



# **“Lets Drift Apart”: The Issue of Stacked Gene Crop Spraying for Nursery**



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# Four Part:

1. Drift:
  - a) **Statistics** – record pesticide misuse investigations 2017
  - b) **Key principles**
  - c) **What is the problem?**
2. Carryover:
  - i. **Soil**
  - ii. **Plant**
3. Long-term:
  - A. **Indirect**
  - B. **Direct**
  - C. **Combo**
4. Conclusions

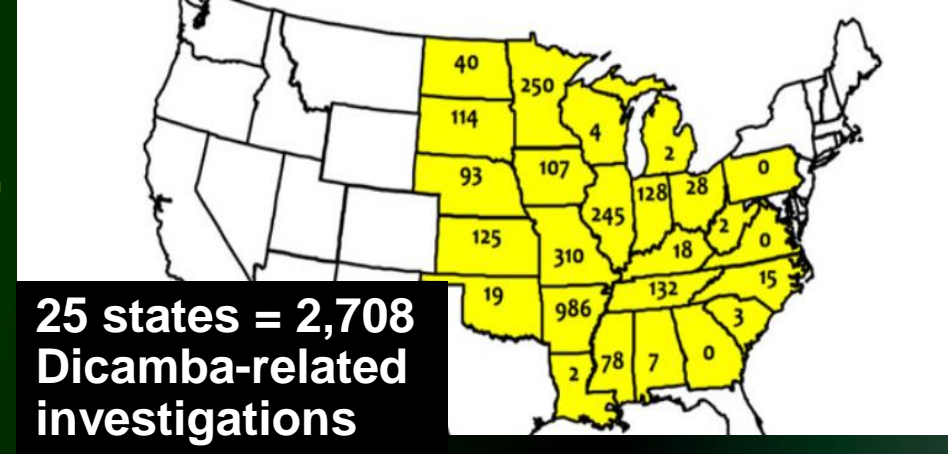
Define: Application not hitting “target” -- moves “off-target.”





# 1a. Show me the Data

- State Investigations: (October 15, 2017) :  
Integrated Pest Management, University of Missouri



Order & State	#Official Complaints (Reported to respective State Dept. of AG's)	Estimated # of Acres Impacted (Based on complaints & State Extension Specialist)
#1 - Arkansas	986	900,000 ac.
#2 - Missouri	310	325,000 ac.
#3 - Illinois	245	600,000 ac.
#4 - Minnesota	250	265,000 ac.
#5 - Tennessee	132	400,000 ac.





Everything not better in 2018:

Iowa as July 2, 2018 = 121 pesticide use complaints

Iowa 2017 total = 107

Iowa July 2, 2017 = 82

Dicamba not the only problem

Dicamba and 2,4-D = most widely used PGR herbicides

However, issues with clopyralid, triclopyr, picloram, and aminopyralid.

### Nursery issues:

Glyphosate

Atrazine

ALS herbicides



Iowa, spreading of hay contaminated with picloram onto fields planted to soybeans  
(Source: Hartzler and Anderson, 2018).





# How did we get here???

Step 1 - Take a crop - add glyphosate resistance (Group 9)

Step 2 - Promote use of residual herbicides tank mixed with glyphosate (ex. ALS pre-herbicides) (Group 2)

Step 3 - Super weeds develop-- Group 9 + Group 2 resistance

Step 4 - Advocate “extreme” cocktails in tank mixes



# How did we get here???

Step 5 – Non-target crop injury increases

Step 6 – Add growth regulator (Group 4) resistance to crop

Step 7 – Non-target crop injury escalates severely!!

Step 8 – Impose new restrictions on application of dicamba (Group 4)

Step 9 – Worry about reducing the injury to the GMO crops???





# “SOYBEAN INJURY SHOULD DECREASED IN 2018”... SOYBEAN'S ???

Football  
helmet  
testing  
began in  
1912.



Gee –  
I wonder ... could  
that cause  
damage?

Impossible...

# YES - SOYBEAN INJURY IS AN ISSUE

The field left  
of the road  
was sprayed  
with a dicamba  
product.

The green strip of  
Xtend soybeans next  
to the road acts as an  
unintentional check  
for yield potential.

To the far right of  
the road you can  
see visible damage  
to non-dicamba  
soybeans



PHOTO: TODD LEWIS



A historical photograph showing a massive pile of bison skulls, stacked high to form a large mound. A person is standing on the very top of the pile, providing a sense of scale. Another person is visible at the base of the pile. The scene is set in an open, flat landscape under a clear sky.

100,000 Bison skulls  
1870 poacher stands in  
front.

**Bigger Issue:**

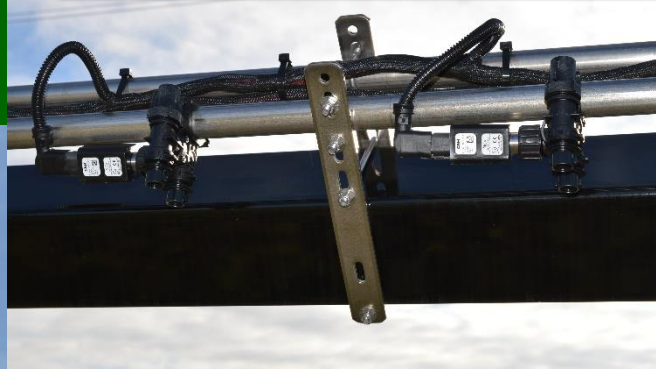
**Zero tolerance** is  
not usually the best  
option??

