Probabilistic exposure assessment for edge-of-field watercourses next to fruit orchards and avenue tree nurseries in NL

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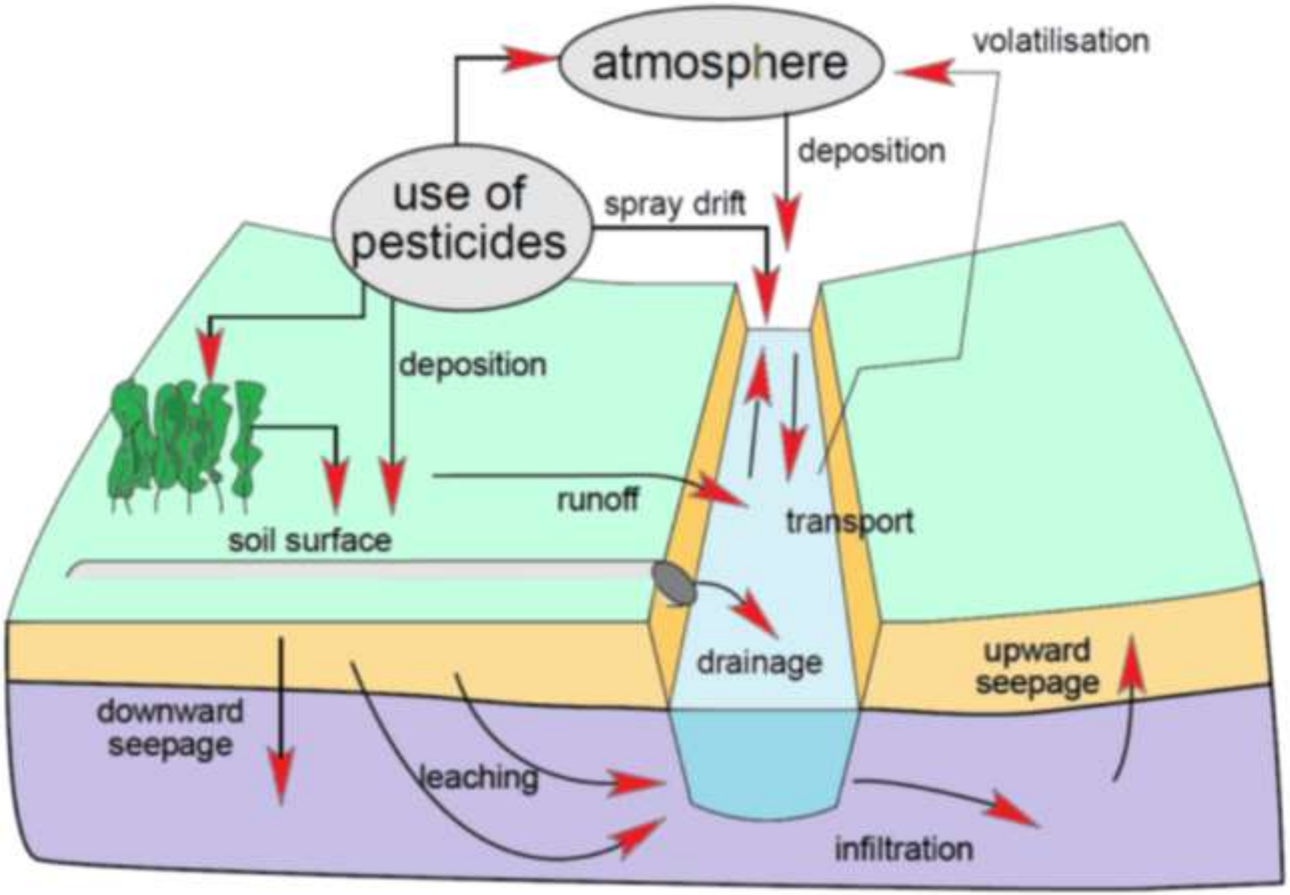
Overview

- Introduction
- The probabilistic way to pesticide exposure assessment
- Application to fruit orchards
- Application to avenue tree nurseries
- Application to herbicide treatments
- Conclusion

Pesticide exposure routes into a watercourse

Entry routes after a spray application to edge-of-field watercourse



Pesticide exposure assessment

- Main objective of the project:

  Development of *higher-tier assessment tool* for authorization of pesticides in various crops regarding the risk of *exposure* of *aquatic organisms* to *pesticides*

- Considerations/limitations:
  - Scale = The Netherlands
  - Edge-of-field watercourses only
  - Spray drift is major entry route
  - As realistic as possible

- This presentation focuses on:
  - Fruit orchards
  - Avenue tree nurseries

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The probabilistic approach: a ‘multi-stage rocket’

