Precision application case studies: Lower dose = lower risk?

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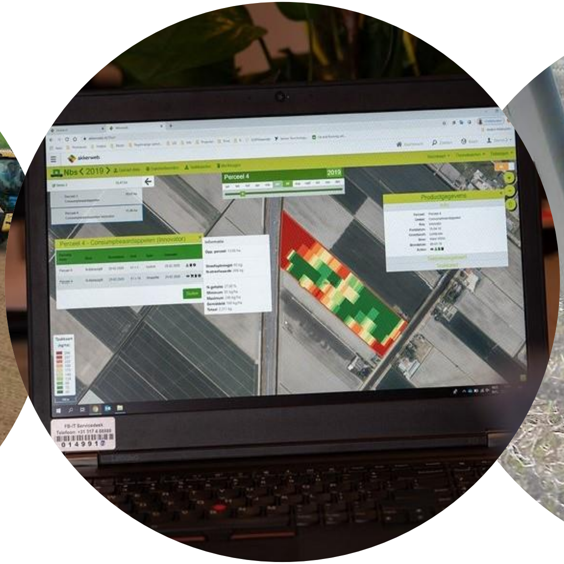

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Outline:

- Operationalize Definitions for Precision Application
- Which types of PPP are we talking about?
- Protection goals (ecotoxicity)
- Case study examples at Wageningen University & Research
    - In-field: Groundwater modeling
    - In-field: Soil organisms
    - Off-field: Surface water – drift analysis
- Future risk assessment
    - What do we probably need to support future risk assessment?

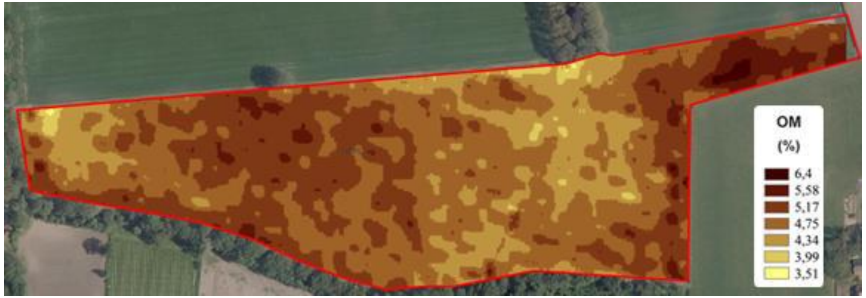
Goals risk assessment: establish ‘safe’ dose rate

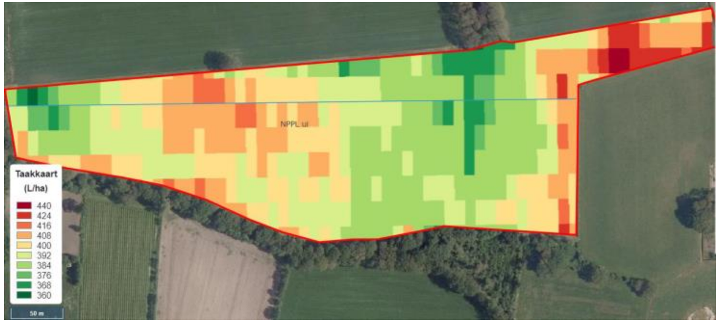
- Conservative, worst case use, label requirements
- ERA for PPP registration in EU and MS: homogenous pesticides application according the max. advised dose is assessed, GAP.
- Some options for **<10%** spot treatments, no guidance on how to assess **reduced dose** potential with precision applications
- Precision risk assessment methodology?
    - Max use per year (total g/ha/crop season)
    - Repeated application/shorter interval if PA is used ?
    - Include precision applications as a mitigation, or part of scheme? Label advise, e.g. use only if ... ?

Definitions Precision Agriculture

- Van Boheemen et al. (2022) Wageningen Research, Report WPR-1118 https://doi.org/10.18174/566499

"Exactly meeting the needs of plants or animals within space and time
while respecting economic and social boundaries
and taking into account environmental aspects"





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Pictures from: Van Boheemen et al., 2022

Definitions Precision Agriculture (PA)

Apply only at the right time at the right place at the right dose.

Proposed definition: only PA if...

site-specific measurements are done

+ a site-specific decision is made, and

+ this decision is subsequently carried out site-specifically

Measurement/decision: on-the-go PA or *chained PA*

Application: Spot-wise or *Variable rate* or *Hybrid*

Excludes band application, innovative full field (mitigation) techniques

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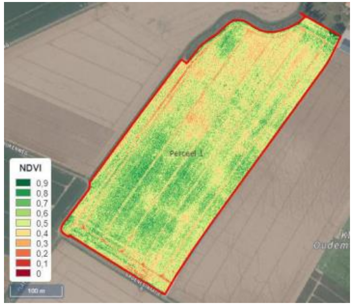
Precision techniques for crop protection

- Field receives precise treatment, determined with great accuracy using the latest technology.
  - Actions to be determined per m² or per plant
  - Spatial resolutions differ

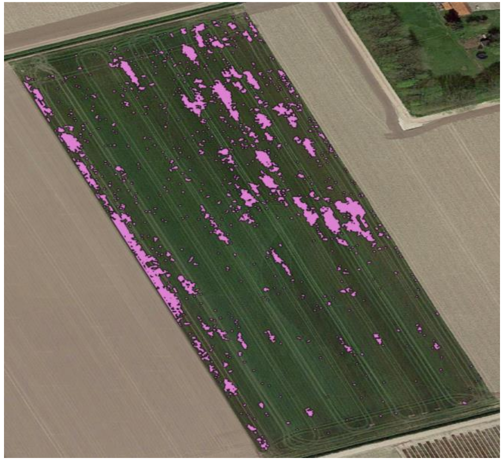


Chained precision application:

1. Scan: Biomass scan in potato field for a desiccant spray task

2. Decide: task map

3. Apply: variable rate per 10 m
via total spray boom / nozzle sections



On-the-go application
1+2+3: based on scanning of weeds while driving (field thistle in carrot crop)
-> apply spot treatment

Pictures from: Van Boheemen et al., 2022

PA for different PPP types?

