

Pesticide Losses from Agricultural Lands: Concepts and Examples

2005 Southern Region Water
Quality Conference

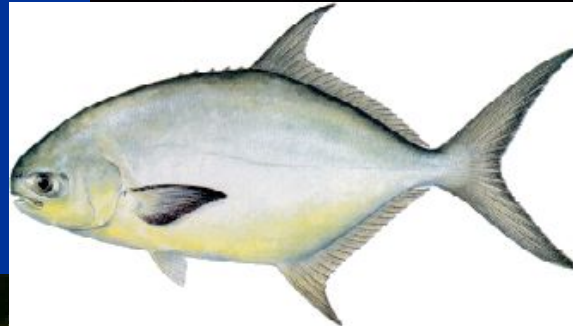
Chris Wilson
UF/IFAS-IRREC
October 25, 2005

Outline

- Ecological risks (When pesticides are a problem)
- Basic principles of water quality influencing ecological risks and fate
- Pesticides
 - Non-target deposition
 - Runoff losses

Non-target Ecological Effects

- May occur at various levels, including:
 - Individual (lethal or sublethal)
 - Single organism
 - Multiple organisms



■ Risk = f(Toxicity + Exposure)

Ecological Risk?

■ Risk = $f(\text{Toxicity} + \text{Exposure})$

■ Toxicity:

■ Inherent (i.e. there is a mode of action)

■ Exposure

■ Concentration

■ Duration



D.L. Scotto



PCW



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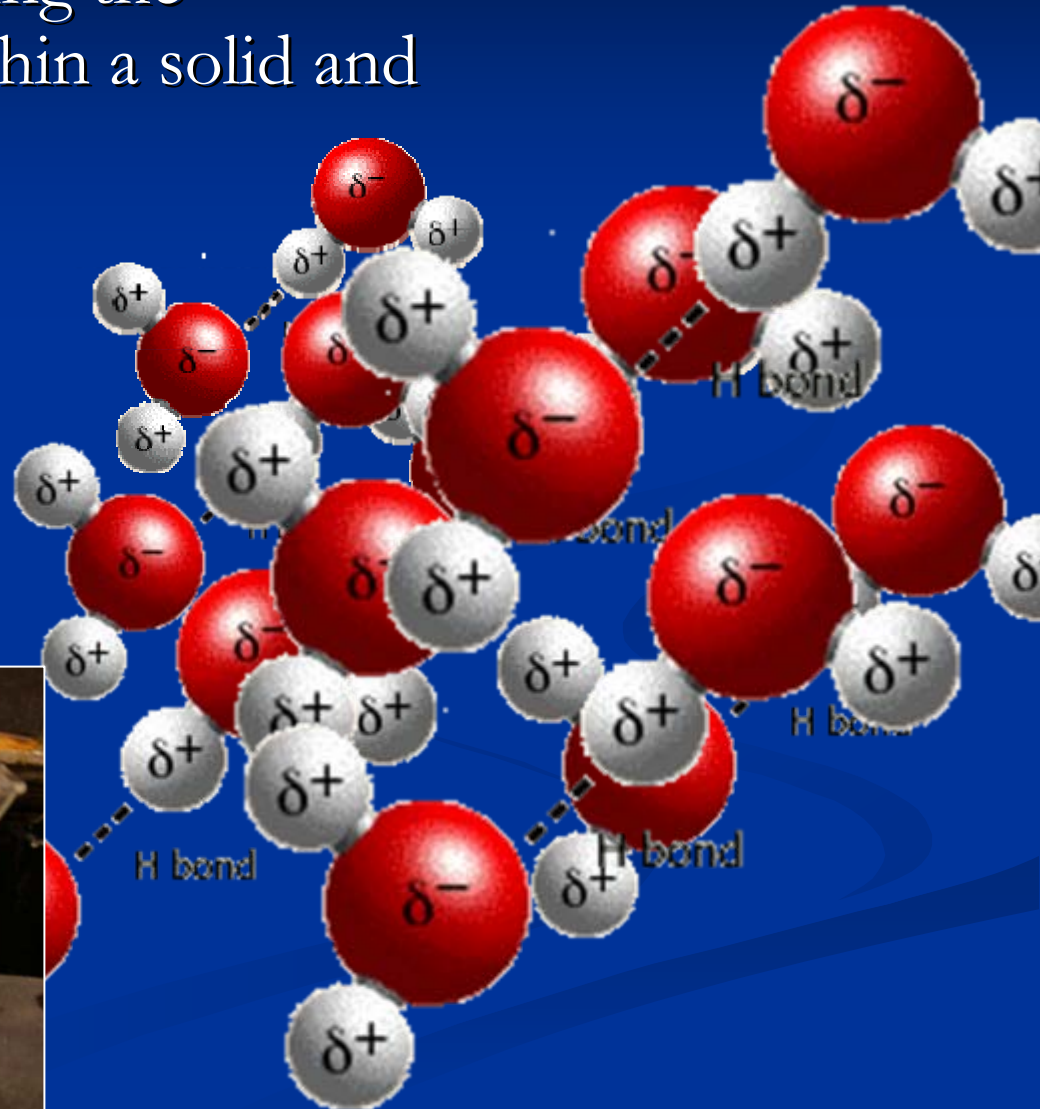
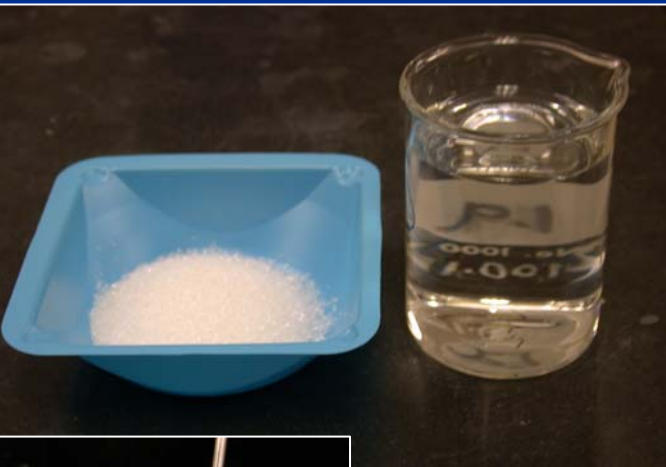
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Important basic principle of water quality

