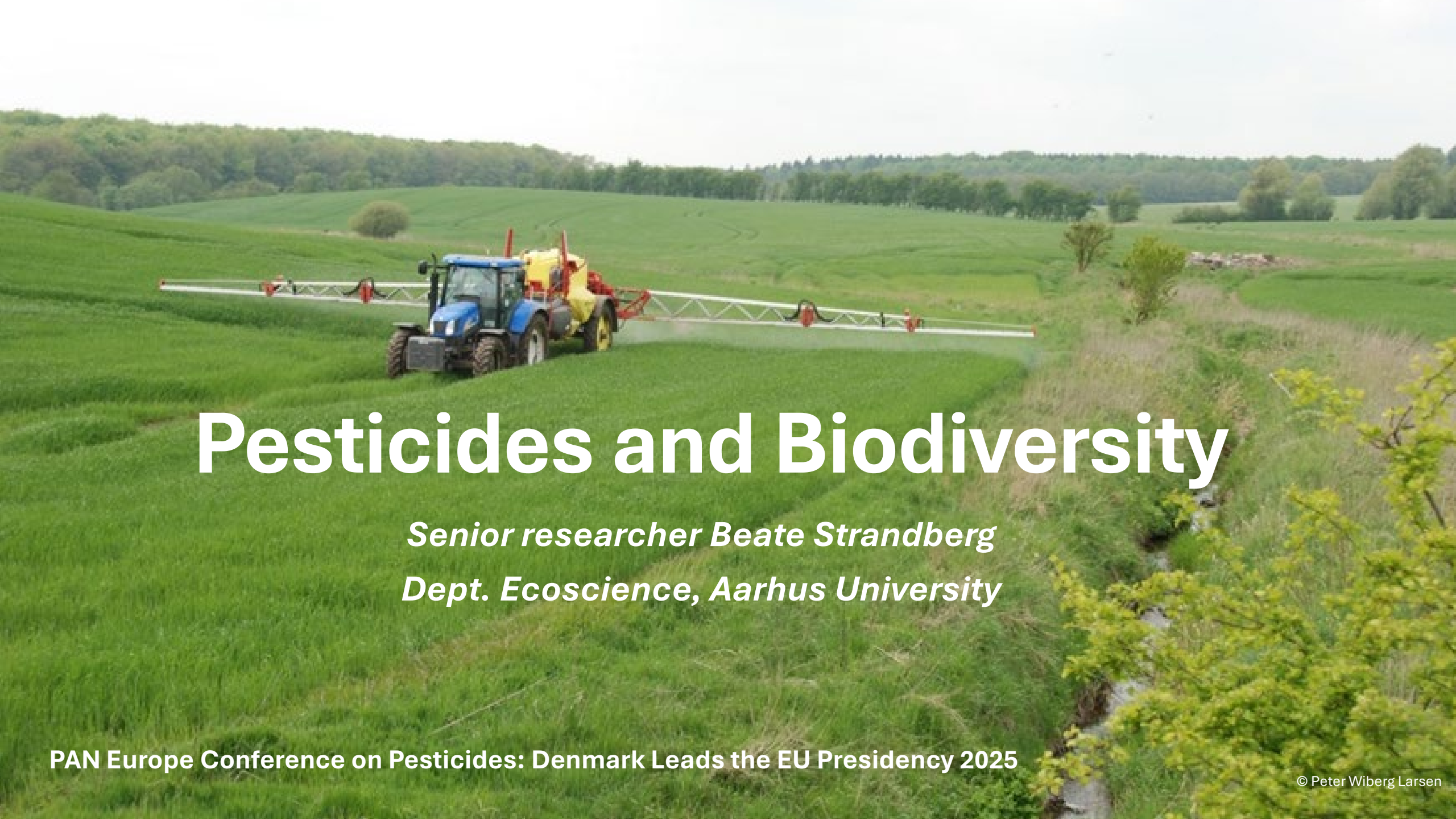


Pesticides and Biodiversity

Senior researcher Beate Strandberg

Dept. Ecoscience, Aarhus University

PAN Europe Conference on Pesticides: Denmark Leads the EU Presidency 2025

Pesticides are designed to kill
(PPP= plant protection products)

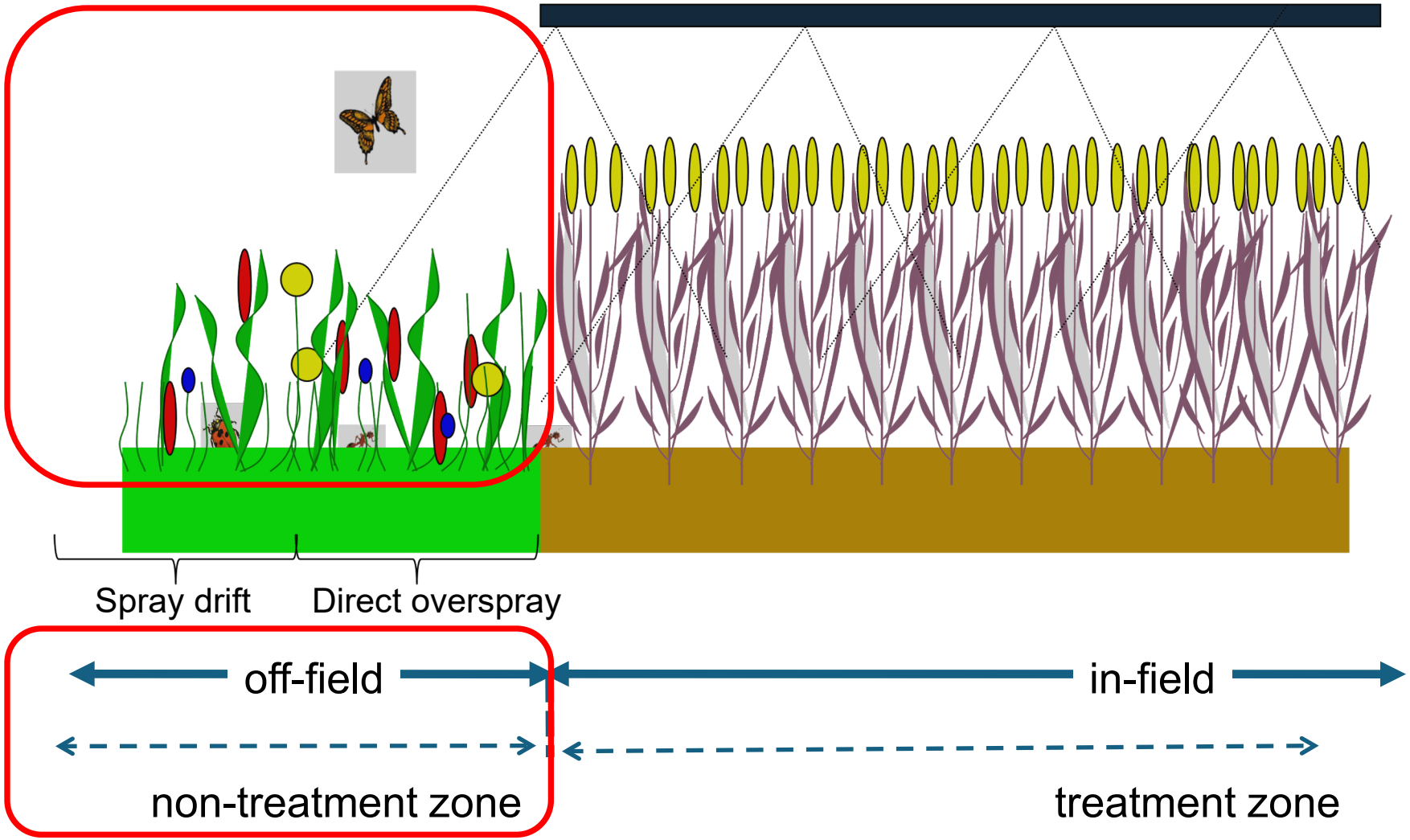
Target organisms

- Plants (Weeds)
- Insects (Pests)
- Fungi + Bacteria (Diseases)

