Oak Leaf Tatters – A Chemical Connection?

A Pilot Study in Spring, 2006

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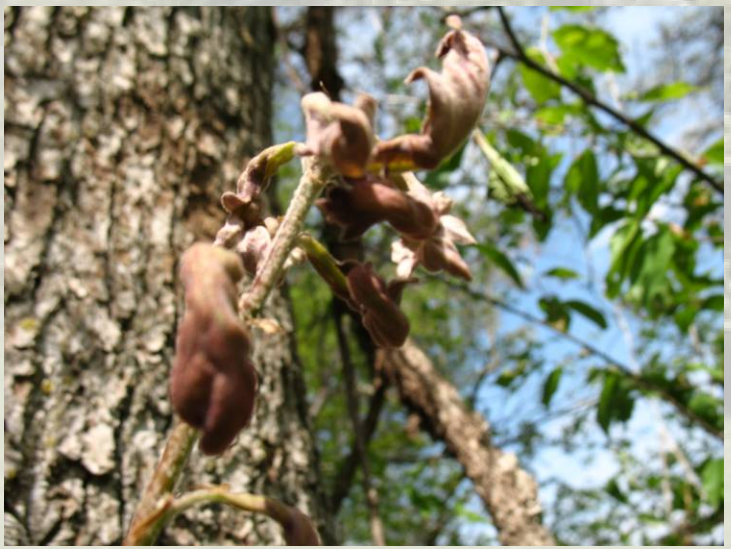
What is Oak Tatters?



- Abnormal curling of newly emerging leaves
- Occurs only in the Spring
- Has been reported in MN, WI, IL, IN, IA
- Mostly seen on white and bur oaks, but can occur on red oak and hackberry

5/2/06

5/9/06

5/16/06

What happens after Tatters

- White oaks will use stored starch reserves to create a new flush of normal looking leaves.
- Concern is how much reserves do our mature oaks have left??

Tatters does not affect all trees

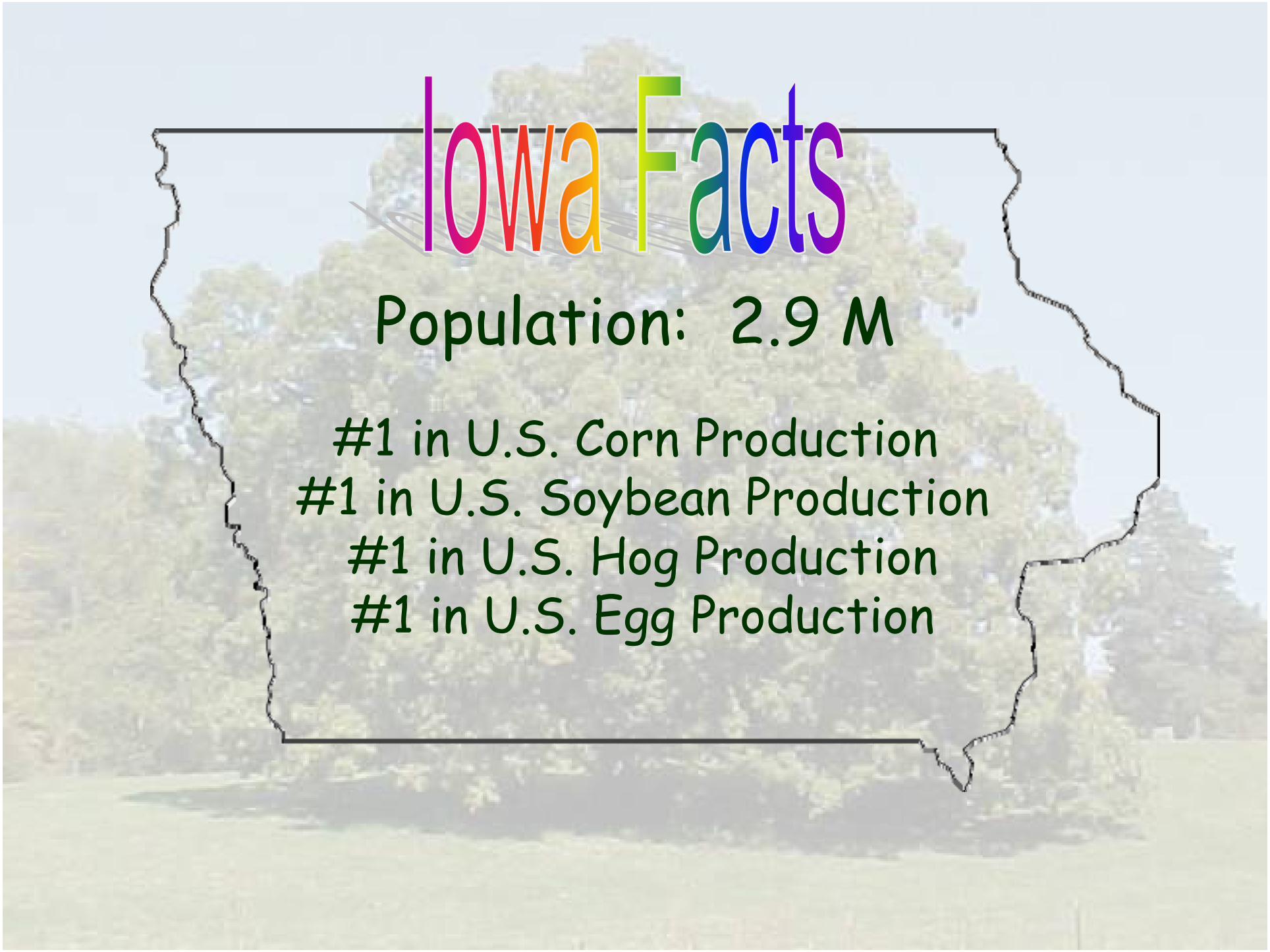
- Trees within the same species break dormancy at different times
- This explains why neighboring trees can be normal next to tattered trees.
- Occurs on any aged tree; has been reported on urban and rural trees

Eliminating Possible Causes

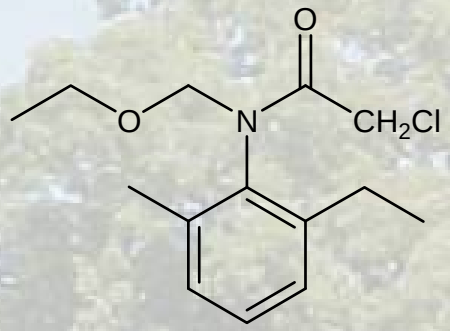
- We have used on site temperature sensors to rule out frost damage
- No insects or diseases have been found on the leaves
- Wind can tatter leaves, but usually affects mature leaves

University of Illinois Study

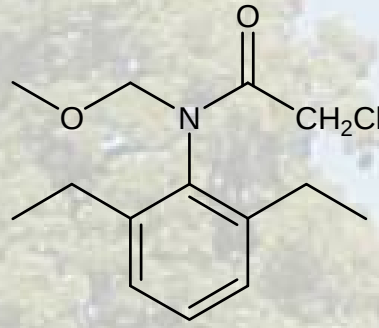
- Looked at white oak in 2004
- The objective was to determine if herbicide drift could cause tatters
- Treated trees at three stages with a variety of chemicals
- Swollen bud, leaves unfolding, and leaves expanded
- This study indicated a possible link between tatters and chloroacetamide herbicides when leaves are unfolding


Iowa Facts
Population: 2.9 M
#1 in U.S. Corn Production
#1 in U.S. Soybean Production
#1 in U.S. Hog Production
#1 in U.S. Egg Production

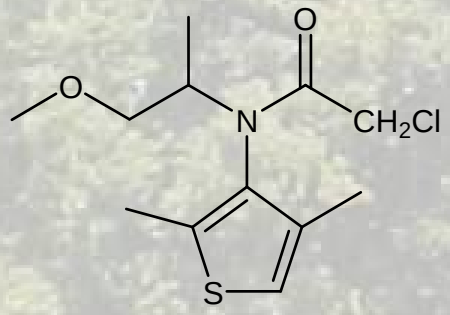
Chloroacetanilide/Chloroacetamide Herbicides