Launch Apollo 11; 1969
courtesy: NASA

implementation into ‘**DRAINBOW**’:
exposure assessment model for
exposure of aquatic organisms to ppp
due to *drift* and *drainage*
and subsequent *fate* in the watercourses

selection of
representative (local) configuration
corresponding to a 90% exposure level

exposure assessment model:
probabilistic analysis for whole NL:
simulation of ppp deposits onto
all watercourses next to *all orchards* in NL

GIS maps

spray drift model:
compute deposits of
plant protection product (ppp)
onto edge-of-field watercourse
next to an orchard

one orchard, one ditch

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Spray drift model for fruit orchards: SPEXUS

Spray drift model SPEXUS:

(**sp**ray drift **ex**posure model for **u**pward and **s**ideways applications)

- empirical, based on 20 years of field trials
- apple tree orchards (most important fruit crop in NL)
- regression analysis revealed most important factors

Major factors:

- wind speed
- wind direction
- ambient temperature
- canopy density (→ *BBCH*)
- orchard size
- sprayer settings

The probabilistic countrywide approach

- Implementation of the SPEXUS model into countrywide exposure assessment model (whole NL)

  Finding a 90th percentile risk of exposure to ppp
  for all edge-of-field watercourses
  next to all fruit orchards in NL

  → *annual max PEC_{90}*

- This requires:

  A. Realistic mapping of orchards and watercourses → *spatial configuration*

  B. Realistic weather conditions → *temporal configuration*

spatial configuration (fruit orchards)

Location, orientation, geometry of edge-of-field watercourses next to fruit orchards

All combinations of:

area of orchards per district (14)

water body type (44)

water depth (9)

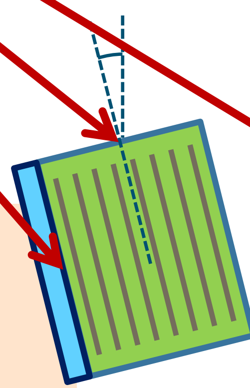
orchard orientation (18)

orchard side where water body is located (4)

14 meteorological districts

defined by soil type and water body characteristics

discretized to 9 levels in summer half of year



→ about 74,000 spatial configurations are simulated, weighted according to their probability of occurrence

temporal configuration

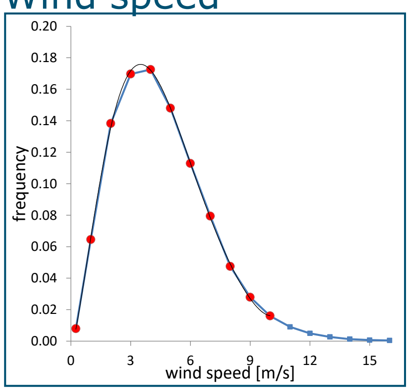
- Variables that change over time
  - *crop stage (BBCH → DOY)* — *depends on spray application scheme*
  - wind speed
  - wind direction
  - ambient temperature

  } use regional division (meteorological districts)

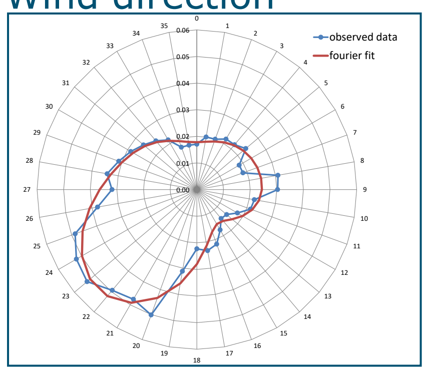
→ Frequency distributions

F (district, DOY)