- At present, mainly used for application of herbicides
  - soil herbicides, specific weeds, biomass (haulm destruction)
- Other target pests for PA?
  - **Fungicides**: avoid too low dose risking resistance/too late timing
    - Field specific conditions (wet patches ?)
  - **Insecticides**: (mobile) pest species invade over space & time
    - Field edge protection ?
    - Nematodes (non-mobile) ?
      - Soil application ?

Picture: canolacouncil.org/canola-encyclopedia/diseases/alternaria-black-spot/

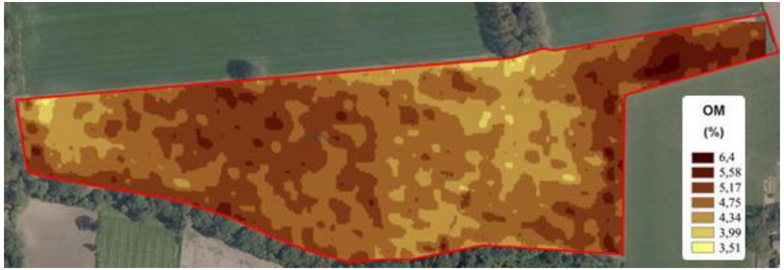
Protection Goals for herbicides

- Which protection goals benefit from lower herbicide dose via PA ?
  - In-field:
- Groundwater: GW limits for all PPP: average reduced dose ?
- Birds & Mammals: Food: spotwise (≤10%) for chronic exposure
- Bees: mobile: landscape, flowering stage (weeds)
- Soil organisms: low-mobility, but low sensitivity ?
  - Off-field:
- Aquatic organisms: drift/drainage/run-off: algae/macrophytes
- Non-target plants: drift: specific target
- NTA: drift: herbivores (~pollinator juveniles)

Case study in-field – Groundwater

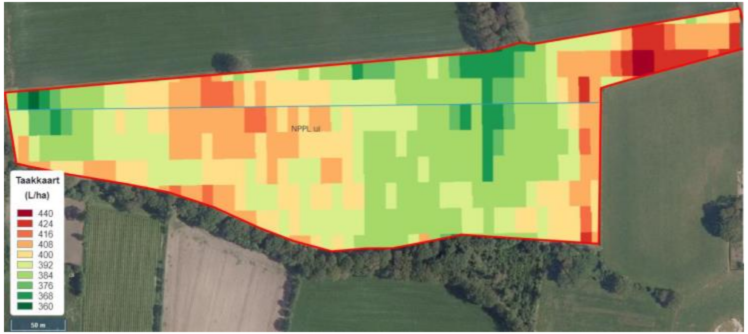
- Sensors for making soil scans to map spatial variability of soil properties (soil herbicide).

soil scan: organic matter content in top 30 cm



dimethenamid-P: slightly mobile (Kom 66 L/kg)

decision model: $\text{Dose}_{(\text{min},\text{max})} = a \cdot \text{OM} + b$



–> perform risk assessment using reduction of advised dose

Underlying assumption:

Risks are averaged out over the entire field – Is this justified?

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Pictures from: Van Boheemen et al., 2022

Case study in-field - Groundwater

- Ter Horst et al. (*in prep*) Wageningen Research

EU GW endpoint: 80^{th} percentile leaching **concentration at 1 m depth** below a treated field;

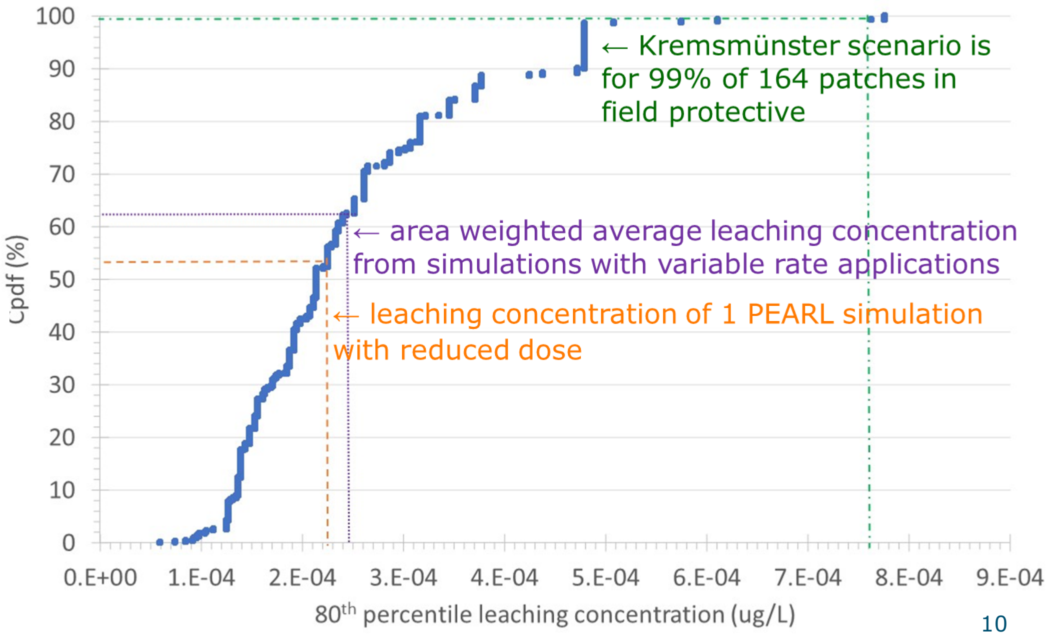
PEARL simulations for 164 patches

vs.

