



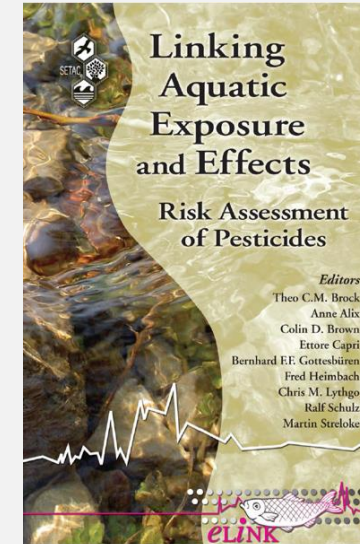
ELINK-2

Integrated exposure and effect modelling at different spatial scales

**Dirk Nickisch, Bas Buddendorf, Nika Galic, Bernhard Gottesbüren,
Judith Klein, Devdutt Kulkarni, Melissa Reed, Nicoleta Suci**

<https://elink2.info>

Objectives of the ELINK-1



- ELINK-1 took place in 2007
- Book “Linking Aquatic Exposure and Effects” was published in 2010
- The principal objective of the ELINK 1:
Bring together specialists in aquatic exposure and effects assessment, to improve guidance on linking exposure and effects in the aquatic risk assessment procedure for pesticides under the Plant Protection Products Directive 91/414/EEC
- Find a way forward in addressing the uncertainties posed by time variable exposures

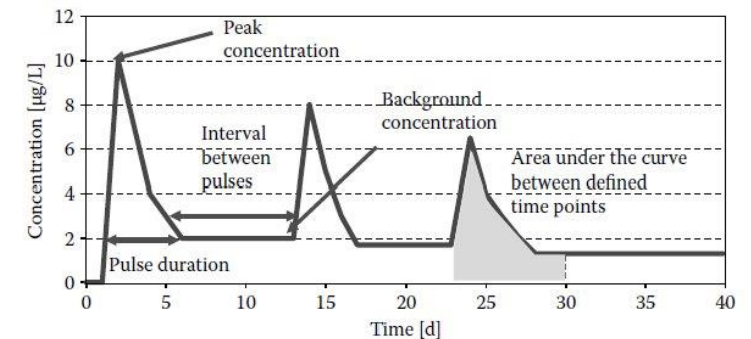


FIGURE 4.7 Key characteristics of the exposure profile that may inform the risk assessment.



Recommended approaches

- **Generalised exposure profiles and tiered exposure assessment**
- **Peak or TWA concentrations**
- **The Species Sensitivity Distribution (SSD) approach**
- Use of refined exposure single species and population studies
- **Toxicokinetic and toxicodynamic modelling**
- The model ecosystem approach
- Ecological models in pesticide risk assessment
- Ecological field data



- 9th EMW - European modelling workshop (2018): First presentations with topics linking exposure and effect modelling
- 10th EMW (2022) Resolutions¹: Establish a working group on linking exposure and effect modelling
- 11th EMW (2023):
 - Joint format with fate and effect modellers
 - Resolutions²: Mainly common topics that are linked are mentioned

1. http://www.igordubus.com/pfmodels/EMW10_resolutions.pdf
2. <https://esdac.jrc.ec.europa.eu/projects/pesticides-modelling>



12th EMW (2025) Resolution:

4. Conceptual Coupling of Exposure and Effect Models

The goal is to promote the conceptual coupling of exposure and effect models to model environmental systems holistically, reducing hidden complexity.

- Action 1: Refined Discussion Focus (ELINK2): The ELINK2 discussion should define the required "exposure metrics" or "exposure variables" (not just models) needed for effect modeling, covering both local and landscape-level effects.
- Action2: The participants of the ELINK2 workshop shall discuss which exposure models are needed for effect modelling and develop tangible case studies in which full exposure profiles are used to simulate the effects on species.

ELINK-2

Why a second WS?

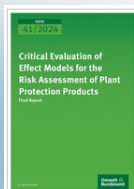
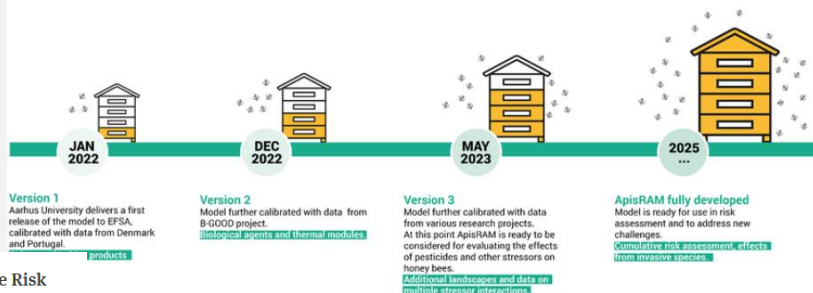


