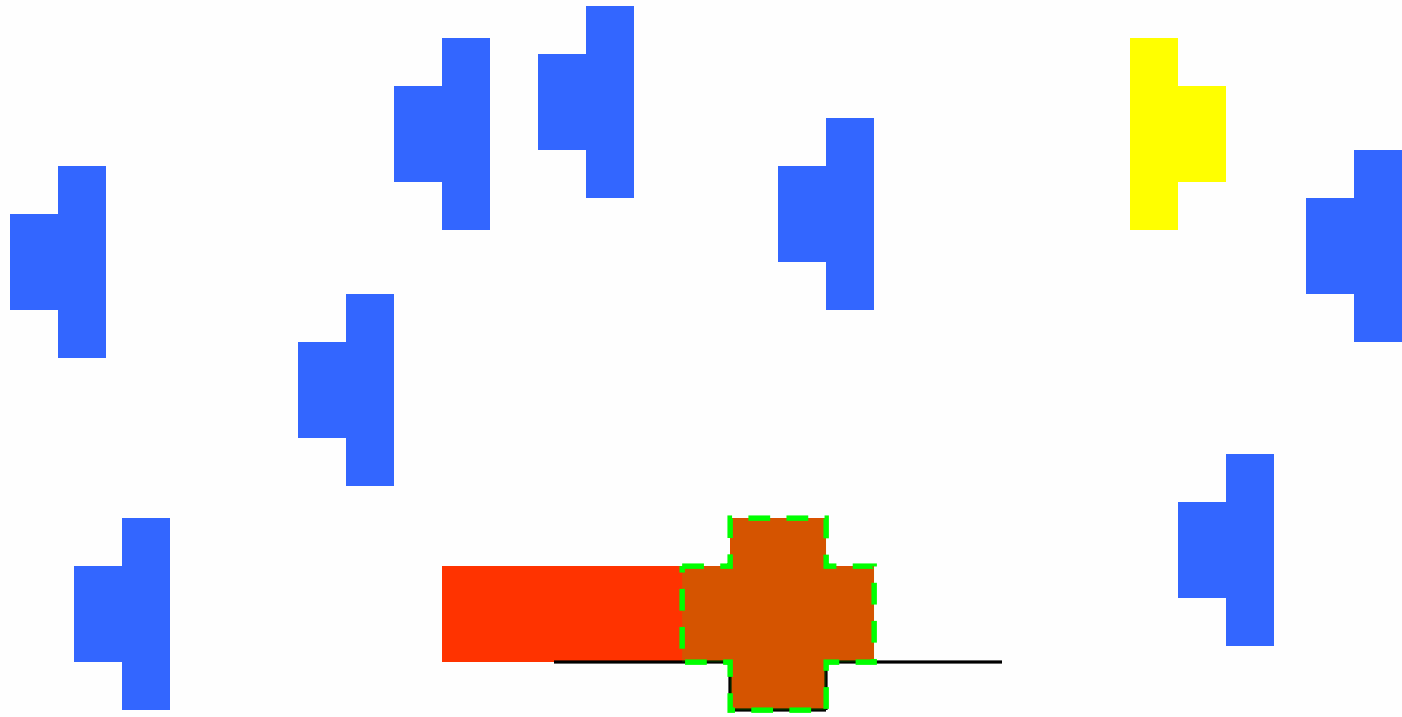
Target Enzyme system



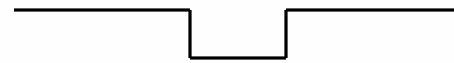
Target Enzyme system



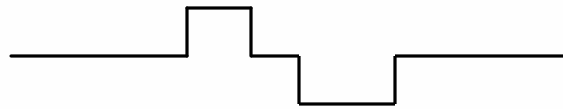
Target Enzyme system



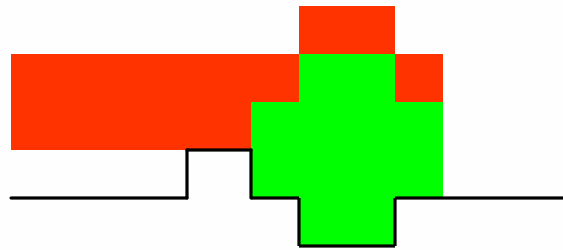
Target Enzyme system



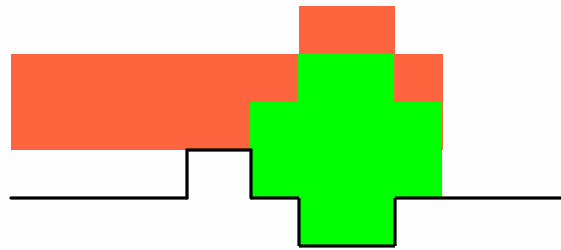
HR Enzyme system



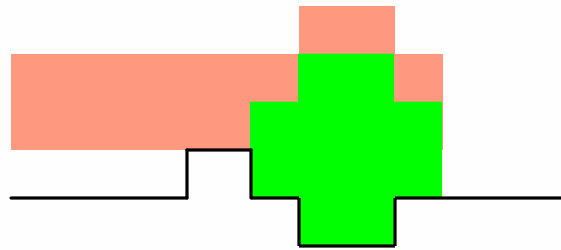
HR Enzyme system



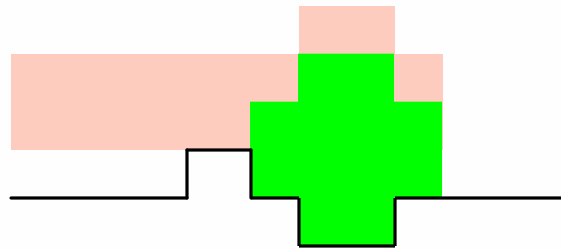
HR Enzyme system