Maybe for - *Ebola*  
virus (or similar) --  
*but weeds ???*



# 1 a. DATA – What else is contributing:

## Drift doubles as boom height doubles





## 1a. Data – DRIFT DOUBLES AS BOOM HEIGHT DOUBLE

- *Well Beaver ...* if you knew your multiplication and division ... you would see by putting the boom 4' (48 ") off the ground, and the nozzles at 18" apart the drift potential multiplies by a factor of 2.6 X's... which means --- even if the wind is 10 mph – **you have a problem!!!**
- But if you spray in 15 mph wind... well then you need to multiple  
 $1.5 \times 2.6 = 3.9$

**Gee Dad.. That's like 4X's the drift!!!**



# SAY WHAT NOW???

**Good  
thing  
someone's  
got some  
intel...**





• Let me try to explain it another way Opie!

If the wind is blowing toward neighbor and they have a sensitive crop: Then:

1. High tractor = High boom
2. High Boom = Down wind neighbor SOL
3. SOL Neighbor = MAD !! Neighbor = Black eye

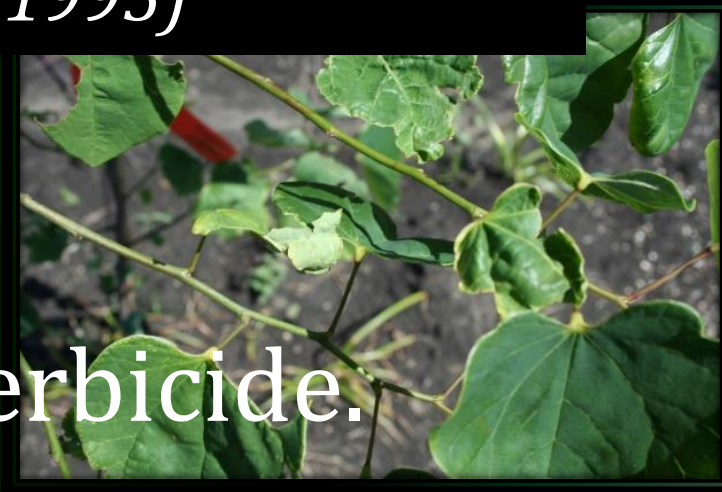
That dirty ....  
I'll show him  
where to put  
his boom- !!



## 1b. Key Principles of Drift

*Drift Injury is Typified by Variability (DEXTER, 1995)*

Red Bud - Lontrel



### Not - Uniform:

#### I. Over more than one species – Maybe Not!

- Herbicide drift can occur with any herbicide.
- However, the risk of damaging drift is **directly correlated to the level of susceptibility** of the **non-target** plant to the herbicide being applied (Dexter, 1995).

*Dexter, A.G. 1995. Herbicide spray drift. North Dakota State University Extension Service EXT-A-657.*



# MOST IMPORTANT DETERMINANT OF HERBICIDE INJURY

## Crop Sensitivity

- Rate
- Coverage
- Age



## 1b. Key Principle

**Sensitive to Indaziflam SC - *Ilex Xmeserve* 'China Boy,'  
and *Spirea bumalda* 'Goldflame' – 09/11/2015**



For example, a **non-target** plant which would be significantly injured by 25% of a normal herbicide application rate is more likely to sustain a yield loss from drift as compared to a **non-target** plant which would be significantly injured by 50% percent of a normal application rate (Dexter, 1995).



## *1b. Key principles of Drift*

### *DRIFT INJURY IS TYPIFIED BY VARIABILITY (DEXTER, 1995) - CASE STUDY – IN GROUND PEONIES, 2016*

#### **II. Widespread > 20% - Patchy/ Inconsistent**

- Non-target crop doses can even exceed those applied to the target crop (Dexter, 1995) by downwind accumulations.
- A small portion from each sprayer pass drifts onto the non-target area (Dexter, 1995).

Severe peony injury and death where - sprayer turned.



Some labels warn - do not spray while turning  
= target crop loss, i.e. (DuPont™ Resolve® Q  
label, 2011.

## *1b. KEY PRINCIPLES OF DRIFT*

### Secondary drift:

Off-site movement of the active ingredient through the air after - droplets deposited on water, dust.

**Most common form is vapor drift = volatile herbicides**

Atrazine landing on dust particles moving in the air - **do not breakdown** (ATSDR, 2015).

Wind-blown dust containing atrazine = one reported 180 miles (ATSDR, 2015).



Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Public health statement for atrazine. <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=336&tid=59>



## Secondary drift:

- Within 1MAT - only one significant rainfall event = 0.59".
- Insufficient rain to wash dust off from good foliage cover (A) = not **into soil**
- (B) not commercial damaged ( $\leq 3$ ) = dense.
- (C) 80% crop damage = open soil widespread.
- Atrazine soil applied, **root-uptake**, post emergence, Group 5, photosystem II inhibitor



# Case Study for Drift – Real Life

Tank mix - Applied in late April, 2016 to corn fields adjacent to two *Paeonia* sp. (peony) fields:

- I. Resolve<sup>®</sup> Q - 2 ALS (Group 2)
- II. Breakfree<sup>®</sup> ATZ – VLCFA inhibit. (Group 15) and PSII inhibit. (Group 5)
- III. Ammonium nitrate (AN) [(NH<sub>4</sub>)(NO<sub>3</sub>)] (34-0-0)]

Resolve Q - [rimsulfuron 18.4% by wt. (Group 2)] + [thifensulfuron-methyl 4.0% by wt. (Group 2)] (DuPont™, E. I. du Pont de Nemours and Co., Wilmington, DE).