BeeGUTS–A Toxicokinetic–Toxicodynamic Model for the Interpretation and Integration of Acute and Chronic Honey Bee Tests

European Precision Application Task Force (EUPAF)

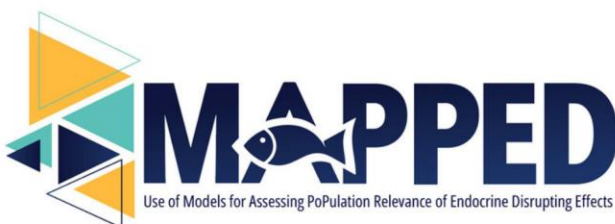


Development of the ApisRAM model for risk assessment of honey bees



Chemicals, Soil, Land, Agriculture Critical Evaluation of Effect Models for the Risk Assessment of Plant Protection Products

Mechanistic effect models (MEM) have become increasingly popular in the field of environmental risk assessment (ER) remains numerous open questions public. This report provides a scientific critical assessment of their relevance for studies. Finally, the report offers suggestions for development for implementation in industries, consultancies, academia. Sept 2019, Berlin; the presentation



In press



EESE – EU Environmental scenarios for ERA of non-target organisms

cvasi package 1.0.0

Calibration, Validation, and Simulation of TKTD Models

SolBeePop: A model of solitary bee populations in agricultural landscapes

EFSA peer review group

APODEMUS, a Population Model for the Wood Mouse: Transparent Conceptual Model Development with Stakeholder Involvement

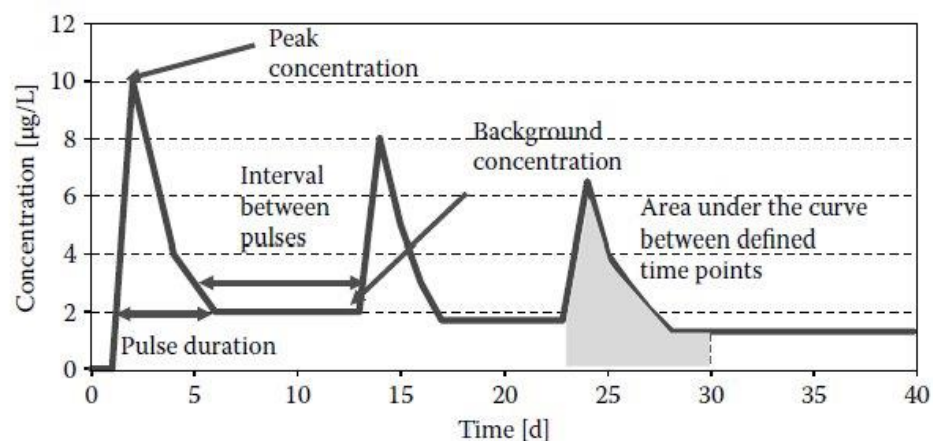


DEB-TKTD EP_x Predictor

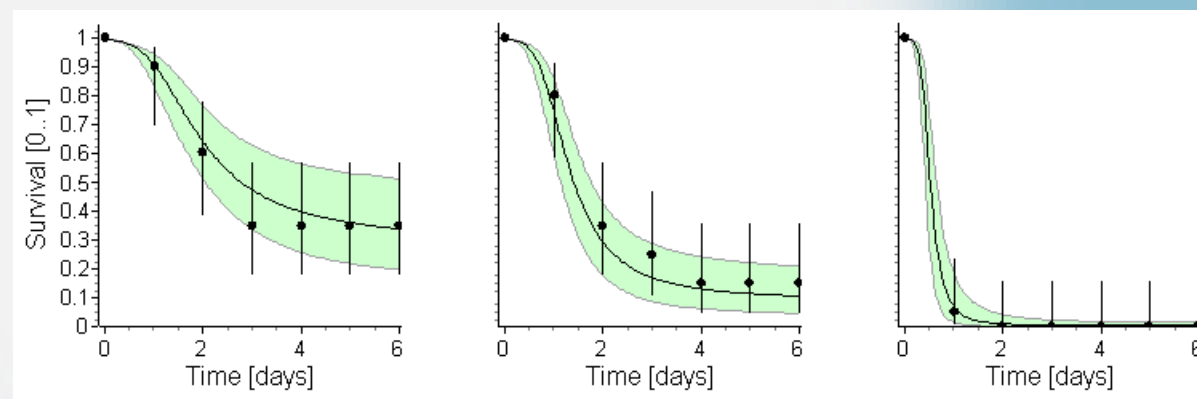


Challenges in linking models

- Conservative assumptions are used for the exposure
- One scenario representing a European area, PEC is calculated with mean values for pesticide behaviour, without uncertainties but for realistic worst-case scenarios
- Uncertainties and probabilistic are one of the main discussion topics in the ecotoxicological RA