- Water solubility
- Affinity for organic carbon
- Susceptibility to degradation (half-life)

Solubility

- The process of overcoming the intermolecular forces within a solid and solvent.



Always remember

- if it dissolves in water, it can move off-site in water

Affinity for Organic Carbon

- Most carbon-based pesticides have some affinity for organic carbon in soils/sediments.
- K_{oc} constant describes individual pesticide affinity for organic carbon

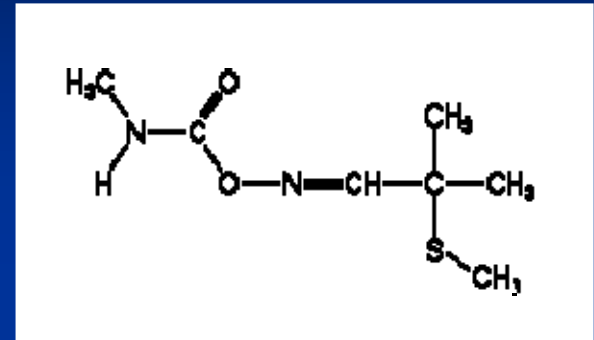
- $K_{oc} = \frac{\text{(adsorbed chemical per wt. OC)}}{\text{Concentration in water}}$

Concentration in water

Half-life

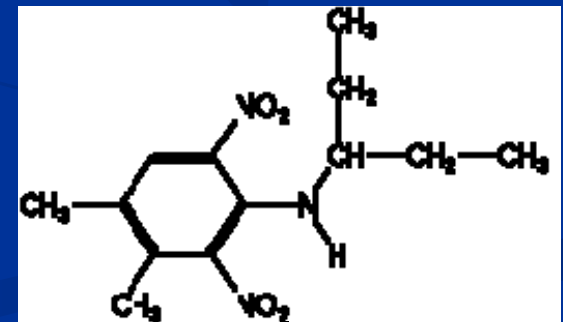
- May be influenced by:
 - Solubility
 - More soluble, more likely to move with water
 - Affinity for organic materials
 - \uparrow OC content, \downarrow $[\text{H}_2\text{O}]$
 - pH
 - Oxidation/Reduction potential
 - Co-occurrence of other materials

Aldicarb



Very soluble

Pendimethalin



Not very soluble

Pesticide fate influenced by:

- Environmental Properties:
 - Atmospheric conditions
 - Rainfall timing
 - Soil properties
 - Organic carbon
 - Antecedent moisture

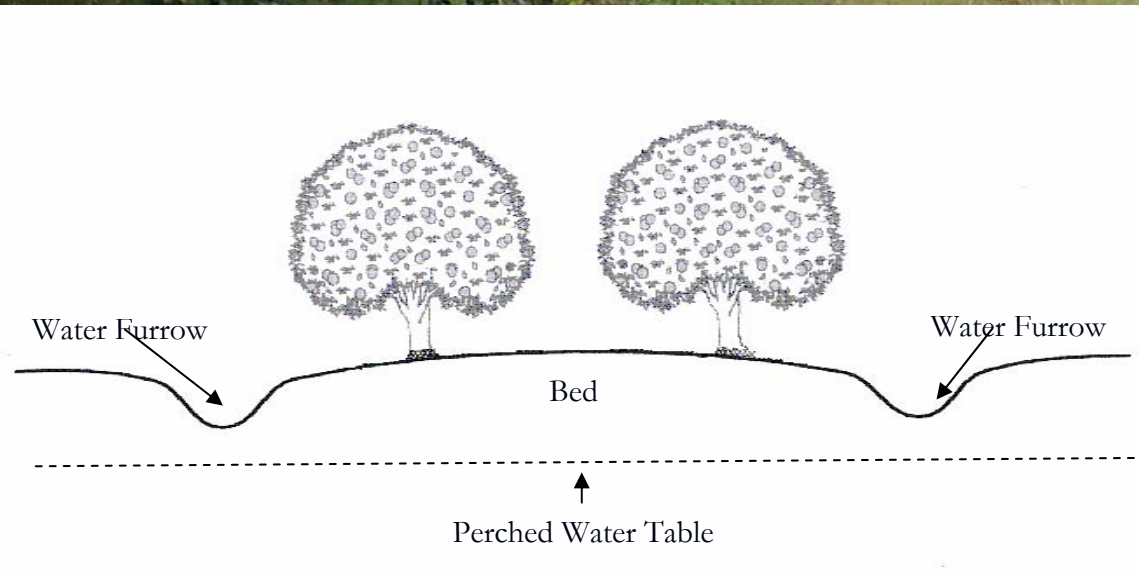


■ Risk = f(Toxicity + Exposure)