Breakfree ATZ - [acetochlor 32.6% by wt. (Group 15) + (atrazine and related triazines 24.4% by wt. (Group 5)] (DuPont)

*Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America (WSSA) Classification system of herbicide modes of action (MoA) ([wssa.net/wp-content/uploads/HerbicideMOAClassification.pdf](http://wssa.net/wp-content/uploads/HerbicideMOAClassification.pdf))*



## *Drift Injury is Typified by Variability (Dexter, 1995)*

Field	Cultivar	Mean of phytotoxicity rated scores'	SDAL Soil Test Result Soil	SDAL Foliage Test Result
<b>Good</b>	Unknown	1.6a <sup>x</sup>	1.1 ppb	208 ppb
<b>GLG</b>	Alexander Fleming	7.1bc	3.2 ppb	44.1 ppb
<b>GLG</b>	Tulip Pink	8.6d	13.4 ppb Atrazine & 5.7 ppb Acetochlor	63.1 ppb
<b>Burnside</b>	Big Head Pink	6.0b	--	65.4 ppb*
<b>Corn</b>	65.4/96.6 X100 = 68%		96.6 ppb* Atrazine	

y = Visual ratings based on a 0-10 scale with 0 being no injury and  $\geq 3$  commercially unacceptable. Each increment from 0 represents a 10 % increase.

Atrazine is translocated only in the xylem;  
thus, phloem transport is not occurring



Atrazine found in the  
foliage at 63.1 ppb =  
severe foliar necrosis  
versus chlorosis in a  
less sensitive crop





Subsequent have come along  
and said – we found 2,4-D on  
your peonies at:

10.4 ppb = 0.0104 ppm

9.6 ppb = 0.0096 ppm

18 ppb = 0.018 ppm

(Feucht, J. - Journal of  
Arboriculture 14(9):

September 1988) says:

0.52 ppm damages trees

•• 0.18 = non-damaging





**Lots of things curve leaves up but  
downward cupping – that is epinasty –  
and that's a PGR**



**Downward rolling of leaf margins,  
elongation of leaf tips, leaf strapping**



# Oak



An elongation – a strapping of the foliage + downward + marginal



# Group 15 = Drawstring – effect on foliage



Peonies - 2016

1/24/2019

Breakfree® ATZ [acetochlor +  
atrazine Group 5 in late April

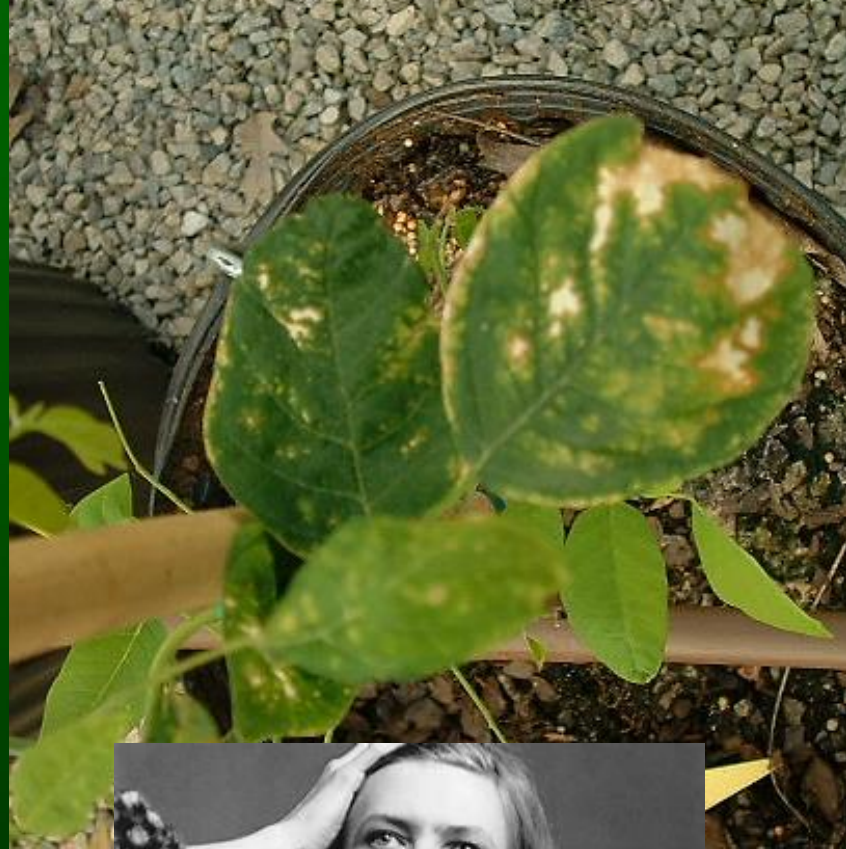




# 1 b. Secondary Drift

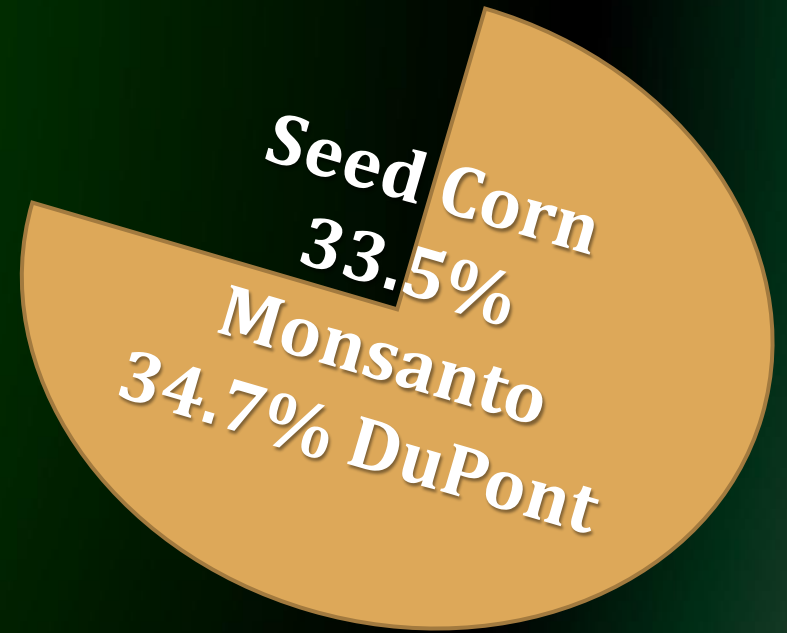
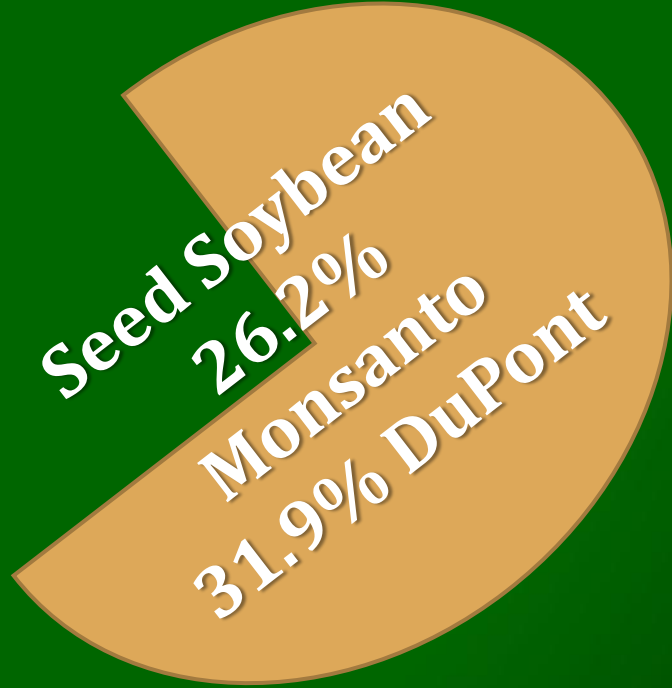
- Most common form is vapor drift = volatile herbicides

**Diphenylether =  
Goal  
PPO herbicide  
-lipids and  
proteins are  
oxidized = Leaky  
cell membrane =  
rapid  
disintegration =  
contact burn**



OMG – it is volatilizing!!





### 1 c. What Is The Problem?

Three main dicamba products sold:

BASF – Engenia

Monsanto – XtendiMax with Vapor Grip

DuPont - FeXapan

Incentives to buy,  
ex. XtendiMax +  
Warrant = \$11.50  
per acre – cash  
back



## 1c. What is the problem:

Ag. Producer needs to better understand issues of nursery/ landscape crops

- ✓ High-value
  - ✓ Long- replacement
  - ✓ Not monoculture – many species, many ages = same field
- 
- “Not so bad” idea
  - Nursery/landscape sold by quality – aesthetics – “Not so bad” = “Not so sold”

## 1c. What is the problem:

Onus is on the applicator:

- Doing everything to reduce/ eliminate “target” crop injury
- Not taught what is best to reduce/ eliminate injury to “non-target” crop
- Ex. New State and EPA Restrictions regarding date of applications





## MINNESOTA

The Minnesota Department of Agriculture (MDA) imposed restrictions for all new dicamba formulations. All three of the formulations, XtendiMax, Engenia and FeXapan, are "restricted use pesticides" for retail sales to and use only by Minnesota certified applicators.

The formulations cannot be applied after June 20 to help reduce the potential for volatility and movement. MDA notes that the majority of Minnesota soybeans are still in the vegetative growth stage by June 20, and research has shown that plants in the vegetative stage are less affected than those in the reproductive stage.

The herbicides also now cannot be applied if air temperatures in fields are above 85°F or if the National Weather Service's forecast high temperature for the nearest available location exceeds 85°F.

## Minnesota

- The big three formulations

Cannot be applied after June 20

-- Why June 20?

Is before June 20 a good time for nursery crops?



## IOWA

The Iowa Department of Agriculture and Land Stewardship issued a special local need registration for XtendiMax. It requires expanded dicamba training, which includes:

- New use pattern for dicamba-tolerant soybeans
- Application requirements including wind speed and direction and buffers
- Information about temperature inversions
- Enhanced record keeping
- Required spray tank cleanout
- Details about off-target movement

The department worked with Iowa State University to develop these topics and will approve the training. It says the expanded training should help reduce problems associated with off-target movement. More information is available at <https://www.agribiz.org/dicamba-training>.

## IOWA

- The big three formulations
- Use dicamba -tol. soybeans
- Wind speed 10 mph from 15 mph
- Wind direction and

## **Buffers**

Will this help with the truck sprayers???



# 1 a. DATA – What else is contributing:

## Drift doubles as boom height doubles



### Top states where users searched for self-propelled sprayers:

This is sourced from search traffic for sprayers in 2017.



1. Illinois
2. Minnesota
3. Arizona
4. Iowa
5. Nebraska
6. Texas
7. Wisconsin
8. Alabama
9. Missouri
10. Ohio

3  
4



### 3 -5. Sudden, Point in Time, Not Spreading, Initial Injury most Intense – Dependent on herbicide

#### Soil Bioassay

- Collect 2" deep
- 10 seed/ pot
- 30-45 days



Burnside 20% germ.⇒

⇐ Good 100% germ.

Lettuce for **acetochlor** (*per* El. Nahhalet al., 2013)

**Germination** – lettuce - Group 15, preemergence, shoot inhibitor (MoA).

El-Nahhal, Y., Y. Awad and J. Safi. 2013. Bioremediation of acetochlor in soil and water systems by cyanobacterial mat. International Journal of Geosciences 13:880-890.