ELINK book (2010)



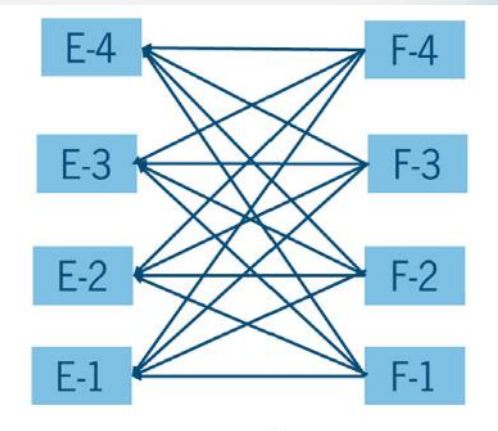
<https://openguts.info/>

Challenges in linking models



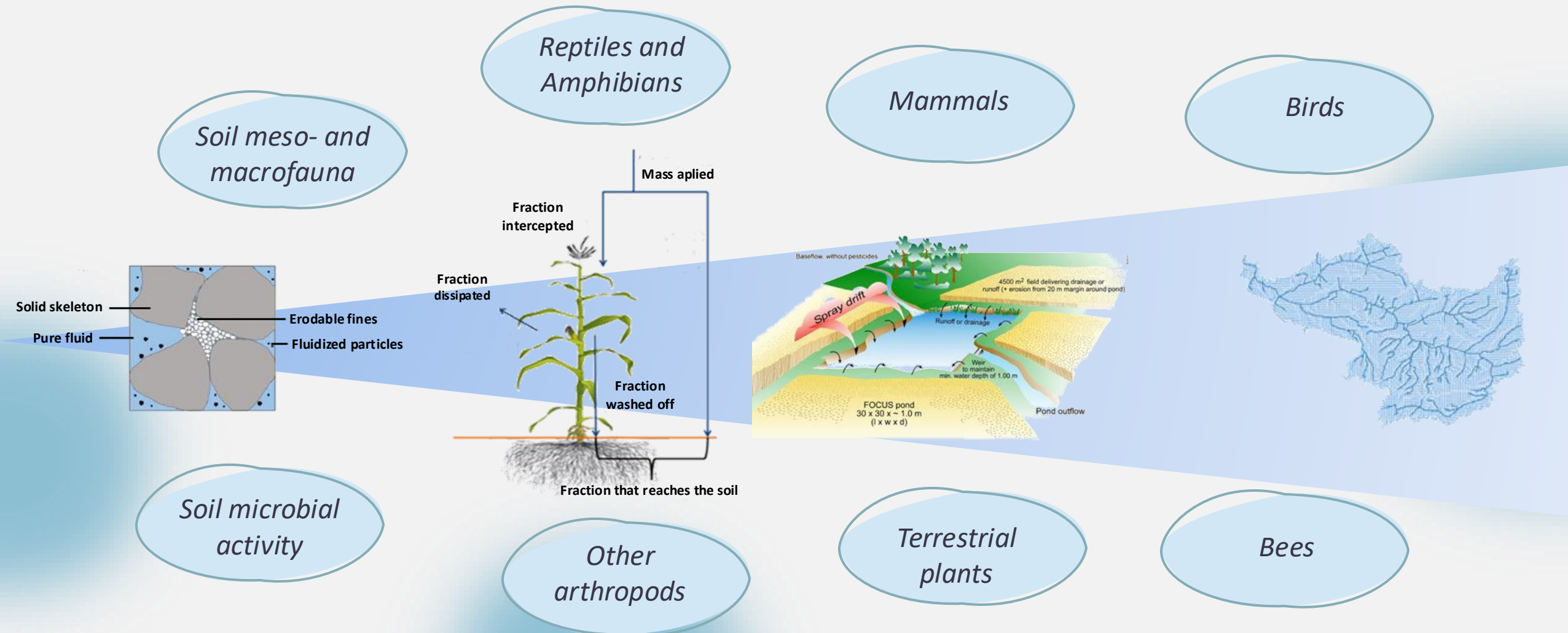
- From lower to higher tier means from simple to more complex, from high abstraction to more realism
- Can we really combine all the tiers and the different assumptions?
- Example:
 - Pearl was designed 30 years ago for the calculation of concentrations in soil and in groundwater in 1 m depth.
 - Can such a model be used to estimate the exposure of a substance on the soil surface as a proxy for exposure to the sensitive skin of an amphibian moving across the soil?