1 run on weighted average soil OM

Field average reduced dose = small difference with patch specific

due to weak sorption non-linearity (dimethenamid-P: n_F 0.965).



Case study in-field: Soil organisms

- Considered non-mobile species: population recovery not via dispersal

(EU) No 546/2011: Tier 1 TER: [Reproductive NOEC / PECsoil] > 5

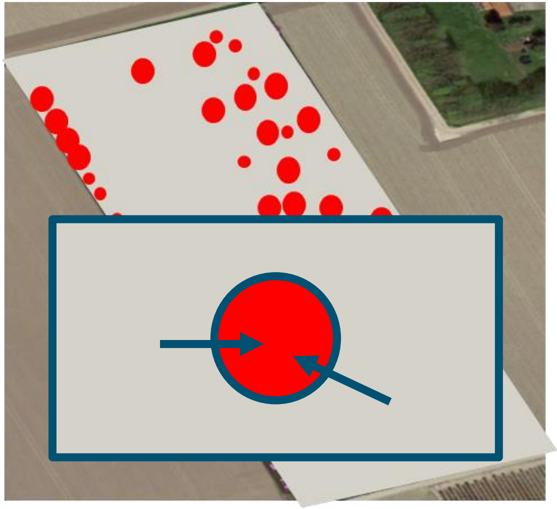
- Recovery within 1 year can occur via reproduction of surviving species
  - Demonstrate with higher tier field test

- Future direction of soil risk assessment *:

Focus on Ecosystem services, “tolerable effects”

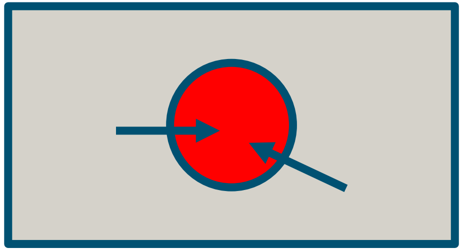
- If PA is applied, “tolerable effect” in some patches

Q: Can affected sub-populations recover
via dispersal from non-impacted patches?



* EFSA Scientific Opinion 2017, 15(2):4690

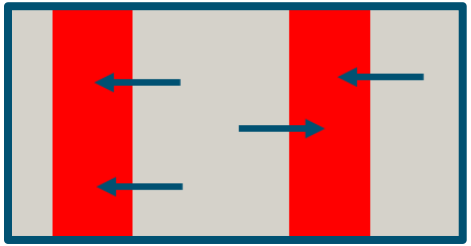
Case study in-field: risk to soil organisms



To be clarified, research needs to:

- Define maximum patch radius for the most vulnerable in-soil “Service Providing Unit”
- Define the maximum patch area to be repopulated (source-sink cap.)
- Healthy in-field population during full crop-season (in non-PA zone):

Case study with Band/furrow/strip ?



Can negligible impact from full PPP scheme (use besides Spot PA) be shown?

Can these limitations be checked during PF with on-the-go detection ?

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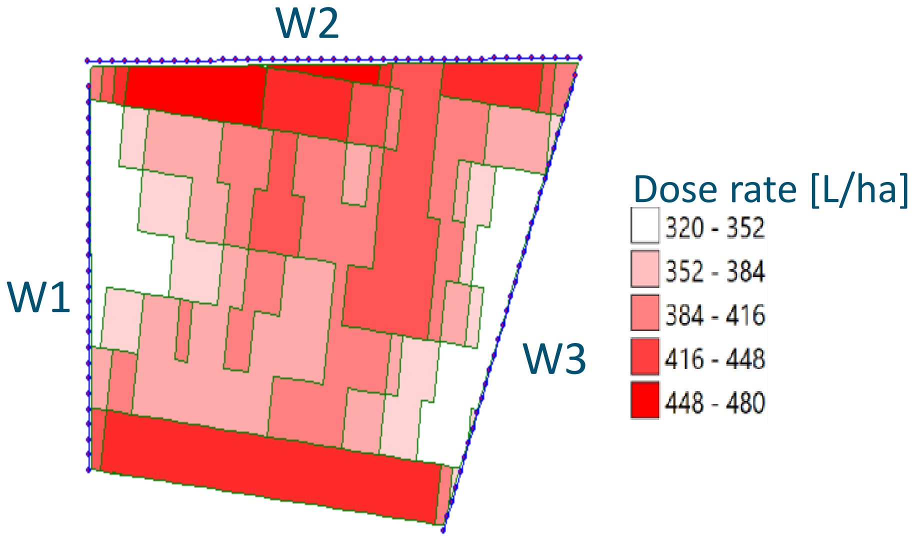
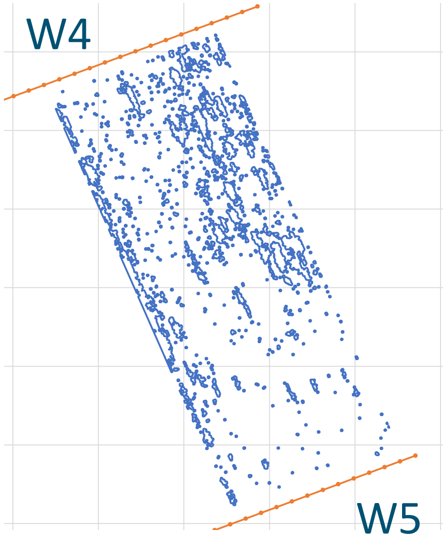
Case study off-field: Surface water