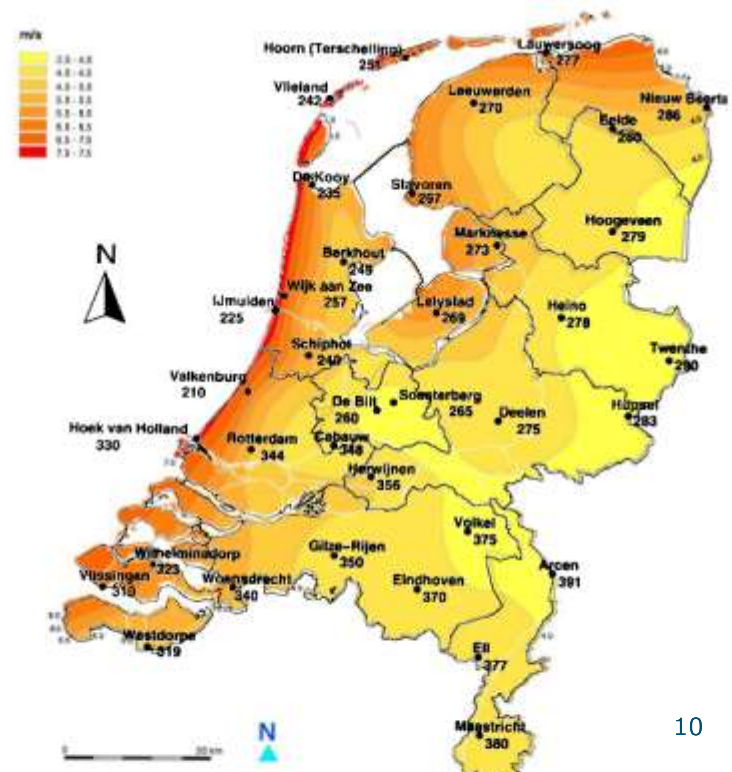
Wind speed



Wind direction



annually averaged wind speed



modified from: KNMI klimaatatlas

Representative local scenario

We faced two practical problems:

(1) numerous different scenarios possible!

(2) final DRAINBOW model cannot cope with so many scenarios...

→*It is impossible to carry out a full-scale probabilistic exposure assessment combining exposure and fate for all situations countrywide !*

Workaround:

Using a local scenario representing countrywide 90% exposure level

local scenario implies:
one orchard, one watercourse,
at a selected location in NL

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Exposure assessment, countrywide and local

countrywide scenario simulation

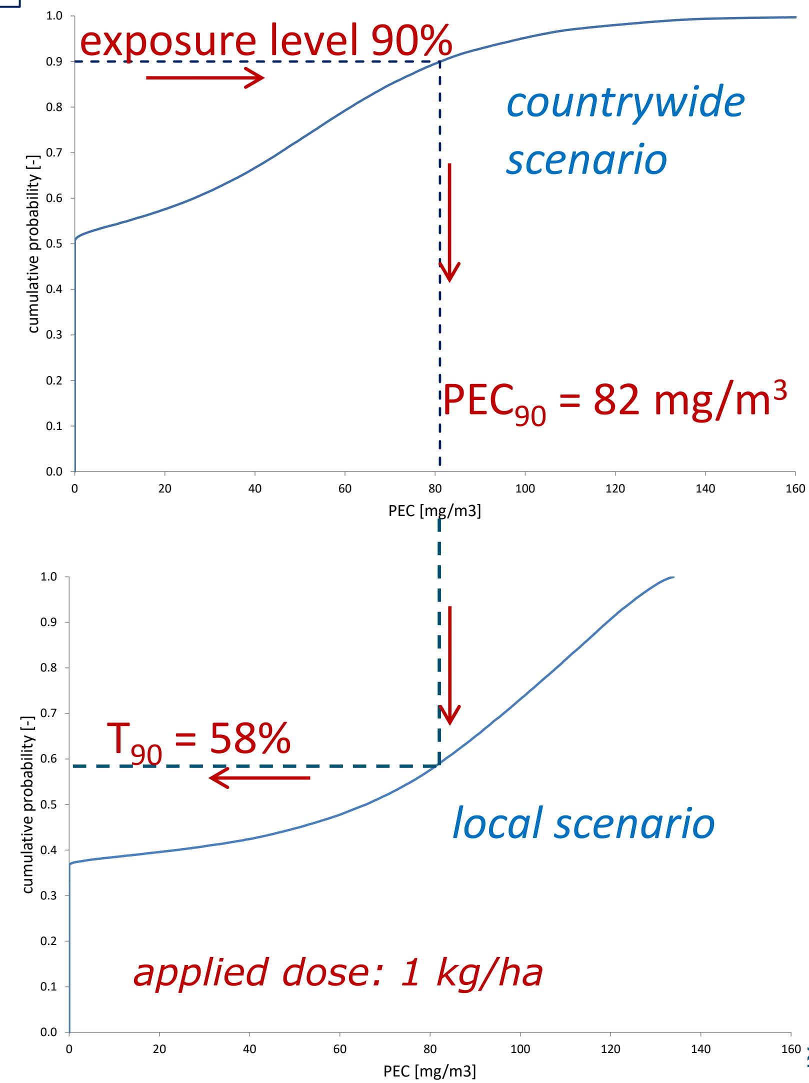
90% drift exposure (concentration PEC_{90})

do same simulation for the selected local scenario

the countrywide PEC_{90} occurs in local watercourse too, but at different probability level: T_{90}

*for this probabilistic **example** scenario: the **local 58th** percentile PEC corresponds to the **countrywide 90th** percentile PEC*

cumulative probability density curve



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Establishing T_{90} values for different situations

The countrywide-local combination procedure is applied to a wide range of situations:

- Different dates (→ growth stages; spring - summer)
- One or multiple spray applications per season (1, 3 or 15)
- Accounting for different application techniques (spray drift mitigation; crop-free buffer strips)

→ table of 350 T_{90} values !

