Quantifying Trapping Efficiency of Vegetative Filter Strips For Pesticide Registration

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Organization of Presentation

Background

VFS Modeling within Regulatory Exposure Assessment

Objectives

Approach

Results

Summary
Vegetative Filter Strip (VFS) has been used as a BMP for the control of pollutant loading to streams and other environmentally sensitive habitats.

VFS is sometimes imposed as a mitigation practice on labels.

Specification of the required VFS characteristics is largely subjective, due to the lack of a quantitative methodology for predicting runoff buffer efficiency.

Example of Label Language

“Construct and maintain a minimum 15-foot wide vegetative filter strip of grass or other permanent vegetation between field edge and down gradient aquatic habitat.”
Quantifying the efficiency of VFS is a challenge for regulators and registrants (in USA, Canada and Europe):

- In a recent endangered species risk assessment (Response to Biological Opinion), EPA-EFED required a minimum of 100 ft no spray zone adjacent to salmon habitats
  - The agency does not have “a quantitative methodology for predicting runoff buffer efficiency” with confidence
- In Europe, country regulators questioned the validity of VFS efficiency factors (FOCUS Landscape Mitigation Factors)
Background: A Pesticide Trapping Model

VFSMOD (Vegetative Filter Strip Modeling System) is a tool that can be used in regulatory exposure assessments to define the required VFS characteristics:

- Finite-element, field-scale, storm-based model; routes incoming hydrograph and sedigraph; calculates pesticide trapping efficiency
- The software, manuals and publications on the model are on: http://carpena.ifas.ufl.edu/VFSMOD
Background: VFSMOD

Used by state regulators and city engineers for design and evaluation of buffer strips for erosion control

Incorporated into a Google Earth tool and SSURGO soil maps and spatial databases that can be accessed over the web:
http://www.envsys.co.kr/~vfsmod/
Background: VFSMOD

CEMAGREF, a French public research institute, has incorporated VFSMOD into an agricultural management tool developed for the French Ministry of Agriculture.

ECPA (European Crop Protection Association) adopted VFSMOD as the tool for runoff mitigation assessment as part of the AIM project.
Utility programs were developed to run VFSMOD within EPA (PRZM/EXAMS) and EU (FOCUS) surface water exposure models.

Procedure for modeling effect of VFS on aquatic exposure was introduced.

Publications on performance, sensitivity analysis and incorporation of VFS modeling in EPA and EU exposure modeling are available.
Background: Application of VFSMOD within EPA PRZM/EXAMS Modeling

Results from the application of PRZM/VFSMOD/EXAMS showed:

• Relationship between pesticide reduction, VFS length, and rainfall plus runon event size is nonlinear and complex

Results from the application of PRZM/VFSMOD/EXAMS showed:

- The impact on environmental exposure concentrations (EECs) is dependent on whether calculating an *acute or chronic* EEC
- The impact on EECs is dependent on the pesticide characteristics

**Illinois Corn Scenario In-Season Application**

\[
\text{EEC Reduction} = 100 \times \left(1 - e^{-\frac{t}{t_{1/2}}} \right)
\]

\(K_{oc} = 100 \text{ L/Kg}\)

VFS Modeling within Regulatory Exposure Assessment: Objectives

Overall objective is to develop a simplified tool to identify the proper VFS needed to address aquatic and terrestrial risk.

The first step is to identify the critical input factors for quantifying concentration reduction of pesticides by VFS in aquatic exposure assessments.

Subsequent Steps:
- Discriminant Analysis
- Metamodeling
PRZM/VFSMOD/EXAMS modeling was applied to three distinct and representative scenarios: Illinois corn, California tomato, and Oregon wheat.