Real World Examples

Bedded Citrus



Direct Deposition on Water Surfaces





Inside On/Outside Off



Inside Off/Outside Off
(Tree Trunk)



Outside On/Inside On



Outside Off/Inside Off
(Edge of foliage)

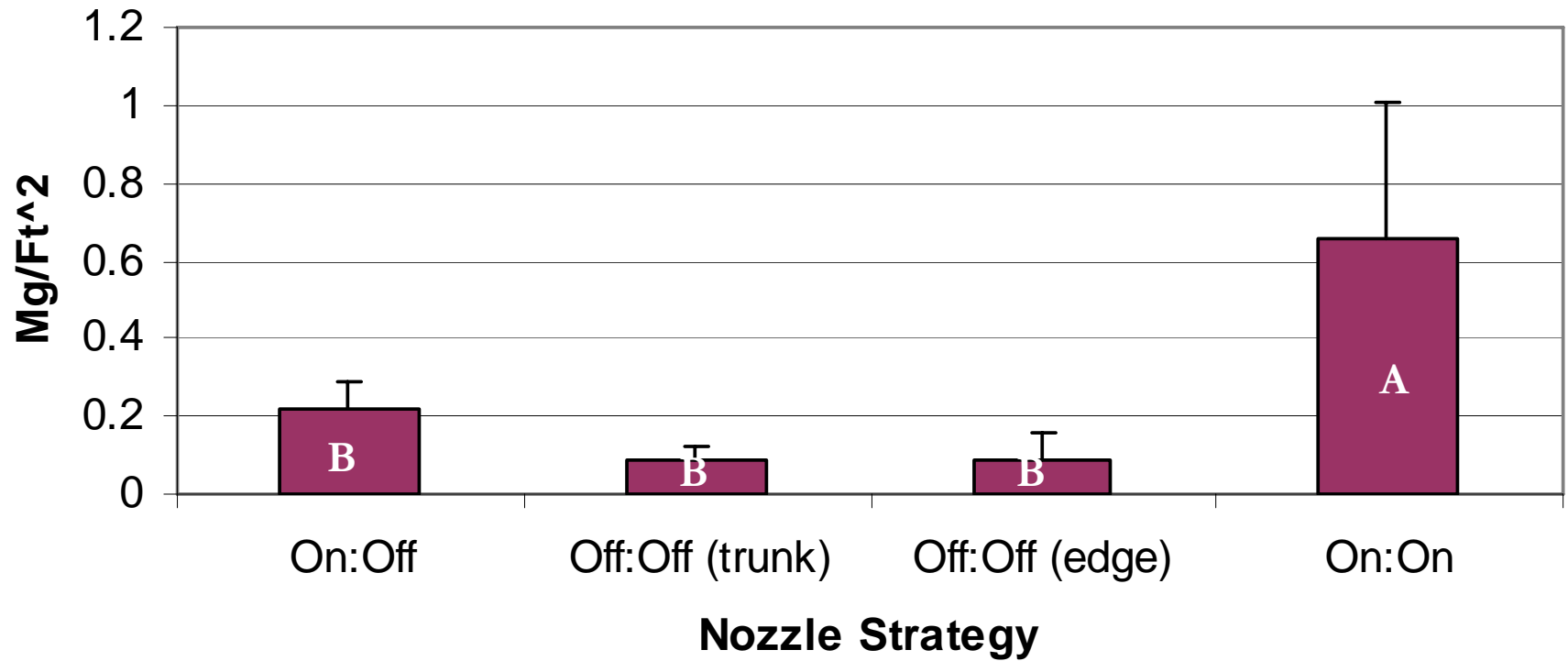
Retrieval of Targets

Teflon targets placed within and on both sides of irrigation/drainage ditch



Results

July: Within Ditch



Direct Deposition on Water Furrow Surfaces?