(for *upward/sideways* applications in *fruit* orchards)

→ apply interpolation for situations not covered

In this way we can obtain good estimates of countrywide PEC_{90} and local percentile T_{90} for all practical cases.

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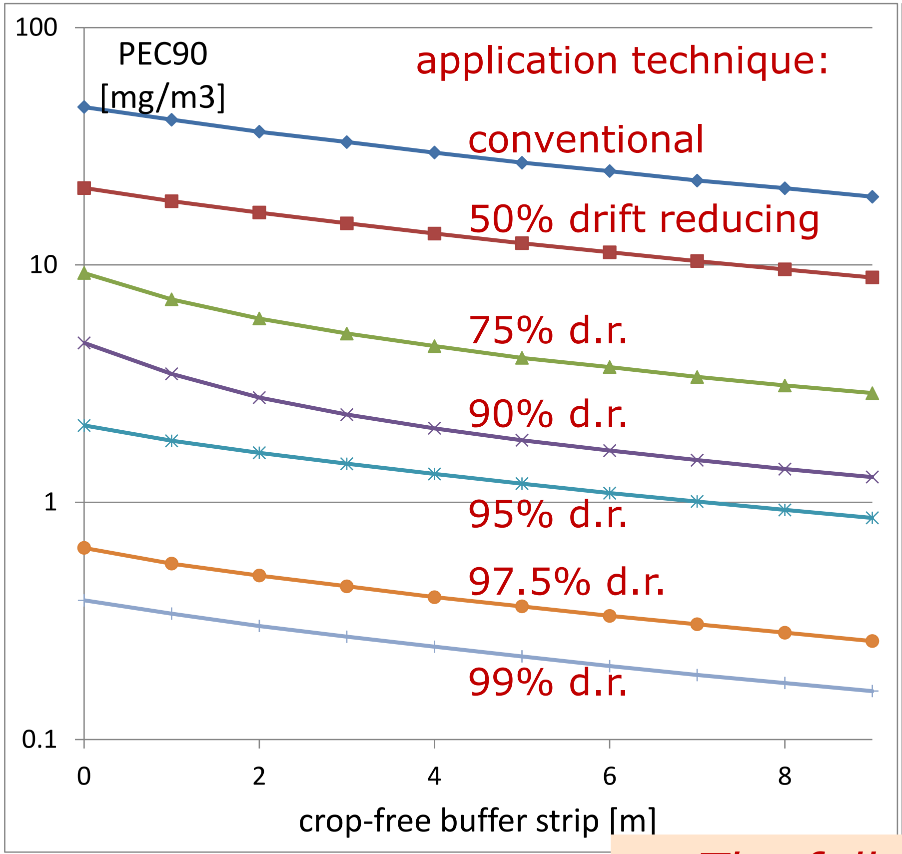
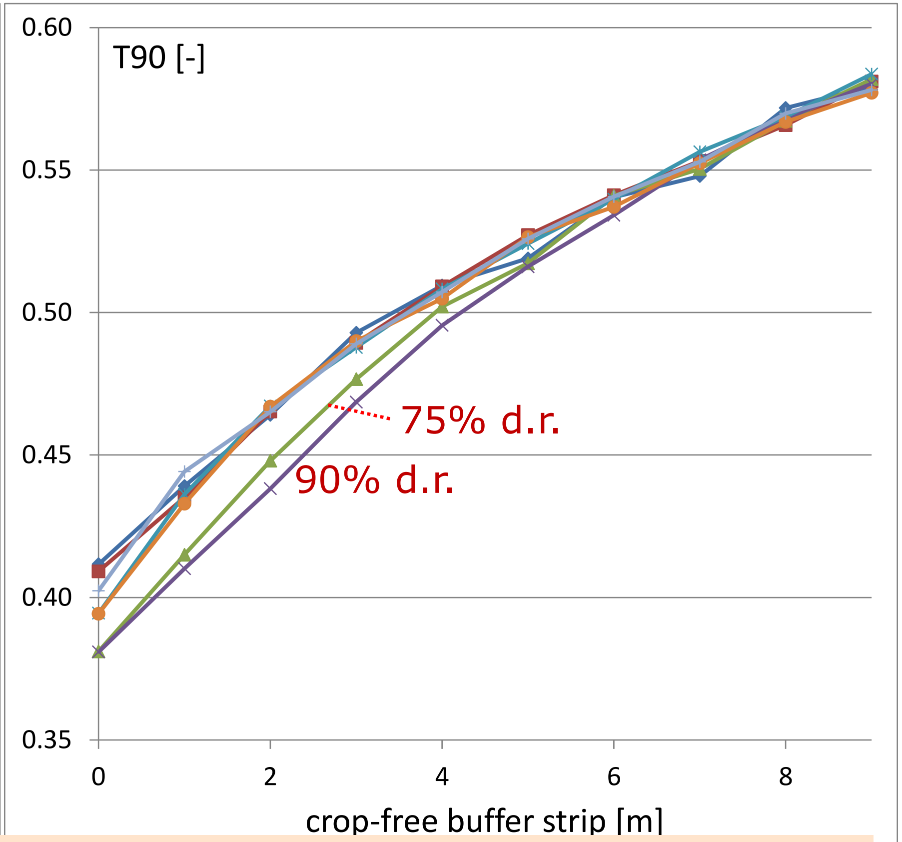
Example: PEC_{90} and T_{90} for fruit orchards