HR Enzyme system

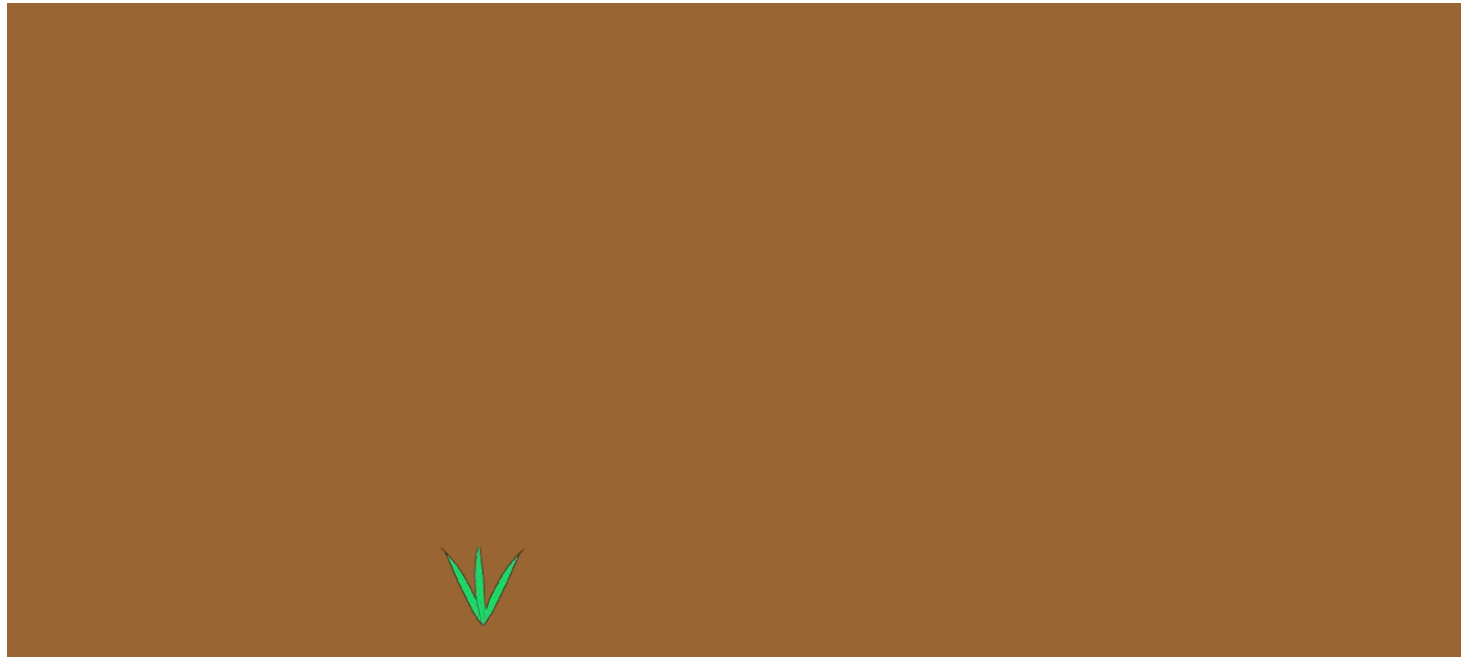


HR Enzyme system

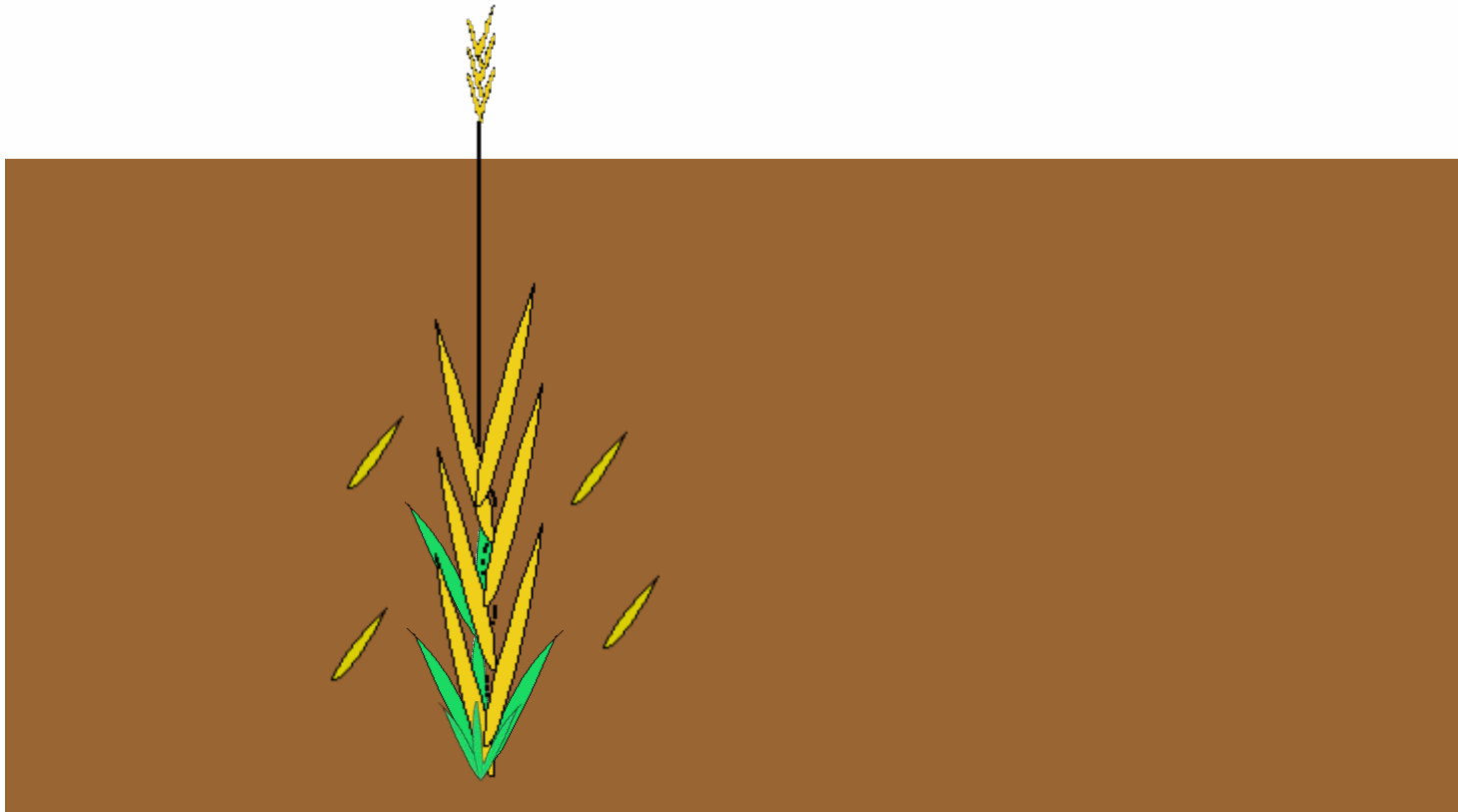


HR Enzyme system

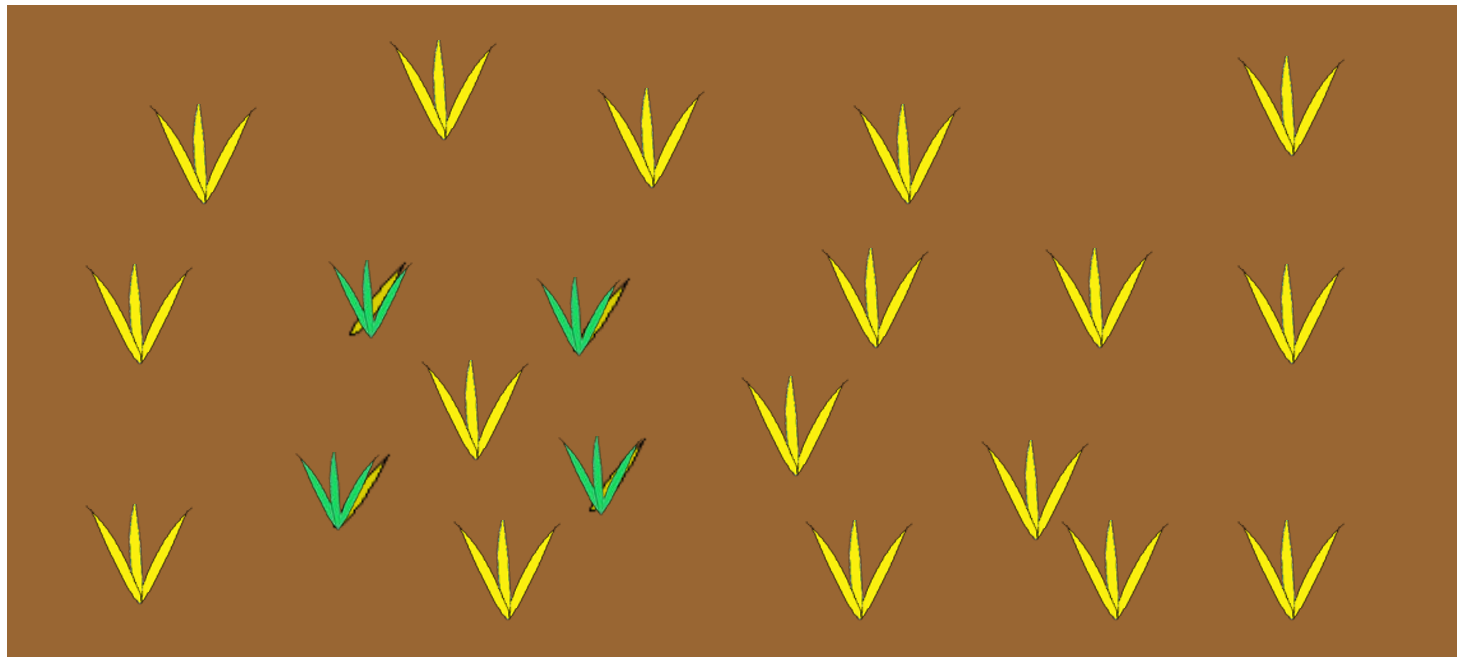
How does resistance increase



How does resistance increase

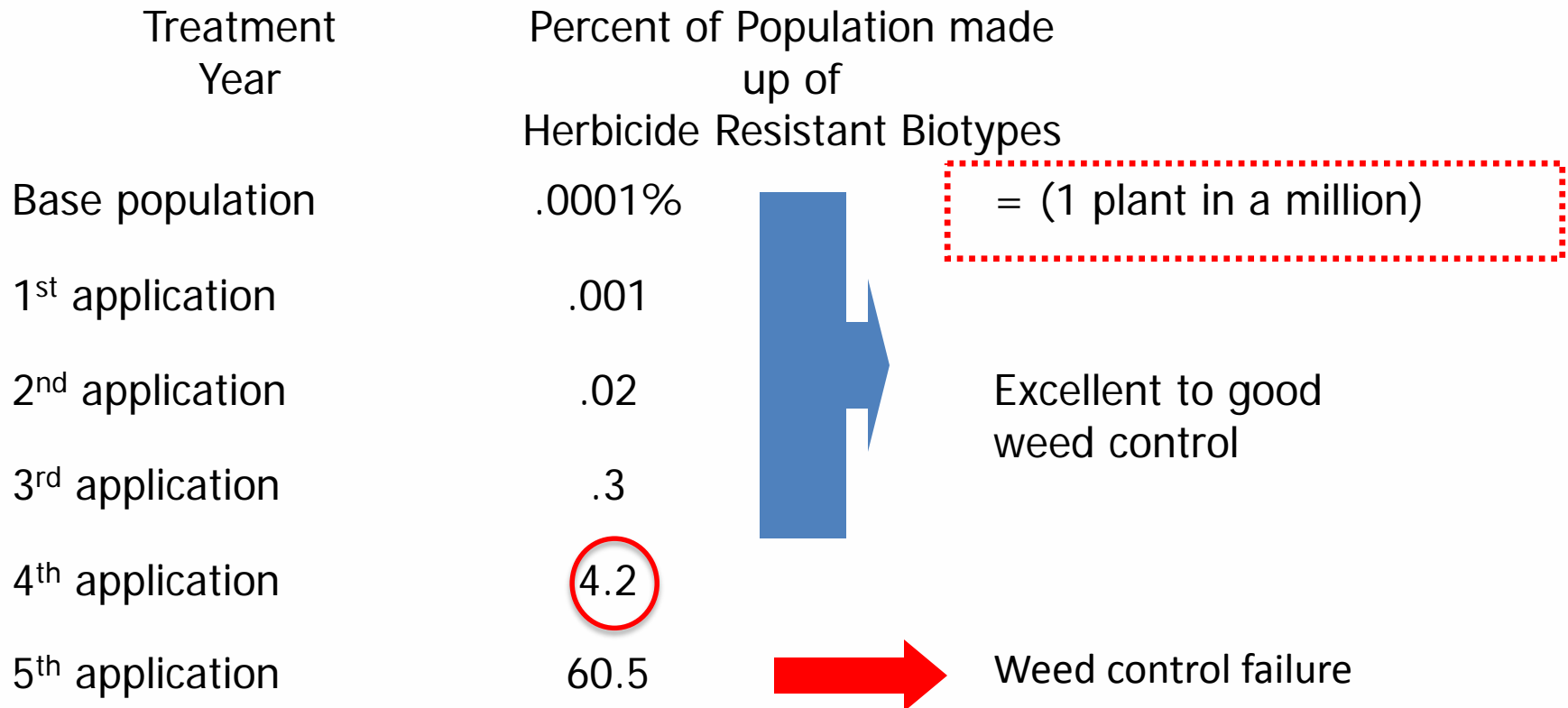


How does resistance increase



How fast does resistance increase?

Progression of resistant weeds exposed to annual applications of Group 2 herbicides (Glean scenario)