## 2. Carryover – i. Soil

Sugarbeet for atrazine (Washington State Publications, 1987 and 2011).

### Post-germination

Several weeks - soil applied, root-uptake, postemergence, Group 5, photosystem II inhibitor.

Unlike the acetochlor atrazine effect continues as long as the atrazine is in the root zone.



## 2. Carryover – i. Soil

BIOASSAY CUCUMBER –  
GROUP 4 (GR)

Callus, brittle stems, epinasty –  
**Mulch 4 yrs later**





# Bioassay Beet – Group 7 (PS<sub>II</sub> Inhibitor)

- Germination occurs but followed by rapid loss of chlorophyll.
- Prompt death by starvation.
- Field soil with 2.9% organic matter and Diuron 4L applied Mar. 2014, IN. (Picture taken by H. Mathers, July 2015).

## 2. Carryover - Soil



# Most Important Determinant of Long-term Injury - Soil

- **Carry-over - Soil?:**

- Does it persist in the **soil?**

- **Long half-life**

- Group 5 - Atrazine = 60 d

- Group 15 - Acetochlor = 10-20 d

- Group 2 - Plateau = 2-4 d

- (Curran and Lingenfelter, 2012)

- ✓ Potent in small quantities – Group 2

- ✓ pH – more acid more residual

- ✓ Soil type, O.M. content



## 2. Carryover – ii. Plant

Inhibition or damage caused: epinasty=downward twisting, abnormal leaf and stem growth, callus tissue formation, death

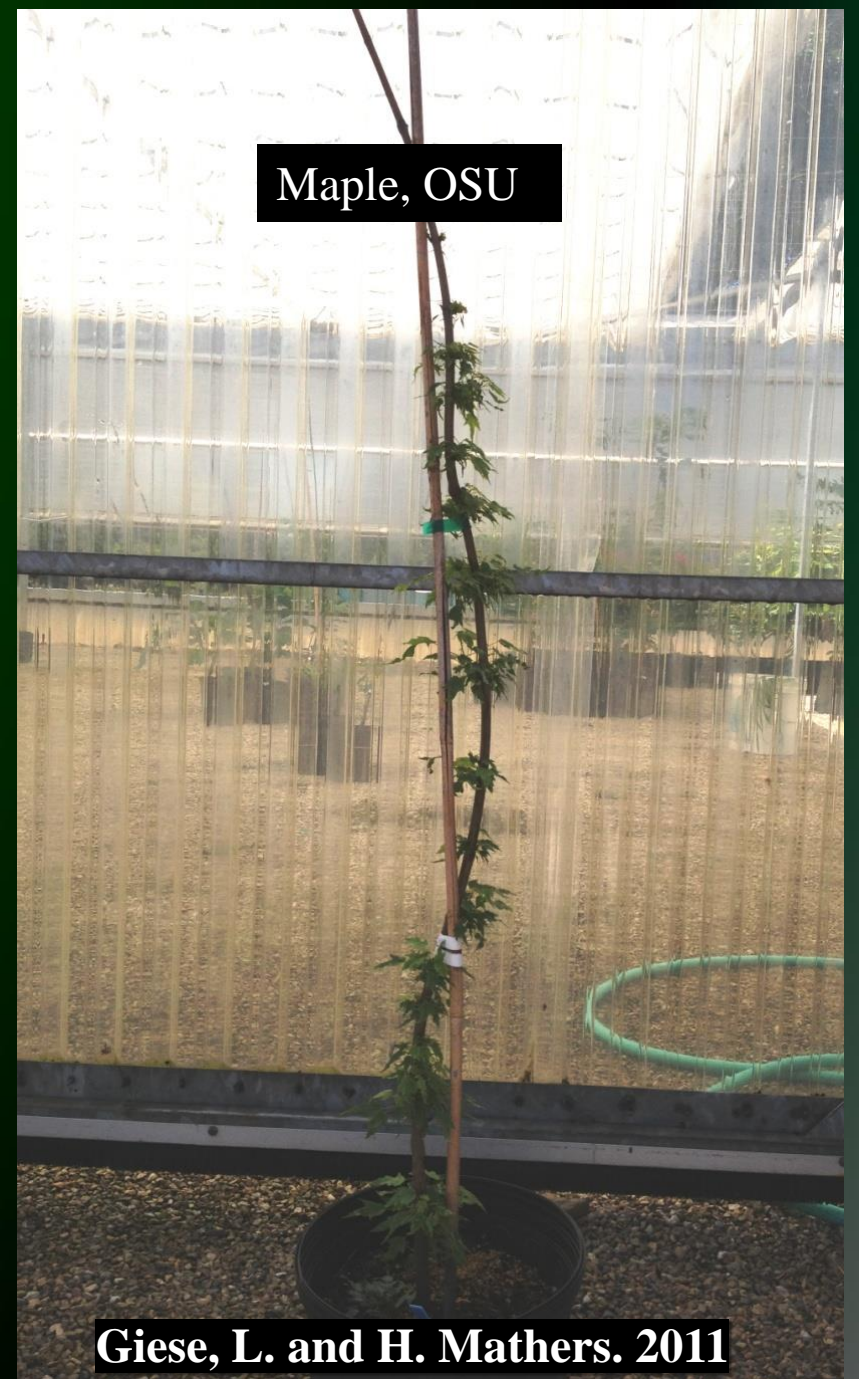


**GROWTH  
REGULATORS**



# Carry Over – ii. Plant

- Broken down quickly in soil
- Breaks down “very” slowly in the plant
- Remaining for years (Stasiak *et al.* 1991 and 1992)
- Giese, L. and H. Mathers. 2011.
- Visible injury one and two years after