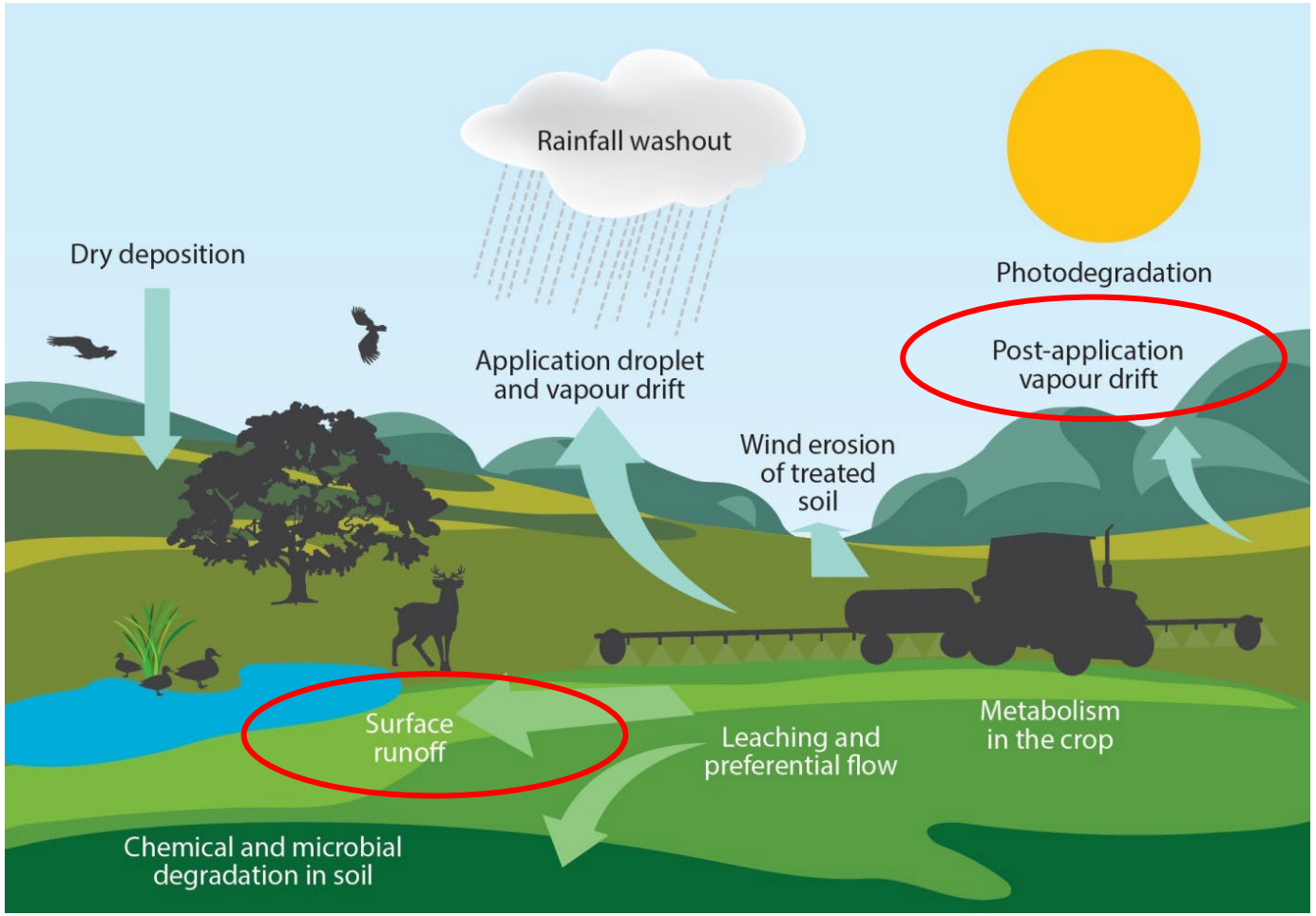
Non-target organisms

- Plants
- Insects
- Fungi + Bacteria

Defining non-target organisms



Pesticide movement to surroundings



Cessna et al. 2005

Pesticide concentrations reaching non-target organism

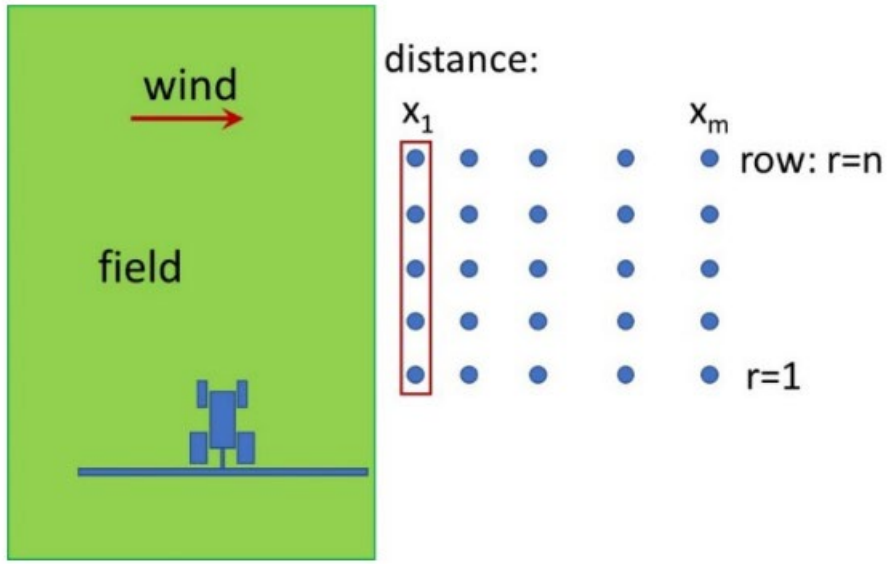
Estimated fractions of pesticide reaching off-field:

Generally, below 3-5 % (crops such as cereals, fruit trees, grapes), aerial application (20-60%)

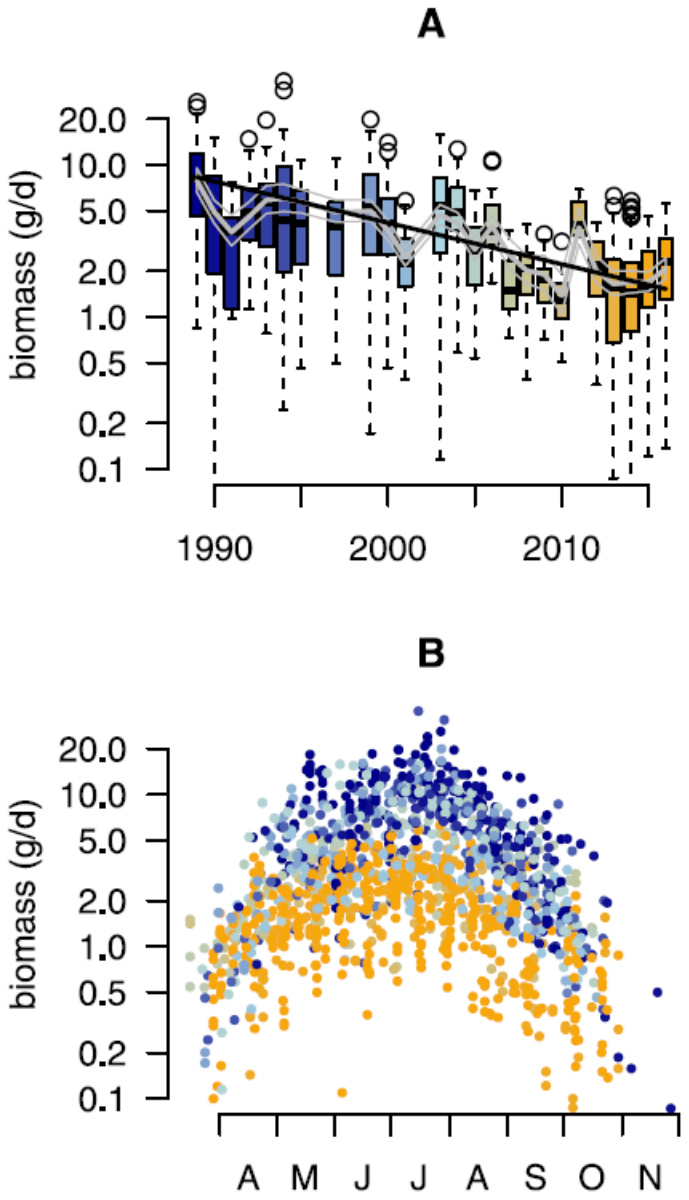
Zhang et al. 2024 Environmental Pollution 342 (2024) 123135