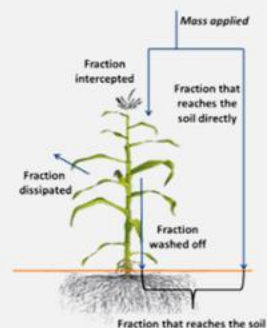
Criss cross approach



Amphibians and reptiles opinion (EFSA 2017)

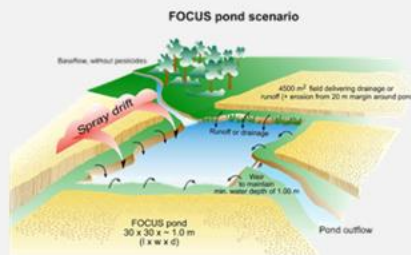
Challenges in linking models





EL-SA

Plant scale:
modelling at the interface plant and
soil



EL-ME

Medium/field scale:
modelling at edge-of-field and field



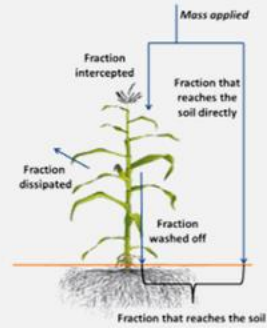
EL-LA-Terra

Landscape scale:
landscape modelling related to
terrestrial non-target organisms



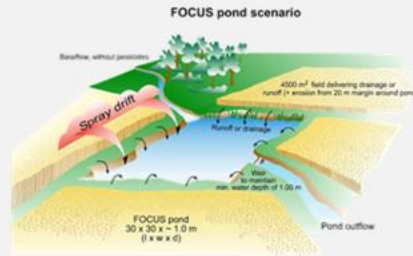
EL-LA-Aqua

Catchment scale:
landscape modelling related to
aquatic non-target organisms



EL-SA

Plant scale:
modelling at the interface plant and
soil



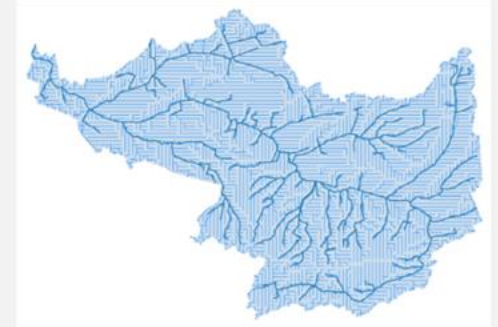
EL-ME

Medium/field scale:
modelling at edge-of-field and field



EL-LA-Terra

Landscape scale:
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EL-LA-Aqua

Catchment scale:
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EL-Data

Generic methodology of spatial
data



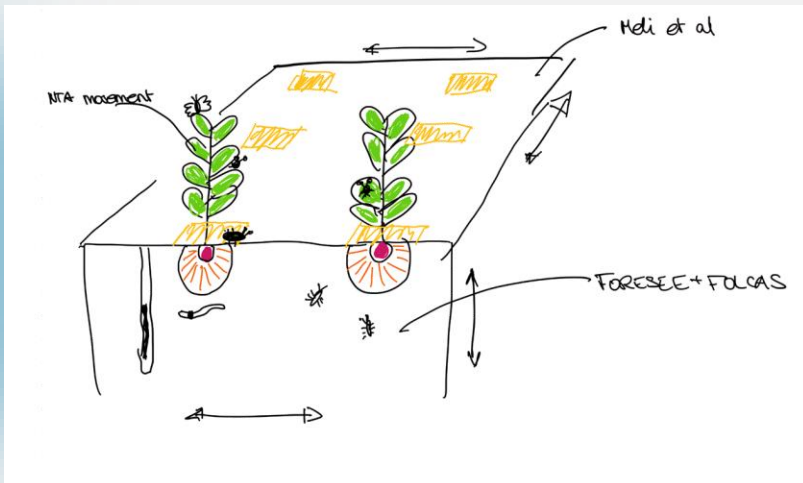
ELINK-2 Case studies



EL-SA

Potential case study

- NTA movement on plants
- Collembola
 - Vertical movement
 - Horizontal movement



Roeben, V. (ELINK2, March 2026)