Teflon Targets



Vydate Application

- Vydate (a.i.: oxamyl)
 - 9/28/03 - 1 pint per acre
 - 5/7/03 - 2 pints per acre



Deposition

■ 2002

■ 0.3-0.7%

■ 0.120-0.275 g/furrow

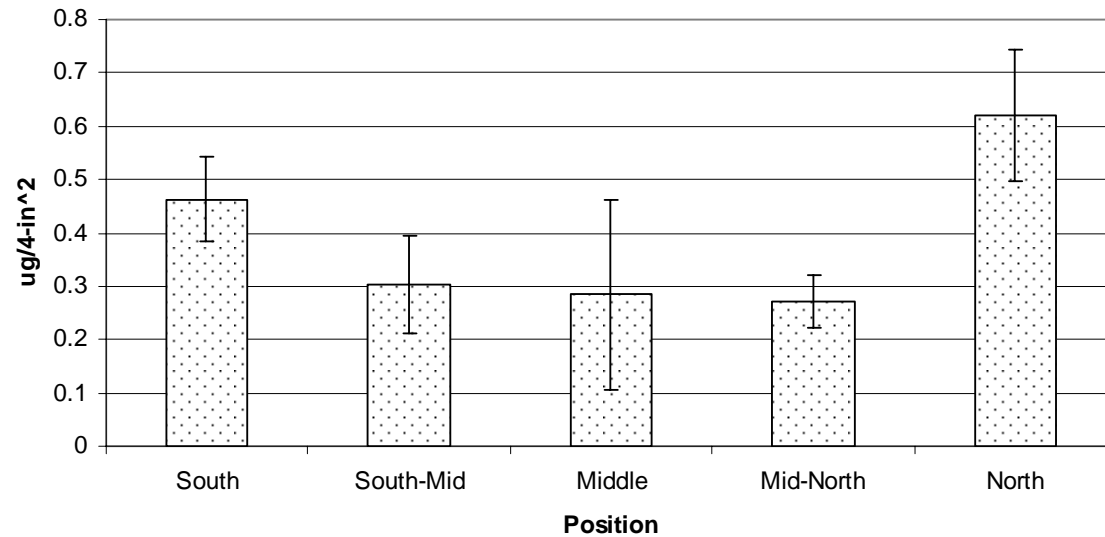
■ 2003

■ 13-20%

■ 10-16 g/furrow

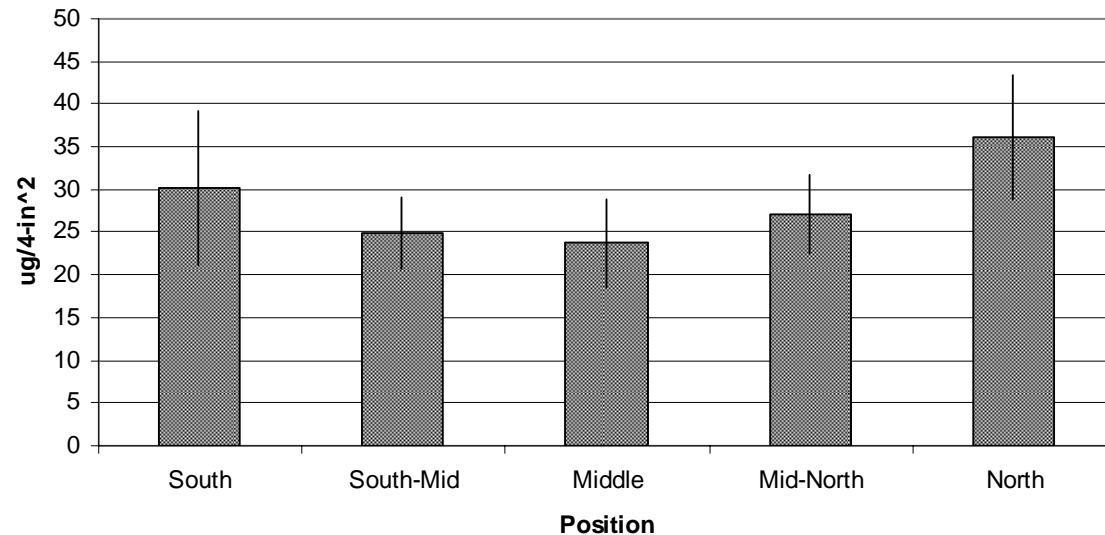
Oxamyl Deposition Across Water Furrows

- 9/28/2002 -



Oxamyl Deposition Across Water Furrows

- 5/7/2003 -



Pesticide losses in surface runoff water?



Pesticide Losses in Runoff Water



- Does herbicide bandwidth influence losses of pesticides and nutrients in surface runoff water?

Herbicide Bandwidth Treatments (from trunk)

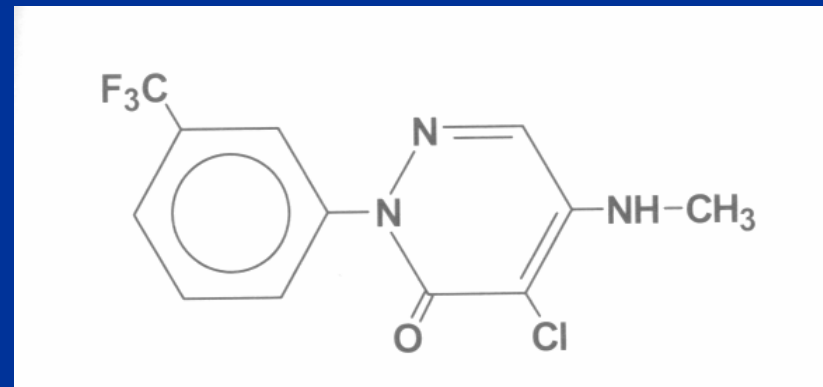
- Solicam (a.i.: norflurazon)
 - 4 ft
 - 3 #/acre
 - 7 ft
 - 5.3 #/acre
 - 10 ft
 - 7.5 #/acre
- Wabasso soil series



Norflurazon

(4-chloro-5-methylamino-2-(α,α,α -trifluoro-*m*-tolyl)-3(2*H*-pyridazinone))

- **Chemical family:** Fluorinated pyridazinone (phenylpyridazinone)
- **Vapor Pressure:** 2.66×10^{-9} kPa at 20°C
- **Water solubility:** 28 mg/L
- **K_{ow} :** 280 ± 15 at 25°C
- **Mode of Action:** In plants, blocks carotenoid biosynthesis by inhibition of phytoene desaturase (Vencill 2002).



