Options for more effective and flexible spray drift mitigation

Neil Mackay, DuPont UK Ltd.
...on behalf of MAgPIE Working Group
Content

• Spray drift – background and influences
• Implications for risk assessments
• Mitigation and management strategies
• Regulatory status quo in Europe
• Agronomic considerations: Practicality and implementation
• Recommendations for future toolbox expansion and flexibility
Spray Drift

• Spray drift is defined as the transfer of small spray droplets out of the target area due to wind, exacerbated by poor application practices or incorrect nozzles.

http://www.topps-life.org/spray-drift.html
Factors Defining Spray Drift

- **Key Factors:**
  - Nozzle choice
  - Boom height/crop height
  - Wind speed
  - Wind direction
  - Proximity to sensitive area
  - Filtering by downwind vegetation
  - Temperature
  - Air humidity
Factors Defining Spray Drift

- Key Factors:
  - Wind speed
  - Wind direction
  - Temperature
  - Air humidity
  - Proximity to water
  - Proximity to sensitive area
  - Crop treated
  - Adjacent vegetation
  - Droplet size
  - Application technique
  - Calibration of sprayers
Aquatic Exposure Assessment

Three aquatic routes of entry simulated within three types of edge of field water bodies
• Ponds (essentially static)
• Stream (flowing water body)
• Ditches (dynamic, semi-static)

Spray drift representation:
• Curves derived from Rautmann drift tables
• Arable, fruit crops, vines, hops, backpack

Drainage Simulation:
• MACRO model (6 EU scenarios)

Run-off Simulation:
• PRZM model (4 EU scenarios)
Primary route of exposure to non-target organisms at edge of field is assumed to be drift;
- Non-target arthropods
- Non-target terrestrial plants

Spray drift representation:
- Curves derived from Rautmann drift tables
- Arable, fruit crops, vines, hops, backpack
Objectives

• Is there scope to expand options to introduce greater flexibility and effectiveness?
  • Are there options proposed in some Member States (MS) that could be used more widely to complement and expand our current tools?

• Is there scope to introduce greater effectiveness in strategies for take up of drift mitigate measures?
  • Are there MS experiences and practices with management of mitigation that could introduce more flexibility/customisation by farmers?

• Is there scope to harmonise handling/communication of drift mitigation?
  • Can we manage all this while still keeping labels simple and clear?
Direct Mitigation Options

Reducing spray drift at source...
...avoid smaller droplets

Spray drift reduction technology (SDRT)
Adjustment to application equipment
boom height, speed

Image Credit: www.deere.com
Indirect Mitigation Options

Reducing exposure after application...
...avoid droplets reaching non-target environments

Wind direction
Wind speed
Temperature
Humidity

No spray zones
Buffer zones
Natural vegetation strips
Windbreaks
Hail nets

Image Credit: www.omafra.gov.on.ca
Fundamentals: Spray Drift Representation

<table>
<thead>
<tr>
<th>Zonal</th>
<th>National</th>
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<tr>
<td>FOCUS / Rautmann</td>
<td>FOCUS / Rautmann</td>
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<td>FOCUS / Rautmann</td>
<td>National drift reference</td>
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<tr>
<td>FOCUS / Rautmann</td>
<td>Mutual Recognition Only</td>
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</tbody>
</table>

** National drift values for non-professional use
Non-EU
Differences between countries in assumptions used to characterise drift and spray drift reduction effectiveness clearly exist:

- Starting point (0-value) for distance measurements in drift trials?
- Interpretation of label S-Phrase buffer widths in practice?
- Which methods are used to assess drift reduction (e.g. field trials, wind tunnels, droplet measurements)?
- Standards (e.g. wind speed, temperature, crops, crop growth stages/heights, boom height)?

Workshop proposal:

- Fundamentals are more effectively addressed independently via spray physics working groups
- Focus on general principles of mitigation – what is used and how is it used?
- Can we widen options and build upon regulatory and technical experience?
Risk mitigation measures, risk assessment and labelling in the EU 28: Introduction to the MAgPIE toolbox

Illustration: Lack of Harmonisation

Maximum Permissible Regulatory No Spray Zone Widths

- Harmonisation on basis of most restrictive standard? 😊
- Greater flexibility with SDRT mitigation options? 😊
- Greater flexibility with label communication? 😊

Bar chart showing maximum permissible regulatory no spray zone widths in different EU countries for orchard and field use. The chart compares the harmonisation on basis of the most restrictive standard and the flexibility with SDRT mitigation options and label communication.
Illustration: Lack of Harmonisation