EL-ME

Potential case study concepts

- Homogeneous exposure, no consideration of ecology
- Homogeneous exposure, consideration of ecology (e.g. movement)
- Heterogeneous exposure, no consideration of ecology
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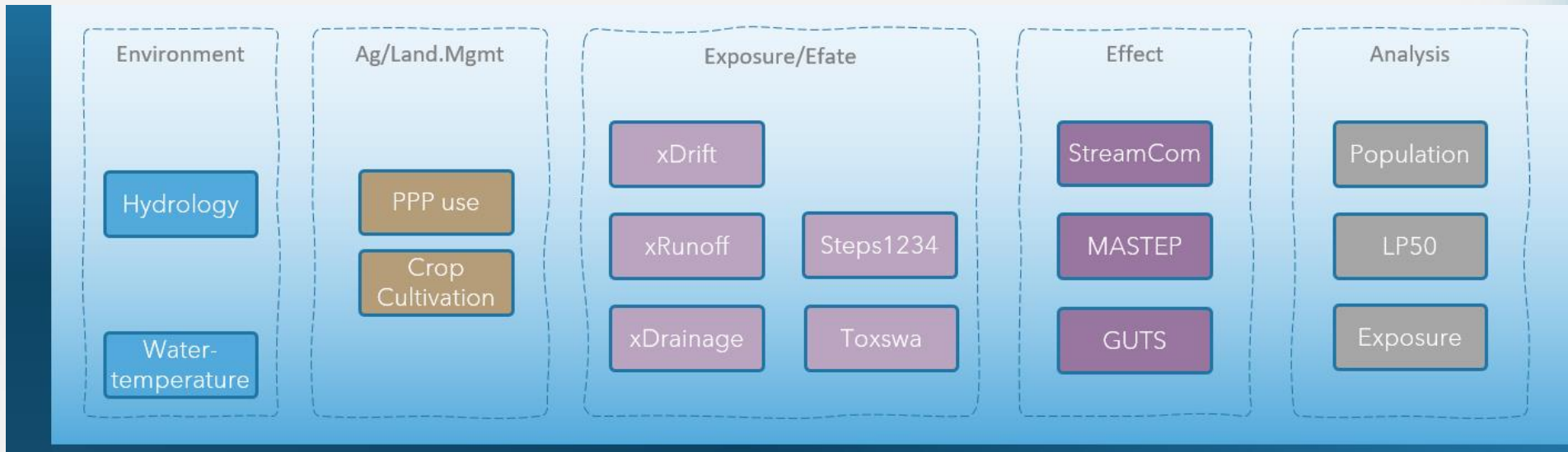


Schäfer, D. (ELINK2, March 2026)

ELINK-2 Case studies



- Landscape working groups are working in the **xLandscape** environment
- **xLandscape** is a modular framework for building landscape models
- With a modular design based on Component-Based Software Engineering (CBSE), xLandscape integrates various components to create flexible, open-source models for diverse applications