# *Carryover Injury is also Characterized by Variability*

## **2. Carry Over - Plant**



Spirea

Control

Glyphosate 1/16



Buxus

Glyphosate 1/16

Applications – 11/2010

Evaluations – 04/2011

## Results / Discussion: Shikimic Acid

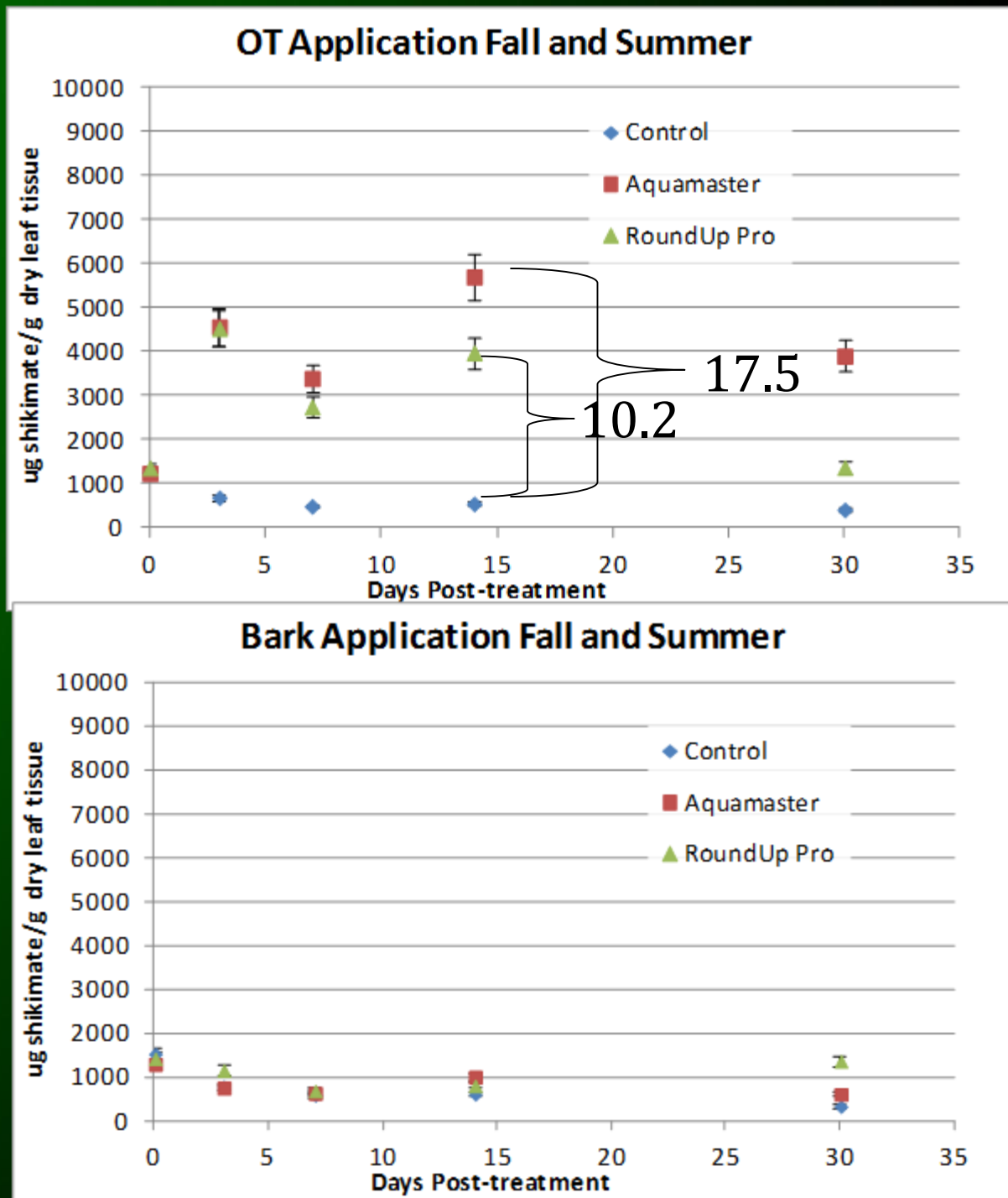
### Quantitative Mass Spectrometry: LC-MS/MS

- Similar LC method with mass spec detection
- Higher sensitivity and selectivity
- Internal standard:  $^{13}\text{C}$  labeled glucose
- CV = 9% for extraction and analysis



# Results / Discussion: Shikimic Acid Analysis

Giese, L. and H. Mathers. 2013



Raeder and Burke (2015); Injected  $^{14}\text{C}$ -glyphosate below the graft basal (BGB), above graft basal (AGB), and foliar application in actively growing 'Gala' apple trees.

**Basal applications increased absorption of glyphosate compared to foliar.**

28 DAT, average absorption was 87, 93% and 45 % for BGB, AGB, and foliage, respectively. Translocation 28 DAT was <3% for BGB, AGB. While translocation of glyphosate from the foliage was high; however, high absorption by basal applications compared to foliar = supports Daniel and Mathers, 2005.



# Your Trees on Crack!





# DAUGHTER PLANTS - LOOK LIKE SPRAYED



Twisting, strapping of leaves, and auxin-like injury symptoms.