Stimulation of Runoff



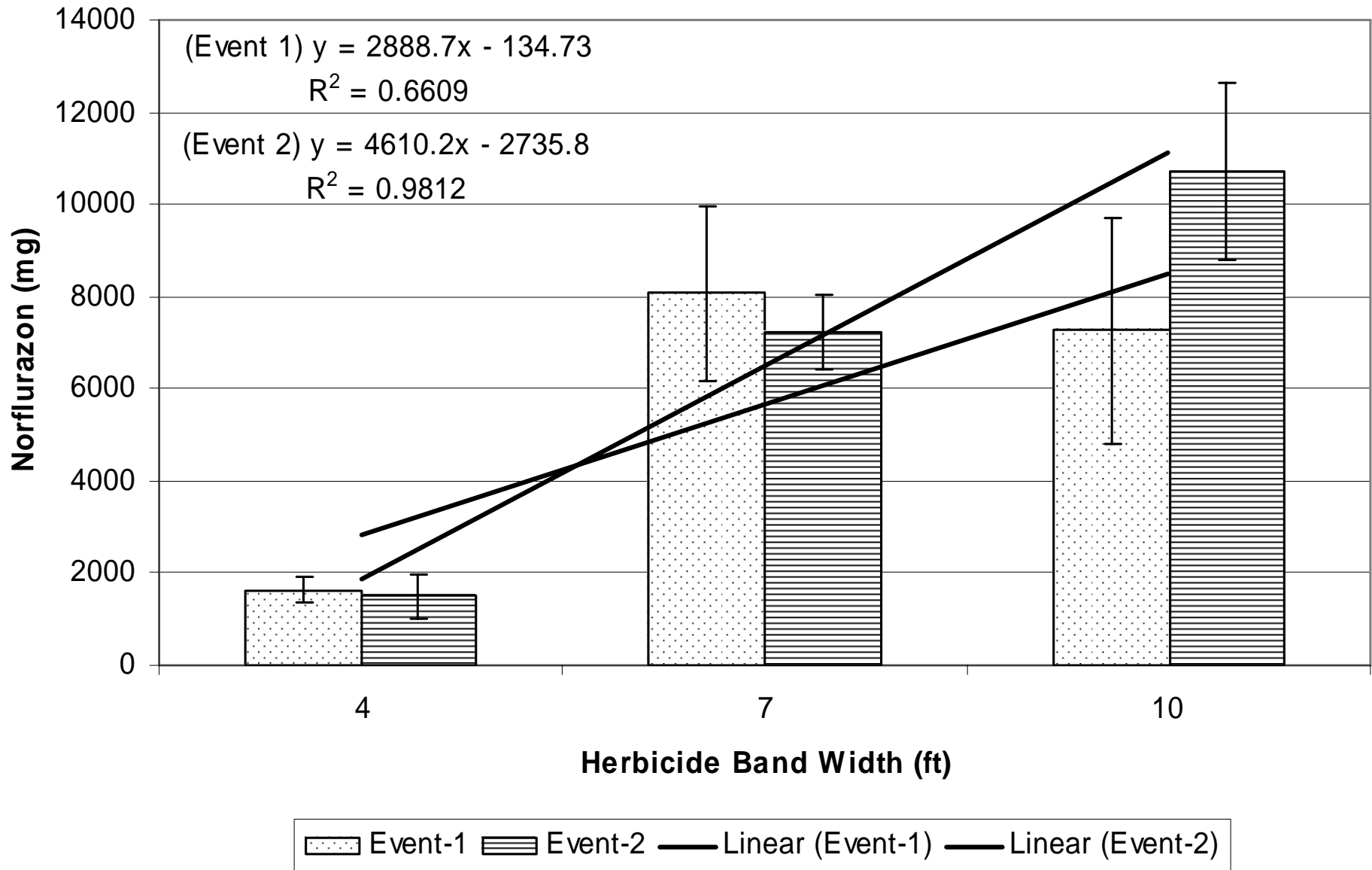
Rate: 0.18 in./hr

Sampling and Flow Measurements



$$[\text{Concentration (mg/L)}] \times [\text{Flow Volume (L)}] = \text{Load (mg)}$$