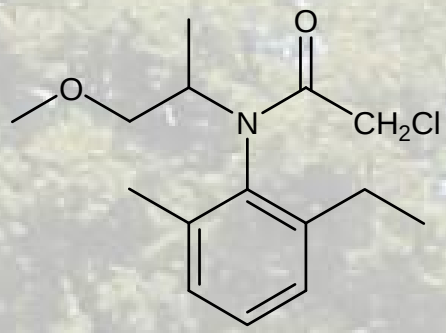
Acetochlor



Alachlor



Dimethenamid



Metolachlor

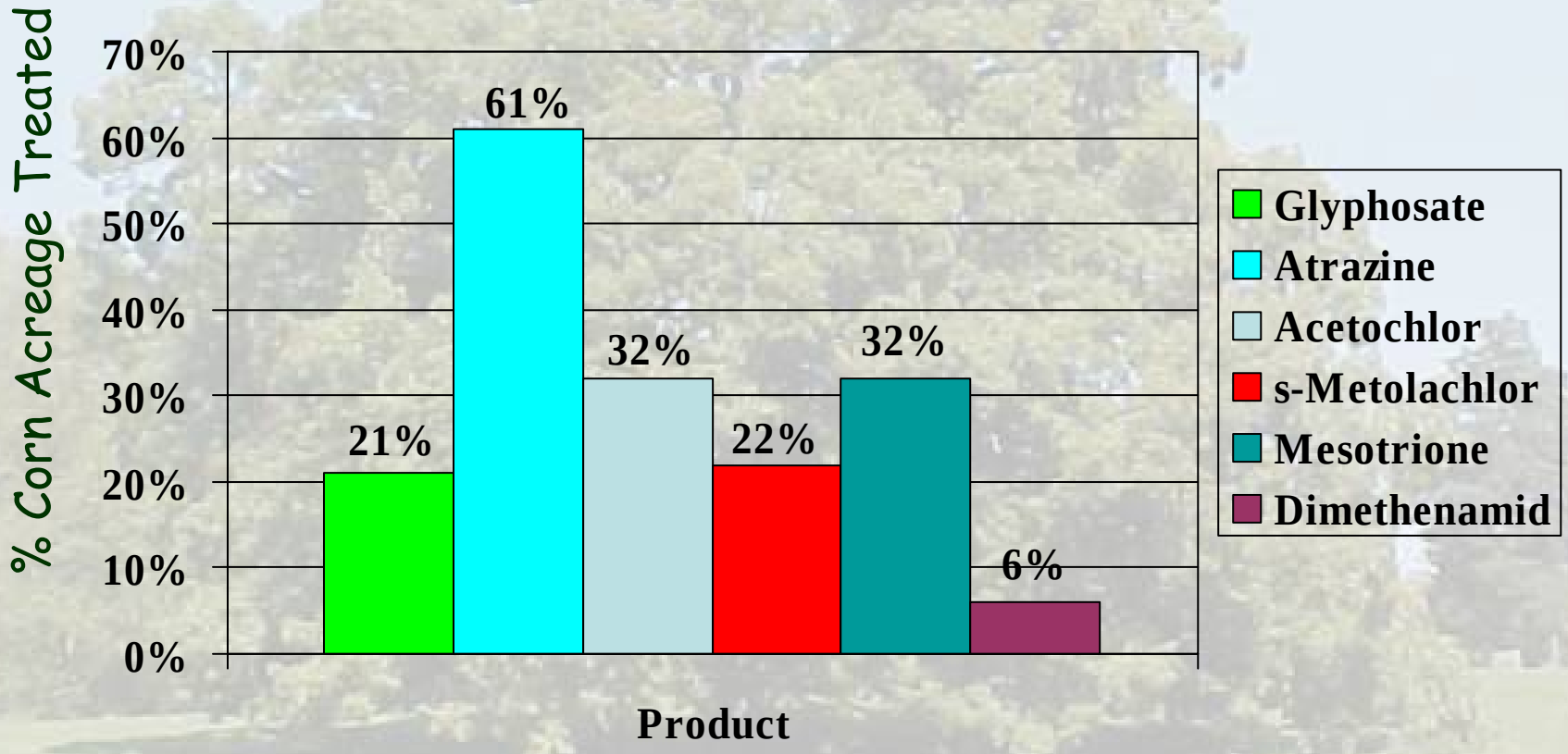
Acetochlor

- Chloracetanilide herbicide for control of grass and broadleaf weeds in corn
- Effective weed control at use rates lower than competitor products...thus considered more "environmentally friendly"
- Conditional registration granted by EPA in 1994
- Conditions attached to registration due to environmental concerns

Acetochlor Conditional Registration Agreement

- May not be used on certain coarse soils or when water table is 30 feet or less due to concerns of acetochlor getting into groundwater.
- Extensive water monitoring studies to ensure groundwater not getting contaminated.
- Use of other corn herbicides must decrease by target amounts (alachlor, metolachlor, atrazine, EPTC, butylate, 2,4-D)

2005 Iowa Pesticide Use for Corn



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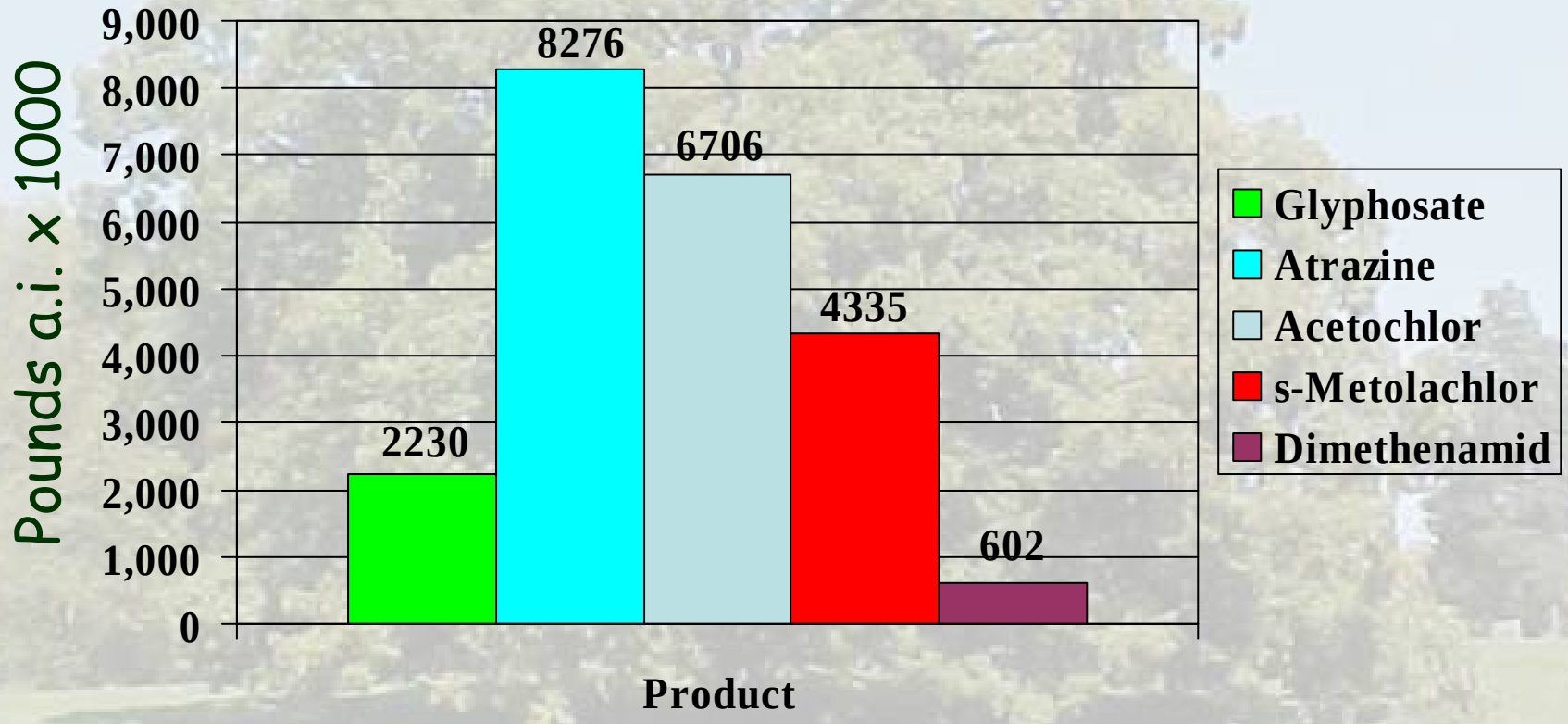
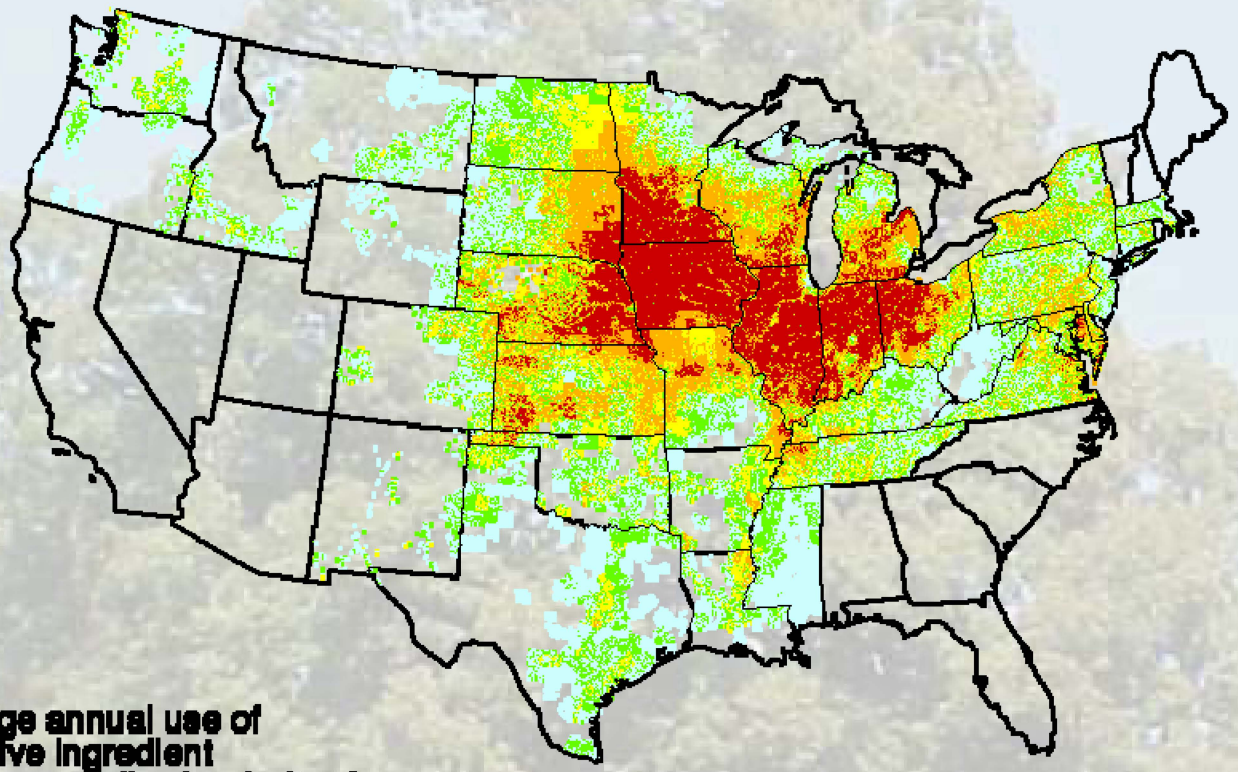