Upper 90th percentile annual Peak and 60-day concentrations represented the acute and chronic EECs.
Global sensitivity analysis (GSA) screening method (Morris) was used to identify the most important input factors as functions of the scenario and in terms of acute versus chronic EECs based on discrete uniform probability distributions for 5 input factors:

- VFS length (VL)
- Organic-carbon adsorption coefficient (Koc); half-live in water (Kw) and half-life in soil (Ks)
- Application timing (Timing)

Sensitivity analysis looked at the effect of input parameters on % reduction in acute and chronic EECs
VFS Modeling within Regulatory Exposure Assessment: Approach

Sensitivity Analysis - Morris Method:
• Provides qualitative ranking of the parameters
• Uses few randomized simulations to map relative sensitivity
• Identifies a subset of more important parameters for quantitative analysis
• Provides an early indication of the importance of first order effects vs. interactions
• Morris Method results in two sensitivity measures:
  - $\mu^*$ (Mean of absolute values)
  - $\sigma$ (standard deviation)
Modeled scenarios:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>County</th>
<th>Soil</th>
<th>Emergence Date</th>
<th>Harvest Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL Corn</td>
<td>McLean County, IL</td>
<td>Adair, Clay Loam</td>
<td>1-May</td>
<td>20-Oct</td>
</tr>
<tr>
<td>CA Tomato</td>
<td>San Joaquin, CA</td>
<td>Stockton Clay</td>
<td>1-Mar</td>
<td>1-Sep</td>
</tr>
<tr>
<td>OR Wheat</td>
<td>Marion County, Or</td>
<td>Bashaw, Clay</td>
<td>1-Sep</td>
<td>1-Jul</td>
</tr>
</tbody>
</table>
## VFS Modeling within Regulatory Exposure Assessment: Approach

### Input Factors:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koc - Adsorption Coefficient (L/Kg)</td>
<td>20, 200, 2000</td>
</tr>
<tr>
<td>Aquatic degradation Half-life (days)</td>
<td>10, 100, 1000</td>
</tr>
<tr>
<td>Aerobic Soil Half-life (Days)</td>
<td>10, 100, 1000</td>
</tr>
<tr>
<td>Application timing</td>
<td>Pre-emergence (10 days prior to emergence date)</td>
</tr>
<tr>
<td></td>
<td>In-season (30 days after emergence date)</td>
</tr>
<tr>
<td></td>
<td>Post-harvest (10 days after harvest date)</td>
</tr>
<tr>
<td>VFS Length (m)</td>
<td>1, 5, 9</td>
</tr>
</tbody>
</table>
VFS Modeling within Regulatory Exposure Assessment: Results

$\mu^*$ -- Higher value reflects higher importance (direct effect)
  - VL is the most important
  - Ks is the least important

$\sigma$ -- Larger value indicates higher interaction:
  - Kw and Timing have larger interaction with the other parameters
  - Ks has the least interaction
Acute Exposure:
- Ranking in term of importance: VL > Timing > Kw > Koc > Ks
- Timing and Kw have higher interactions
- Importance of Timing relative to Kw is higher for Illinois Corn than the other two scenarios
VFS Modeling within Regulatory Exposure Assessment: Results

Chronic Exposure:

- Ranking in term of importance: VL > Timing > [Kw—Koc] > Ks
- Timing and Kw have higher interactions
- Importance of Timing is higher for Illinois Corn than for the other two scenarios
Timing and VL – Illinois Corn Scenario:

- For a particular Timing + VL:
  - On the average, reduction in acute and chronic EECs are not significantly different.
  - The variability in EEC reduction is larger for acute than for chronic: compound specific characteristics play a significant role in reducing the EECs.
- Mean reduction in EECs is higher for the Post-harvest application.
Timing and VL – Oregon Wheat

Scenario:

• On the average, reduction in acute and chronic EECs are not significantly different
• Variability in EEC reduction is larger for Post-harvest application, particularly for the bigger buffer size (9 m)
Summary

A percent mass reduction in pesticide entering the receiving water body does not always correlate to an equivalent EEC percent reduction and depends on several important factors such as the pesticide’s mobility and persistence and whether one is calculating an acute or chronic EEC.

VFS length followed by Timing of application are the most influential parameters, and soil half-life is the least important.

Acute and chronic exposure reductions vary significantly based on EPA scenario.

Reductions in acute EECs were typically less than percent reductions in chronic EECs because acute exposure was driven primarily by large events.
THE END

THANK YOU FOR YOUR ATTENTION.