Norflurazon Losses - Winter



Airblast Application

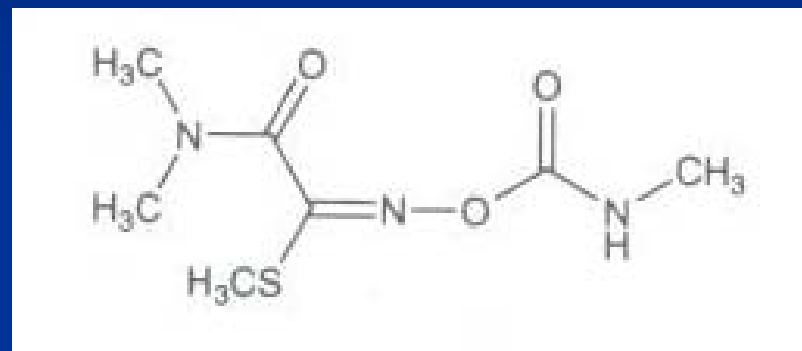
- Vydate (a.i.: oxamyl)
 - 8/12/03 – 2 pints per acre
- Copper
 - 6/2/2003
 - 3 lbs/acre



Oxamyl

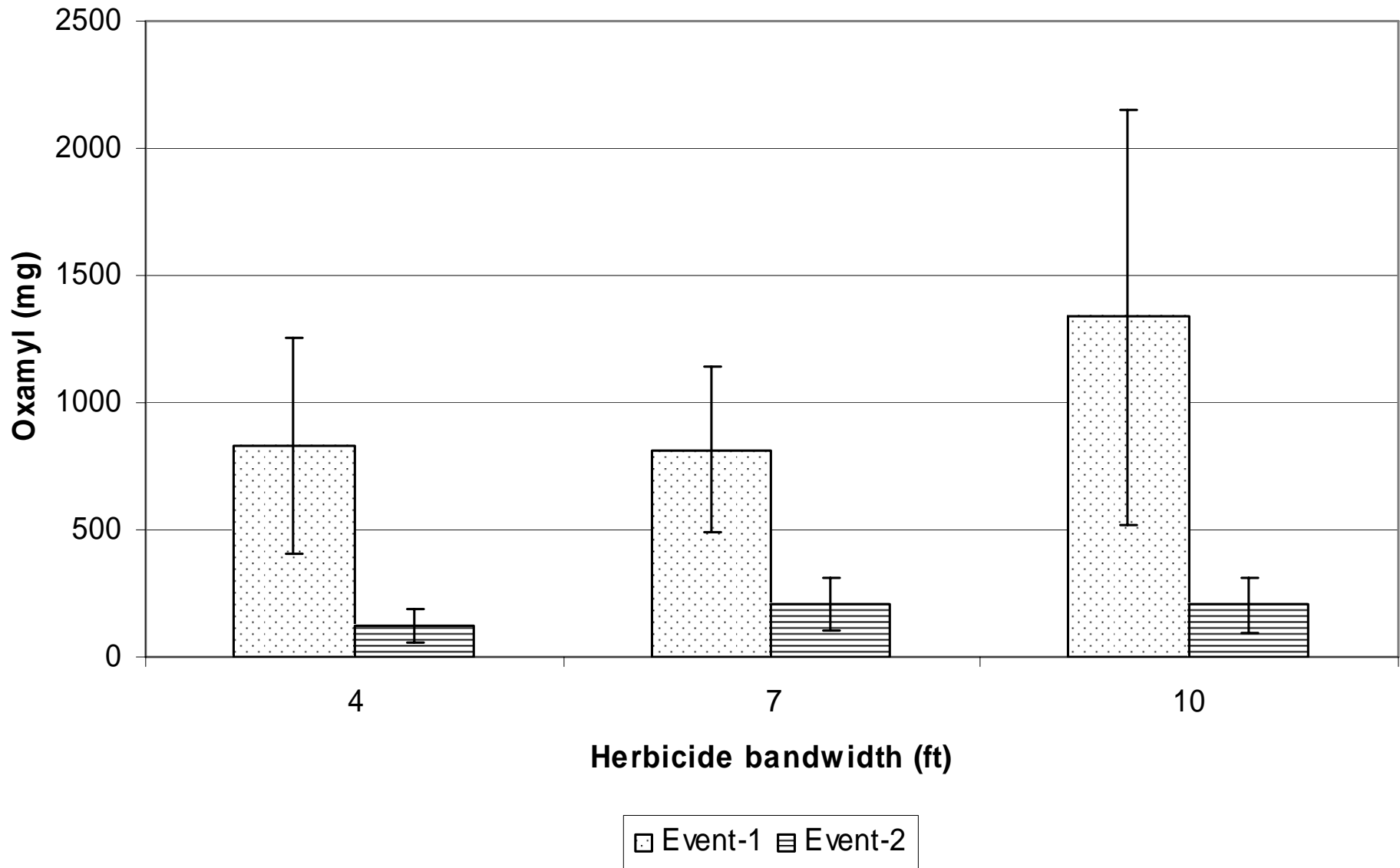
(N,N-dimethyl-2- methylcarbamoxyloxyimino-2-(methylthio)acetamide)