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F: Field
V: Vegetables
O: Orchards
B: Bush berries & nurseries

Source NEU work-sharing guidance (Apr’14)

Note:
- NEU zone have made significant strides towards harmonisation & co-operation
- Despite this, currently only harmonisation for 1 no spray buffer width for one use (Orchards @ 20 m)
- To achieve meaningful improvements in efficiency greater flexibility is necessary...
  - Wider range of options
  - Greater flexibility of label communication
Managing Spray Drift ➔
Managing Droplets

- Large droplets have less potential to drift:
  - Fall more quickly
  - Evaporate more slowly
  - Are less affected by wind

- Small droplets arise from:
  - High spray pressure
  - Nozzle design

<table>
<thead>
<tr>
<th>Droplet Diameter (microns)</th>
<th>Terminal Velocity (ft/sec)</th>
<th>Final Drop Diameter (microns)</th>
<th>Time to Evaporate (sec)</th>
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</thead>
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<td>20</td>
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Assumes 90 Deg F, 46% RH, 300 kPa, 3.75% pesticide solution

Assumes 90 Deg F, 46% RH, 300 kPa, 3.75% pesticide solution
Low drift nozzles permitted on label
Low drift nozzles used at discretion of farmer to reduce buffers – cannot be added to label
Unknown or no precedent
## Status: Spray Drift Reducing Technology

<table>
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<th>Country</th>
<th>Not accepted</th>
<th>Negotiable?</th>
<th>25% SDRT</th>
<th>30% SDRT</th>
<th>50% SDRT</th>
<th>75% SDRT</th>
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**F; Field  V; vegetables  O; Orchards**

* Note classification schemes and requirements differ between Member States!
Examples of Further Techniques

Most Member States have limited experience and awareness...NL is a notable exception!

Venturi nozzle (90 % drift reduction)+ one-sided spraying last tree row and reduced air fan setting
(0.36\%\(^1\) or 1.3\%\(^2\) drift with 3 m buffer)

Tunnel sprayer
(1.3\%\(^1\) or 2.5\%\(^2\) drift with 3 m buffer)

Cross flow spraying with a hedgerow planted on the edge of field
(0.9\%\(^1\) or 7.0\%\(^2\) drift with 3 m buffer)

\(^1\) With leaves
\(^2\) Without leaves

(By comparison, a standard orchard sprayer with a 3 m buffer delivers 8.6\%\(^1\) and 17\%\(^2\) drift)
Examples of Other Techniques

**Shielded sprayers**

(0.01% or 0.014% drift with 3 m buffer)

1. Bare soil
2. With grass

**Sensor controlled sprayers**

(4.1% or 12.8% drift with 3 m buffer)

3. With leaves
4. Without leaves
Examples of Compounded Mitigation

- Current buffer zone efficacy in risk assessments are typically represented simplistically and generically...
- Vegetated buffer strips may provide an additional mitigation level, which could be taken into account (for example, Zande et al., 2000)

<table>
<thead>
<tr>
<th>Height of the vegetated strip compared to the crop</th>
<th>Reduction of drift in the 1-5 m zone at the edge of the crop / behind the vegetated strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same height as the crop (50-70 cm)</td>
<td>3 m spray-free BZ: 75%+ 14 m spray-free BZ: 90%+ 24 m spray-free BZ: 95%+</td>
</tr>
<tr>
<td>Vegetated strip higher than the crop</td>
<td>50 cm higher than the crop: 80% 1 m higher than the crop: 90%</td>
</tr>
<tr>
<td>Vegetated margin smaller than the crop (&lt; 20 cm)</td>
<td>Use standard spray drift data (crop free)</td>
</tr>
</tbody>
</table>
Examples of Compounded Mitigation

- Hedgerow (1 m higher than the crop):
  - 25% if hedgerow is bare
  - 50% with intermediate growth stage
  - 75% complete leaves development

- Low Drift Nozzles:
  - 30% stated in GD (mean value of drift reduction available in 2005-2009)
  - Drift reduction >30% would be accepted if studies are available (not stated in the GD)
  - Efficacy trials for comparison with conventional nozzles

- Last row application from the outside towards the inside: 35%

Examples...