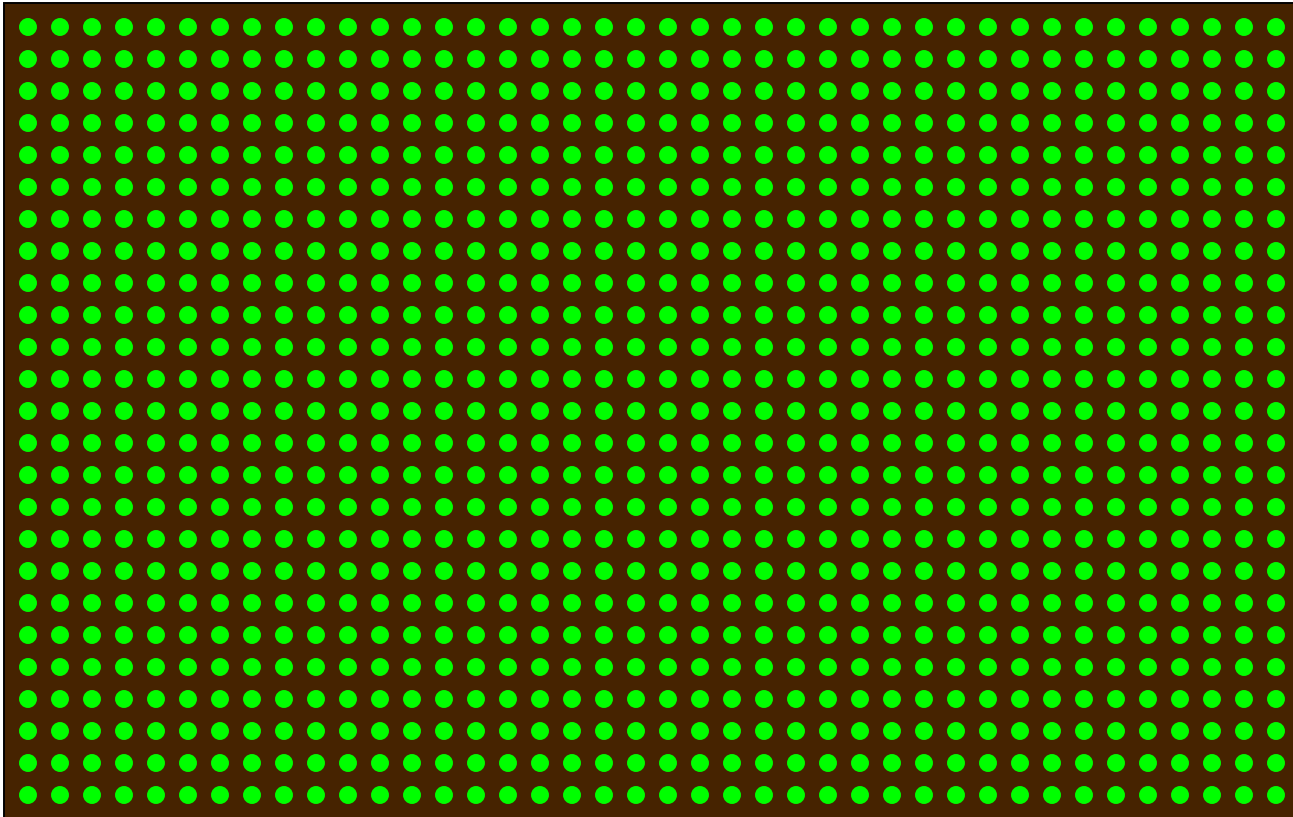


400 plants per sqm = 240 million per quarter section

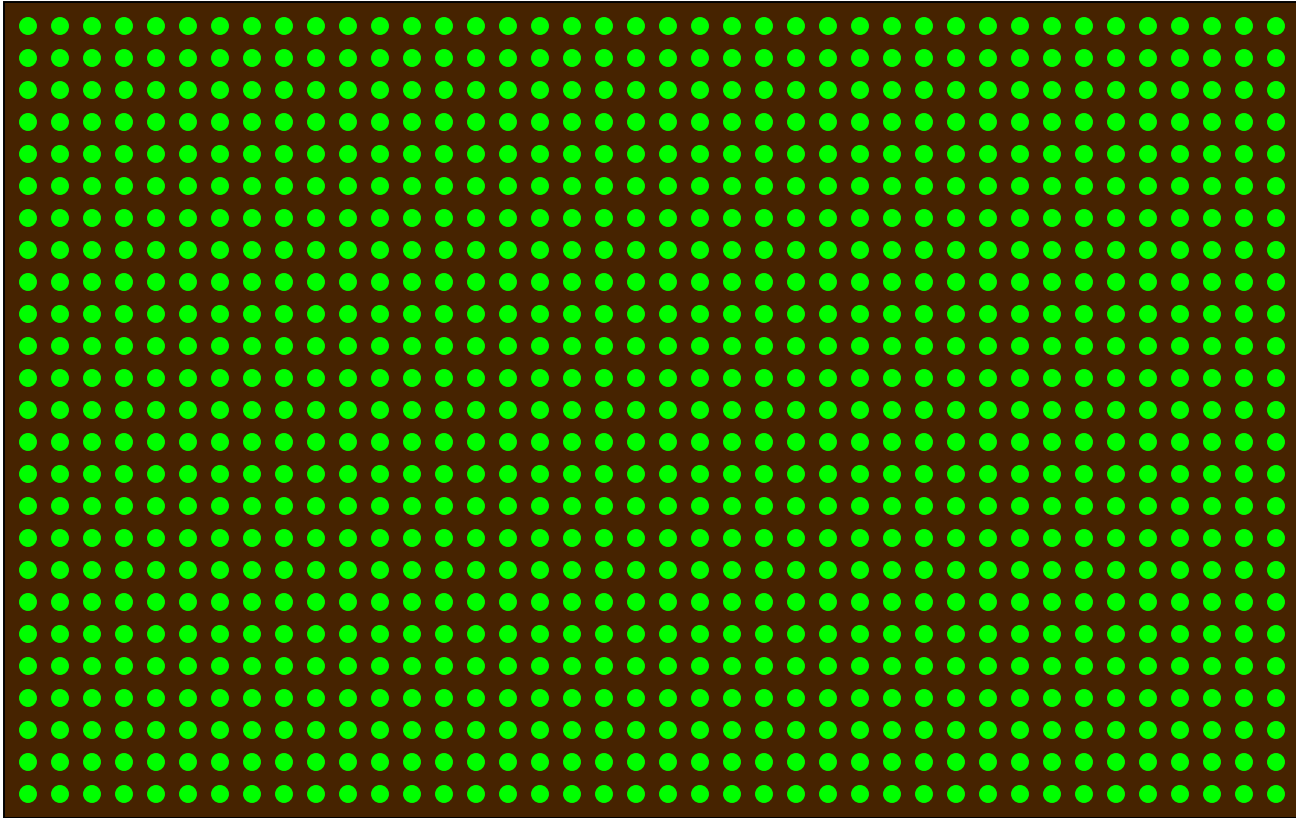
The Great Resistance Spreader!



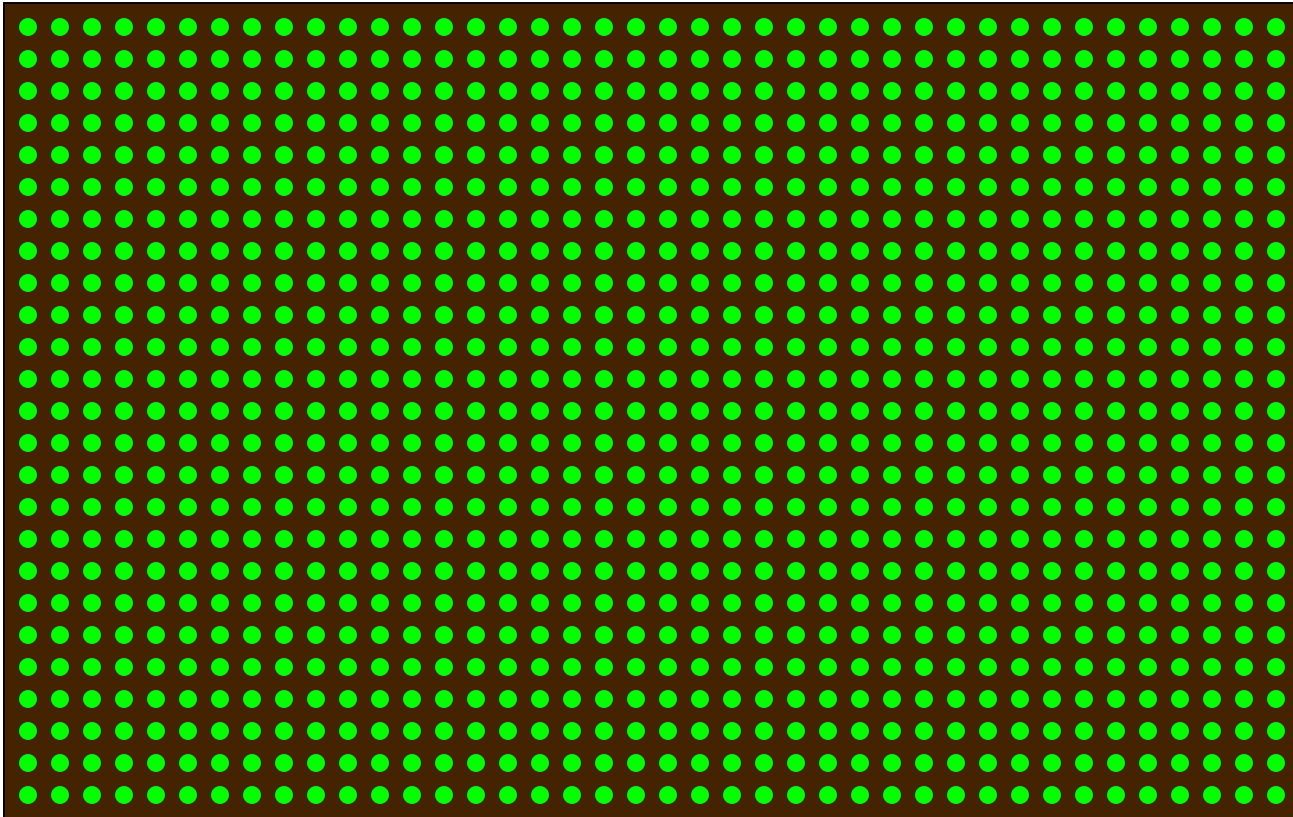
0.0001%



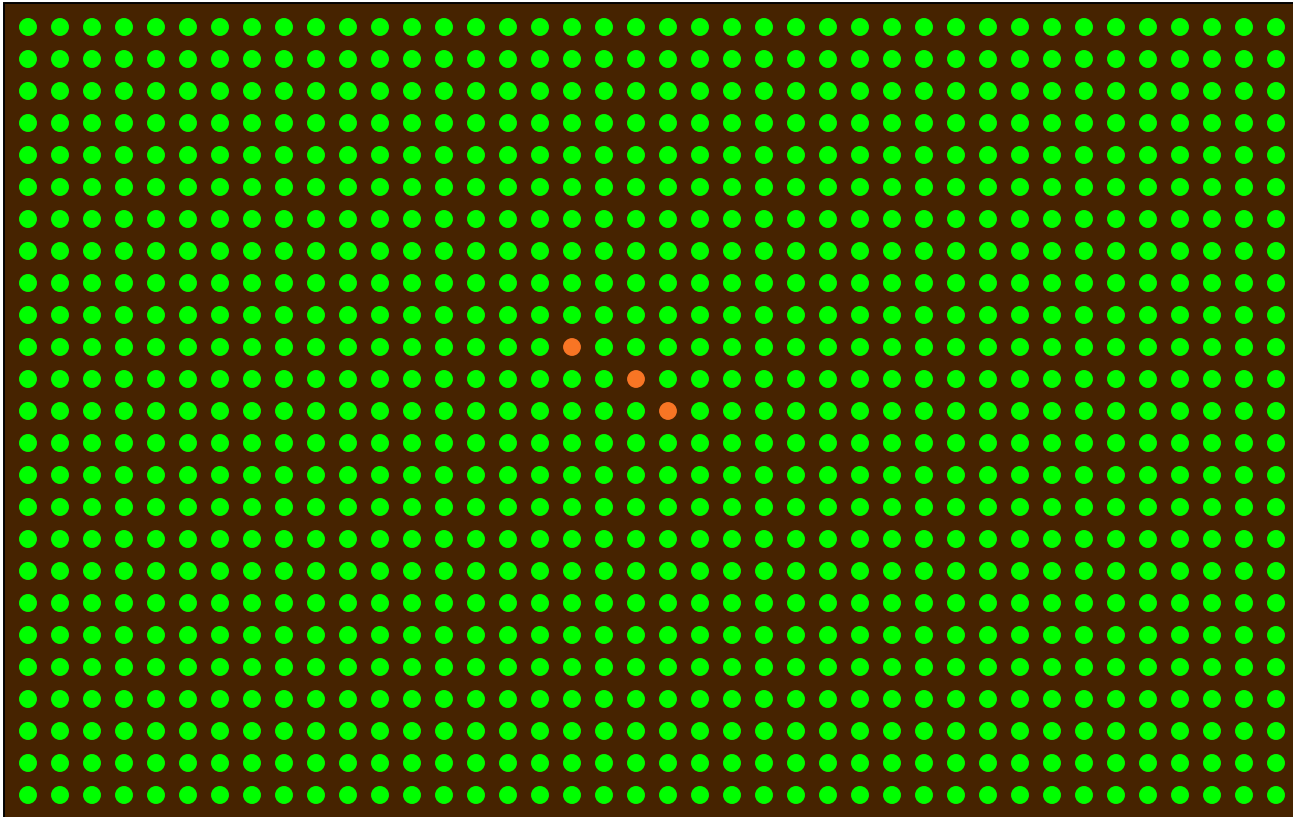
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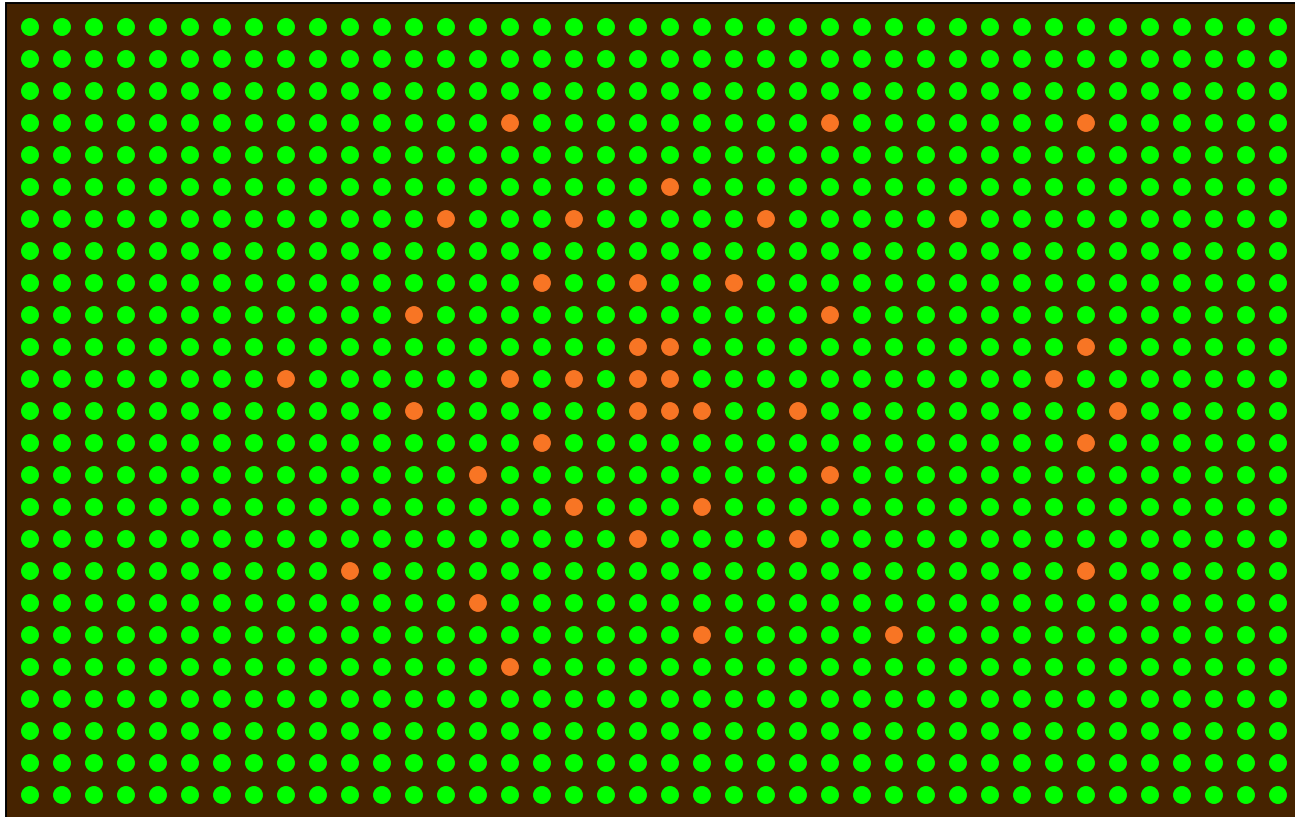
0.02%



