No-Spray Buffer Zones for the Ag/Urban Interface: Derivation Using Drift Modeling & Toxicologically Relevant Benchmarks

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Certainties in Life

- Death
- Taxes
- Paving good farm land with strip malls and housing developments
“Farming on the Edge”
“Farming on the Edge”
WA State Stats

- % Production in Counties within Metropolitan Statistical Area Boundaries
  - 48%

- % Production in Other Urban-Influenced Counties
  - 9%

- 1987 ag. production from urban-influenced counties
  - $1.7 Billion
Neighborly Conflicts??

- Noise
- Dust
- Smell
- Pesticide Drift???
More Certainties in Life

- All pesticide sprays drift!!!
- Drift cannot be eliminated
  - But it can be minimized
What To Do About Inversions?
The Responsibility of Pesticide Users

- To the extent physically possible, keep pesticides on the targeted area
  - Improved efficacy
  - Improved neighbor relations
- Implement Best Management Practices
  - Runoff and leaching
  - Spray Drift
Avoidable & Unavoidable Factors

What You Can & Cannot Control
Size Matters

- The one factor that you have some control over is aerosol/particle size.
The Bigger They Are the Faster They Fall

<table>
<thead>
<tr>
<th>Diameter (µm)</th>
<th>Appearance</th>
<th>Time to Fall 10 Feet in Still Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fog</td>
<td>28 hours</td>
</tr>
<tr>
<td>10</td>
<td>Fog</td>
<td>17 minutes</td>
</tr>
<tr>
<td>100</td>
<td>Mist</td>
<td>11 seconds</td>
</tr>
<tr>
<td>200</td>
<td>Fine Spray</td>
<td>4 seconds</td>
</tr>
<tr>
<td>400</td>
<td>Coarse Spray</td>
<td>2 seconds</td>
</tr>
<tr>
<td>1000</td>
<td>Coarse Spray</td>
<td>1 second</td>
</tr>
</tbody>
</table>
BMPs for Sprayer Operation

- Nozzles producing coarser droplets
- Lower pressure
- Lower boom height
- Increase spray volume
- Drift control additive
- Protective shields

How Practical or Applicable Are these Practices to Air Blast Sprayers??
Orchard Sprayers

- Particle size control not practical

The airblast sprayer is the most commonly used pesticide application equipment in orchards & vineyards
Orchard Spraying--Can Objectives of Particle Size Control Be Achieved??

- Protect non-target receptors
- Possibilities
  - Reduced volume & directed sprays
    - New sprayer technology
  - Swath Displacement
  - Don’t spray end rows
Effect of Boom Height on Spray Drift Deposition

% of Application Rate Deposited

Distance from Edge of Swath (ft.)

2 ft boom ht.

4 ft boom ht.

AgDRIFT Simulation
BMPs for Spraying Operations

- Spray when wind <10 mph
- Do not spray when air is calm (inversion)
- Know what is next door
- Use buffer zones
Regulating Pesticide Spraying

- The Label Is the Law
- Recent/Proposed Changes in Allowable Practices
New Spray Drift Label Language

- Current language:
  - “Do not apply this product in a way that will contact workers or other persons either directly or through drift.”

- EPA is proposing new guidance language for product labels
  - Intended to “clarify expectations for applicators and set definitive standards for application practices”

- For example
  - More specific language on particle size control
  - Specific language to require “no-spray zones”
The Unreality of EPA’s Reality

- **Introduction to Draft Rule:**
  - “EPA recognizes that some de minimus level of drift would occur from most or all applications as a result of the uses of pesticides.”

- **Proposed Guidance Statement:**
  - “Do not allow spray to drift from the application site and contact people, structures people occupy at any time and the associated property, parks and recreation areas, nontarget crops, aquatic and wetland areas, woodlands, pastures, rangelands, or animals.”
EPA’s No Spray Zone

“A no-spray zone is an area in which direct application of the pesticide is prohibited;

This area is specified in distance between the closest point of direct pesticide application and the nearest boundary of a site to be protected, unless otherwise specified on a product label.”
How Big Is Big Enough?