Models based on empirical data

Underestimation of spray drift experimental data in:
69 % Ganzelmeier-Rautmann (2000)
34 % Holterman et al. (2025, EFSA Journal)



More than 75% decline in biomass of flying insects at NATURA2000 sites



Hallmann et al. 2017.
PLoS ONE 12 (10): e0185809

Insect biomass decline predictive for decline in diversity

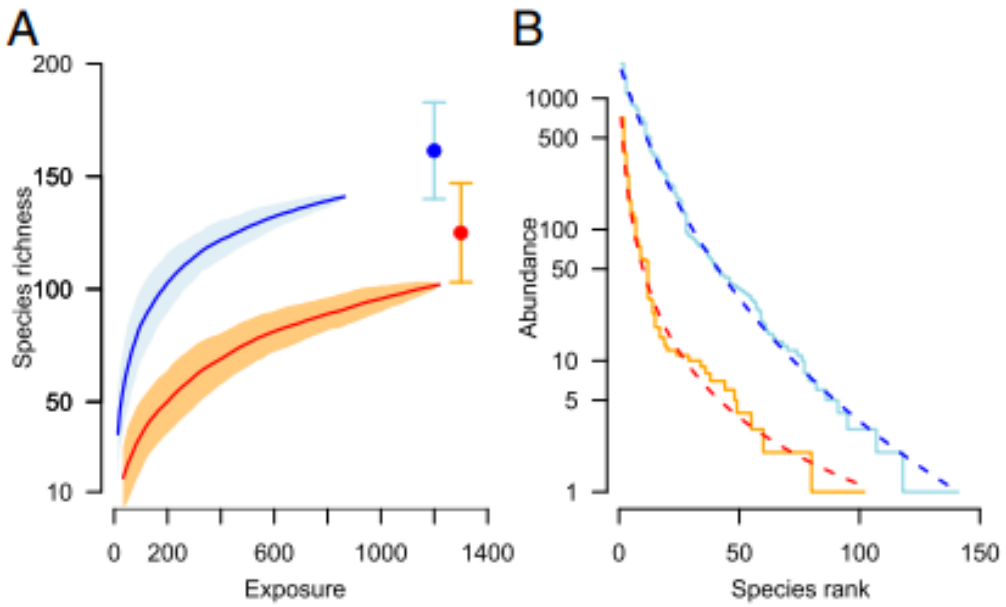
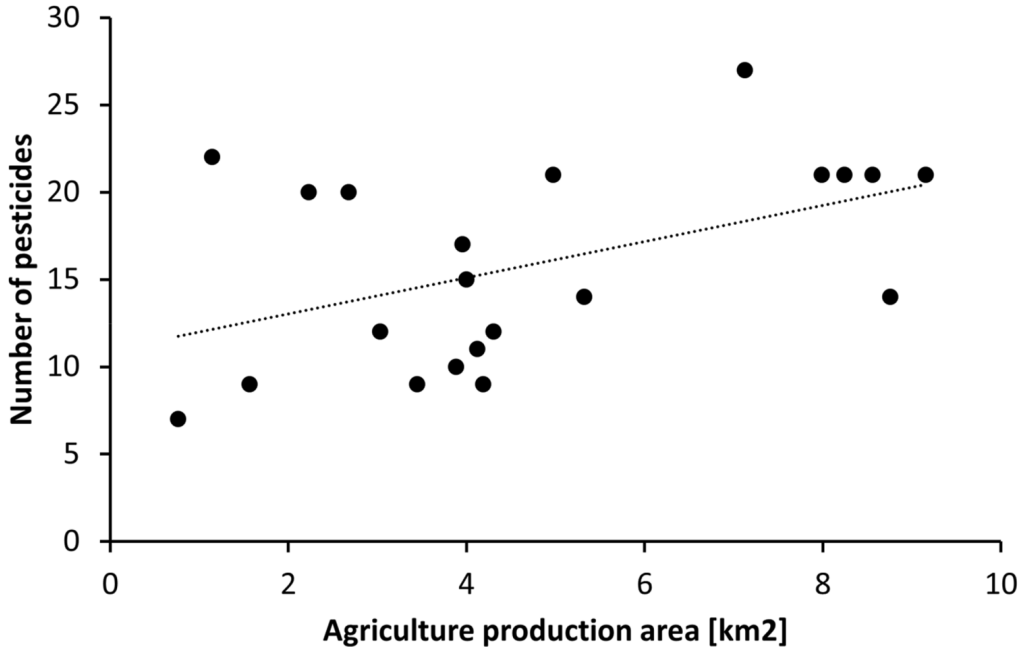


Fig. 2. Comparison of species richness and species relative abundance between 1989 (blue) and 2014 (red) based on six malaise traps in each year. (*A*) Species accumulation curves along with 95% intervals based on 100 random permutations of original data (data pooled within year), against cumulative exposure time (number of trap-sampling days). Points depict Chao's estimates of richness in each year along with 95% confidence intervals. (*B*) Rank abundance curves where solid lines depict data and dashed lines the fitted Zipf–Mandelbrot estimates.

Hallmann et al. 2021.
PNAS 2021 Vol. 118 No. 2 e2002554117

Direct pesticide exposure of insects collected in German NATURA2000 areas

- In Total 47 current use pesticides
- On average 16.7 pesticides/sample
- The number of pesticides correlates to the fraction of agriculture within 2000m to the center of the NATURA2000 area
- In spring (May) herbicides dominated, in summer (August) fungicides