Case 1: Variable



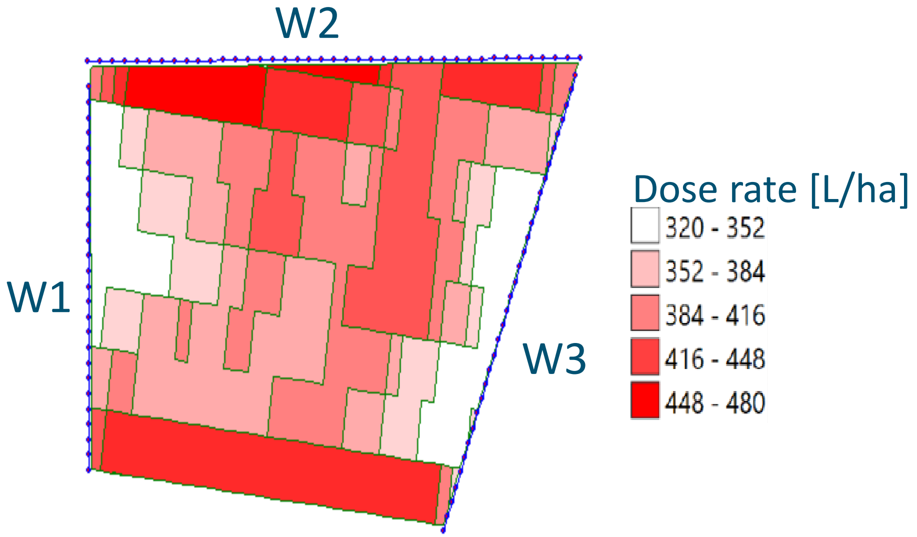
Case 2: Spot

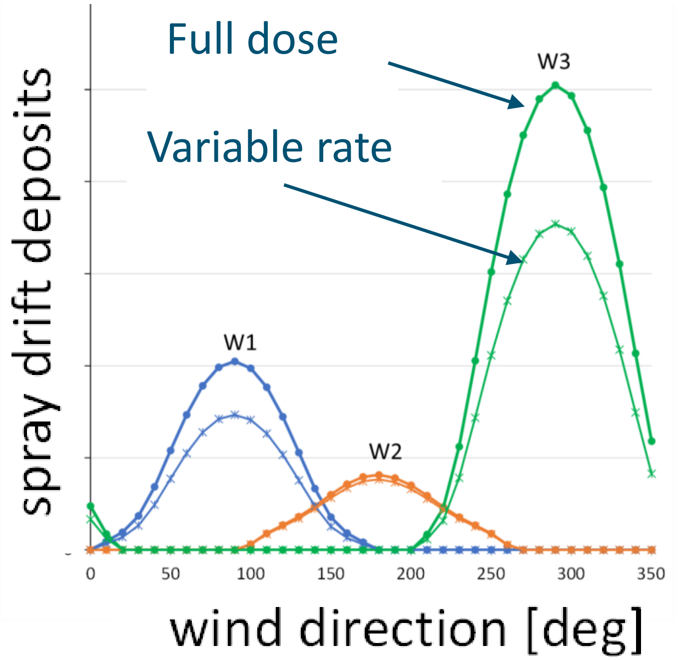


11% area
Received
application

Compare drift deposits in W1-W5 with full dose:
based on different wind directions

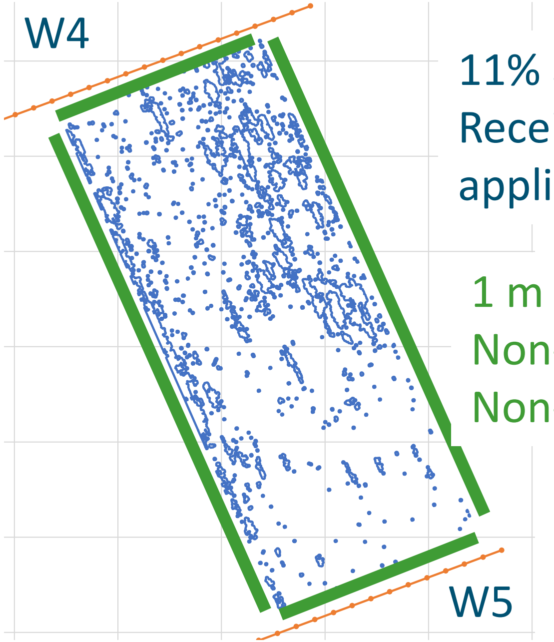
Case study off-field: drift with variable rate