0.3%



4.2%



Resistance vs. Application miss

Application miss

- Geometric patterns to weed patches in the field
 - Sharp defined edges
 - Straight boundaries
 - Parallel lines the width of the sprayer wheels
- Multiple species in the missed area

Resistance

- No sharp lines indicating missed application
 - Boundaries less defined
 - May show a general pattern following combine or other disturbance (i.e. tumble weeds in random lines)
- Nearly impossible to get more than one species developing resistance at same time

Resistant Ryegrass Patches in Australia



Andrew Storrie
NSW DPI

Tumbleweed resistance patterns

Photos Pioneer Coop AgTeam

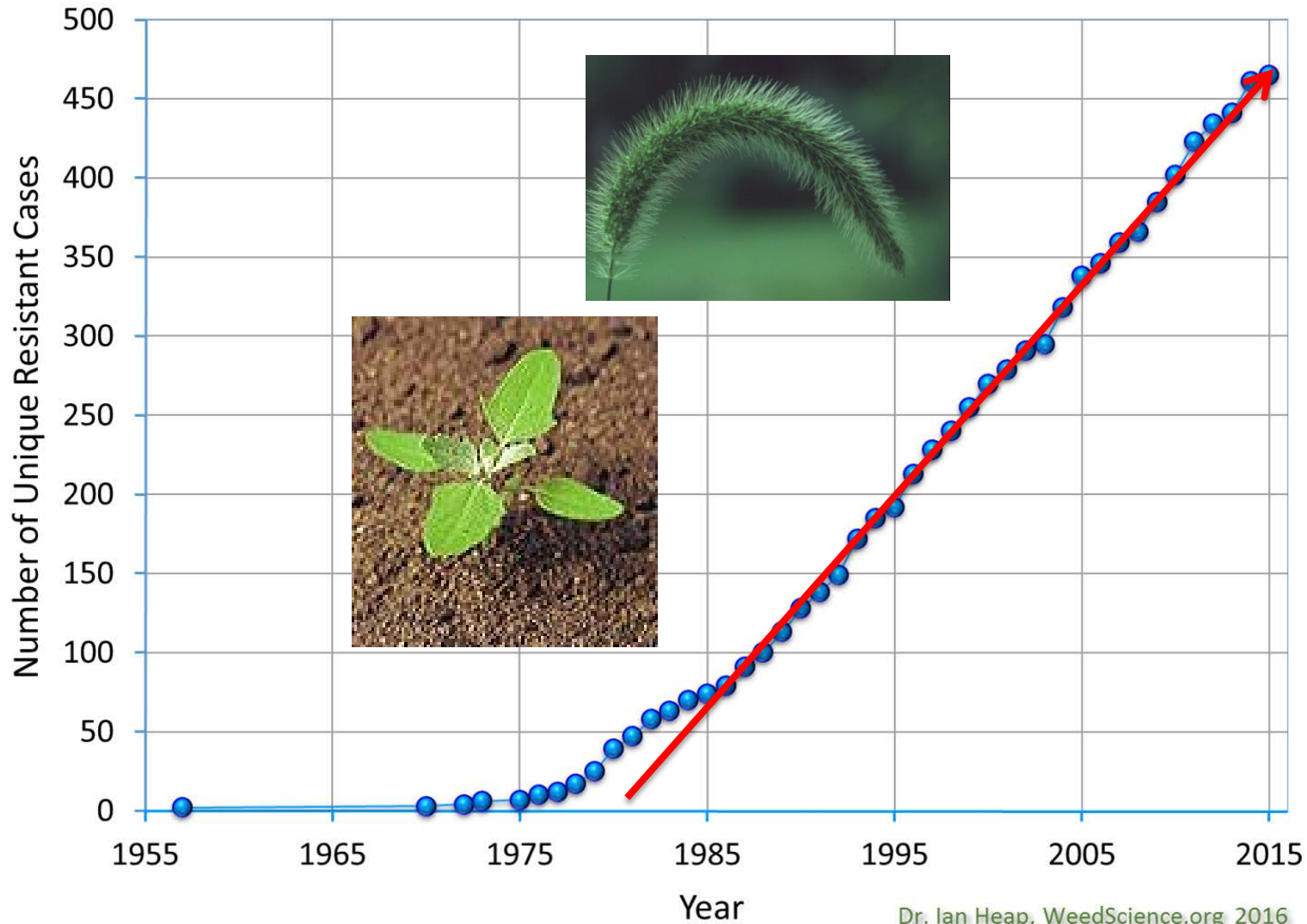


What Resistant Patches are Not



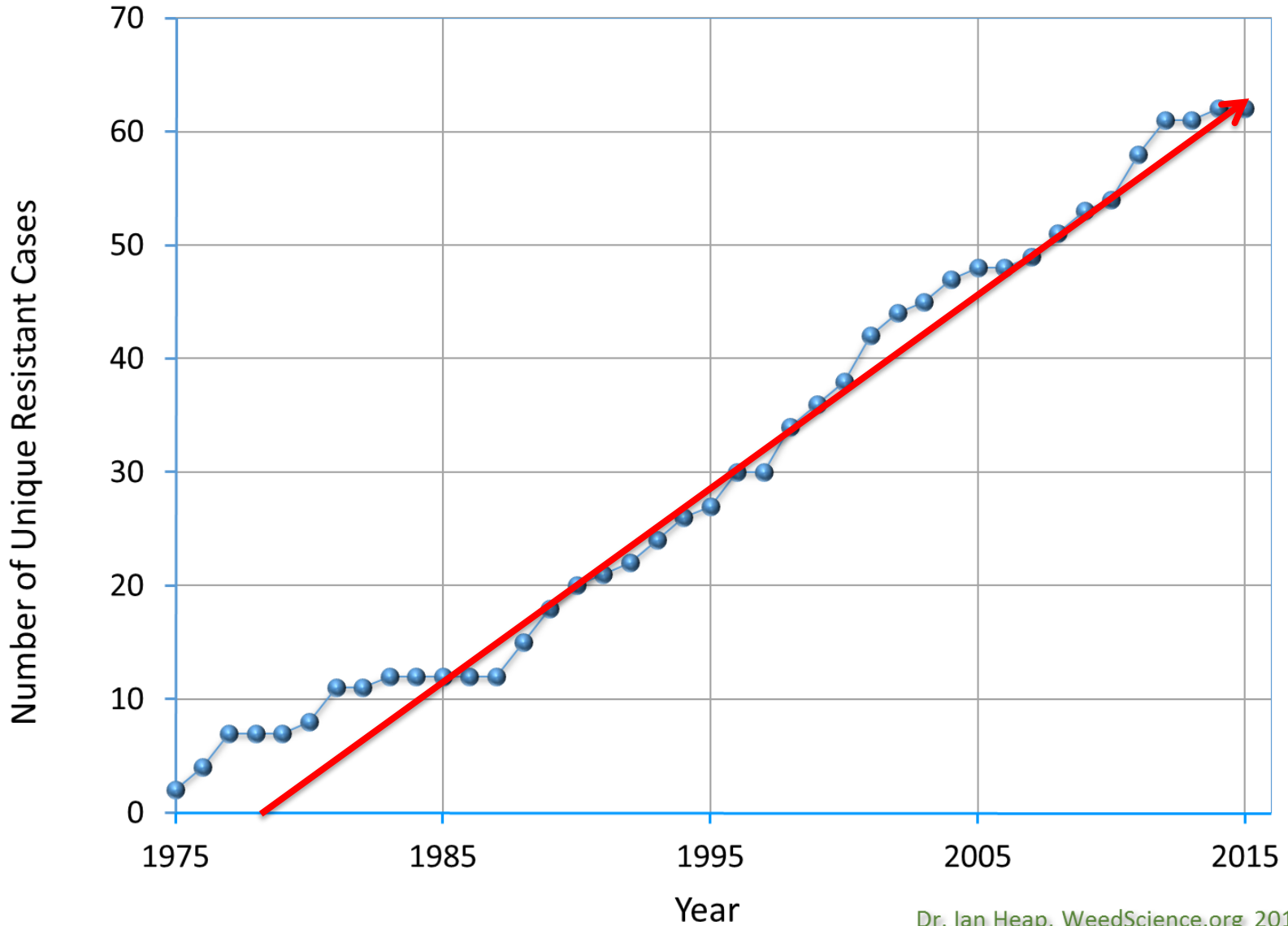
Herbicide-Resistant Weeds Worldwide

Global Increase in Unique Resistant Cases



Dr. Ian Heap, WeedScience.org 2016

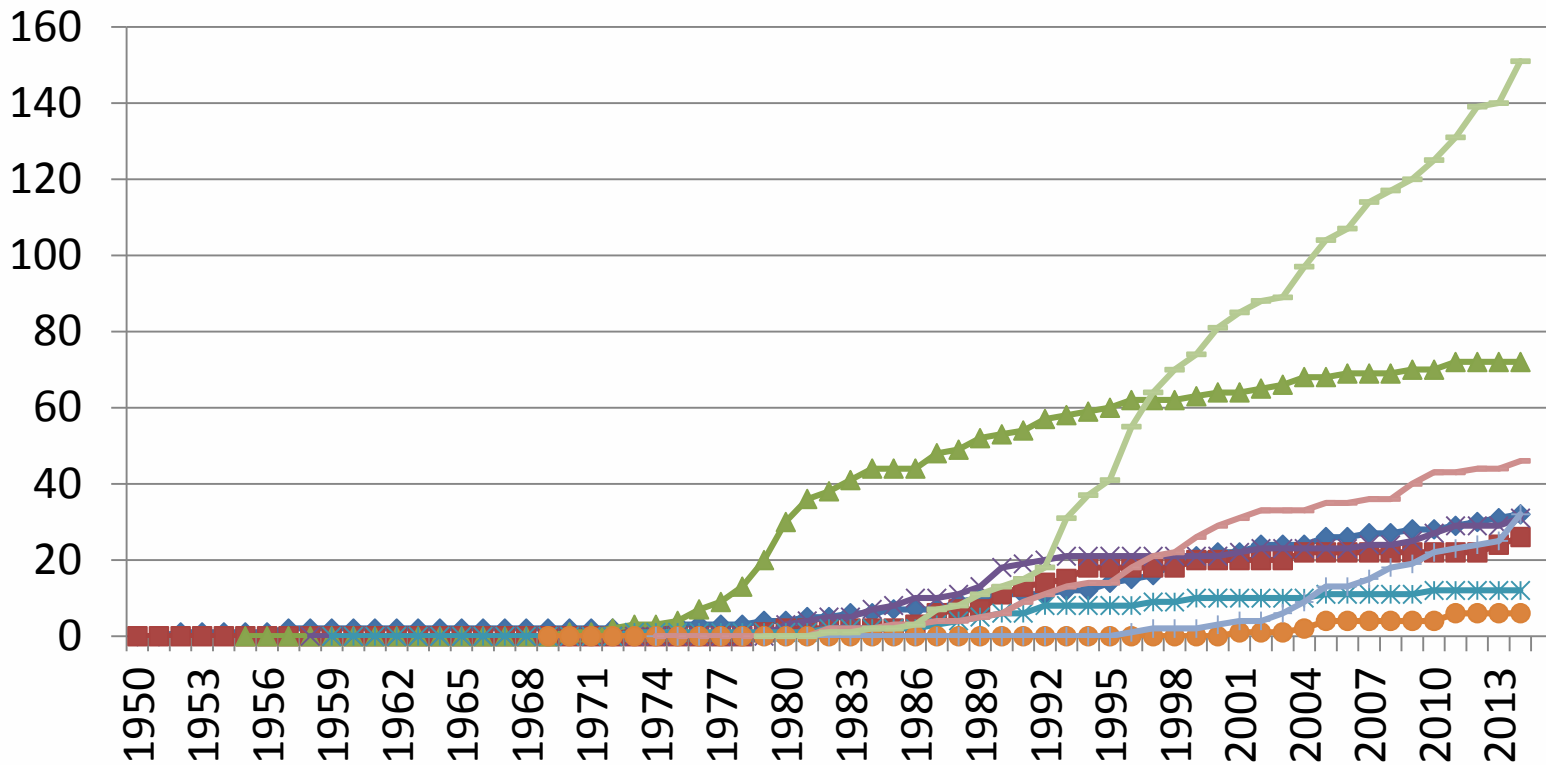
Increase in Unique Resistant Weed Cases for the Canada