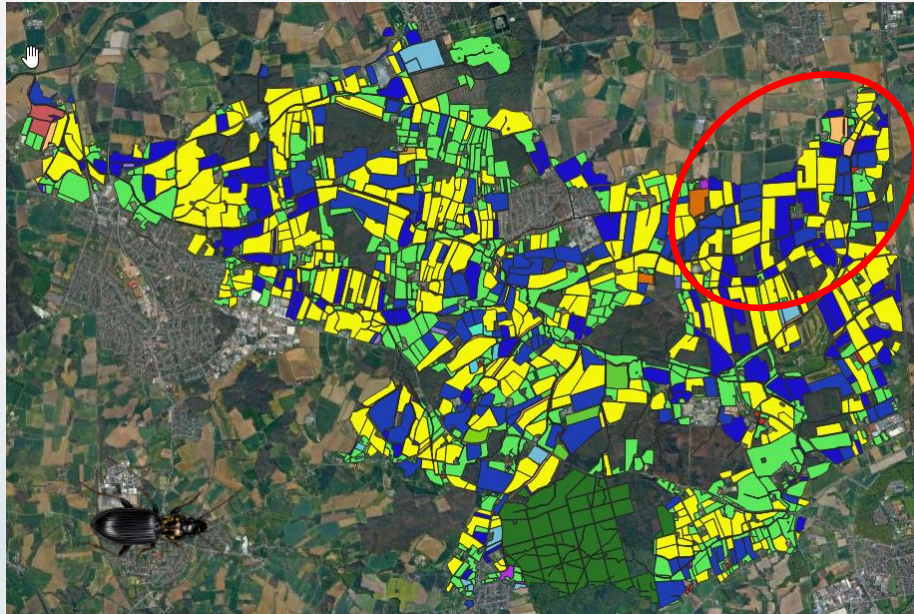


<https://github.com/xlandscape>

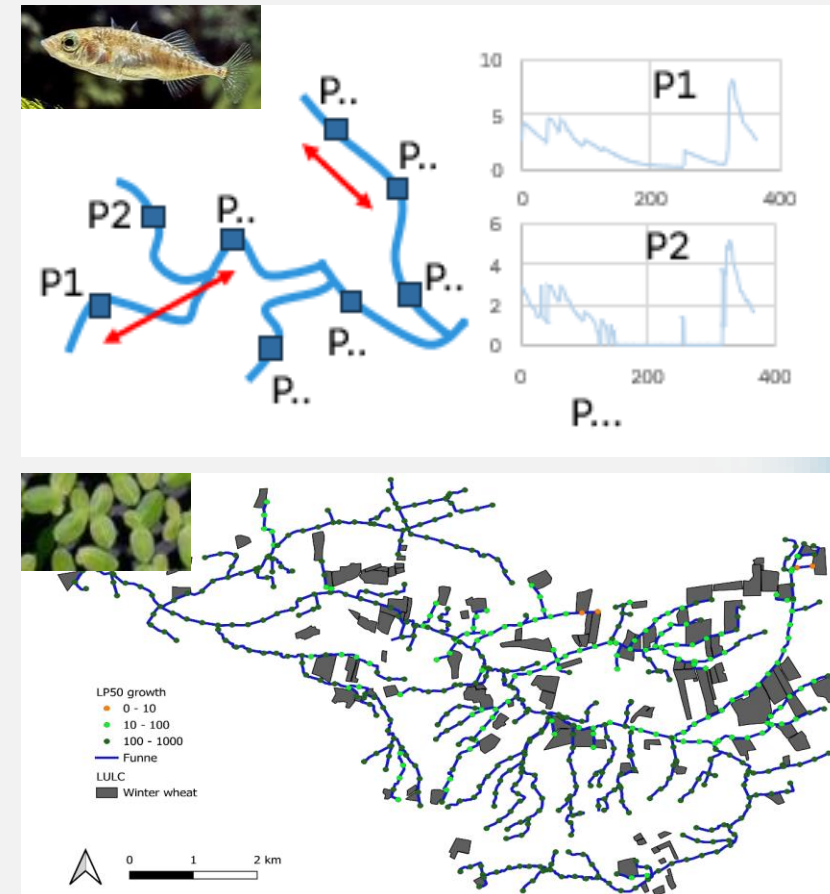
ELINK-2 Case studies



EL-LA_Terra



EL-LA_Aqua



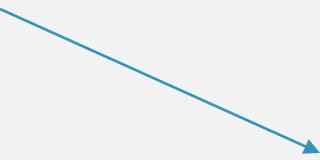
Multsch et al. (XVII Symposium on Pesticide Chemistry, 2024)

ELINK-2 Key questions



Working groups are working on **five key questions** which were defined by the steering committee:

- 1) Spatially explicit vs implicit
- 2) Integration and Feedback
- 3) Extrapolation and Aggregation
- 4) Uncertainty
- 5) Tools and data gaps