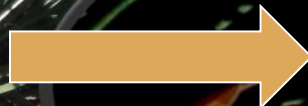
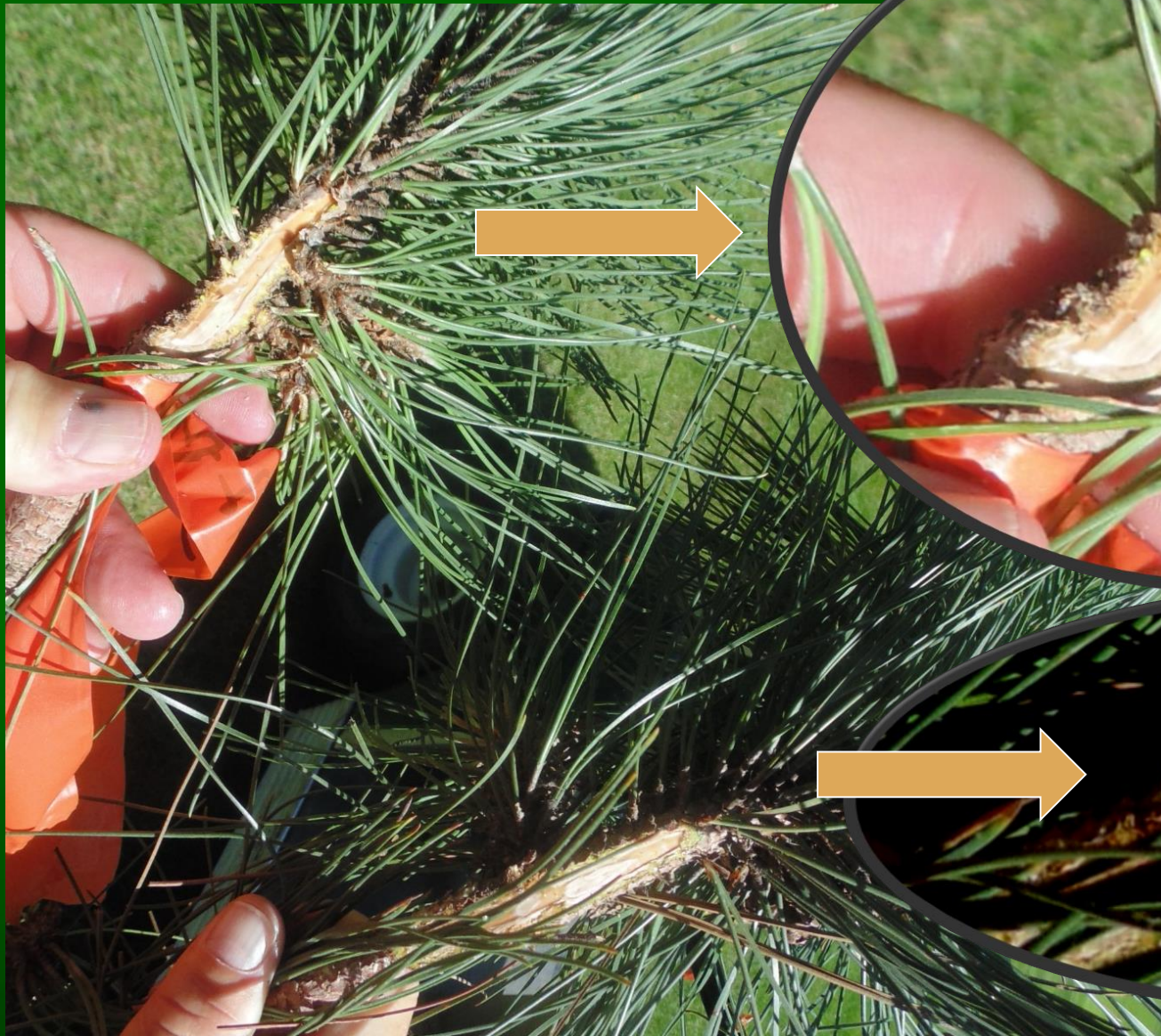
Hutchison et al., 2014



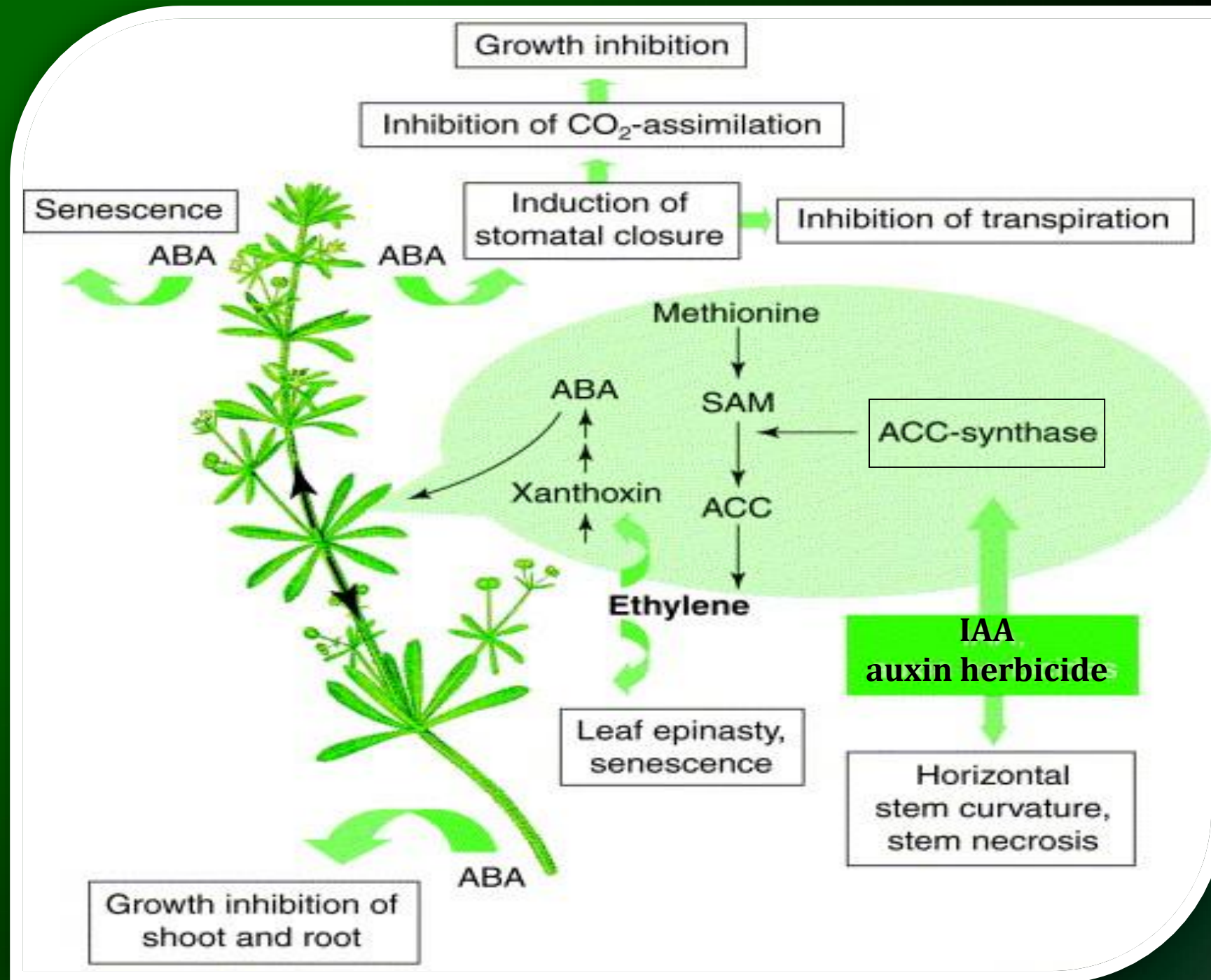
Reduced growth and chlorosis on leaf margins.