<table>
<thead>
<tr>
<th>Last row appl. from outside</th>
<th>Nozzle</th>
<th>TOTAL DRIFT MITIGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes: 35%</td>
<td>Conventional: 0%</td>
<td>35%</td>
</tr>
<tr>
<td>No: 0%</td>
<td>SDRT: 30%</td>
<td>30%</td>
</tr>
<tr>
<td>Yes: 35%</td>
<td>SDRT: 30%</td>
<td>54.5%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Buffer zone (m) indicated on label</th>
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</thead>
<tbody>
<tr>
<td>SDRT</td>
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<tr>
<td>Last row appl. from outside</td>
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<tr>
<td>SDRT+Last row appl. from outside</td>
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</table>
## Overview of Measures

### Buffer Zones

<table>
<thead>
<tr>
<th>Risk mitigation measure</th>
<th>Description</th>
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</table>
| No spray buffer zone   | • No spray buffer zone in the field and/or at the field border to avoid direct spray of off-field area  
                          • Usually product-specific  
                          • Width typically comprised between 1 and 50 meters  
                          • Benefits on all off-field area and organisms through spray drift reduction |
| Wind direction – dependant no spray zone | • No spray zone in the field and/or at the field boarder to avoid direct spray of off-field area  
                                            • Product specific, set as a function of wind speed and temperature based on a user guide (Helper)  
                                            • Benefits on all off-field area and organisms through spray drift reduction |
| Buffer zone of bare soil | • No spray zone at the field border to avoid direct spray of off-field area  
                             • Generic  
                             • Width from 0.25 to 12 metres if used with spray drift reduction technology  
                             • Benefits on all off-field area and organisms through spray drift reduction |
Overview of Measures

Spray Drift Reduction Technology

<table>
<thead>
<tr>
<th>Risk mitigation measure</th>
<th>Description</th>
</tr>
</thead>
</table>
| Drift reducing spray nozzles (incl. adjusted spray pressure, etc) | • Generic or product-specific  
• Benefits on all off-field area and organisms through spray drift reduction                                                                 |
| Special equipment/machinery (Wings-/Tunnel-/Band sprayer etc) | • Generic or product-specific  
• Benefits on all off-field area and organisms through spray drift reduction                                                                 |
| Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment etc) | • Generic or product-specific  
• Benefits on all off-field area and organisms through spray drift reduction                                                                 |
| Precision treatment (as sprayers’ equipment)                | • Spray limited to the area of the crop identified as to be treated by the farmer – supported by GPS technology  
• Used on some crops and depending on the growth stage  
• Data on use and benefits are needed to propose detailed recommendations |
## Overview of Measures

### Implementation in Countries

<table>
<thead>
<tr>
<th>Examples of risk mitigation measures</th>
<th>Status</th>
<th>Risk Assessment Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No spray zone</td>
<td>Well established tool</td>
<td>• Wide variation in accepted standards for buffer widths currently limits harmonisation opportunities</td>
</tr>
<tr>
<td></td>
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<td>• Readily represented in current risk assessments</td>
</tr>
<tr>
<td>Wind direction – dependant no spray zone</td>
<td>Promising tool implemented in some Member States</td>
<td>• Taken into account in local user risk assessment as a means of reducing reliance on buffers (e.g. Swedish “helper” (Hjäpredan scheme))</td>
</tr>
<tr>
<td>Drift reducing spray nozzles (incl. adjusted spray pressure, etc)</td>
<td>Promising tool implemented in some Member States</td>
<td>• Precedents available for how techniques may be incorporated into regulatory risk assessment to reduce reliance on buffer zones</td>
</tr>
<tr>
<td>Special equipment/machinery (Wings-/Tunnel-/Band sprayer etc)</td>
<td>Well established tool</td>
<td>• Precedents available for how techniques may be incorporated into regulatory risk assessment to reduce reliance on buffer zones</td>
</tr>
<tr>
<td>Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment etc)</td>
<td>Well established tool</td>
<td>• Precedents available for how techniques may be incorporated into regulatory risk assessment to reduce reliance on buffer zones</td>
</tr>
<tr>
<td>Precision treatment (as sprayers’ equipment)</td>
<td>Under development</td>
<td>• Representation of impact of proportion of area treated likely to be case by case</td>
</tr>
<tr>
<td>Forest aerial application - max. 50% area treated, no spray on the forest edges, standard buffer zones</td>
<td>Promising tool implemented in some Member States</td>
<td>• Aerial drift models utilised to provide input into standard regulatory models</td>
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<td>• Representation of impact of proportion of area treated likely to be case by case</td>
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Agronomic considerations: Practicality and implementation
Constraints?

• Take up by farmers and regulators may be constrained by perceptions;
  • Impact on product efficacy?
  • Practicality of implementation?
  • Availability?
  • Economics?
  • Awareness?
  • Enforceability?