- different application techniques, crop-free buffer strips
- 3 spraying events in August (full-grown canopy); dose 1 kg/ha





The full set of (350) computed situations gave T_{90} values ranging from 0.17 to 0.72

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Avenue tree nurseries

upward/sideways spray applications

Same approach using countrywide/local scenario procedure, but simplifications are possible (or required):

- Spatial situation is less complicated:
  - Limited number of relevant regions
  - Limited number of relevant waterbody types
- Spray drift: no sophisticated 'SPEXUS-like' model available:
  - Experimental spray drift curves are used instead
  - Limited experimental data
  - Wind direction is the only environmental variable left!
  - Limited number of available drift reducing techniques

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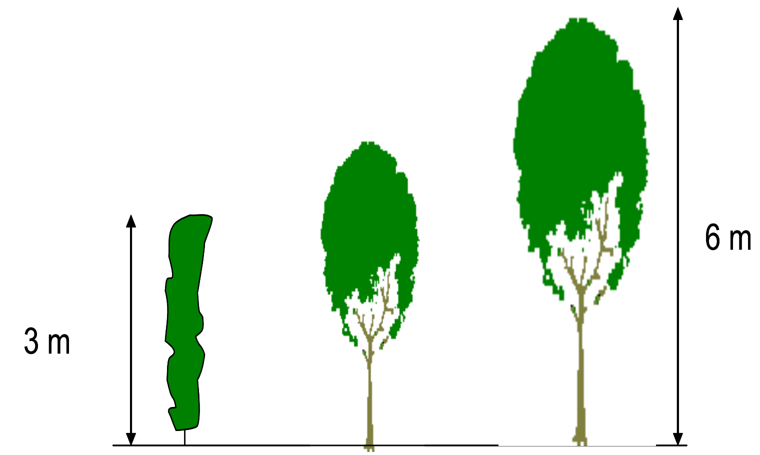
Avenue tree nurseries