Dr. Ian Heap, WeedScience.org 2016

History of Herbicide Resistance

- ◆ Grp 4 (1942)
- ✕ Grp 22 (1958)
- + Grp 9 (1971)
- Grp 7 (1951)
- * Grp 3 (1959)
- Grp 1 (1974)
- ▲ Grp 5 (1955)
- Grp 14 (1969)
- Grp 2 (1979)



Dr. Ian Heap, www.weedscience.org

Increase in Glyphosate-Resistant Weeds Worldwide

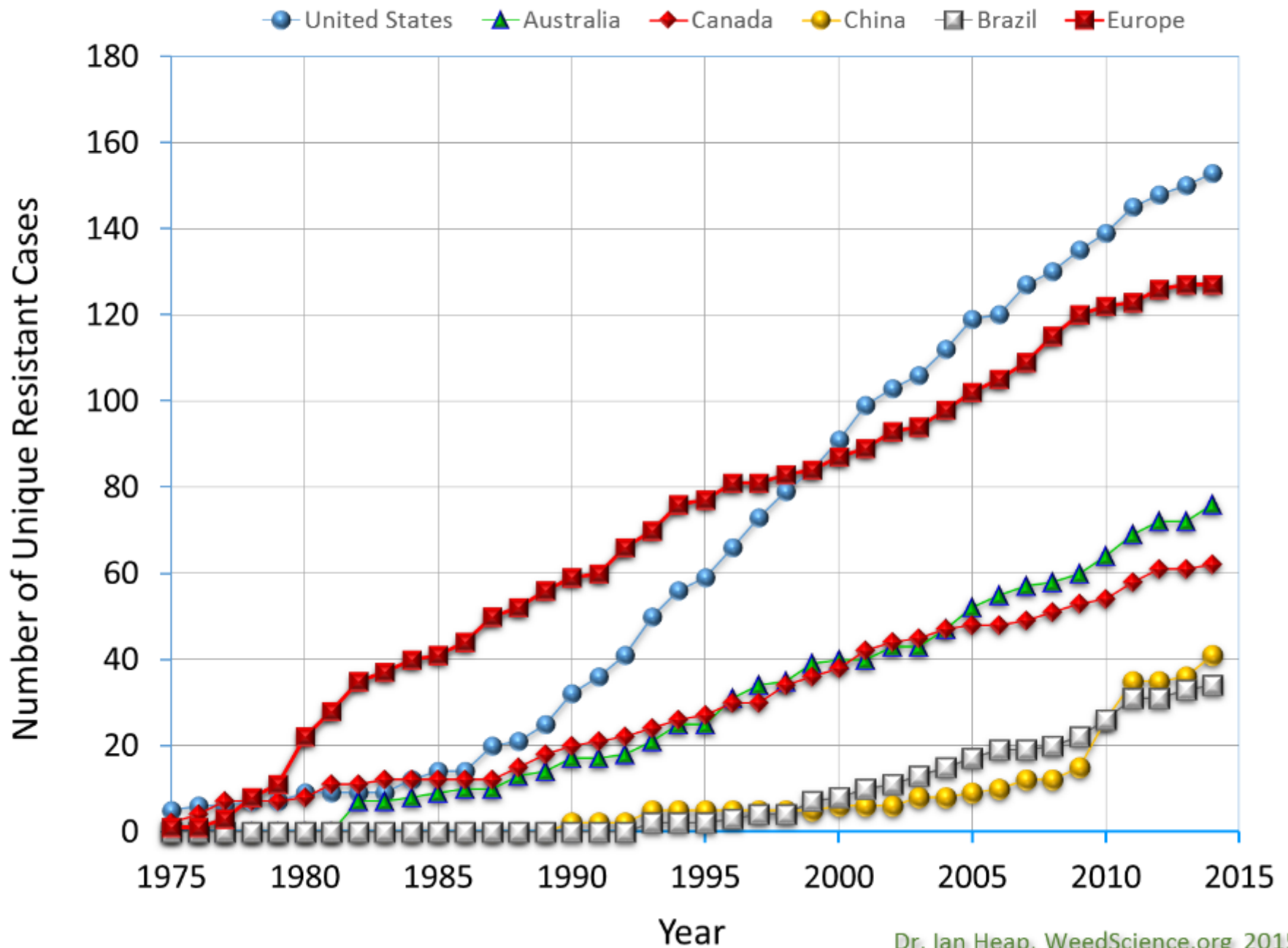


Where Does Canada Rank?

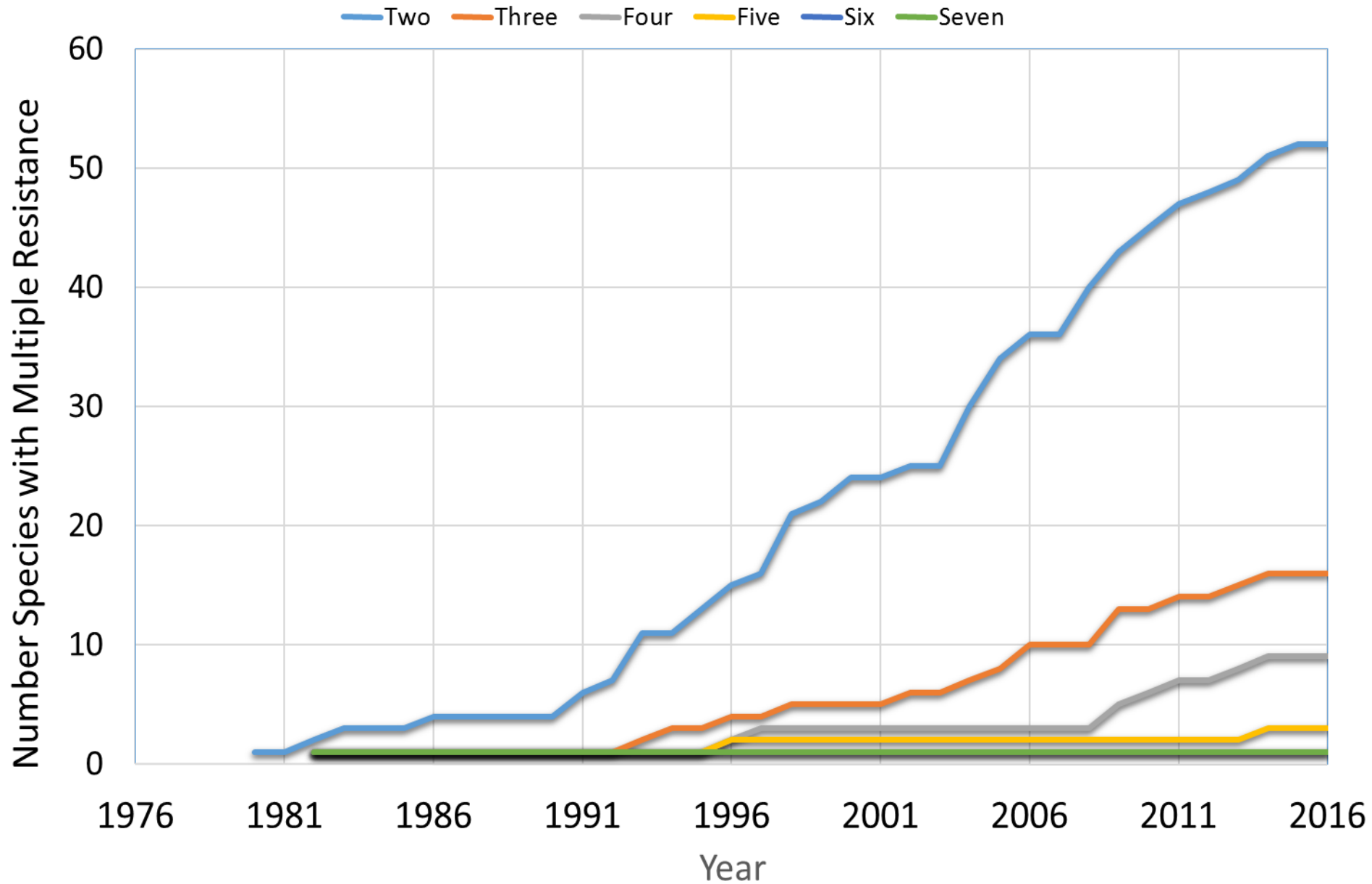
<i>Country</i>	<i>Number of Resistant species</i>
<i>USA</i>	150 (144)
<i>Australia</i>	75 (66)
<i>Canada</i>	61 (60)
<i>China</i>	41 (36)*
<i>France</i>	44 (35)
<i>Japan</i>	33 (33)
<i>Spain</i>	33 (33)
<i>Germany</i>	32 (32)
<i>Brazil</i>	34 (31)
<i>Israel</i>	30 (29)
<i>Italy</i>	30