ACETOCHLOR - herbicide

2002 estimated annual agricultural use

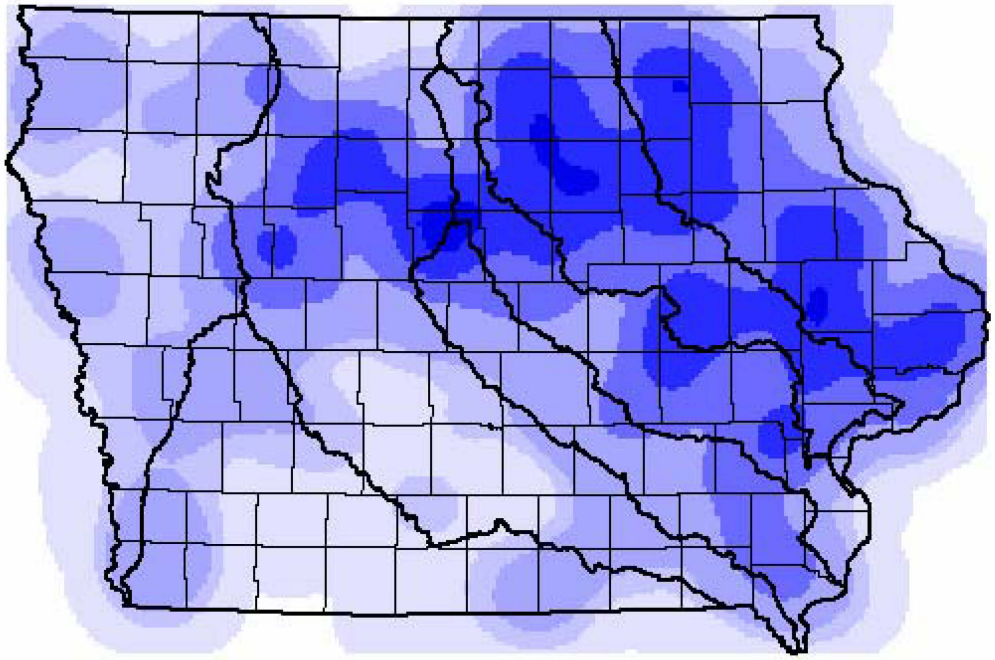


Average annual use of active ingredient (pounds per square mile of agricultural land in county)

- no estimated use
- 0.001 to 0.154
- 0.155 to 0.915
- 0.916 to 4.666
- 4.667 to 21.221
- >= 21.222

Crops	Total Pounds Applied	Percent National Use
corn	36140636	100.00

Interpolated Density Surface of Total Alachlor Sales in 1992



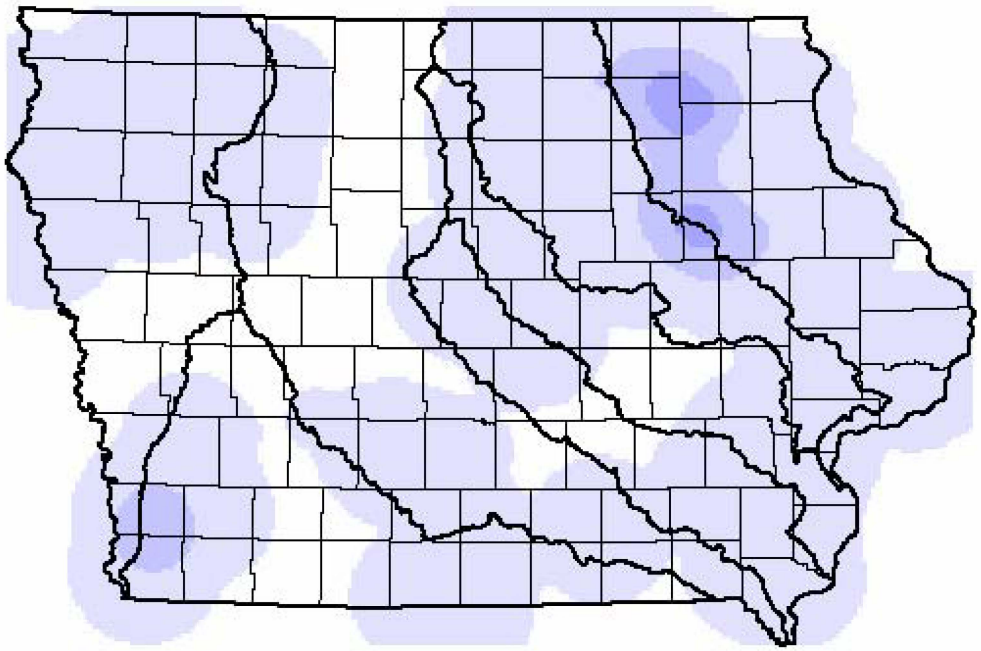
Density of Alachlor Sold 1992 (lbs./sq.mi)
- 0.1 - 10
- 10.01 - 20
- 20.01 - 55
- 55.01 - 100
- 100.01 - 145
- 145.01 - 175
- 175.01 - 200
- 200.01 - 230
- 230.01 - 260
- No Data

Author: Iowa Geological Survey
Note: Utilization of Kernel Interpolation
Bandwidth = 30 miles

100 0 100 200 Miles

N

Interpolated Density Surface of Total Alachlor Sales in 1999



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Routes of Pesticide Exposure

- Spray drift during pesticide application
- Volatilization of chemical after application
- Entrainment of contaminated soil particles
- Rain deposition

Hypothesis:

Oak Tatters is associated with elevated levels of Acetochlor in Leaf Tissue, Rain and/or Air

Based on

- Pesticide in Rain and Air, UHL, 1996-7
- Study done at the University of Illinois
- Onset of condition coinciding with introduction of Acetochlor to the market
- Field observations of proximity to cropping and timing of symptoms

Analytes for Study

- Heavily Used
  - Acetochlor
  - Metolachlor
  - Dimethenamid
- Not Used Extensively
  - Alachlor
  - Butachlor
  - Propachlor

Internal Standard (not sold in US)

- Metazachlor

Design

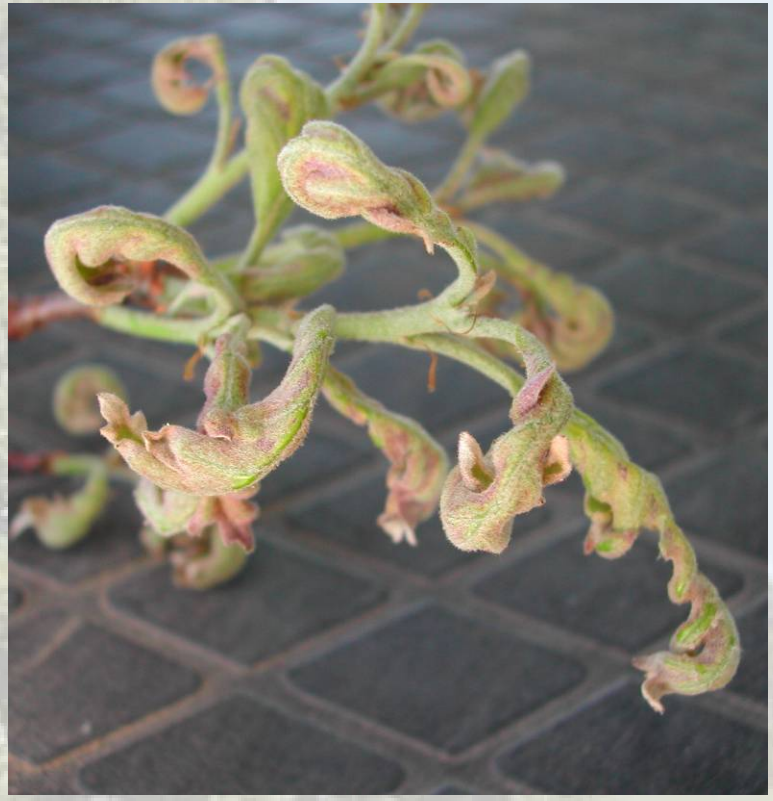
- From April 10 through May 18 in 2006
- Two sites for a variety of proximity to or isolation from cropping
- Collected Leaf, Rain, and Air Samples
  - Leaf – collected by Forestry staff with observations about damage and stage of growth
  - Air – collected on portable personal air samplers
  - Rain – Collected using Teflon funnels into Teflon bottles