• In general, these concerns are over-stated and suggest lesser awareness

• Address through support for;
  • Best management practice awareness raising campaigns
  • Technology inventories
  • User-directed tools to support customised assessments
Improving Awareness

Best Management Practices (BMPs)

Landscape BMPs
Buffer / retain remaining drift

PPP app methods / technology BMPs
Reduce drift at source

Spraying within the zone of awareness
buffer zone + 20 m
## Practical BMP Tools

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<tr>
<th><strong>Input parameters</strong></th>
<th><strong>Options</strong></th>
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<tbody>
<tr>
<td>Temperature</td>
<td>10, 15 or 20 °C</td>
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<tr>
<td>Wind speed at 2 m height</td>
<td>1.5, 3 or 4.5 m/s</td>
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<tr>
<td>Dose rate</td>
<td>¼, ½ or full dose</td>
</tr>
<tr>
<td>Spray boom height</td>
<td>25, 40 or 60 cm</td>
</tr>
<tr>
<td>Spray droplet size</td>
<td>Fine, Medium or Coarse</td>
</tr>
<tr>
<td>Use of particular spray drift reducing techniques</td>
<td>50, 75 or 90 percent reduction</td>
</tr>
</tbody>
</table>

[http://www.sakertvaxtskydd.se/](http://www.sakertvaxtskydd.se/)
Improving Awareness

Practical BMP Tools

- [http://topps-drift.org](http://topps-drift.org)
- User-directed tools to develop customised drift evaluation;
  - Meteorology
  - Field conditions (crop and adjacent vegetation)
  - SDRT used
  - Boom height
  - Driving speed
Recommendations for future toolbox expansion and flexibility
Review of Safety Phrases

• Refine for more effective / flexible communication of mitigation options?
• How to allow for wide range of options?
• How to address local constraints and circumstances?
Labelling: Buffer Zones

Current status:

- SPe3, recommended on products’ labelling when transfers via spray drift need mitigation for the protection of aquatic organisms and non-target arthropods

Proposed update to introduce the protection of other groups of organisms

SPe3: To protect [aquatic organisms / non-target plants / non-target arthropods / insects] from spray drift respect an unsprayed buffer zone of (distance to be specified) to the edge of the field/surface water bodies. The edge of the field is either the edge of the crop or, in the presence of a margin strip, the edge of a margin strip.

Where environmental conditions are taken into account, buffer zones may be adapted as follows:

-(to be added to the SPe3) The buffer zone may be adjusted as a function of wind speed, wind direction and temperature conditions based on available recommendations.
Application equipment to reduce spray drift and losses

Effective tools:

- Spray drift reduction nozzles
- Special equipment/machinery (Wings-/Tunnel-/Band)
- Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment etc)
- Precision treatment (as sprayers’ equipment)

Proposed additional text to be added to a SPe3:

- The buffer zone may be reduced to (distance to be specified) if a combination of spray drift reduction technologies such as drift reducing spray nozzles, special equipment to reduce spray drift or directed spraying technique [is / are] used providing at least (% of drift reduction to be specified).
Example Spray Drift Mitigation

- **Example:** The virtual insecticide *Super-Antilouse* is evaluated at zonal level for early use in stone / pome fruits.

The regulatory risk assessment for the product identified a risk mitigation need for spray drift of 88%.

- Defined national toolbox of measures for farmers to choose from, e.g.

<table>
<thead>
<tr>
<th>No-spray zone</th>
<th>Mitigation</th>
<th>Special equipment</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 m</td>
<td>33 %</td>
<td>Tunnel sprayer</td>
<td>75 %</td>
</tr>
<tr>
<td>5 m</td>
<td>50 %</td>
<td>Cross-flow sprayer</td>
<td>33 %</td>
</tr>
<tr>
<td>10 m</td>
<td>75 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 m</td>
<td>90 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drift-reducing nozzle</th>
<th>Mitigation</th>
<th>Directed spraying techniques</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR 50%</td>
<td>50 %</td>
<td>Shield deflector</td>
<td>50 %</td>
</tr>
<tr>
<td>DR 75%</td>
<td>75 %</td>
<td>One-sided air fan</td>
<td>66 %</td>
</tr>
<tr>
<td>DR 90%</td>
<td>90 %</td>
<td>&amp; spraying</td>
<td></td>
</tr>
<tr>
<td>DR 95%</td>
<td>95 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example Spray Drift Mitigation Implementation in Countries

Farmers’ choices to manage risks at field level to comply with 88% mitigation need (using multiplicative effectiveness for measure combinations), e.g.