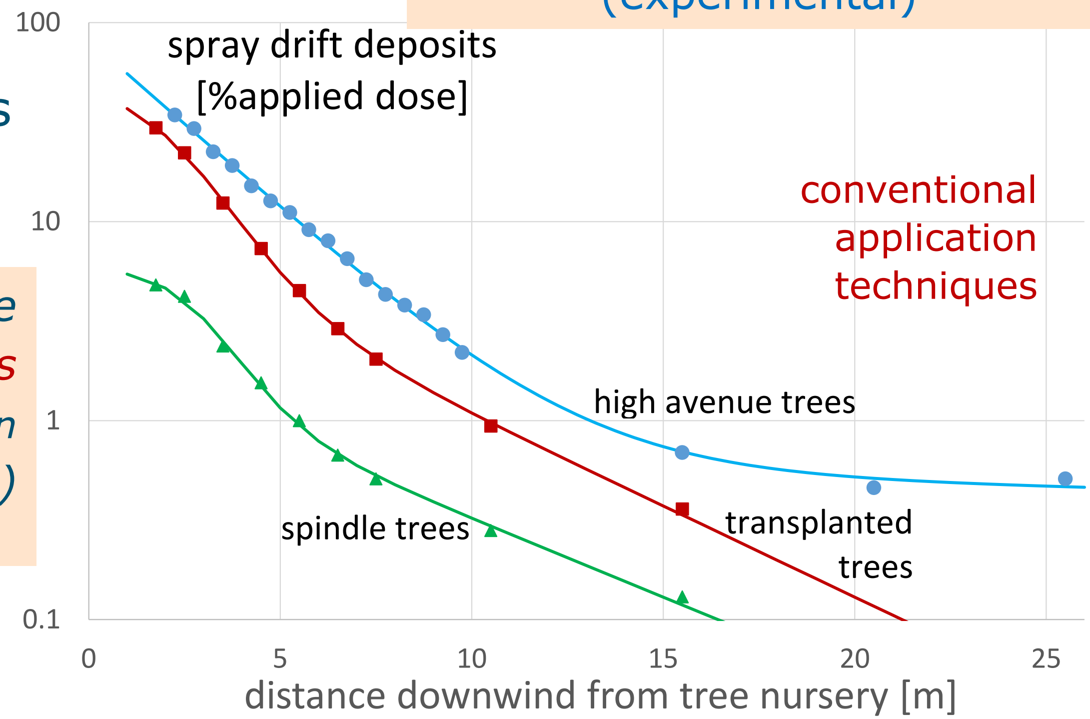
upward/sideways spray applications

Three basic 'growth stages' considered independently:

- *spindle* trees: relatively small and narrow trees
- *transplanted* trees: intermediate stage, giving the canopy more space
- *high* avenue trees: last stage at the nurseries



downwind spray drift deposits as a function of distance (experimental)