Sites

- ICS – "Iowa City Site"
  - Southwest of West Branch, IA
  - Open wooded area surrounded by Fields
- WPH – "White Pine Hollow"
  - White Pine Hollow Forest Preserve
  - Heavily wooded
  - Relatively isolated

Leaf Samples

- Collected by Forestry Personnel
- Noted Damage to Correlate to Analytical Results
- Extracted by routine UHL methods
- Analyzed by LC/MS/MS



Leaf Samples

- Some leaves protected by pollination bags
  - Prevented access by rain and air
  - Prevented damage

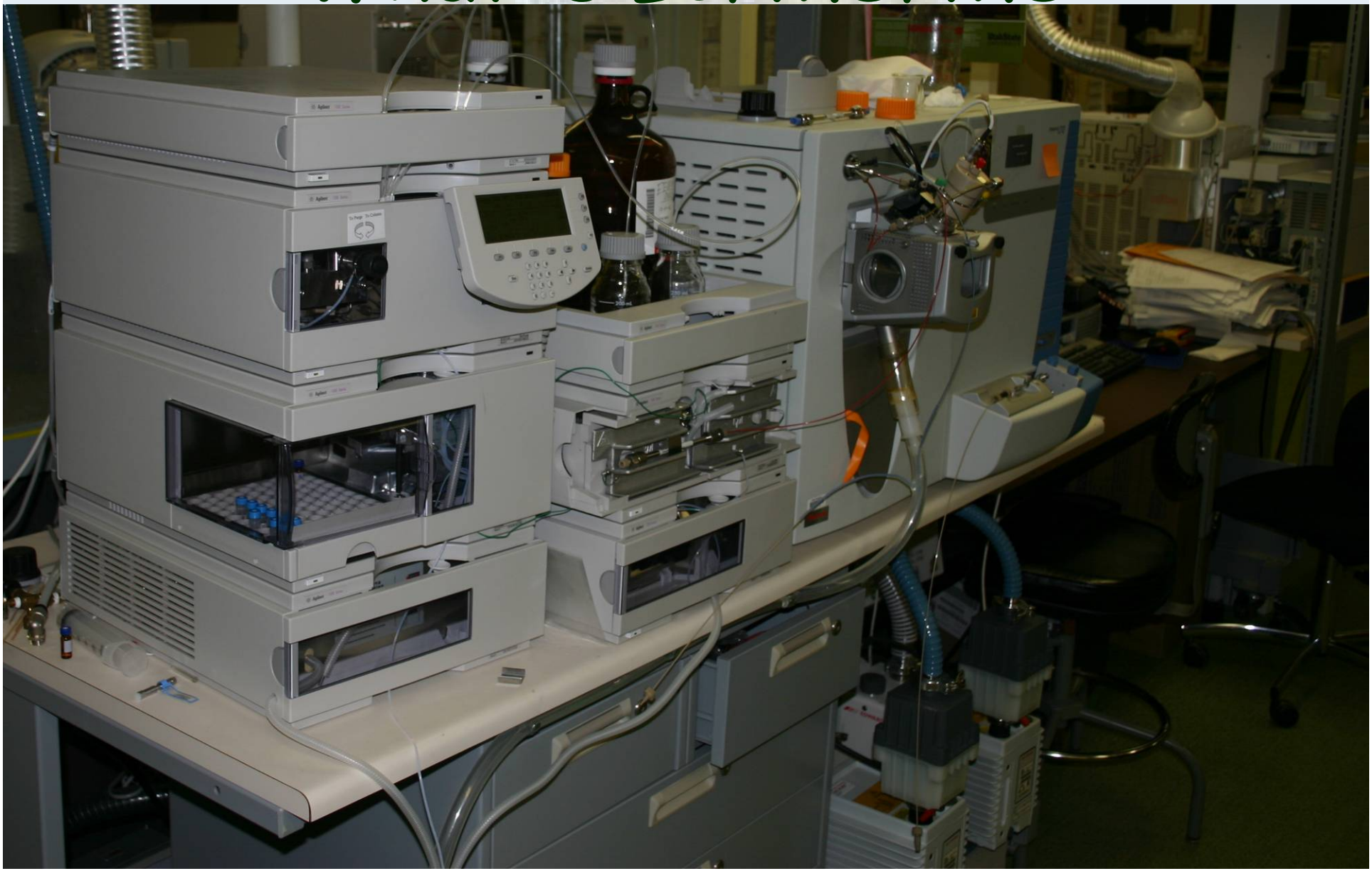
Air Samples

- For 24 hours
  - On 1 min., off 2 min.
  - 3 L/min while on
  - 1400 Liters of air
- PUF media
- Extracted at UHL
- Analyzed by LC/MS/MS

Rain Samples

- Collected with Teflon funnel into Teflon Bottle
  - Included wet and dry precipitate
  - Separate rain gauge to measure amount of rain
- No extraction, only filtering
- Analyzed by LC/MS/MS

What is LC/MS/MS



What is LC/MS/MS

- Separate your compounds on Liquid Chromatograph (LC)
- Ionize all the compounds present
- Look for the ion with the specific mass that hopefully indicates your compound
- Smash that ion into smaller bits that even better indicate your compound

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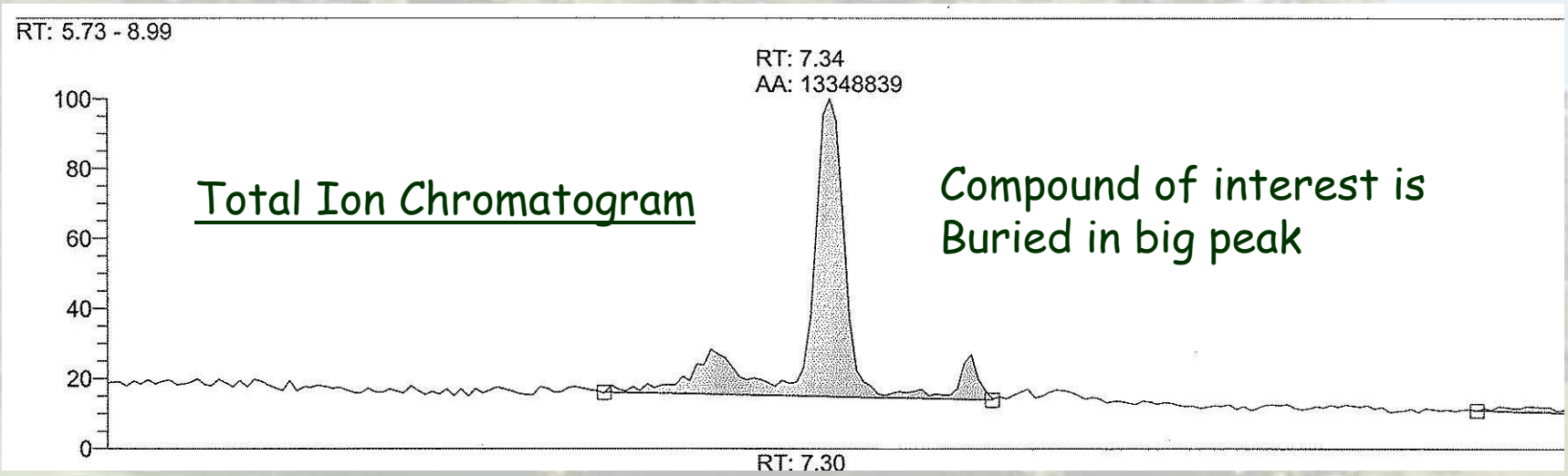

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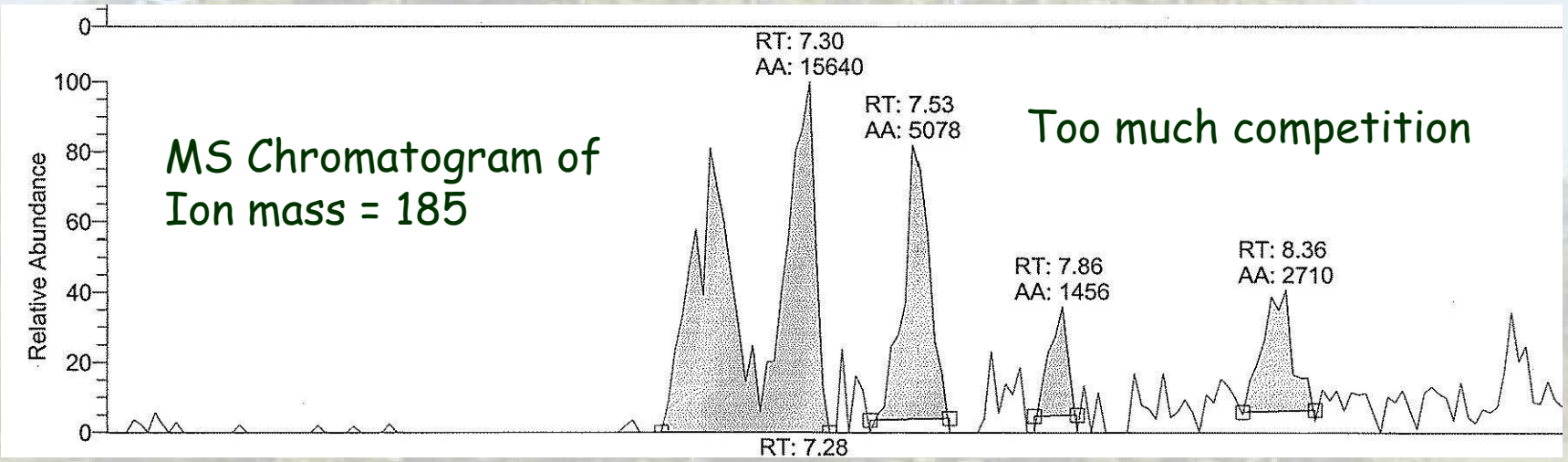