* China has added 25 biotypes over the last 4 years

Increase in Unique Resistant Cases for Selected Countries and Europe



Weeds Resistant to Multiple Sites of Action within a Population



So it appears...
we continue to paint
ourselves into a corner



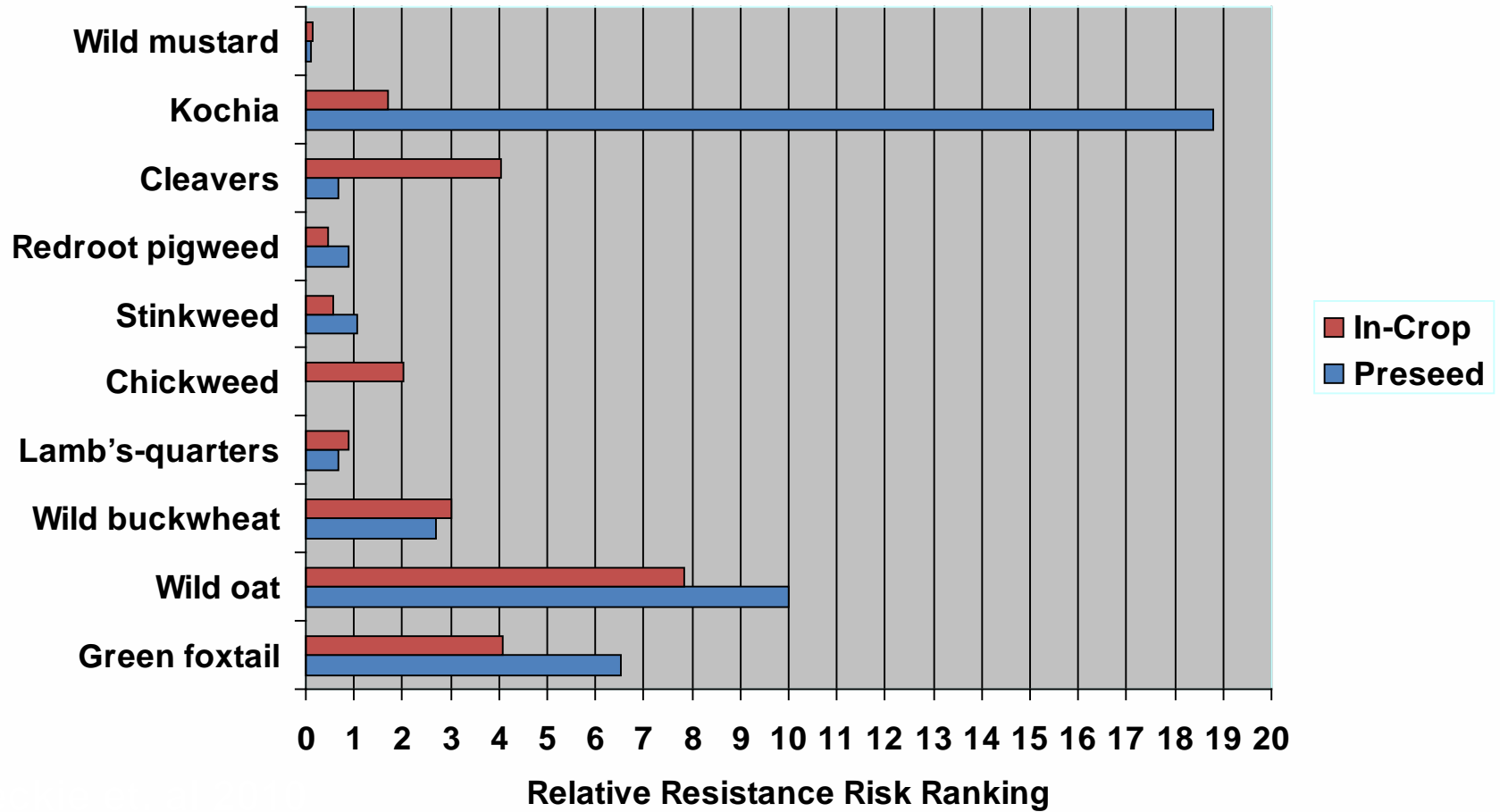
Resistance Developments in W Canada

- Two different studies have shown that roughly 90% of kochia populations are resistant to Group 2 herbicides
- Can we say these products control or even suppress any more? No removed from GCP on stand alone Group 2s.
- Group 2 resistant wild mustard common in Lentil increasing in regions of Saskatchewan
- Group 2 resistance also reported in stinkweed, wild buckwheat, annual sow-thistle, shepherd's-purse, common chickweed, cleavers, hemp-nettle
- Group 1 resistance to Persian darnel
- Kochia Resistance to glyphosate

Risk of Selecting for glyphosate resistance in Saskatchewan?

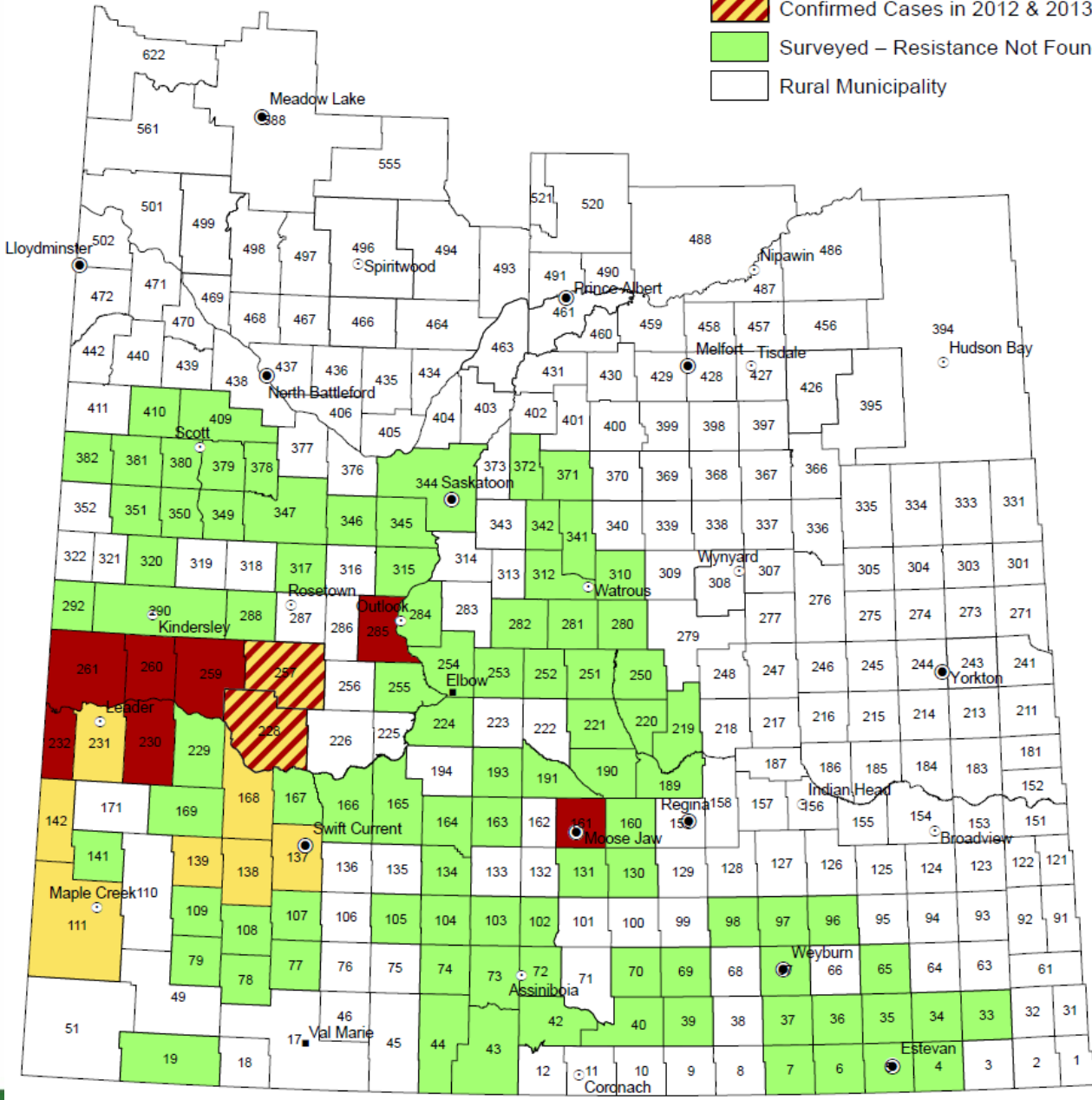
- Increase in frequency of the use of any Herbicide Group in the rotation increases the risk of resistance
- Glyphosate is generally thought to be a low risk mode of action (Group) – becomes higher risk the more it is used per season
 - Glyphosate resistance in weeds evolved easily in several species under high frequency of glyphosate use in the rotation
- Modeling conducted by Dr. Hugh Beckie (AAFC) predicted kochia as most likely to develop glyphosate resistance, followed by wild oat
- Tightened canola rotations need to rotate HR canola types
- Check ***www.weedtool.com*** to evaluate for specific risk

Weeds at Risk of Glyphosate Resistance in Western Canada



Dr. Hugh Beckie, AAFC Saskatoon

- Confirmed Cases in 2012
- Confirmed Cases in 2013
- Confirmed Cases in 2012 & 2013
- Surveyed – Resistance Not Found
- Rural Municipality



Straw poll

- Who think they have resistance?
- Who are actively managing it?
 - Who has a rotation longer than 4 years (needs to be different crops)?
- Who understands “Herbicide Groups” concept?
- Who understands what active ingredient is in their herbicide?
- How long can you “rest” a herbicide group before it will work again on a resistant weed?

The Harsh Reality

- Group 2 herbicides will no longer control kochia. Cleavers, wild oat and wild mustard are not far behind!
- **Once a weed is resistant to a herbicide group it will be forever! There is no going back to a susceptible population over time!**
 - the ‘fitness’ level most resistant biotypes is equal to that of the susceptible.
- Low level (< 1%) is not an economic problem in a diverse rotation/mixing system.
 - It is unlikely that the average person would notice anything below 25%
 - 5% if you are really good!

The Harsh Reality

- There are a finite number of pathways in a plant that herbicides will work on!
 - Chemical manufacturers are not holding back on you
- Using the 'other Group 1' (clethodim) is not rotation
- Switching to a Group 2 grass control herbicide is not a long term solution to Group 1 wild oats
- Glyphosate resistance has happened in Canada!

New Strategies to Manage Herbicide Resistance

- Start with good basic agronomy
 - Proper crop rotation (ex. Cereal, Pulse, Cereal, Oilseed) (include short term perennial forages),
 - Fertilize to soil test,
 - Select competitive varieties (AKA tall, leafy, fast growing),
 - Till strategically (ex. kochia lines in fallow)

New Strategies to Manage Herbicide Resistance

- Rotation of Herbicide Groups
 - Finding more and more that this delays resistance but doesn't really reduce the odds of getting it
 - Weed seed dormancy is the issue
- Tank mixing different Groups is better since it actually reduces risk
- Next trend is Herbicide Layering

Herbicide Layering

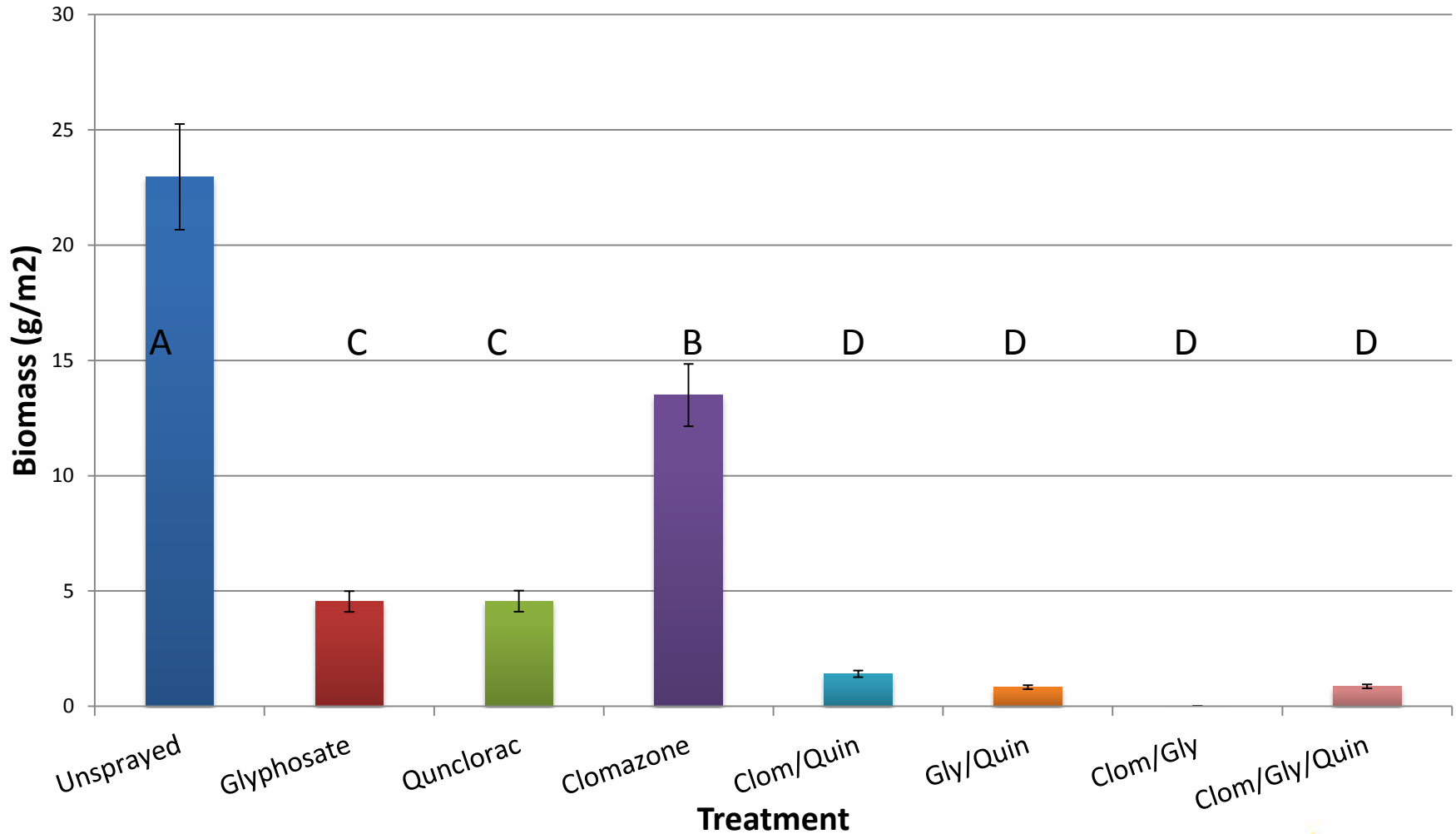
- Use of multiple active ingredients and Herbicide Groups to control the same weed in the same field in the same year
 - Not necessarily in the same tank load
- Can also provide improved weed control and return on investment in the absence of resistance
- Layering may be used to reduce multiple resistance in one weed or address several weeds each prone to resistance to different Groups