these three growth stages have different spray drift curves (due to different application techniques, different crop interception)

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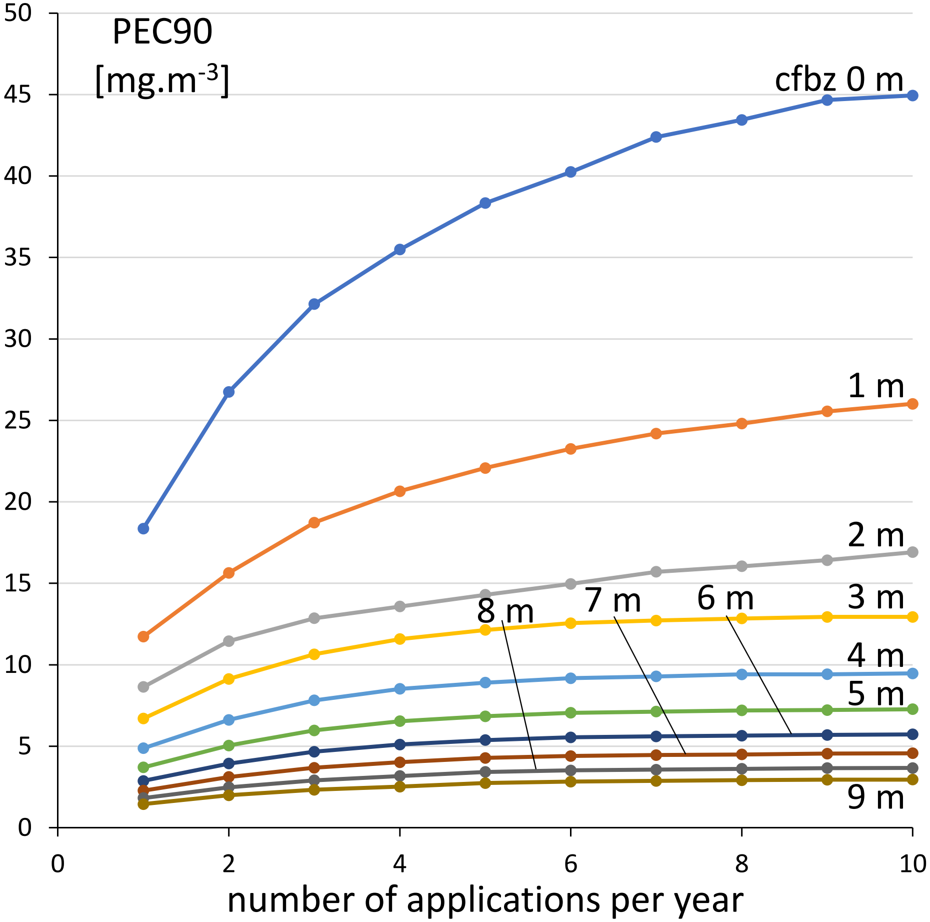
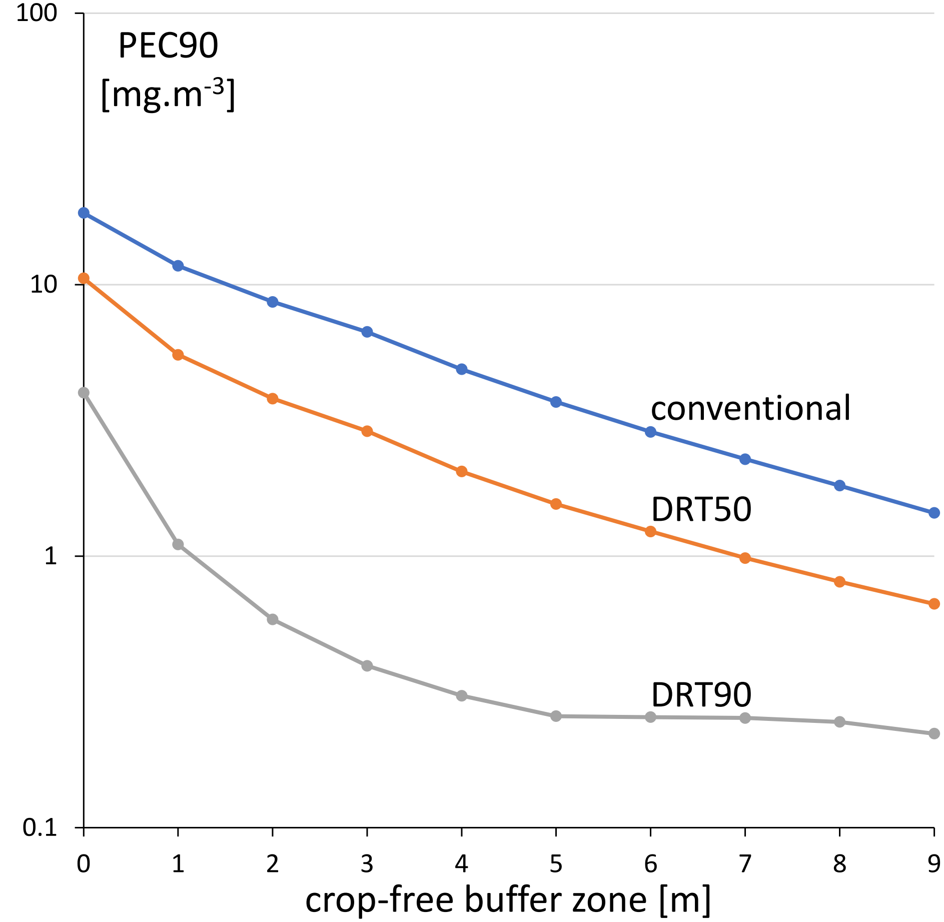
Example: PEC_{90} for transplanted avenue trees