Brühl et al. 2021 Nature (2021) 11:24144

Pesticides and degradation products in ambient air

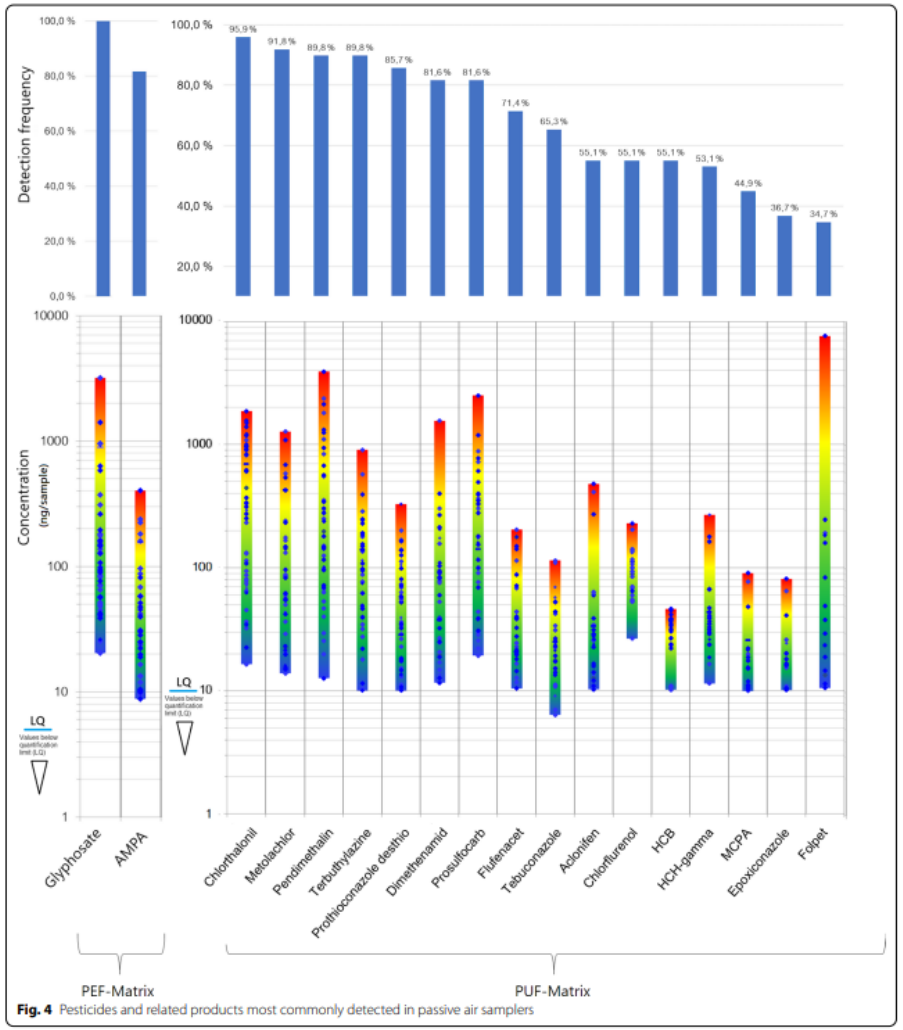


Fig. 4 Pesticides and related products most commonly detected in passive air samplers

Sampling included

- Nature reserves
- Organic fields
- Other off-field situations

Results relevant for

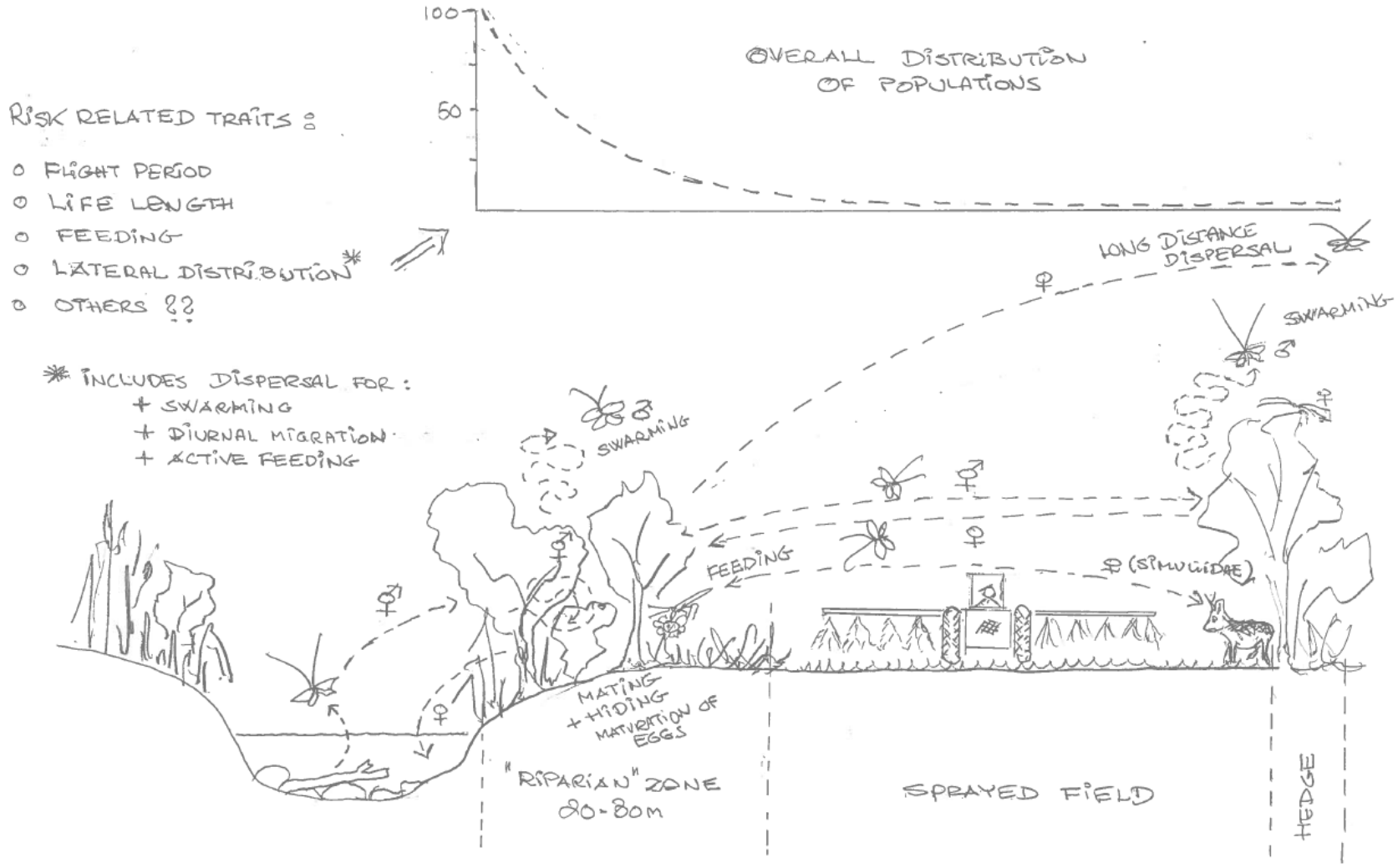
- Biodiversity
- Ecosystem services (e.g. pollination, natural pest management)
- Organic farming

Kruse-Plass et al. 2021 Environmental Science Europe 33:114

Effects of pesticide exposure on biodiversity

- Direct effects (lethal and sub-lethal concentrations)
- Indirect effects/food web effects (bioaccumulation)

Pesticide exposure of terrestrial stages of freshwater insects



© Peter Wiberg Larsen

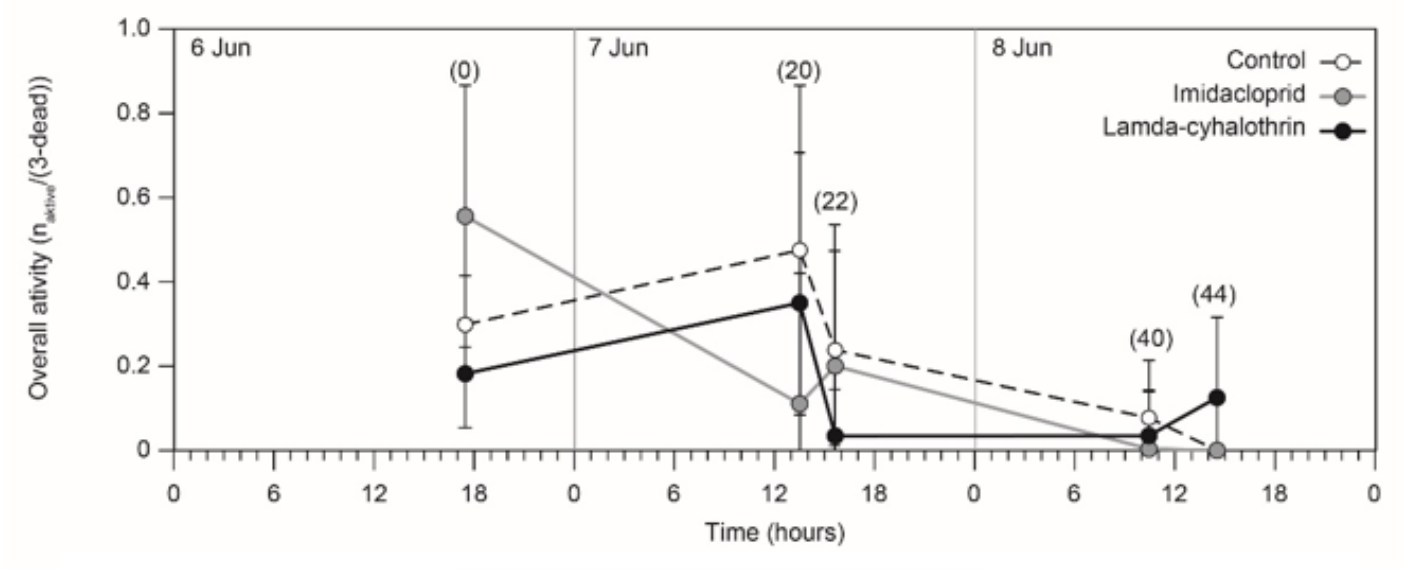
Direct effects (LD_{50}) of a neo-nicotinoid and a pyrethroid on stoneflies, a mayfly, caddisflies and honeybee