- No set formula for determining how large an effective buffer zone should be
- Idealized Objectives
  - Maximal reduction of pesticide transport
  - Minimal removal of productive land
  - Meet all water quality criteria
  - Do no harm to your neighbors
Strategy for Setting Reasonable Buffer Zones

- Determine toxicological (or regulatory) criteria to be met
- Determine relationship between spray drift deposition and distance
- Overlay the two to obtain buffer zone
Establishing Buffer Zones

- Compile toxicological data
  - **Endpoints**
    - LOAEL--lowest observable effect in dose-response bioassays
    - NOAEL--dose at which no effect observed
    - RfD--NOAEL/100 (Reference Dose: reasonable certainty of no harm)
  - **Toxicokinetics**
    - Dermal absorption efficiency

- Information Sources
  - Registration Eligibility Decision Documents
Establishing Buffer Zones

- Compile Distance-Deposition Function
  - AgDRIFT Model
    - Developed by Spray Drift Task Force--an industry consortium
    - Based on a combination of empirical studies and theoretical models of particle movement
    - Sanctioned by EPA
The computer model AgDRIFT® and its companion drop size distribution model DropKick® describe a proposed overall method for evaluating off-site deposition of pesticides applied by aerial, ground, and orchard airblast spraying means, and for evaluating the potential of buffer zones to protect sensitive aquatic and terrestrial habitats from undesired exposures.

These models are provided to the U. S. Environmental Protection Agency’s (EPA) Office of Pesticide Programs (OPP) as a product of the Cooperative Research and Development Agreement (CRADA) between the EPA’s Office of Research and Development, USDA Agricultural Research Service (ARS), USDA Forest Service, and the Spray Drift Task Force (SDTF), a coalition of 39 pesticide registrants formed to develop a comprehensive database of off-target drift information in support of pesticide registration requirements. The protective assessment methodology represents the joint work of industry and EPA researchers working under this agreement as the modeling subcommittee of the SDTF.

AgDRIFT® and DropKick® are protected by copyright laws and international copyright treaties, other intellectual laws and treaties, and the end-user licence agreement under the Help Menu.
AgCAT Run 2
Tier III Deposition

Fraction of Application Rate

Distance (ft)

0.6
0.5
0.4
0.3
0.2
0.1
0.0

Deposition

AgDRIFT® AgCat Run 1.agd 2.03 02-04-2002 22:44:42
Model Validation


Transect “downfield” of Christmas tree plantation in riparian area

Silica gel on flexible aluminum “drift card” (10 x 20 cm)
Chlorothalonil Drift & Deposition: Christmas Tree Plantation Site 1, Transect 1

- Measured
- AgDRIFT 75% RH
- AgDRIFT 96% RH

µg/cm² vs. Meters from Stream Bank

X-axis: Meters from Stream Bank
Y-axis: µg/cm²
Chlorothalonil Drift & Deposition: Christmas Tree Plantation
Site 1, Transect 2

Measured AgDRIFT 96% RH
AgDRIFT 75% RH
AgDRIFT 96% RH
Azinphos-methyl (mg/m$^2$)

Measured
- Spray A
- Spray B

Modeled
- Spray A
- Spray B

Air Blast Sprayer
(Average of 2 Transects)

Within Orchard
Outside Orchard

LOQ

Meters from Outside Tree Row

0.001
0.01
0.1
1
10
100

-20
0
20
40
60
80
100
Drift Deposition Experiment (Crop Year 2003)
Phosmet Application (3.9 kg/ha); Airblast Sprayer;
Commercial Apple Orchard (5-acre block)
Case Study--
Toxicological Parameters

- Orchard application of Guthion 50SP
  - Soluble packet formulation
  - Application rate: 1 lb Al/acre = 112 mg/m²
  - Active Ingredient: azinphos-methyl
    - Acute Reference Dose (aRfD) based on rodent acute neurotoxicity study: 0.003 mg/kg
      - Represents a 300 fold safety factor based on a LOAEL of 1 mg/kg
      - 42% dermal absorption efficiency

- Assume naked 10 kg child is the ‘receptor’
  - Total Body Surface area = 0.682 m²

- **Question:** At what distance from the last tree row is exposure “safe”??
Title

Orchard Airblast—Normal (Pome Fruit, Post Bloom); 20 Tree Rows (start 1)

Combination Orchards

- Normal (Stone and Pome Fruit, Vineyard)
- Dense (Citrus, Tall Trees)
- Sparse (Young, Dormant)