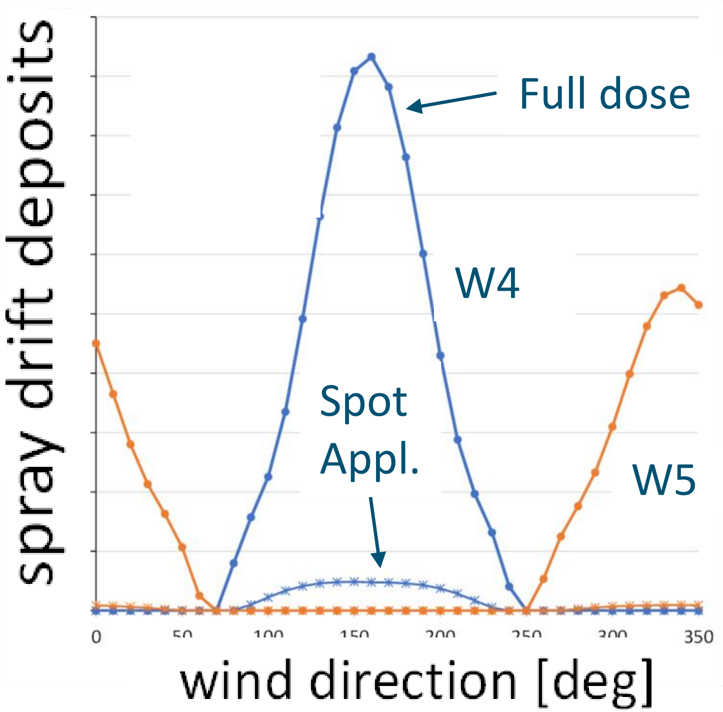
Drift deposits reduction depends on wind direction, and patch dosing alongside field edge

Case study off-field: drift with spot application



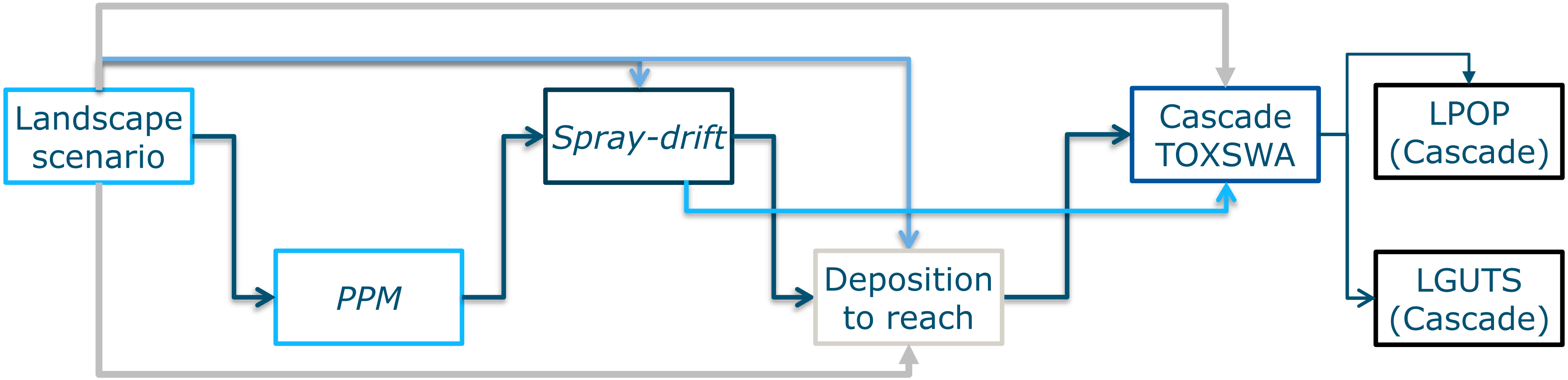
11% area
Received
application

1 m distance:
Non-target arthropods
Non-target plants



Major drift deposit reduction possible for all wind dir.,
also for field edge with many spots

Integrate PA in Landscape assessment: IFEM modular model system



Data flow

Landscape (e.g., GIS, hydrology (CMF), weather)

Hydrological data

Other data

? Toggled by user

Key features explicitly addressed by the model:

- Landscape
- Hydrology and weather
- Farming practices (PPM, Spray drift, Deposition)
- Mitigation (consistent with FOCUS SW Step 4)
- Integrated fate & effect
- Uncertainty/probability:
  - Stochastic drift calculation
  - Monte carlo simulations

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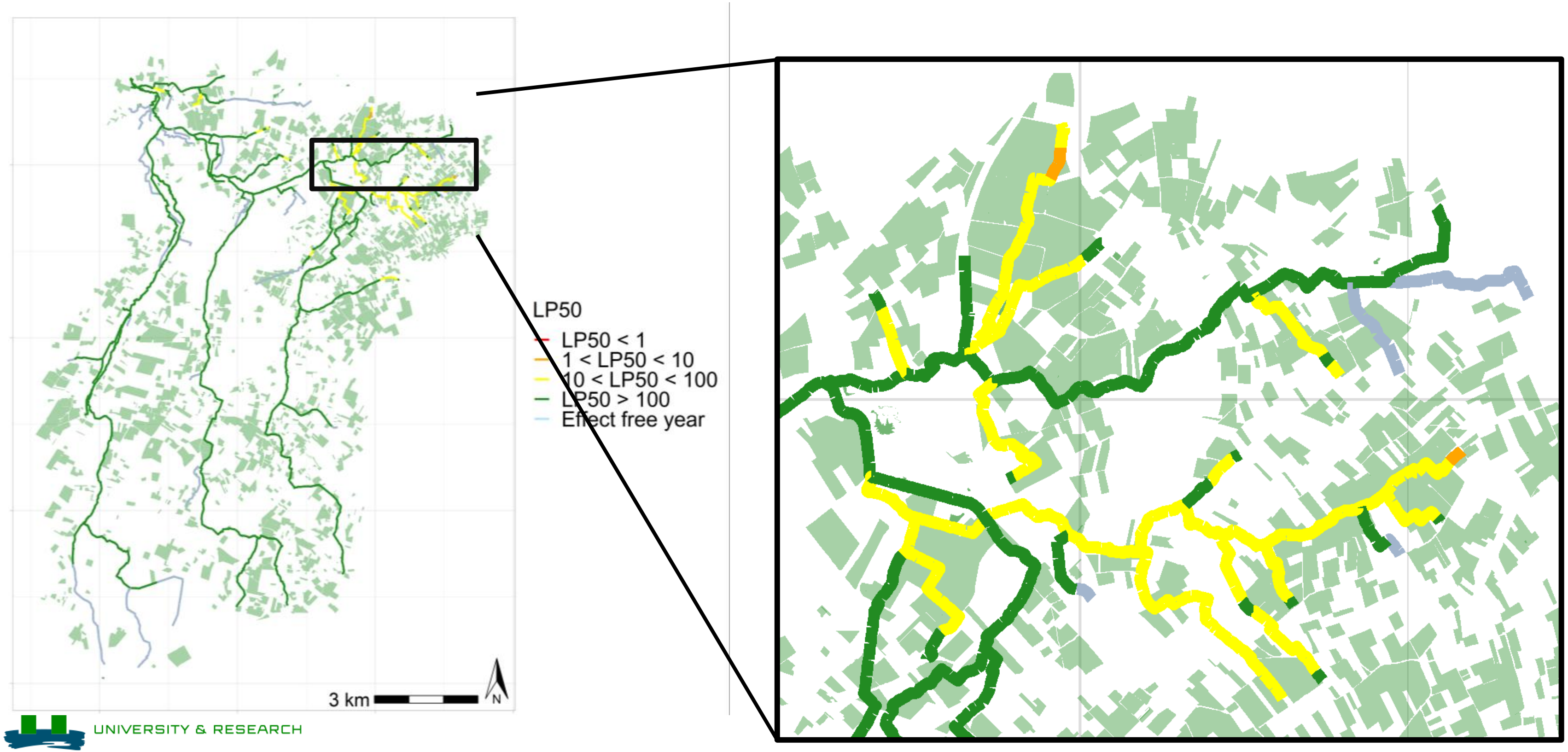
Spatially explicit RA in cultivated landscapes
- evaluate PA as mitigation option in orchard uses?