Species	Insecticide	Exposure time, h	LD_{50}, µg a.i. per individual [95 % CI]
E. danica	Imidacloprid	24	0.1 [0.08-0.3]
	Lambda-cyhalothrin	24	0.006 [0.002-0.02]
L. fusca	Imidacloprid	24	0.01 [0.003-0.1]
	Lambda-cyhalothrin	24	0.0001 [0.000002-(-0.0004)]
N. cinerea	Imidacloprid	24	0.001 [0.00003-(-0.004570)]
	Lambda-cyhalothrin	24	0.00003 [0.000003-0.00004]
A. ochripes	Imidacloprid	48	0.0062 [0.0057-0.0078]
	Lambda-cyhalothrin	48	0.000008 [0.000004-0.000010]
H. angustipennis	Imidacloprid	48	0.007 [0.006-0.01]
	Lambda-cyhalothrin	48	0.0004 [0.00006-0.003]
A. nervosa	Imidacloprid	48	0.002 [0.0002-0.03]
	Lambda-cyhalothrin	48	0.0002 [-0.00002-0.01]
*Apis mellifera**	Imidacloprid		0.081
	Lambda-cyhalothrin		0.038

Bruus et al. 2019

* https://sitem.herts.ac.uk/aeru/ppdb/en/Reports/415.htm

Effect of a neo-nicotinoid and a pyrethroid on caddisfly mating behaviour



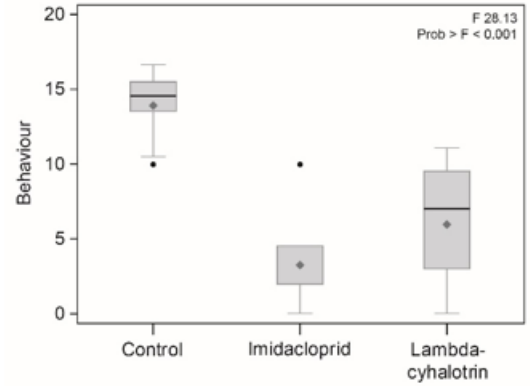
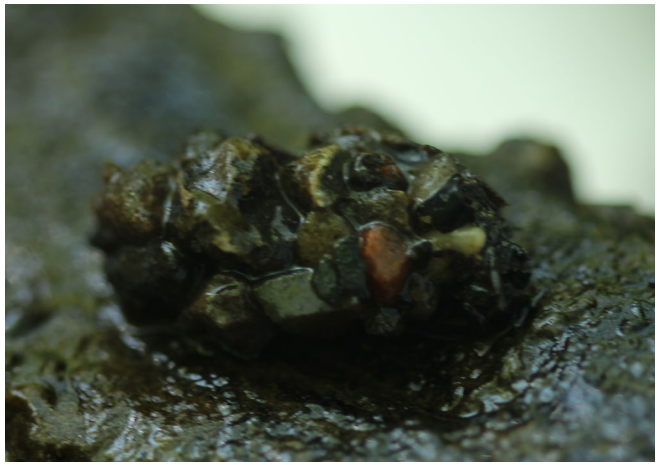


Figure 3. Overall behaviour (added) of adult terrestrial *A. ochripes* exposed to a sub-lethal concentration of imidacloprid (0.02 µg a.i. µL^{-1}), lambda-cyhalothrin (0.2 10^{-6} µg a.i. µL^{-1}) compared to control.