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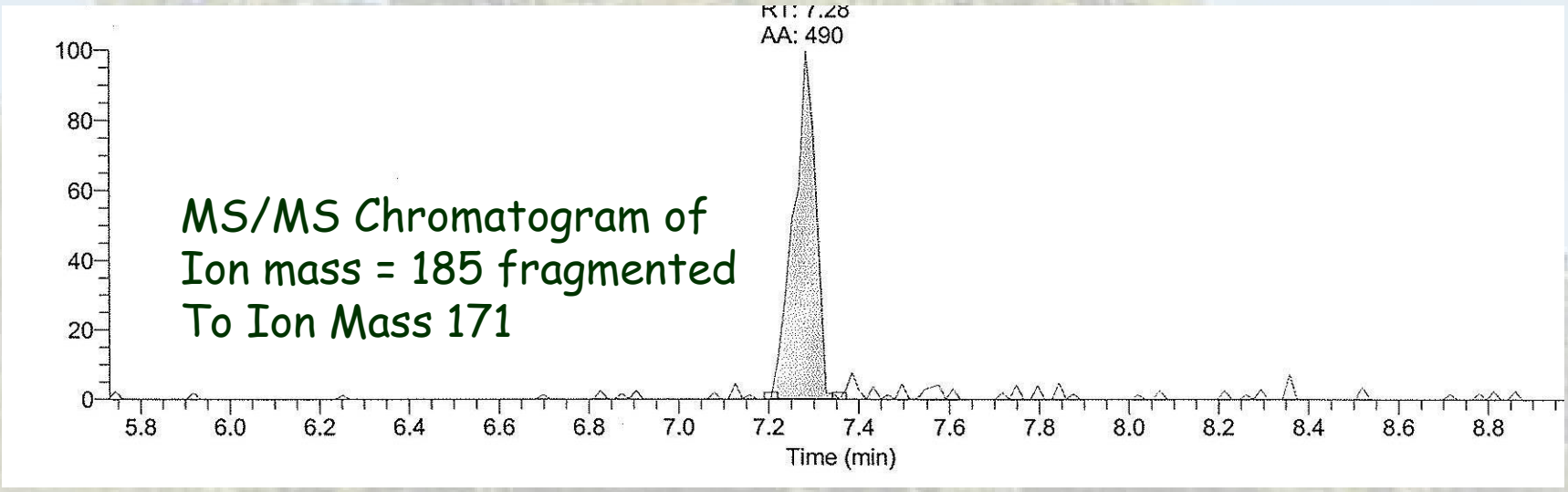
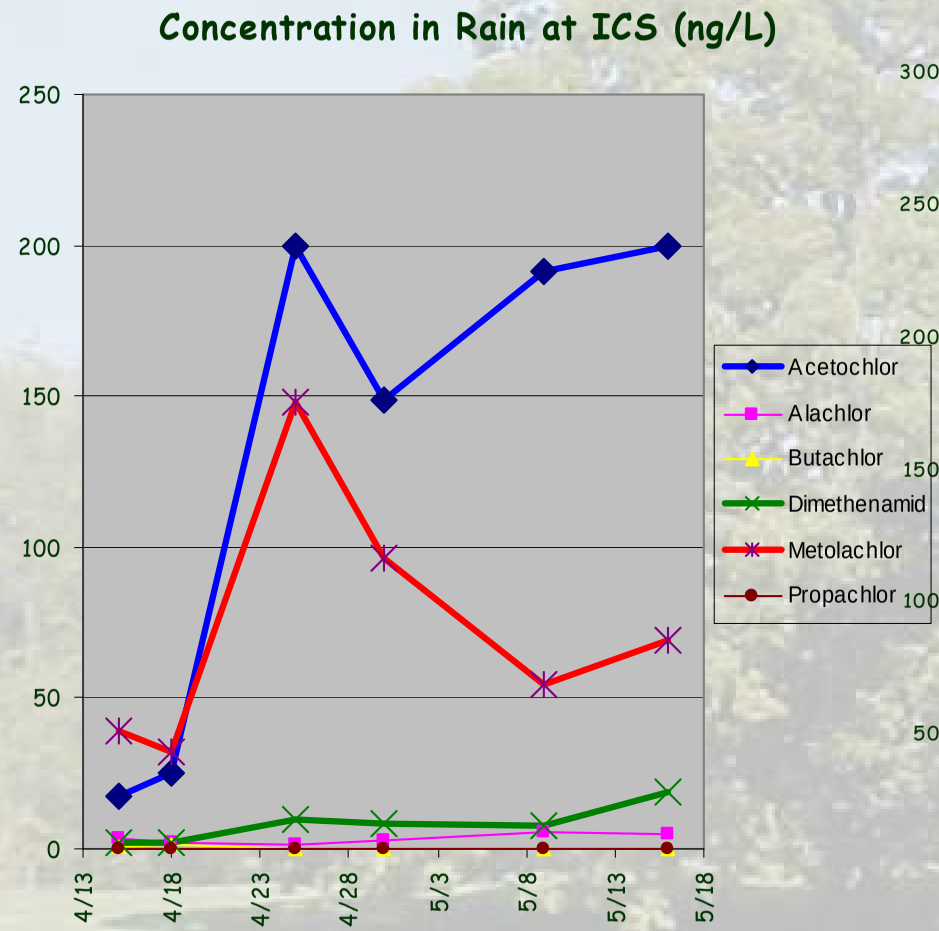
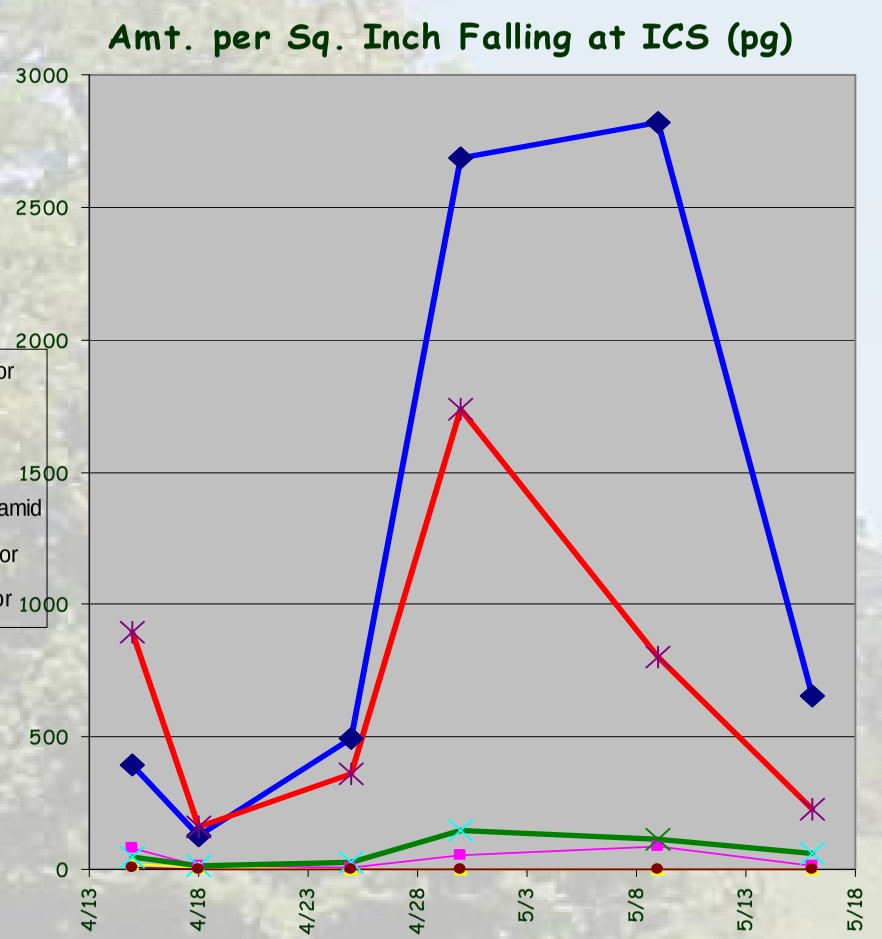