Extended Settings

- Access Extended Settings

Swath Range

Starting Tree Row: 1
Ending Tree Row: 20

Information

Normal (Stone and Pome Fruit, Vineyard)
This composite orchard combines Grape and Apple orchards.
Mean deposition
Application Efficiency (%) (20 rows): 99.85
Orchard Airblast--Normal (Pome Fruit, Post Bloom); 20 Tree Rows (start 1)

Tier I Deposition

Fraction of Application Rate

Distance (ft)
Orchard Schematic & Direction of Drift Assumptions

Start Row

Direction of movement of drift along transect perpendicular to spray swath
Deposition of Orchard Insecticides--AgDRIFT Simulation
Dormant Spray vs. Full Canopy

Chlorpyrifos Dormant Spray (0.56 kg/ha)
Azinphos-methyl Full Canopy (1.12 kg/ha)
Getting The Units Straight

- Drift deposition function yield data with units of proportion of application depositing at distance $x$ from swath
- Toxicological parameters are in units of mg/kg/day
  - $\text{mg/m}^2 = \text{proportion depositing} \times \text{application rate (kg/ha)} \times 1000000 \text{ mg/kg} \times \text{ha/10000 m}^2$
  - $\text{mg/kg/day} = \text{mg/m}^2 \times 0.682 \text{ m}^2 \div 10 \text{ kg}$
Drift Deposition of Azinphos-Methyl (1 lb Al/Acre) During Simulated Airblast Application

Body Dose (mg/kg)

Distance from Outer Tree Row (m)

20 Row Spray
Start Spray Line Between Rows 1 & 2

- **100% Absorption**
- **42% Absorption**
Drift Deposition of Azinphos-Methyl (1 lb Al/Acre) During Simulated Airblast Application

Body Dose (mg/kg)

20 Row Spray
Start Spray Line Between Rows 1 & 2

100% Absorption
42% Absorption

aRfD = 0.003 mg/kg/d

Distance from Outer Tree Row (m)

21 m
48 m
Orchard Schematic & Direction of Drift Assumptions

Direction of movement of drift along transect perpendicular to spray swath.
Drift Deposition of Azinphos-Methyl (1 lb AI/Acre) During Simulated Airblast Application

Body Dose (mg/kg)

Distance from Outer Tree Row (m)

20 Row Spray
- Start Spray Row 1
- Start Spray Row 2
Drift Deposition of Azinphos-Methyl (1 lb Al/Acre) During Simulated Airblast Application

- Body Dose (mg/kg)
- Distance from Outer Tree Row (m)
- 100% Absorption
- 42% Absorption

20 Row Spray
Start Spray Line Between Rows 2 & 3

aRfD = 0.003 mg/kg/day
Effect of Dermal Absorption & Exposure Assumptions on Dose Received by Child AgDRIFT Simulation

- 100% Absorption
- 42% Absorption
- 61.6% Exposed Surface
- Inhalation Adjusted (Based on air residues in Clark et al. 1991)

Body Dose (mg/kg) vs. Distance from Outer Tree Row (m)

- aRfD = 0.003 mg/kg/day

- 11 m
- 21 m
- 48 m
- 75 m
Controllable Factors Shifting Drift-Deposition Curve

- Starting row for spray
- Application rate
- Non-crop vegetative barriers (???)
  - For ex., wind breaks
Conclusions

- AgDRIFT has been developed by an industry consortium to model drift, i.e., estimate downwind deposition
- AgDRIFT worked reasonably well to describe a commercial application to a Christmas tree plantation.
  - Probably because aerial module is stochastic in nature
- Orchard module is empirical
  - Depending on conditions it may over or under-predict drift
  - Not applicable to non airblast orchard sprayers
Conclusions

- AgDRIFT needs further validation, especially for applications on a commercial scale.
  - However, it may be conservative enough to estimate reasonable no-spray buffer zones.
- AgDRIFT can be used in combination with acceptable “safe” levels to estimate worst-case downwind exposures and therefore define the upper bounds of no-spray buffer zones.
- Important to communicate that all sprays drift but the objective of best management practices is to minimize drift to “safe” levels.
Thank you!

- [http://wsprs.wsu.edu/](http://wsprs.wsu.edu/)  
  - WA State Pest Management Resource Ctr.
- [http://feql.wsu.edu](http://feql.wsu.edu)  
  - Food & Environmental Quality Lab
- [http://aenews.wsu.edu](http://aenews.wsu.edu)  
  - Agrichemical & Environmental News
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