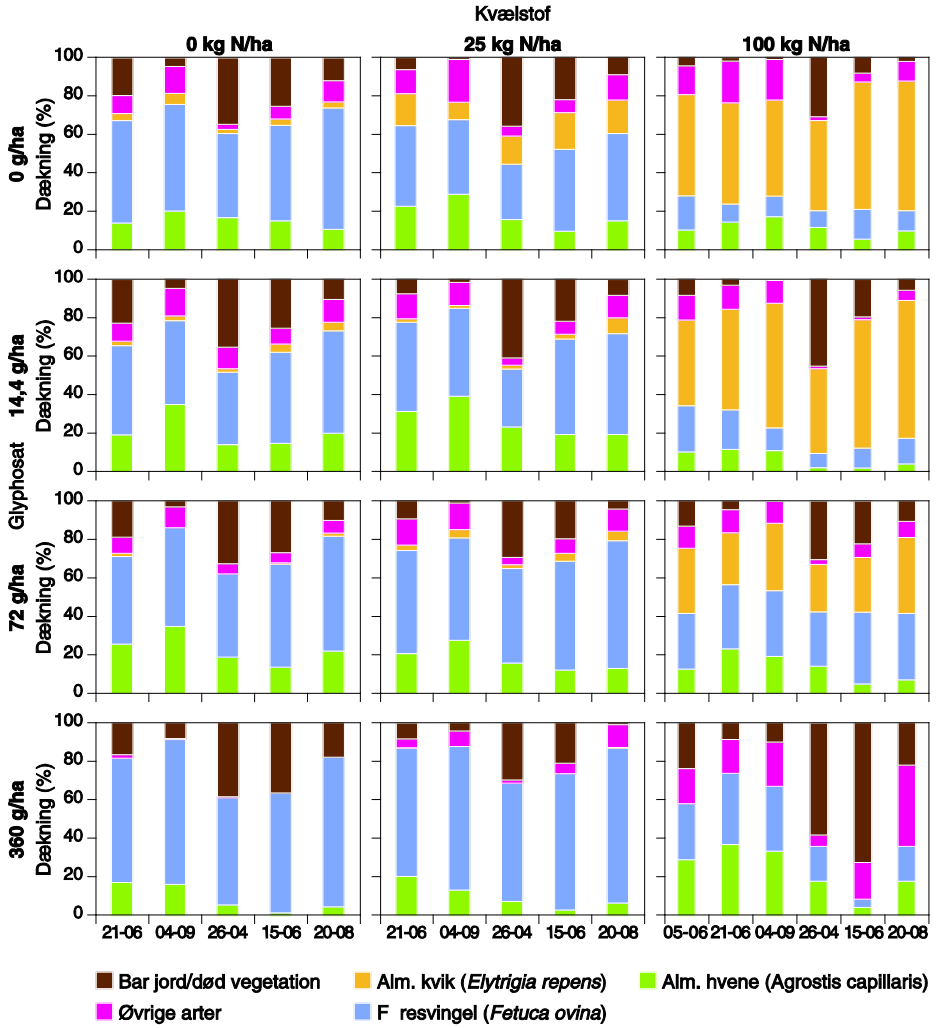
Agapetus ochripes



Strandberg et al. 2019

Combined effect of low doses of glyphosate and nitrogen on species composition

Aerial photo, May 2006



Strandberg et al. 2012

Effect of low doses of glyphosate on species composition

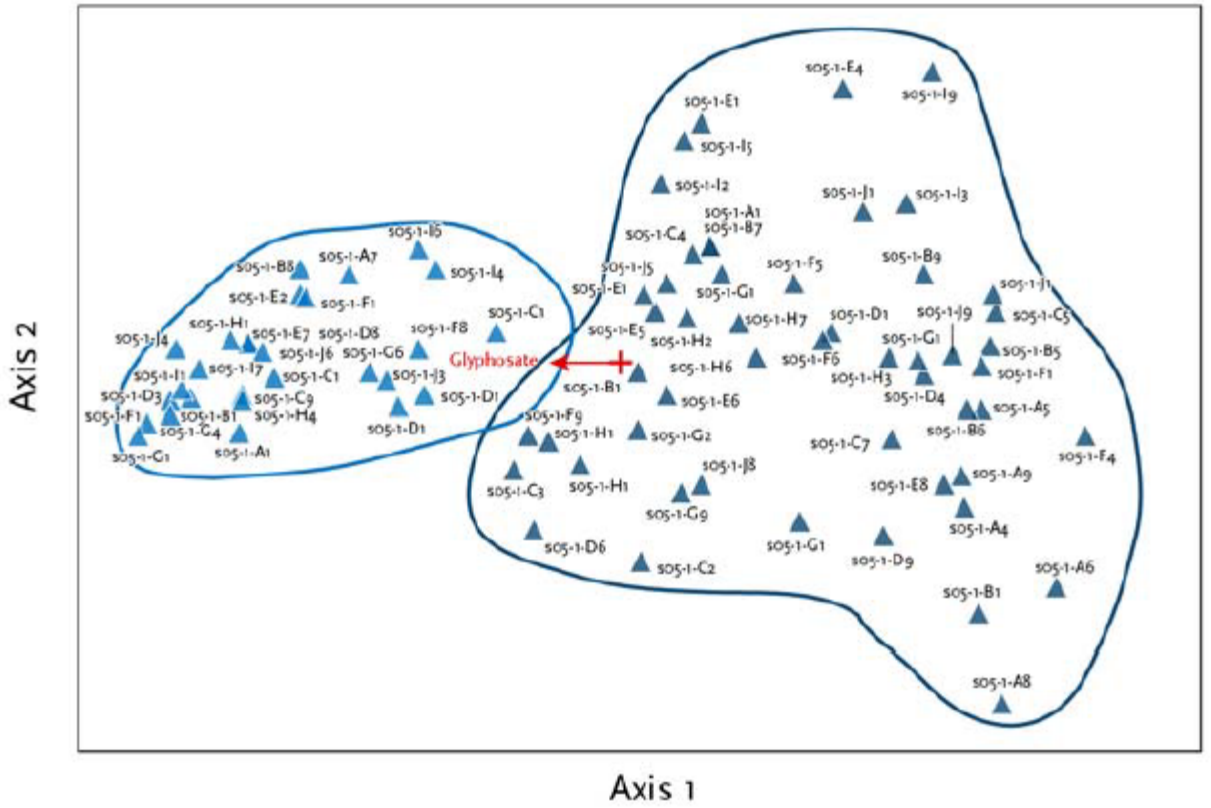
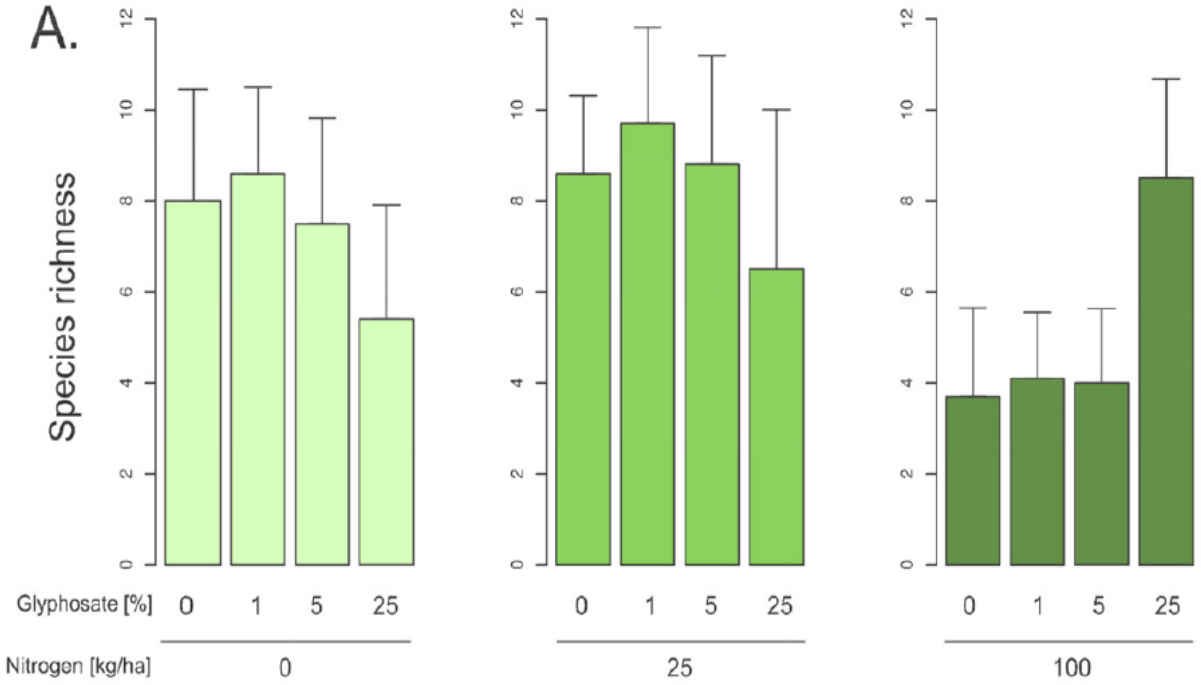


Figure 4.29. DCA ordination based on data on plant cover in June 2006.