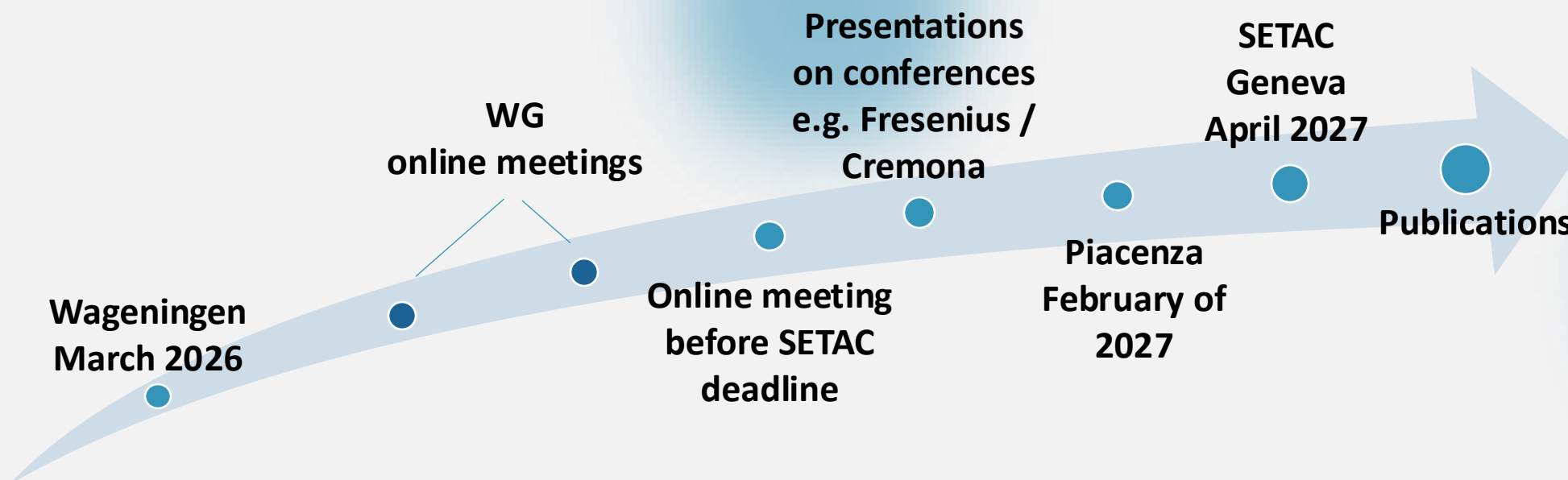


Under what specific conditions, considering factors such as spatial heterogeneity, organism movement across diverse scales (e.g., vertical migration, foraging ranges), and non-uniform exposure patterns (e.g., from a.o. precision agriculture), does the accurate capture of relevant exposure pathways and ecological processes *necessitate* spatially explicit modeling? Conversely, when can spatially implicit modeling be deemed *sufficient* for regulatory purposes, effectively balancing ecological realism with practical utility and data requirements?



ELINK-2

Timeline

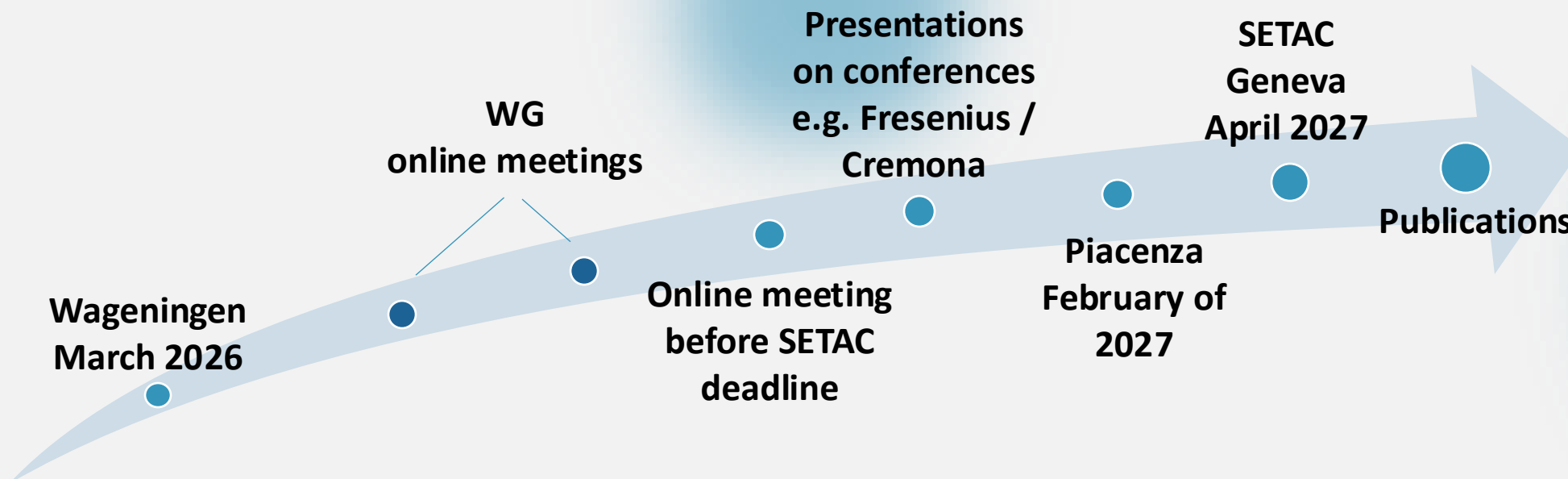


<https://elink2.info>



ELINK-2

Timeline



<https://elink2.info>

**Thank you for
your attention!**



Appendix

Key Questions

Spatially explicit vs implicit:

Under what specific conditions, considering factors such as spatial heterogeneity, organism movement across diverse scales (e.g., vertical migration, foraging ranges), and non-uniform exposure patterns (e.g., from a.o. precision agriculture), does the accurate capture of relevant exposure pathways and ecological processes *necessitate* spatially explicit modeling? Conversely, when can spatially implicit modeling be deemed *sufficient* for regulatory purposes, effectively balancing ecological realism with practical utility and data requirements?