- **Chemical family:** Carbamate
- **Vapor Pressure:** 5.1×10^{-5} Pa
at 20°C



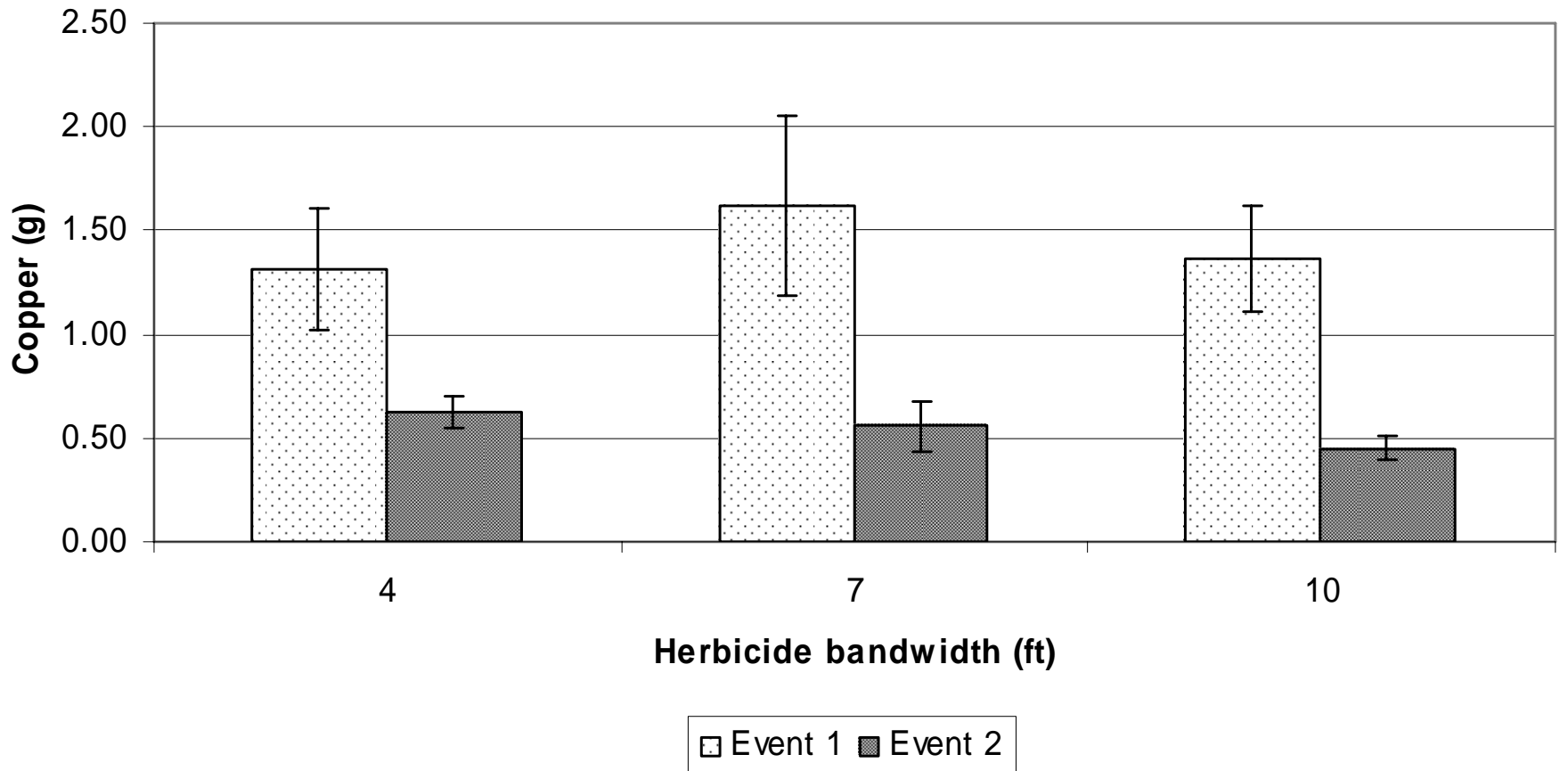
- **Water solubility:** 282 g/L @ 25°C (pH 5)
- **K_{ow}:** 0.36 at 25°C (pH 5)
- **Mode of Action:** neurotoxin, via inhibition of cholinesterase enzyme

Oxamyl Losses (8/12/2003)



Copper (6/3/03)

Wabasso Soil Series



Perspective - Norflurazon

- 1,800-10,000 mg/furrows
 - Vallisneria toxicity threshold: 0.06-0.1 mg/L

- Dilution volumes for 100 water furrows:
 - 475,509 gallons to reach the upper threshold @ 1,800 mg/furrow.
 - 2,641,720 gallons to reach the upper threshold @ 10,000 mg.

Actual predicted runoff volume:

1,253,300 – 2,568,900 gal./100 furrows



Perspective - Oxamyl


- 700-1,300 mg/furrow
 - Effects on *D. magna* at as low as 0.5 mg/L



- Dilution volumes for 100 water furrows:
 - 36,984 gallons to reach 0.5 mg/L @ 700 mg/furrow.
 - 68,684 gallons to reach 0.5 mg/L @ 1,300 mg/furrow.