Use of reduced dose in (future) risk assessment?

- Lower PPP use: improves system health.
- How to operationalize PA as incentive for farmers ?
- Using a reduced dose in risk assessment for single case study: does not necessarily lead to an endpoint that is protective for all other fields **and local conditions** (max. dose related to pest pressure).

Idea for moving forward, case studies to verify lower dose = lower risk

- Exposure Assessment Goals: probabilistic approach based on data of pesticide use, or field specific ?
- Effect Assessment Goals: Tier-3 modelling of population recovery capacity
- Merge "Ecosystem services" concept with detailed spatio-temporal exposure ?
- Push slow regulatory acceptance with fast-tracking stakeholder integration

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Looking forward to discuss & hear from you

SETAC

SETAC EUROPE 33RD ANNUAL MEETING

30 APRIL - 4 MAY 2023 | DUBLIN, IRELAND + ONLINE

overarching theme of “Data-driven environmental decision-making”

Session: Wednesday, May 3rd

7.08- Precision Application – A Way to Reduce Environmental Risk?

CARROT treatment

Seed coating insecticide: oxamyl

Alternative: pirimicarb

Datum	Product	Dosis per hectare	l of kg	Actieve stof	
14/05/2013	Linurex 50 SC	0.35	l	linuron	H
14/05/2013	Actirob B	0.5	l	koolzaadolie	
27/05/2013	Linurex 50 SC	0.35	l	linuron	
27/05/2013	Actirob B	0.5	l	koolzaadolie	
14/06/2013	Sencor	0.1	kg	metribuzin	
14/06/2013	Defi	2	l	prosulfocarb	
27/06/2013	Sencor	0.1	l	metribuzin	
27/06/2013	Defi	2	l	prosulfocarb	
24/07/2013	Aramo	1.5	l	tepraloxydim	
23/07/2013	Nativo 75 WG	0.3	kg	tebuconazol + trifloxystrobin	F
23/07/2013	Trend 90	0.2		isodecyl-alcohol ethoxylaat	
	Xentari WG	1	kg	*Bacillus thuringiensis ssp. aizaw*	Low risk
08/08/2013	Epso Microtop	10	kg	meststof	F
14/08/2013	Ortiva Top	1	l	azoxystrobin + difenoconazool	
26/08/2013	Sencor	0.15	kg	metribuzin	H
26/08/2013	Defi	2	l	prosulfocarb	
26/08/2013	Linurex 50 SC	0.5	l	linuron	
04/09/2013	Horizon EW	1	l	tebuconazol	F
09/09/2013	Xentari WG	1	kg	*Bacillus thuringiensis ssp. aiza*	Low risk
09/09/2013	Epso Microtop	12	kg	meststof	
12/09/2013	Epso Microtop	12	kg	meststof	
24/09/2013	Xentari WG	1	kg	*Bacillus thuringiensis ssp. aizav*	Low risk
09/10/2013	Xentari WG	1	kg	*Bacillus thuringiensis ssp. aizav*	