Sensitive and Specific

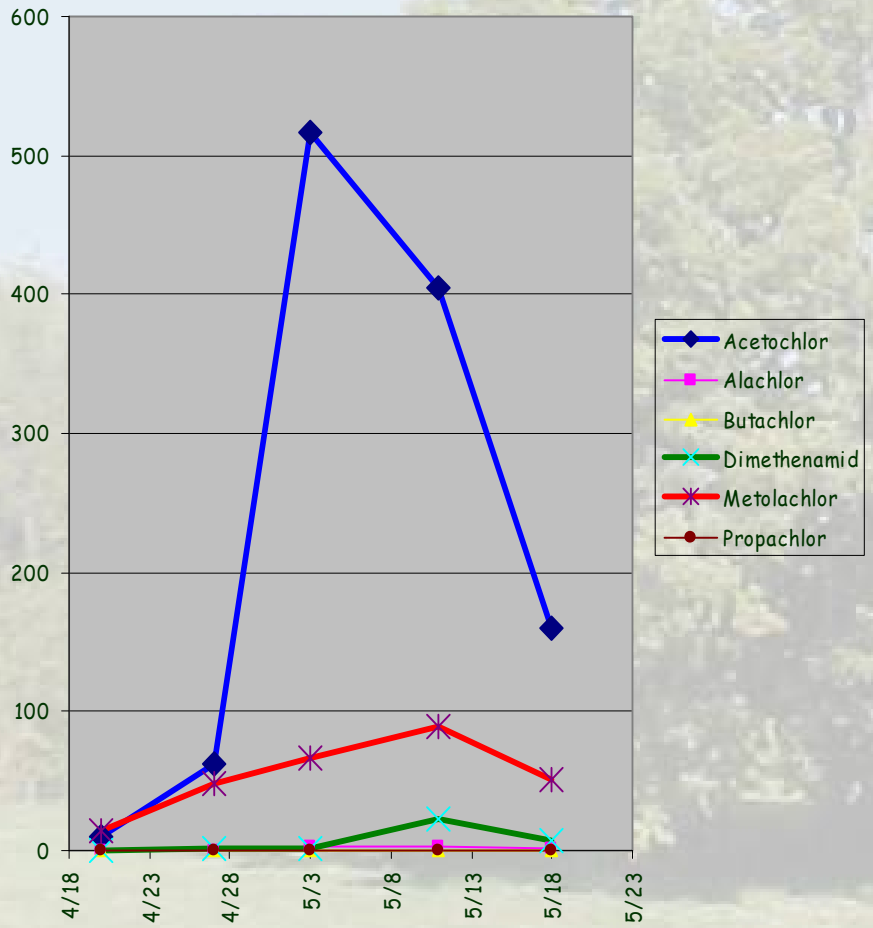
Rain Results at ICS



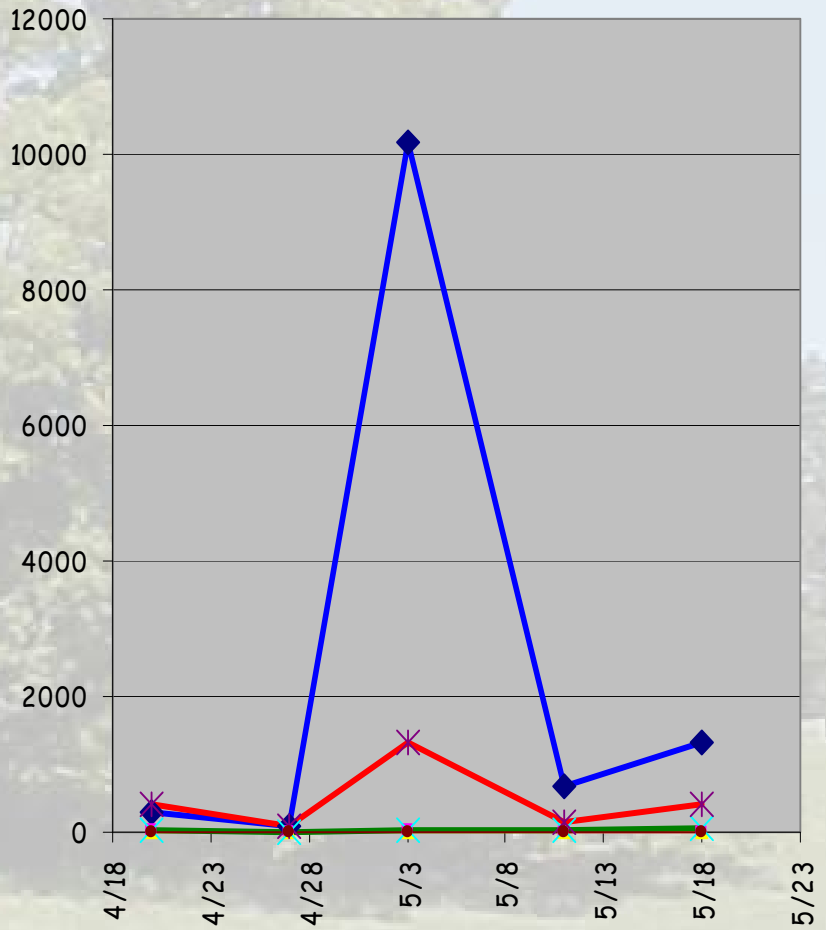


Rain results at WPH

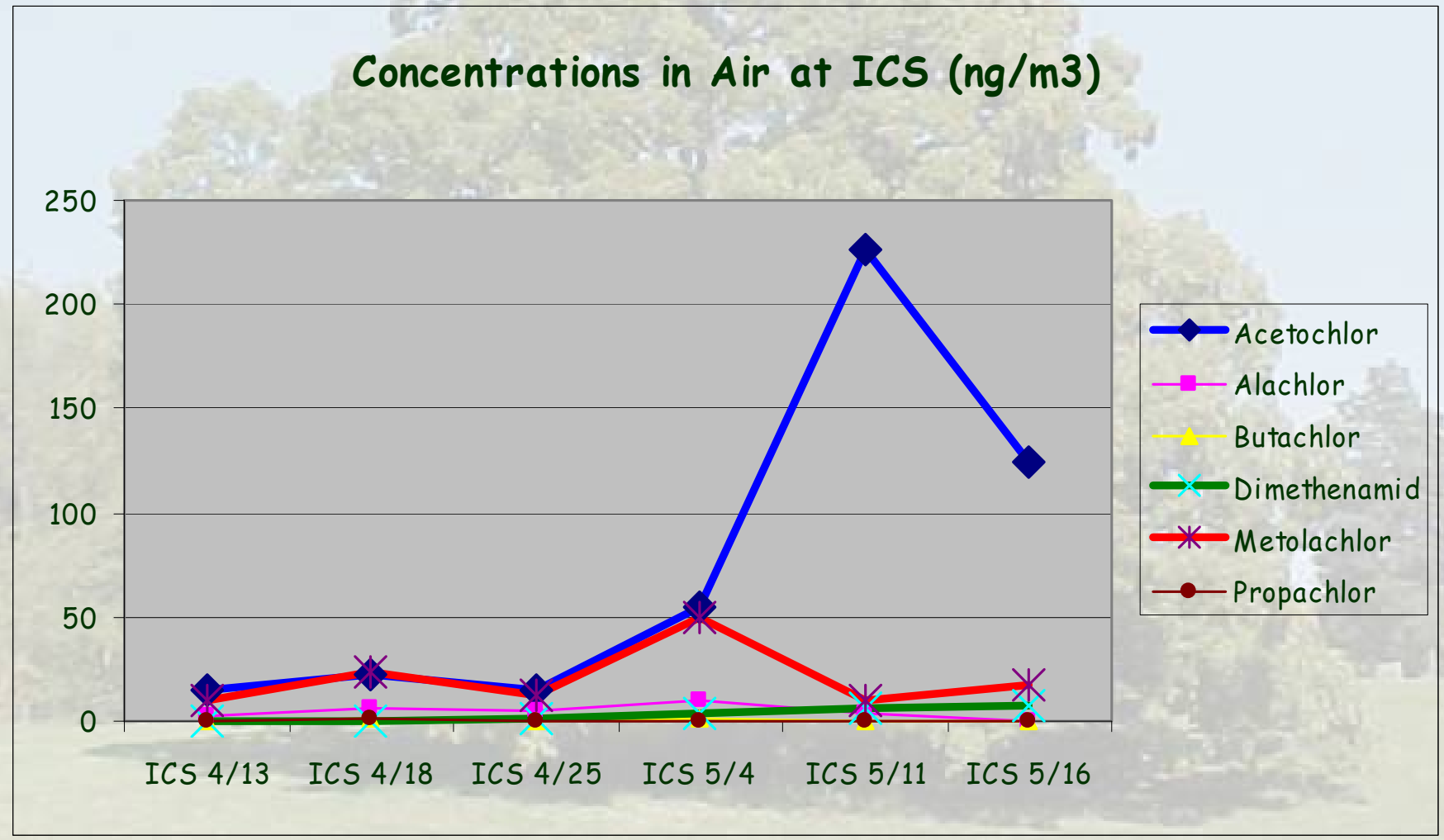
Concentration in Rain at WPH (ng/L)