Key Questions

Integration and Feedback:

How can regulatory risk assessment effectively transition from traditional sequential exposure and effect models to truly integrated frameworks? This includes addressing the benefits and challenges of direct model linkages, harmonizing disparate scales (e.g., TKTD vs. landscape model resolution), and incorporating feedback mechanisms where ecological effects can dynamically alter subsequent exposure patterns.

Key Questions

Extrapolation and Aggregation:

What robust and scientifically defensible rules are essential for extrapolating ecological processes observed at fine scales (e.g. individual organism behavior, microhabitat interactions, abiotic conditions) to broader scales? When aggregating responses, which fine-scale details are most critical and must be retained, and which can be simplified or omitted without compromising the accuracy and regulatory relevance of the assessment, thereby balancing ecological realism with practical utility?

Key Questions

Uncertainty:

Given the inherent complexity and increased data demands of spatially explicit modeling, how can we effectively identify, quantify, and transparently communicate the various sources of uncertainty (e.g., model parameters, input data quality, spatial process representation) to ensure robust, reliable, and defensible environmental risk assessments that meet regulatory standards?

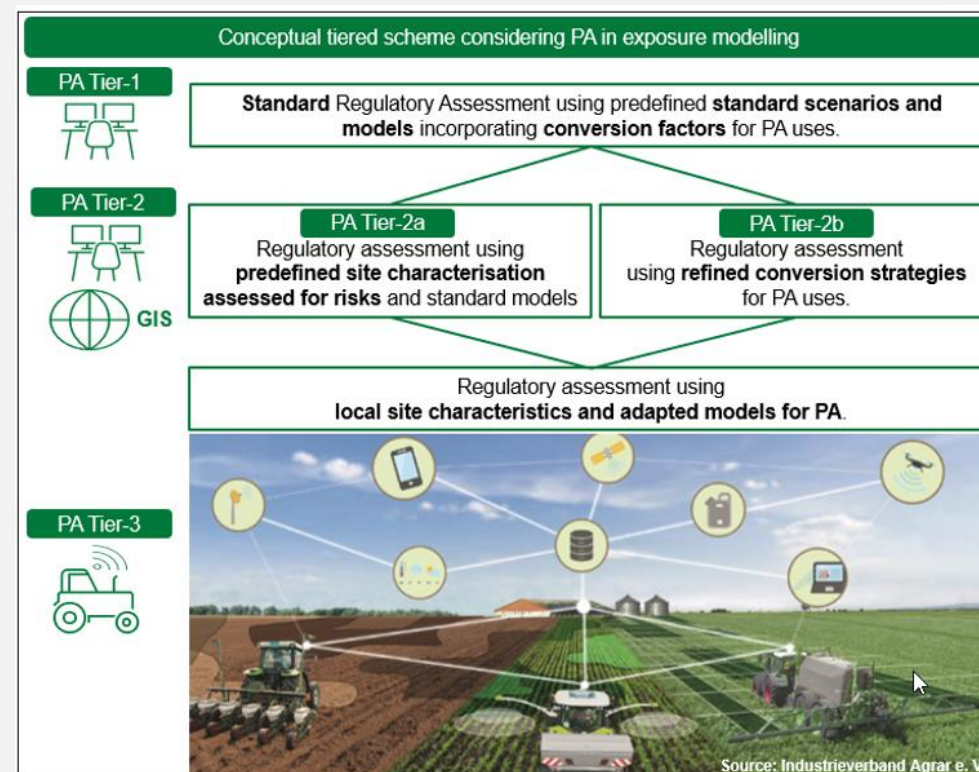
Key Questions

Tools and data gaps: What specific geo- and ecological data, with a particular focus on species movements and habitat use, are critically required for the regulatory application of exposure and effects models designed to capture processes at spatially relevant scales? Furthermore, what are the key gaps in the current modeling toolbox and available data that need to be addressed to inform and prioritize future developmental activities?



Challenges in ERA: future proof

- New methods could affect other assessments
 - Precision application methods
 - Could reduce exposure
 - Could change the effect assessment (movement of individuals)
 - Could increase residues
- How to include advances in modeling and technology in the registration process?



EUPAF 2025:

https://www.bvl.bund.de/DE/Arbeitsbereiche/04_Pflanzenschutzmittel/01_Aufgaben/02_ZulassungPSM/05_psm_EUPAF/psm_EUPAF_node.html