* PPP scheme: Based on PCG report: RAP_OL13 WOVL01_JVS

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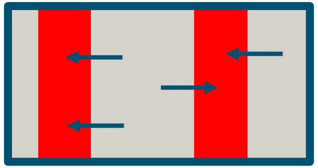
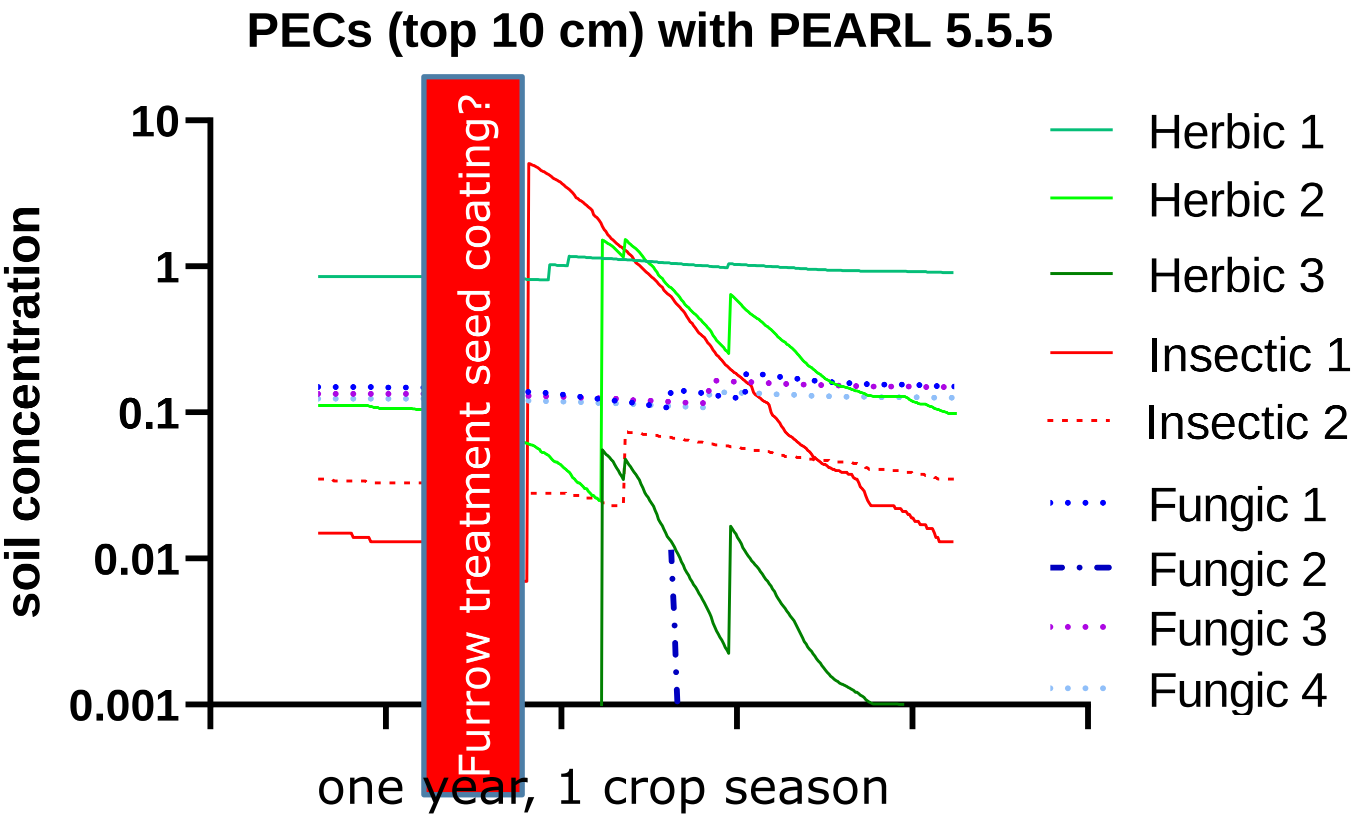
Case study in-field: risk to soil organisms



Example:
Crop: Carrot
Pest: Root-fly
a.s.: oxamyl coat

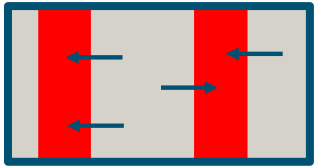
PPP scheme*
example adapted

PECs: FOCUS PEARL
Hamburg scenario



* PPP scheme: Based on PCG report: RAP_OL13 WOVL01_JVS

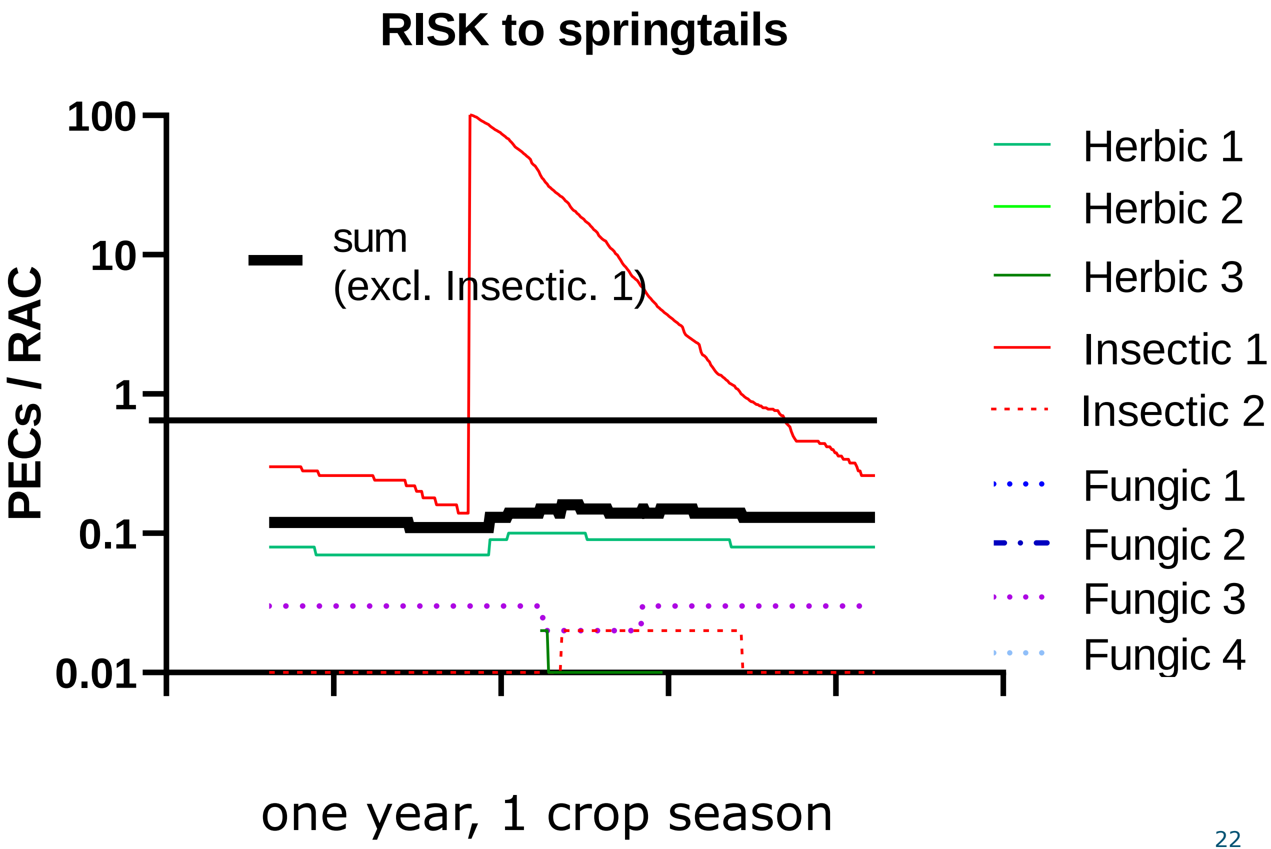
Case study: in-field recovery of soil organisms