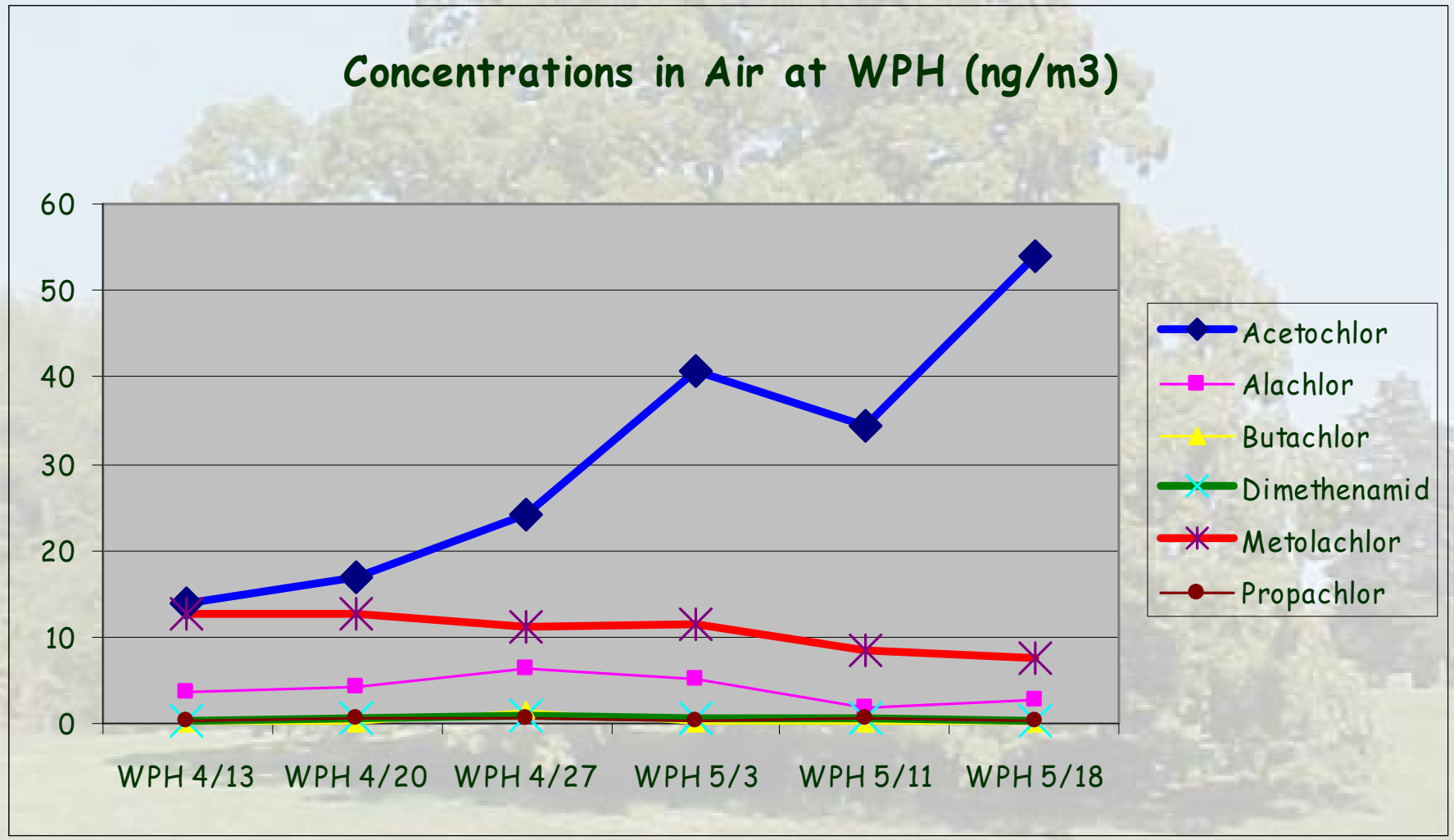
Amt. per Sq. Inch Falling at ICS (pg)