Herbicide Layering in Canola

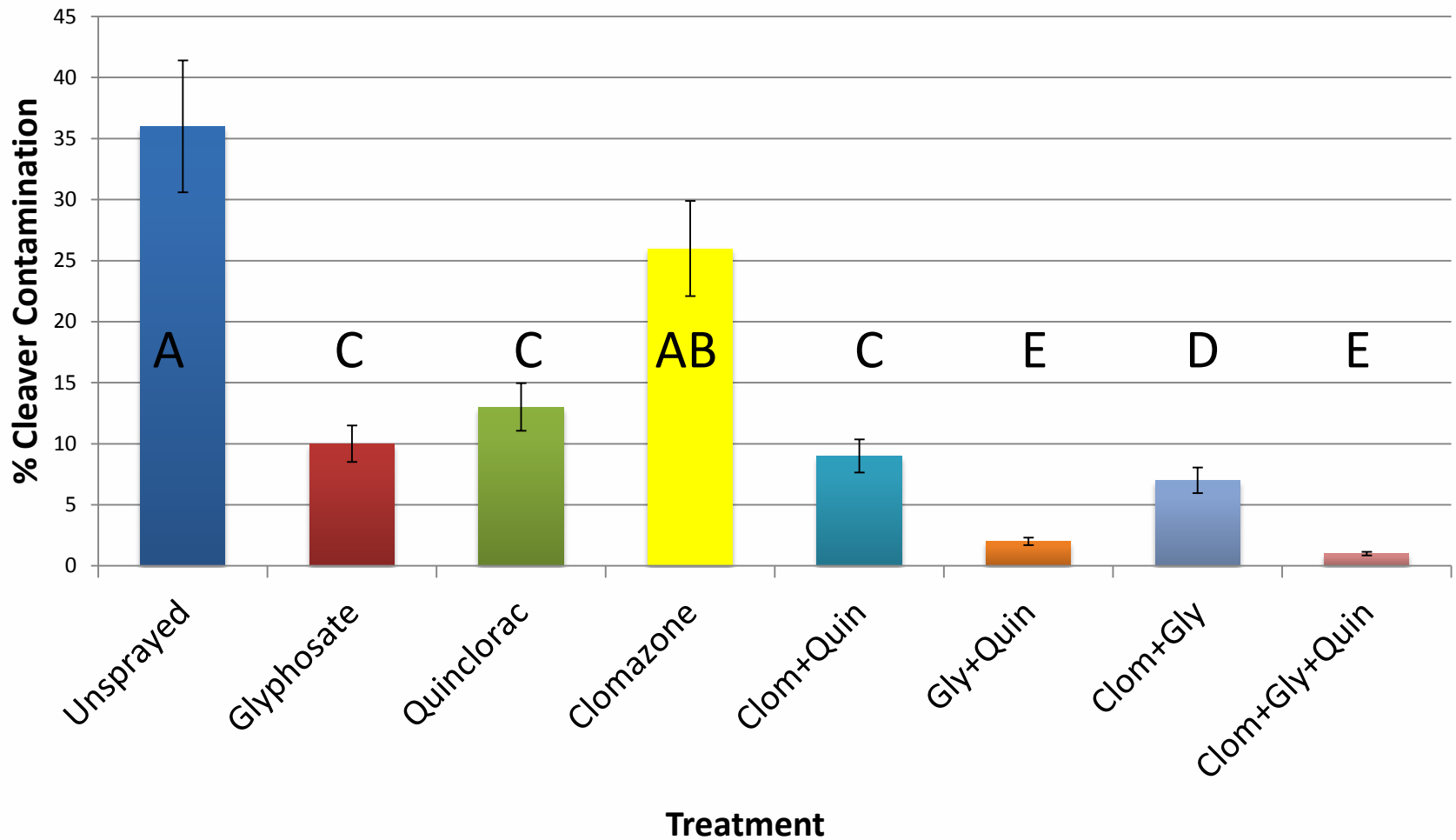
- Translation key:
 - Gly = Glyphosate
 - Gluf = glufosinate = Liberty
 - Quin = quinclorac* = Accord/Facet, Clever, Masterline
Quinclorac
 - Clom = clomazone = Merit/Command (not registered in W
Canada)

- * Note there are currently marketing challenges due to lack of
MRLs in China

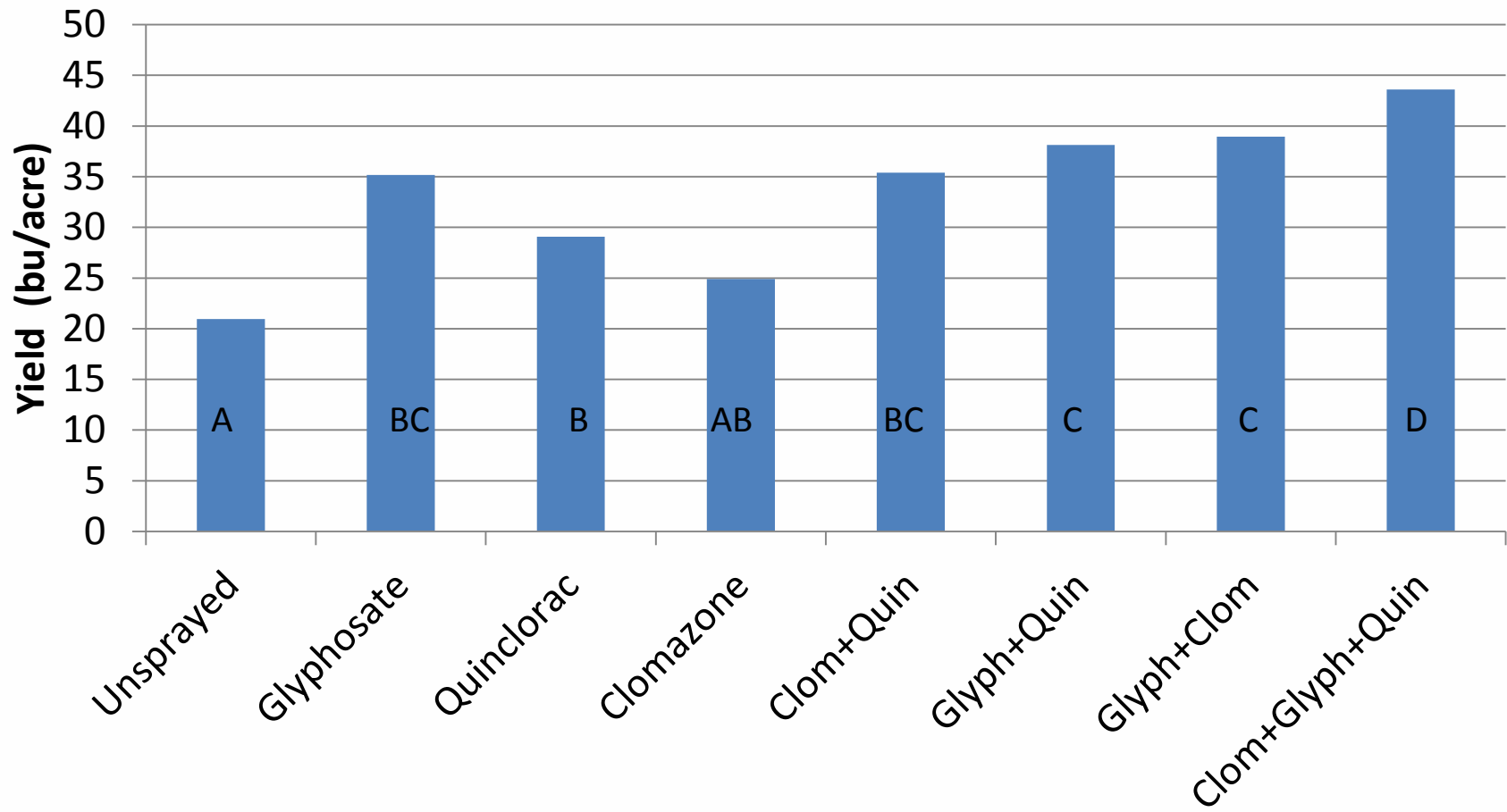
Herbicide Layering in Canola (glyphosate tolerant) Cleavers biomass (2013 & 2014)



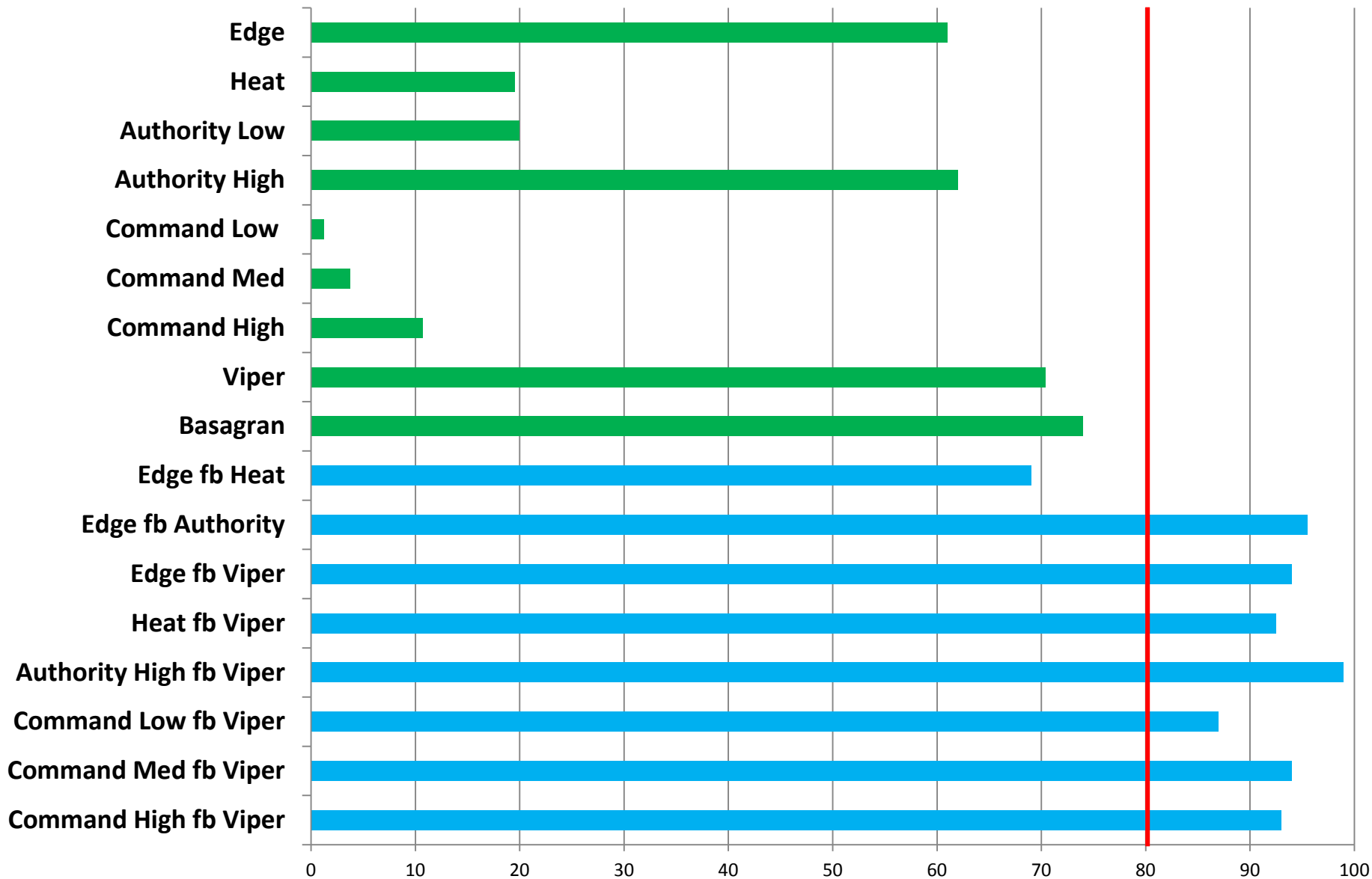
Herbicide Layering in Canola (glyphosate tolerant) Cleaver contamination (2013 & 2014)