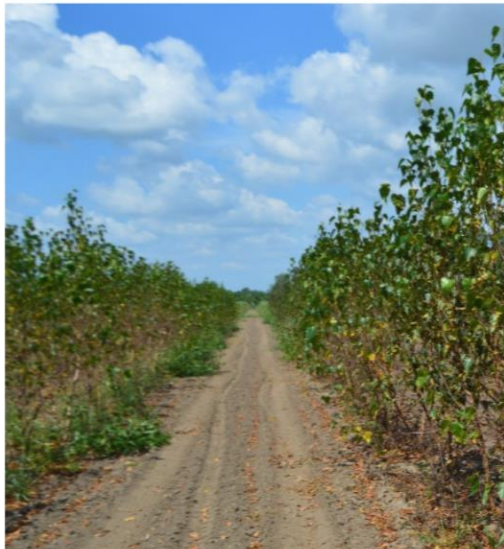
# Partial Cambial Death











Group 4 applied  
- 2015

40 – 50% defoliation  
Mid August, Missouri

1/24/2019

*Betula populifolia* 'Whitespire'



No Group 4 applied





# Most Important Determinant of Long-term Injury - Plant

- Carry-over - Plant ?:
  - Does it persist in the **plant**
  - Slow breakdown in plant – effect 2ndary systems
  - **Mobility** in the plant = more problems esp. to growing points – *Systemic herbicides* – Group 4, Group 9





# SHORT TERM INJURY

- No to limited mobility
- Does not persist, plant or soil

Most long-term injury herbicides will also create short term injuries:

But to consider that one, two and even three years after the application event that no injuries will be present is false

&

That the long-term injury will look like the short term (catastrophic injury) is also false





1/24/2019

Daniel and Mathers, 2011

# Conclusions

## **Herbicide Labelling:**

“It is a violation of Federal law” to use herbicides “in a manner inconsistent with their labelling.”

1. For specific “target” crop(s)
2. For specific rates, gpa, etc.
3. For specific sites
4. For specific conditions – type of sprayer, ht. of boom, temperatures, soil types
5. For application type - directed or OTT – “not on green bark”, “never contact foliage”



# Conclusions

**A product is labelled with a high degree of predictability - as to its performance.  
When a product drifts or carries-over the results are unpredictable !!!**

# Conclusions

- 6. For specified - wind direction and speed
  - ✓ **No** applications – “in conditions promoting drift”
  - ✓ **No** applications – “when wind speeds or gusts exceed 15 mph”; “when wind speed > 10 mph”
  - ✓ **Never** when wind conditions favor drift on “non-target sites” or non-target tissue.
  - ✓ **Avoiding drift is the responsibility of the *applicator***



**Reduced diversity or shifts in the composition of field edge plant communities have been noted with the use of glyphosate and rise in glyphosate resistant crops**

**Reduced and delayed flowering has been noted affecting the ability of pollinating insects to survive I those periods.**

***2Effects of spray drift of glyphosate on non-target terrestrial plants – A critical review. Available from:***

**[https://www.researchgate.net/publication/318604871\\_Effects\\_of\\_spray\\_drift\\_of\\_glyphosate\\_on\\_non-target\\_terrestrial\\_plants - A critical review](https://www.researchgate.net/publication/318604871_Effects_of_spray_drift_of_glyphosate_on_non-target_terrestrial_plants_-_A_critical_review) [accessed Mar 14 2018].**

If glyphosate is having this kind of environmental impact  
What will the addition of dicamba resistance to crops do???

The long-term environmental impacts of these  
programs -- need to be considered and  
researched.



STARTED 1913:  
THE POST OFFICE PUT A STOP TO “BABY MAIL” IN 1915



- One 50 # girl  
was sent from  
FL to Virginia  
for 15

Speci

**Not Every Great Idea is  
Great for Everyone**