PEC_{90} vs number of applications per year, various crop-free buffer zones



PEC_{90} vs crop-free buffer zone width, various application techniques



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Downward spray applications

herbicide treatments in avenue tree nurseries

- For avenue tree nurseries similar limitations hold as with upward/sideways applications:
  - Experimental spray drift curves
  - Wind direction is the only environmental variable
  - Limited number of available drift reducing techniques

- Further simplification:
  - Spray drift is independent of tree growth stage (*same drift curves for spindles, transplanted and high trees*)

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Downward spray applications

herbicide treatments in pome fruit orchards

- Herbicide treatment in pome fruit orchards :
  - Similar to that in avenue tree nurseries
  - Same spray drift curves as with avenue trees

- However:
  - Spatial situation is same as with fruit orchard upward/sideways (same countrywide spatial variation)
  - Spray drift depends on treated area:
    - tree strips (underneath the trees)
    - grass strips (paths between the tree rows, and surrounding the orchard)

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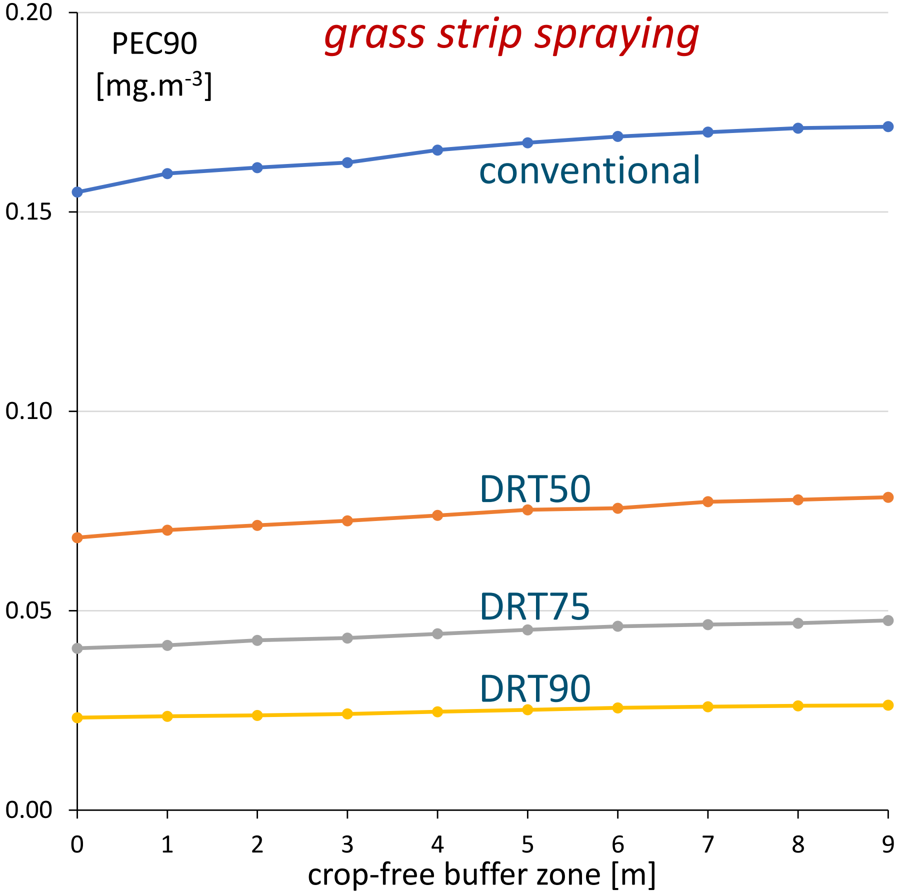
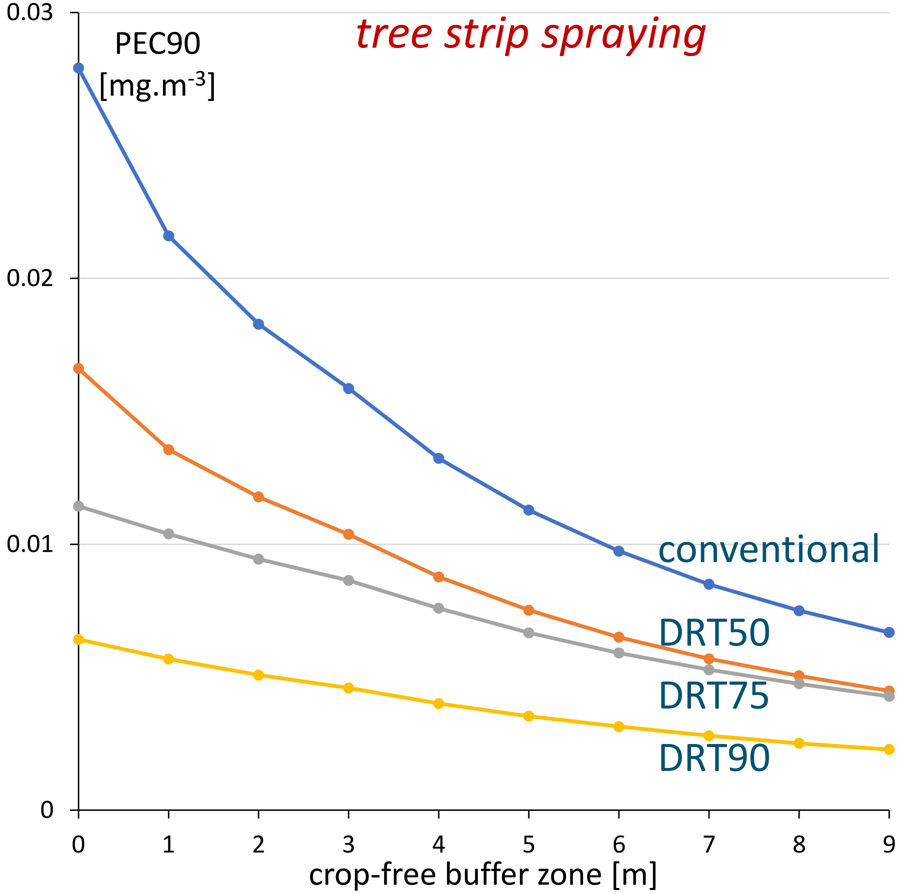
Example: PEC_{90} for herbicides, fruit orchards

Spraying grass strips:
PEC_{90} vs *crop-free buffer zone*,
various application techniques



Spraying tree strips:
PEC_{90} vs *crop-free buffer zone*,
various application techniques



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Conclusion

- Probabilistic approach appears to work for different crops and treatments; for fruit orchards and avenue tree nurseries implementation of *exposure* and *fate* is in final phase
- The *workaround* with a representative *local* configuration cannot be avoided and leads to some complex numerical and interpretational *challenges*
- A procedure to incorporate pesticide input from *drains* has been developed and implemented
- *Regulatory* implementation: combined *exposure* & *fate* as a *higher tier*: we are working on this
- *Field crops*: *upgrade* of similar probabilistic approach is underway

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