Actual predicted runoff volume:

1,253,300 – 2,568,900 gal./100 furrows



Summary

- Turn both sets or the outside-facing nozzles off through the turns

Summary

- Grassed furrows had no effect on losses of soluble oxamyl (insecticide)
- Less herbicide runoff occurred with lower application rates (narrower bandwidths)
 - 4 ft x
 - 7 ft 1.75x
 - 10 ft 2.5x



Dilution is NOT the solution of pollution

- But if it were,
 - Concentration = mass/volume (i.e. mg/L, etc.)
- **NEED:** dilution volumes for 100 water furrows:
 - 16,907,011 – 35,927,399 gallons to reach the TP threshold
 - 17,611 – 6,216,849 gallons to reach TN threshold.

Dilution is NOT the solution of pollution

- But if it were,
- Concentration = mass/volume (i.e. mg/L, etc.)
- FOR 100 water furrows, need dilution volumes :
 - 16,907,011 – 35,927,399 gallons to reach the TP threshold (100 ug/L)
 - 17,611 – 6,216,849 gallons to reach TN threshold (1,500 ug/L).
- Actual predicted runoff volume:
 - 1,253,300 – 2,568,900 gal./100 furrows

Lessons

- Phosphate and nitrate are very soluble in water
- Precision application needed: place in irrigation / root zone
- Always split applications throughout the season

A black snake is coiled on a bed of straw. The text "Thank You!" is overlaid in a stylized, 3D font with a blue-to-pink gradient and a drop shadow.

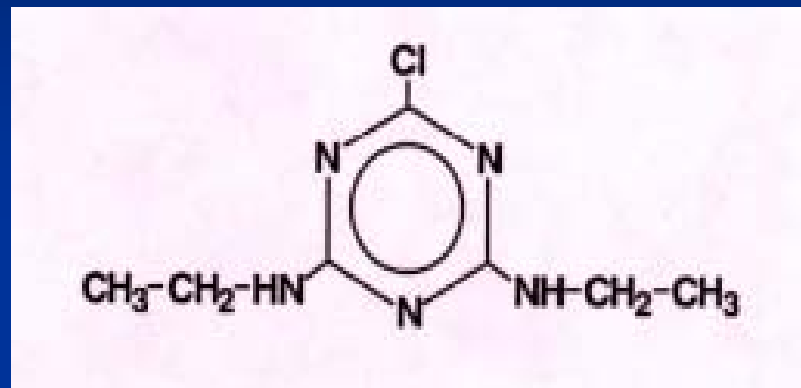
Thank You!

D.L. Scotta

Simazine

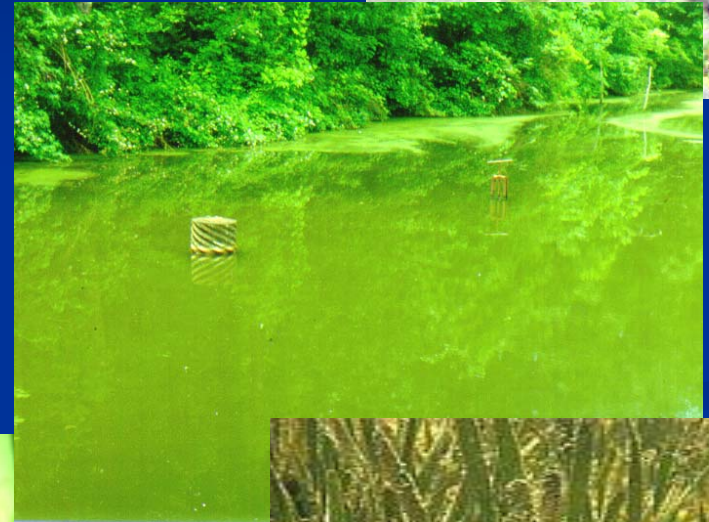
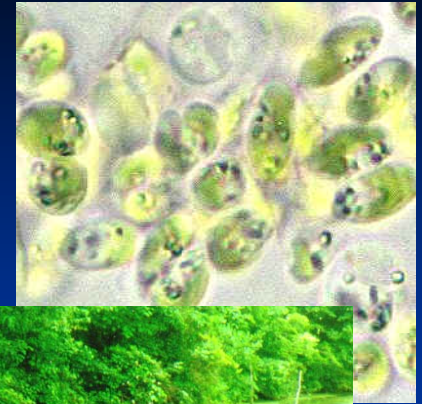
(2-chloro-4,6-bis(ethylamino)-s-triazine)

- **Chemical family:** s-triazine
- **Vapor Pressure:** 8.1×10^{-10} kPa
at 20°C
- **Water solubility:** 3.5 mg/L @ 20°C
- **K_{ow}:** 122 at 25°C
- **Mode of Action:** Blocks photosynthesis by binding to the Q_B-binding niche on the D1 protein of the photosystem II complex in chloroplast thylakoid membranes, thus blocking electron transport from Q_A to Q_B (Vencill 2002).



Ecological Effects

- Increased frequency/intensity of algal blooms
- Decreases light penetration to submersed vegetation
- Ultimately shades out desirable submersed plant species



The Balancing Act



D.L. Scotto



Water quality refers to



■ Water always flows down-hill

- Lakes
- Streams
- Wetlands
- Estuaries

Norflurazon Losses - Wabasso



Event-1 Event-2 Linear (Event-1) Linear (Event-2)