- 90% DR nozzle
- 50% DR nozzle + 3 m no-spray zone + one-sided spraying & air fan
- 50% DR nozzle + 10 m no-spray zone
- 20 m no-spray zone
Case Study

• Modelling and risk assessment demonstrates need for at least 45% reduction in drift for late season use in pome/stone fruit (FOCUS Step 3)

• Classification of risk mitigation based upon mitigation category (50%, 75%, 90%, 95% or 99% drift mitigation) → 50% mitigation class required.

• This may be achieved via a buffer, but it could also be addressed, or supplemented by other equivalent drift mitigation techniques adapted to local policies and standards
No spray zone alone: 10 m wide buffer (Rautmann et al., 2001) → 60% drift reduction
Customisation

No spray zone + SDRT: 5 m wide buffer (Rautmann et al., 2001) + 50% SDRT nozzle → 64% drift reduction

Or...
When 50% drift reduction nozzles are used, a 90% drift reduction can still be obtained when other measures are used in combination (such as hedges, wind nets etc.)
Source: Buses anti-dérive agréées en Belgique pour une réduction de 50%

Buffer → 32%
SDRT → 32%
Customisation

- Standard orchard sprayer + windbreak on the edge of the driving track + one-sided spraying of the last tree row → 58% drift reduction

One sided spraying → 41%
Windbreak → 17%
### Conclusions

<table>
<thead>
<tr>
<th>Problem</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing independent nozzle classification schemes for all States is impractical/inefficient</td>
<td>• MS Regulators may draw upon extensive experience and sound scientific foundation associated with schemes in place in other countries (NL, D, UK) supported by readily accessed SDRT database</td>
</tr>
</tbody>
</table>
| Lack of harmonisation leads to inconsistency in role and take-up of SDRT and other techniques across Europe | • A greater degree of harmonization would:  
  • encouraging technological advances by farmers.  
  • submission of consistent risk assessments  
  • increase zonal regulatory efficiency by avoiding differentiated assessments  
  • Consideration of a **basic** harmonized basis for acceptance of SDRT efficacy thresholds (e.g. 50%, 75%, 90% and 95% effectiveness) is recommended  
  • Expansion to include 99% would:  
    • anticipate further technological advances  
    • allow for options of compounded mitigation |
## Conclusions

<table>
<thead>
<tr>
<th>Problem</th>
<th>Recommendations</th>
</tr>
</thead>
</table>
| Need to increase awareness amongst users | • Encourage support for user-friendly drift management tools;  
  • Swedish “Hjälpreda”  
  • TOPPS-Prowadis drift evaluation tool |
| Need to overcome perceptions and hurdles | • Highlight principles that legal issues should not undermine safety and communication  
  • Accommodate different stakeholder interests recognising “who is responsible?” and “who is best placed to implement?” |
| Need to allow for greater flexibility in label S-phrases | • Present proposals that would support;  
  • More effective / flexible communication of mitigation options  
  • Allow for wide range of options  
  • Accommodate local constraints and circumstances |
A path forward...

- Developing a partnership with the drift research community in Europe and abroad to support improvements in spray drift representation, mitigation and role in risk assessments;

- This includes;
  - Support for fundamental research
  - Organisation of a multi-stakeholder SETAC workshop; DRAW
  - First workshop held Feb 2016, Montpelier, FR

- SETAC DRAW Objectives;
  - Review of available spray drift database;
  - Develop an agreed field protocol for drift studies;
  - Targeted efforts to address measurement uncertainties;
  - Progress towards development of more comprehensive harmonised spray drift representations, including consideration of crop;
  - Proposals for enhanced mathematical modelling to support improved risk assessment;
  - Consideration of impact in diverse risk assessment domains;
  - Development of options for implementation and improved / expanded risk management and mitigation to accommodate revised representation
A path forward...

- Nozzle performance
- Formulation effects
- Greater flexibility with spray drift mitigation:
  - Application techniques
  - Environmental conditions
  - Role of landscape components/structures

- Validation
- Enhanced representation/refinement of role of crop
- Ability to assess droplet behaviour under diverse use conditions
- Assess effectiveness of spray drift management strategies
- Support for risk assessment

Practical and Effective Label Mitigation
Final Thoughts...

- Spray drift is complex...
  - Ground, aerial, orchard/airblast sprays
  - Broad range of technologies of spray equipment
  - Significant differences in vulnerability (weather, landscape)
- But representation has been simplistic...
- Spray drift can be well managed...
  - Training / certification / education
  - New drift reducing technologies (e.g. precision agriculture)
  - Adaptation to landscape and conditions
  - Ensuring options are transparent, practical and effective
- Vast, exciting opportunities for improvement....!
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