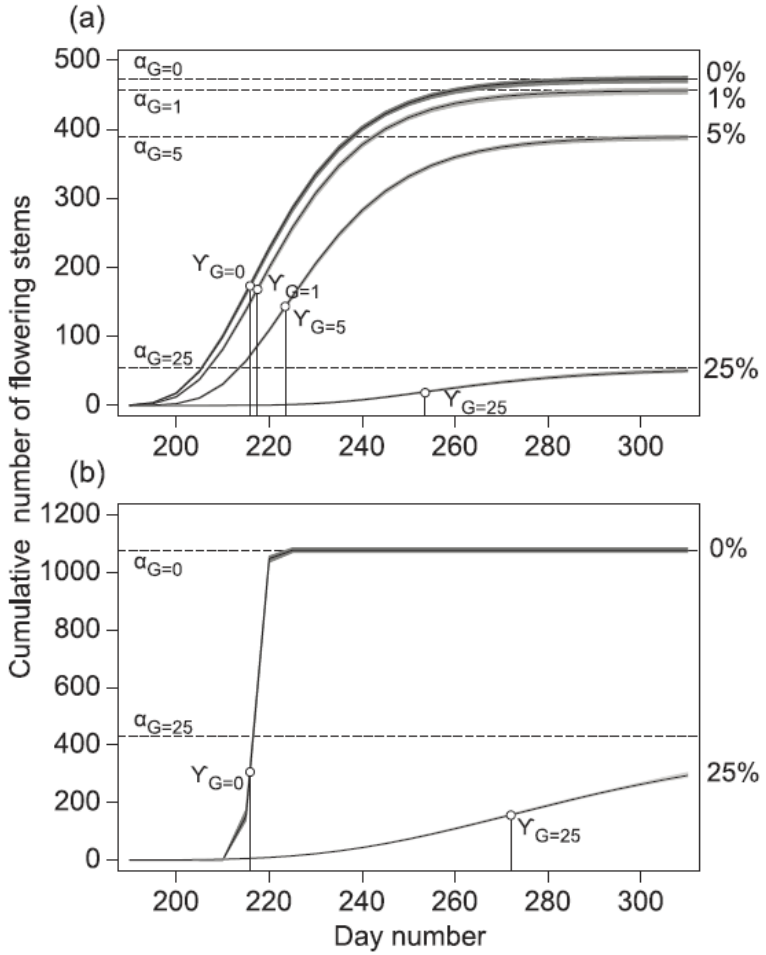
Strandberg et al. 2012

Combined effect of low doses of glyphosate and nitrogen on species composition



Loic et al. 2014

Pesticides affect plant flowering

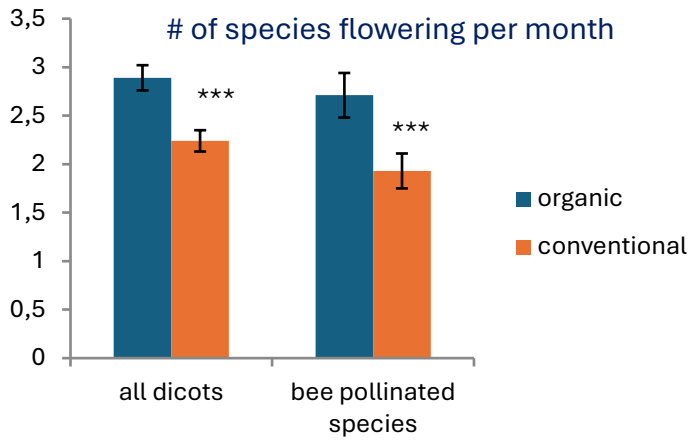


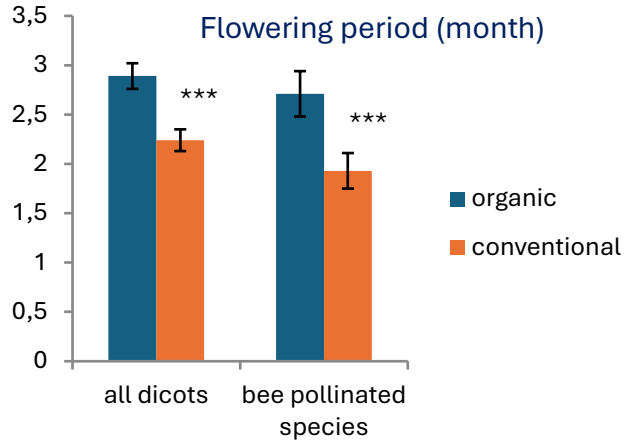
Herbicide (glyphosate) reduces the number of flowers

Herbicide (glyphosate) delays plant flowering

Dupont et al. 2018
AEE 262 (2018) 76–82

Herbicides affect plant flowering (organic and conventional hedgerows)



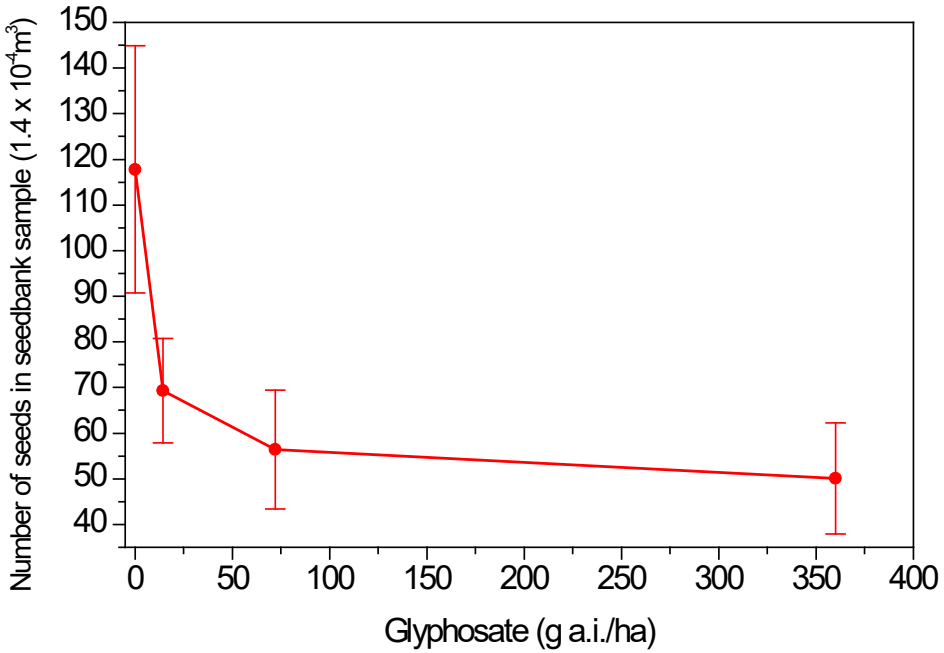


Without pesticide exposure (=organic farming)

- More species flower and at higher intensities (more flowers per plant
- Plant flowers earlier and for a longer period

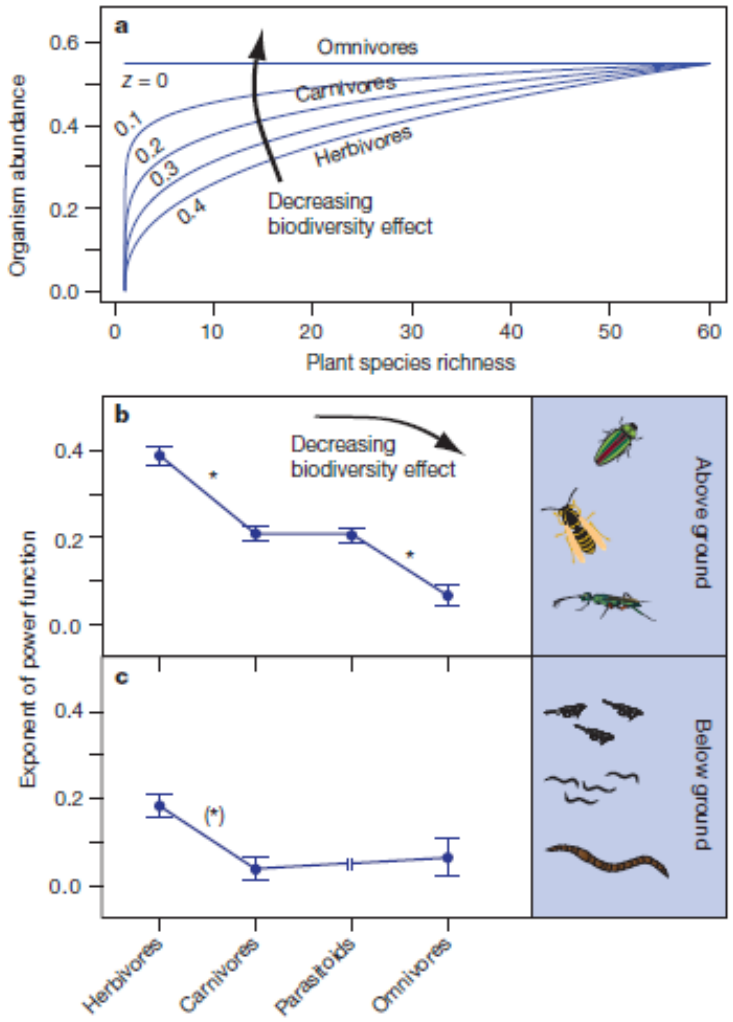
Boutin et al. 2014 Environmental Pollution 185 (2014) 295e306

Effects on soil seed bank



Strandberg et al. 2012

Indirect effects/food web effects



Scherber et al. 2010, Nature

Table 2
Effects of nitrogen, glyphosate and the interaction between nitrogen and glyphosate on reproductive endpoints and pollination interactions of *Tanacetum vulgare* (*** P > 0.0005, ** *P* > 0.005, * *P* > 0.05).