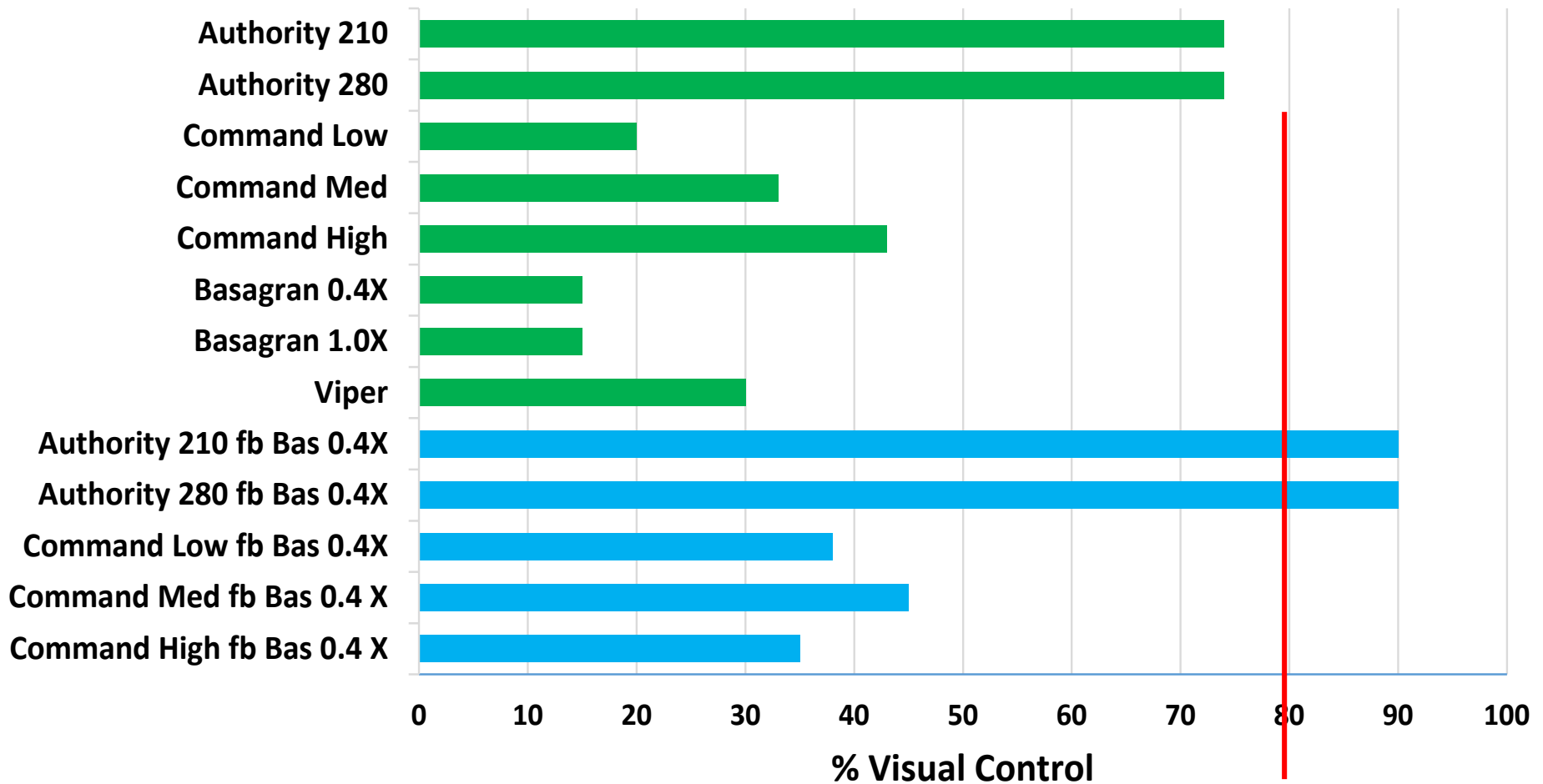
Herbicide Layering in Canola (glyphosate) Yield (2013, 2014)



Group 2 Resistant Cleavers Control Rosthern 2014



Group 2 Resistant cleavers control Rosthern 2015



Willenborg et.al, University of Saskatchewan, 2015

January, 1997

SUMMARY

Pre-emergent Wild Oat Control Means Higher Yields

Wild oats continue to be the number one weed problem in western Canada. Due to high wild oat infestations in 1996, farmers can expect high wild oat pressure again in 1997. Research conducted at Lacombe Research Station and Alberta Environmental Centre have shown that wild oats can cause yield losses of over 30% and earlier the wild oats are removed the greater the yield recovery. Avadex BW is a selective pre-emergent herbicide which provides excellent and extended control of wild oats at the "no leaf stage" which in turn results in maximum crop yields.

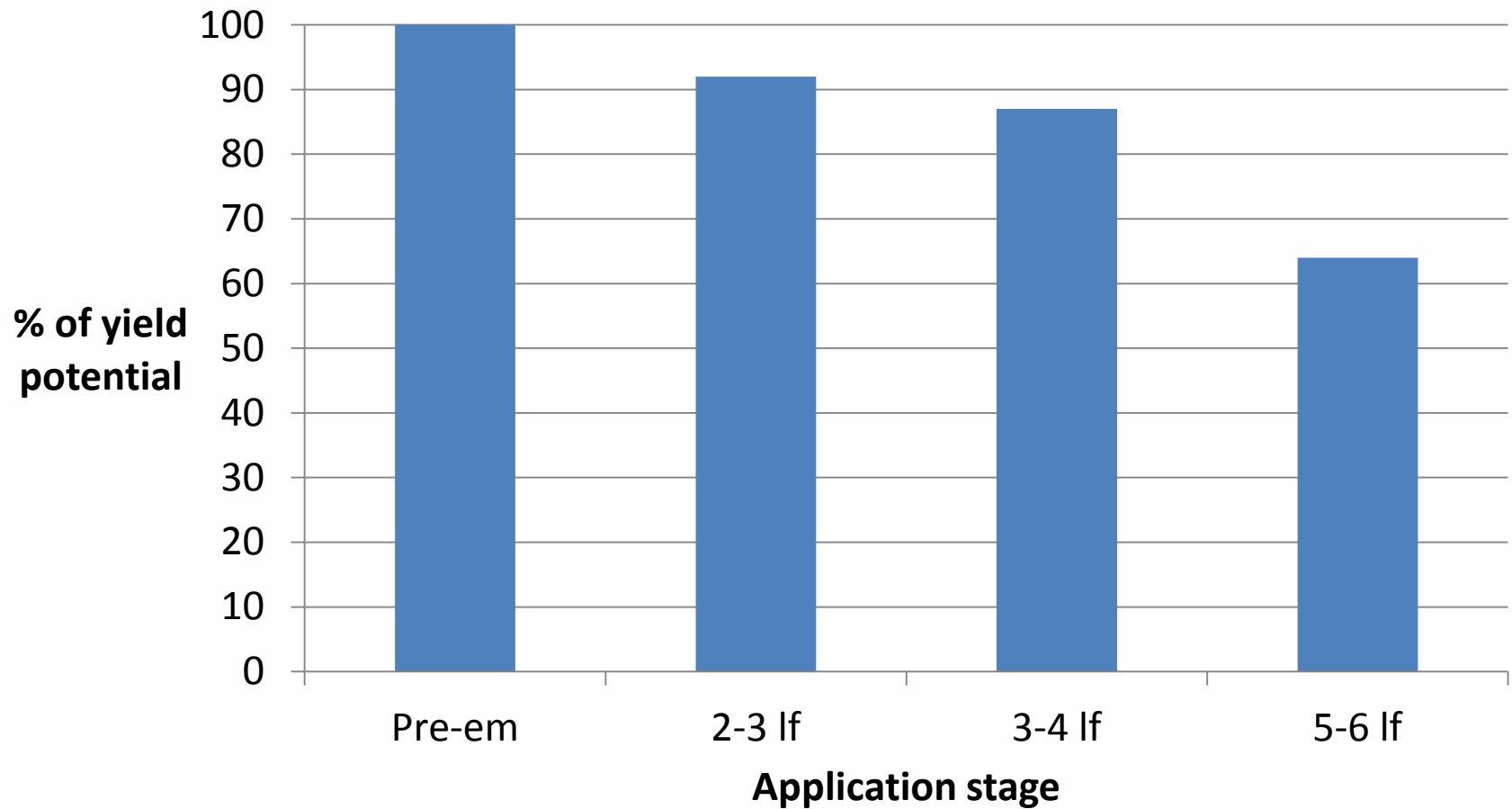
BENEFITS**REMOVAL OF WILD OATS AT THE "NO LEAF STAGE" MEANS:**

- **Wild oat control 4 weeks earlier than post emergents.**
- **Greater yield potential.** Just 6 wild oats/ft² can cause yield loss in wheat of over 13 bushels/acre. Early removal means higher yields.
- **Increased savings on input costs.** Early removal of wild oats protects your fertilizer investment and ensures you fertilize your crop and not wild oats.

PRE-EMERGENT YIELD ADVANTAGE IS MORE IMPORTANT TODAY:

- Higher wild oat infestations and earlier emergence of wild oats means greater yield loss potential
- Higher input costs such as fertilizer means a bushel saved today is worth more

Wheat yield response to time of weed removal



Economic impact of time of weed removal

Application stage*	Yield (bu/acre)	Gross return (\$ per acre)	Economic loss of waiting (\$ per acre)
Pre-em	50	300	0
2-3 lf	46	276	24
3-4 lf	42.5	255	45
5-6 lf	27	162	138

* Most producers will underestimate their leaf stage

Herbicide Layering

- Use multiple herbicides from different Groups to control the same weed, particularly those at high risk of resistance
- Uses soil applied plus post emergent and/or tank mixes
- Herbicides used in layering can contribute without controlling the weed on their own
- Key to success is being getting ahead of the problem – don't wait for the problem
- In Europe producers are layering herbicides
- but they waited for a problem and now have to layer up to six active ingredients in one field at a cost of \$100+ per acre to control one weed - Blackgrass

Thank you!

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