NOEC(tier1)/5 = RAC

Acceptable risk if:
PECs/RAC < 1

Recovery springtails
via migration from
soil between furrows
is likely after ~6 months



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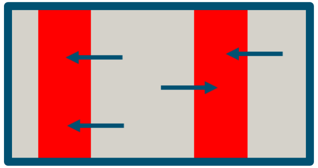
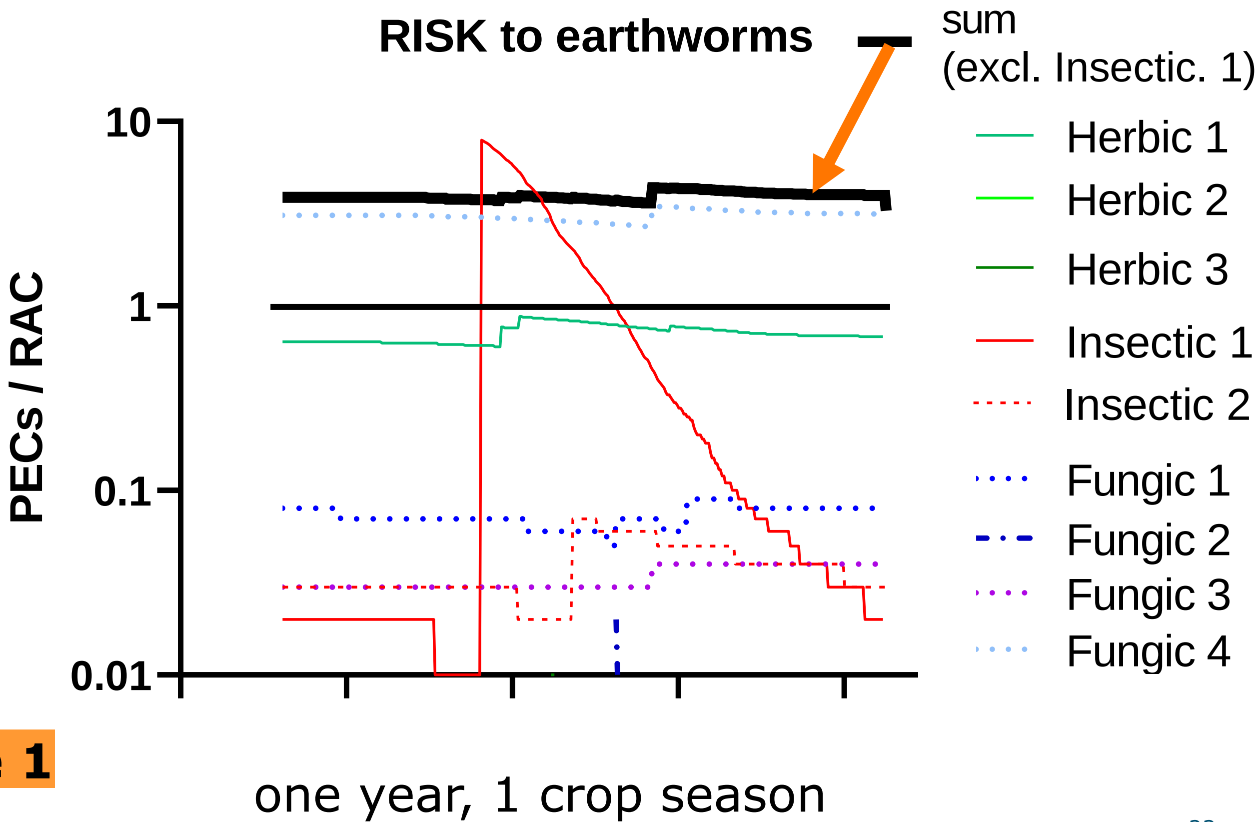


NOEC(tier1)/5 = RAC

Acceptable risk if:
PECs/RAC < 1

Recovery earthworms via migration from soil between furrows may be hampered by **fungicide 4 + herbicide 1**



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