Air results at ICS



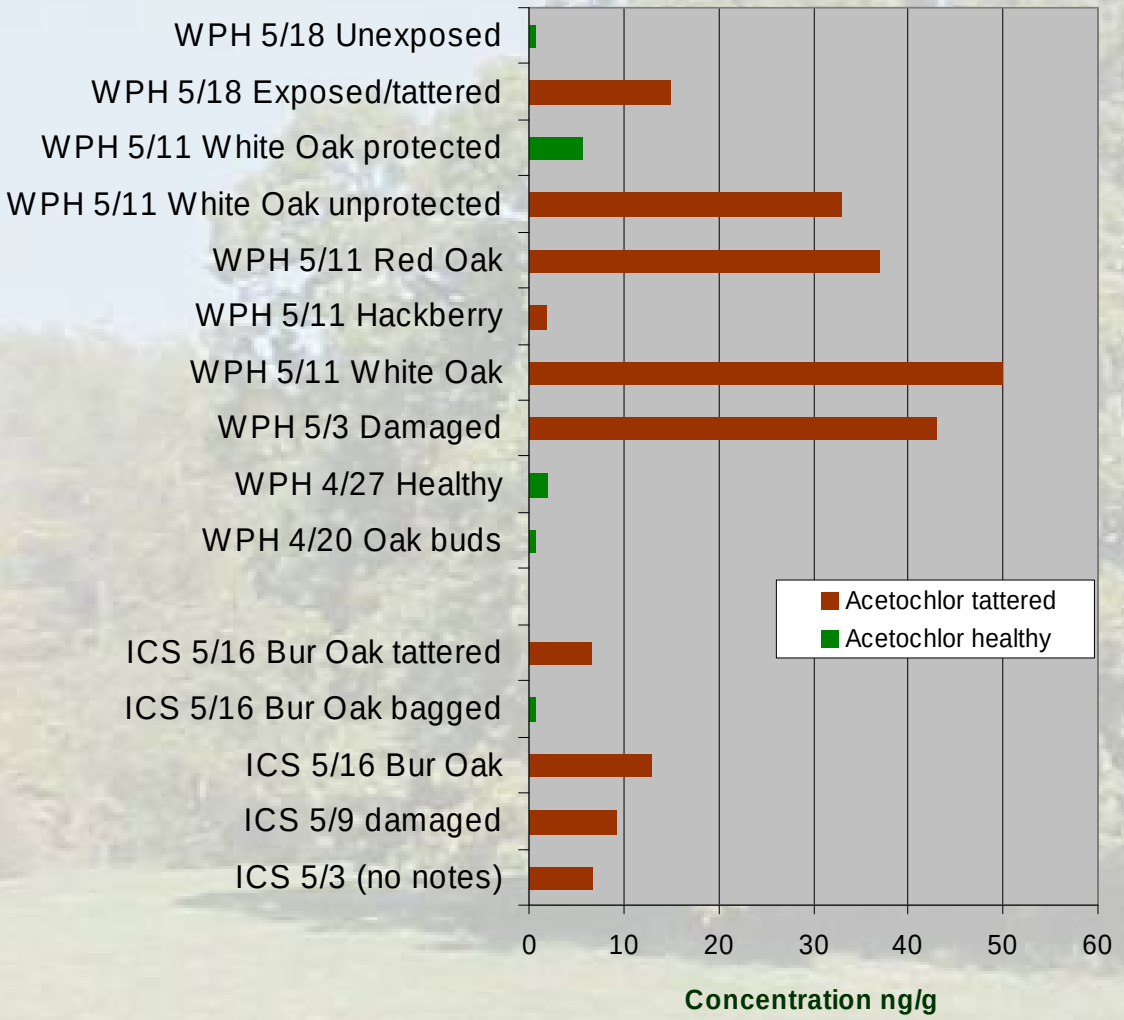
Air Results at WPH



Leaf Results

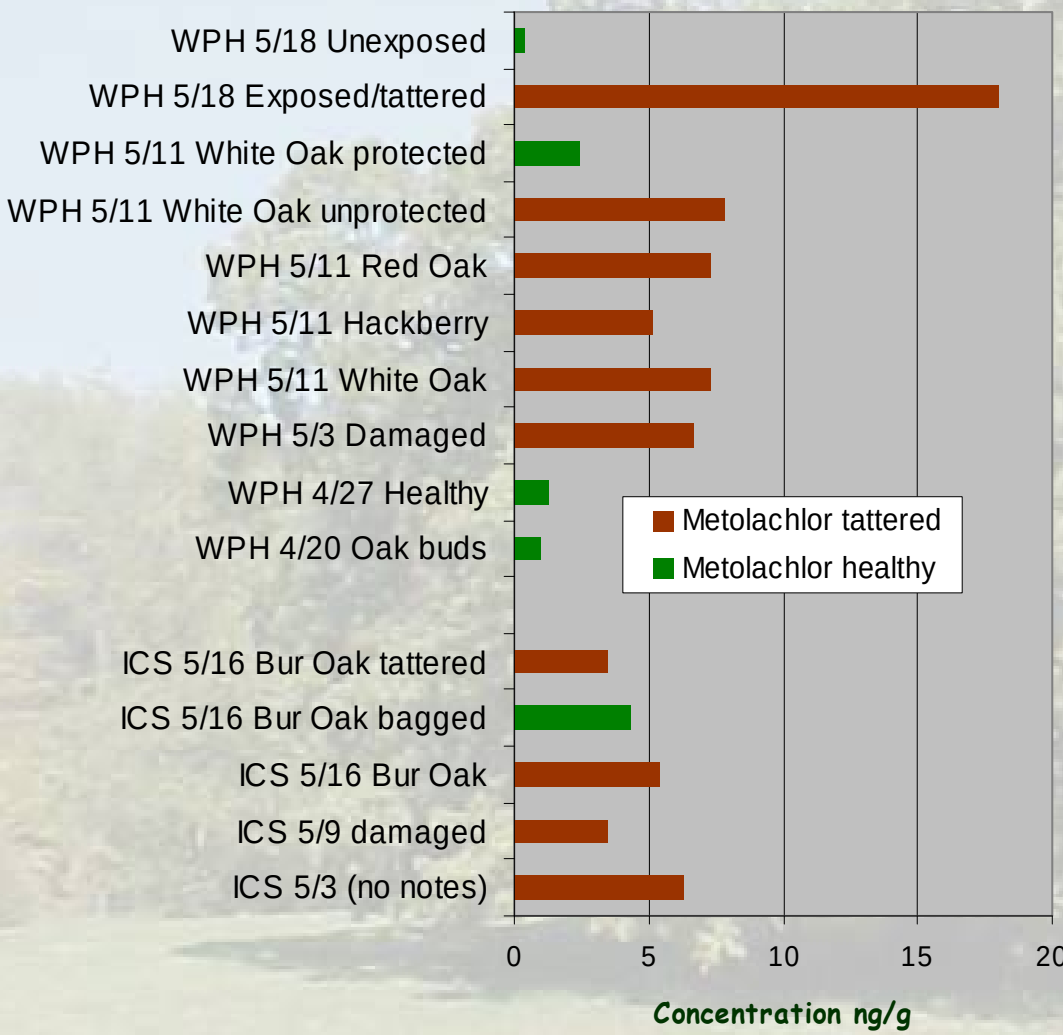
3-May	ICS	(No observations)
9-May	ICS	Showing characteristic damage
16-May	ICS	Foliage Bur Oak
16-May	ICS	Foliage Bur Oak bagged
16-May	ICS	Foliage Bur Oak tattered
20-Apr	WPH	Oak leaf buds
27-Apr	WPH	Leaves and Flowers looked healthy
3-May	WPH	Damaged leaves
11-May	WPH	White Oak
11-May	WPH	Hackberry
11-May	WPH	Red Oak
11-May	WPH	White Oak unprotected leaves
11-May	WPH	White Oak protected leaves
18-May	WPH	Foliage exposed/tattered leaves
18-May	WPH	Foliage unexposed/pollen bag

Leaf Results - Acetochlor



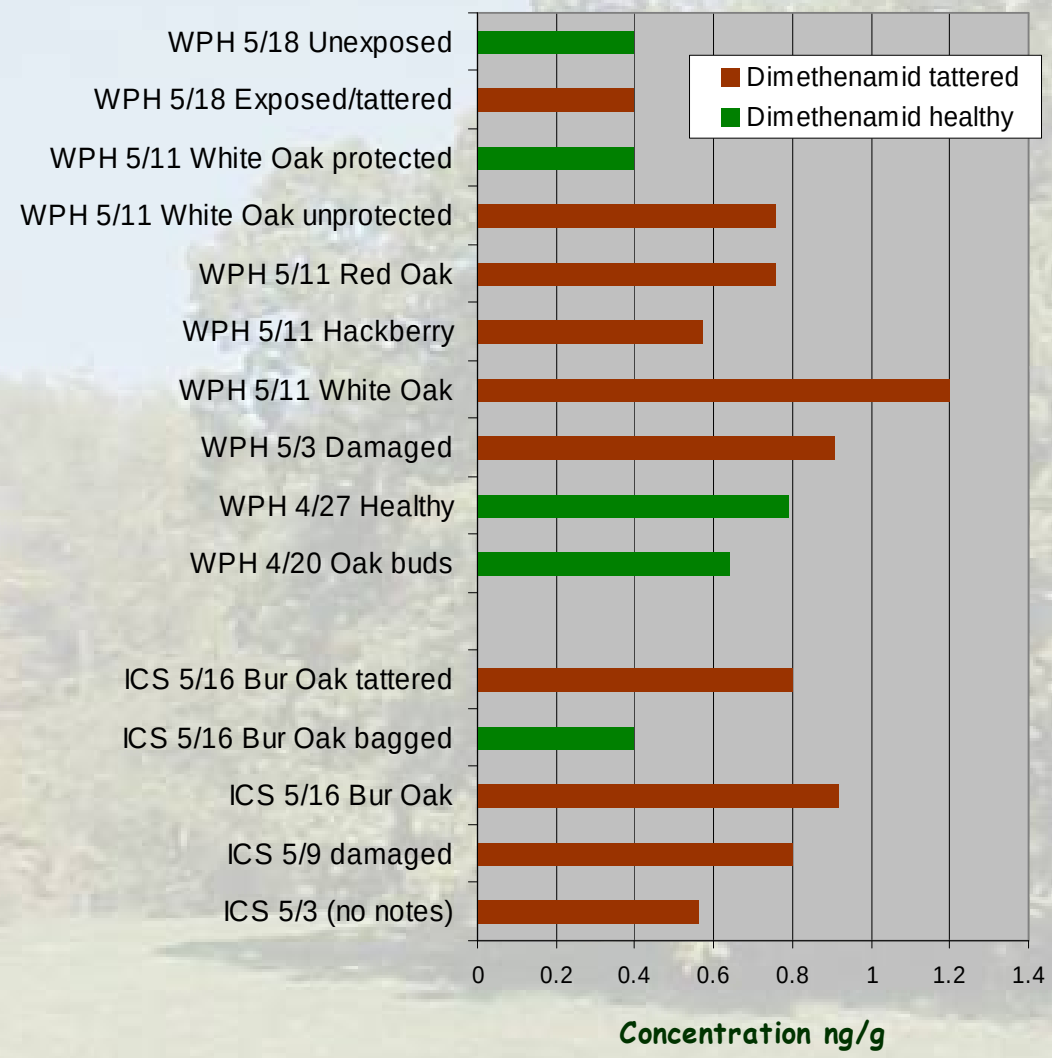
Acetochlor tattered	Acetochlor healthy		
6.7		3-May ICS	(No observations)
9.3		9-May ICS	Showing characteristic damage
13		16-May ICS	Foliage Bur Oak
	0.8	16-May ICS	Foliage Bur Oak bagged
6.6		16-May ICS	Foliage Bur Oak tattered
	0.6	20-Apr WPH	Oak leaf buds
	2	27-Apr WPH	Leaves and Flowers looked healthy
43		3-May WPH	Damaged leaves
50		11-May WPH	White Oak
1.9		11-May WPH	Hackberry
37		11-May WPH	Red Oak
33		11-May WPH	White Oak unprotected leaves
	5.6	11-May WPH	White Oak protected leaves
15		18-May WPH	Foliage exposed/tattered leaves
	0.8	18-May WPH	Foliage unexposed/pollen bag

Leaf Results - Metolachlor



Metolachlor tattered	Metolachlor healthy			
6.3		3-May	ICS	(No observations)
3.5		9-May	ICS	Showing characteristic damage
5.4		16-May	ICS	Foliage Bur Oak
	4.3	16-May	ICS	Foliage Bur Oak bagged
3.5		16-May	ICS	Foliage Bur Oak tattered
	1	20-Apr	WPH	Oak leaf buds
	1.3	27-Apr	WPH	Leaves and Flowers looked healthy
6.7		3-May	WPH	Damaged leaves
7.3		11-May	WPH	White Oak
5.2		11-May	WPH	Hackberry
7.3		11-May	WPH	Red Oak
7.8		11-May	WPH	White Oak unprotected leaves
	2.4	11-May	WPH	White Oak protected leaves
18		18-May	WPH	Foliage exposed/tattered leaves
	0.4	18-May	WPH	Foliage unexposed/pollen bag

Leaf Results - Dimethenamid



Metolachlor tattered	Metolachlor healthy			
6.3		3-May	ICS	(No observations)
3.5		9-May	ICS	Showing characteristic damage
5.4		16-May	ICS	Foliage Bur Oak
	4.3	16-May	ICS	Foliage Bur Oak bagged
3.5		16-May	ICS	Foliage Bur Oak tattered
	1	20-Apr	WPH	Oak leaf buds
	1.3	27-Apr	WPH	Leaves and Flowers looked healthy
6.7		3-May	WPH	Damaged leaves
7.3		11-May	WPH	White Oak
5.2		11-May	WPH	Hackberry
7.3		11-May	WPH	Red Oak
7.8		11-May	WPH	White Oak unprotected leaves
	2.4	11-May	WPH	White Oak protected leaves
18		18-May	WPH	Foliage exposed/tattered leaves
	0.4	18-May	WPH	Foliage unexposed/pollen bag

Future Work

- This study and others show a very strong correlation between oak leaf tatters and exposure to chloroacetanilide herbicides.
- More work is needed to better understand factors that contribute to this effect and what can be done to minimize tatters.
- Source of funding needed to continue this work. Most funding is directed towards impact of chemical exposure to human health.

Acknowledgements

- Mark Vitosh – District Forester
- Bob Hibbs - District Forester
- Bruce Blair - District Forester
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