End point	Effect	df	*t*	*P*
Plant height	nitrogen	527	10.15 ***	0.00
	glyphosate	527	−17.66	0.00
	nitrogen*glyphosate	527	−1.94 n.s.	0.05
Diameter of capitula	nitrogen	237	1.96 n.s.	0.05
	glyphosate	237	0.11 n.s.	0.91
	nitrogen*glyphosate	237	0.15 n.s.	0.25
Visitation rate	nitrogen	48	1.98 n.s.	0.05
	glyphosate	48	−2.31*	0.03
	nitrogen*glyphosate	48	−0.37 n.s.	0.71
Visitor diversity	nitrogen	66	0.63 n.s.	0.53
	glyphosate	66	−8.96***	0.00
	nitrogen*glyphosate	66	1.25 n.s.	0.21
Weight per seed	nitrogen	113	0.77 n.s.	0.94
	glyphosate	113	−0.73 n.s.	0.46
	nitrogen*glyphosate	113	0.80 n.s.	0.43
Weight per seed head	nitrogen	223	2.55 *	0.01
	glyphosate	223	−2.41 *	0.02
	nitrogen*glyphosate	223	0.25 n.s.	0.8

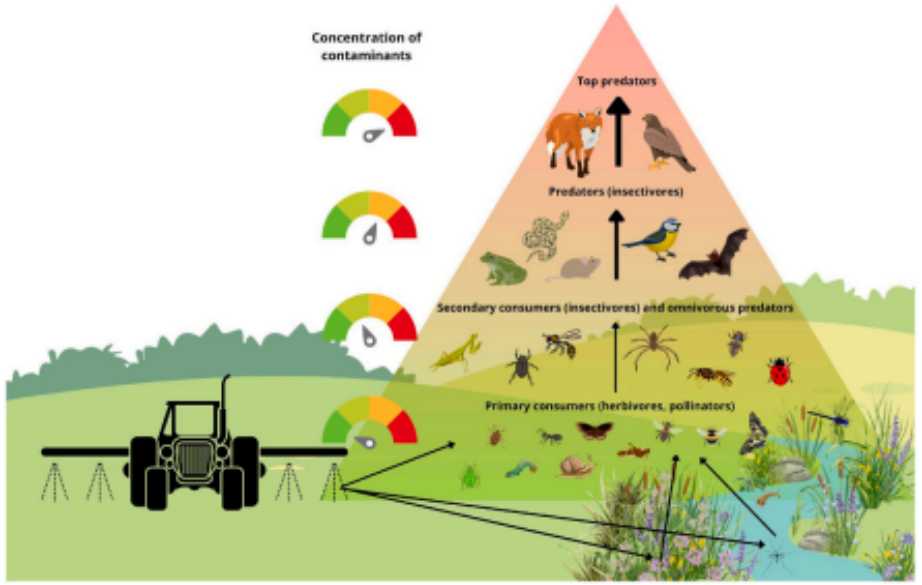
Dupont et al. 2018
AEE 262 (2018) 76–82

Indirect effects/food web effects
Bioaccumulation/biomagnification

HIGHLIGHTS

- Arthropods are important mediators of pesticide transfers in food webs.
- We review evidence of trophic transfers mediated by arthropods in terrestrial food webs.
- Sublethal doses are probably critical for biomagnification processes.
- The trophic structure and complexity of communities influence pesticide transfer.

GRAPHICAL ABSTRACT

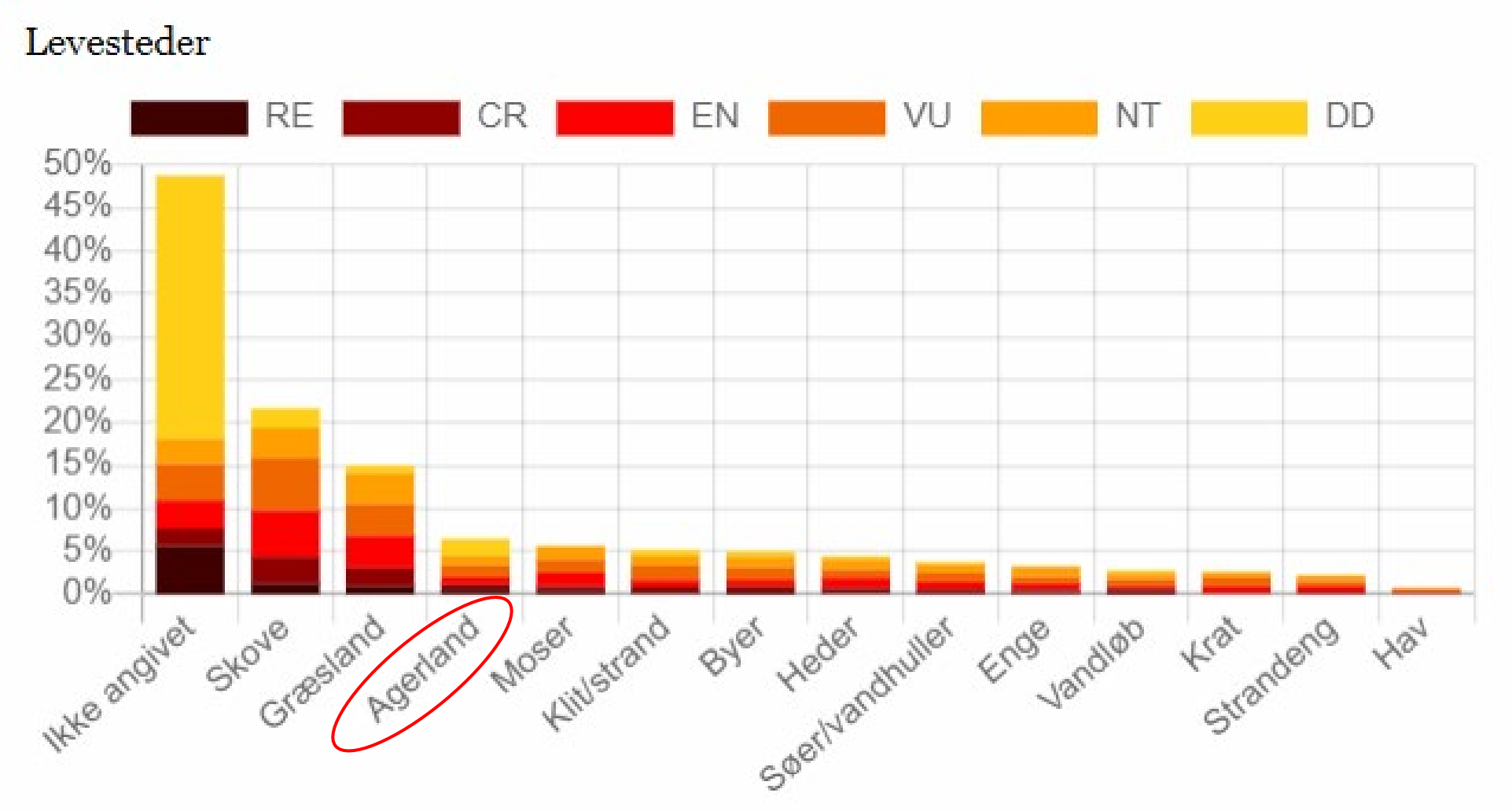


Tison et al. 2024. Chemosphere 357 (2024) 142036

Take-home messages

- Pesticides may have significant effects on non-target organisms
- Both lethal and sub-lethal concentrations impact non-target organisms
- Effects documented for different relevant endpoints (species richness, community composition, behaviour, reproduction) including food web effects
- Pesticides may affect ecosystem services (e.g. pollination, natural pest management)
- An underestimation of number of pesticides and concentrations reaching nature (protected areas) and other non-target areas (e.g. organic fields) may take place

Is it relevant for Red-listed and endanged species?



Moeslund, J.E. et al. 2023. The Danish Red list

Thank you for your attention

Special thanks to colleagues that been part of relevant projects
AU- Ecoscience: Marianne Bruus, Peter Borgen Sørensen, Christian Damgaard, Jes Rasmussen, Peter Wiberg-Larsen, Morten Strandberg
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