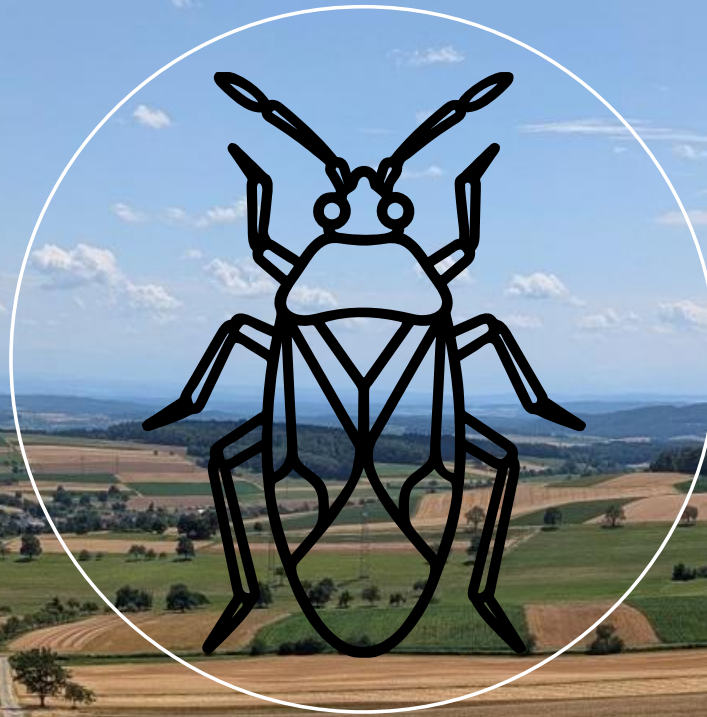




Developing a DEB-IBM for a terrestrial arthropod

How can we bridge the gap between fate modelling concentrations and effect models?

03.09.2026 | S2O16 | Leonhard U. Bürger, Dana Bashkir, Annika Mangold-Döring, Bas Buddendorf

What is the effect of a pesticide on a landscape scale?

Which species?

Which pesticide?

...



Which landscape?

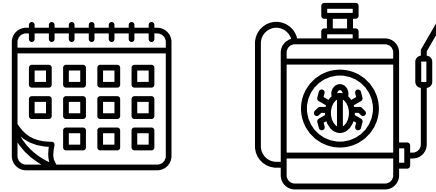
Terrestrial or aquatic?



General idea

Pesticide fate modelling concentrations

- Where?
- When?
- How much?



Effect quantification

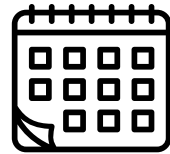
- Lab experiments
- Standard species
- Comparison with fate concentrations
- Safety factors
- ...



General idea

Pesticide fate modelling concentrations

- Where?
- When?
- How much?

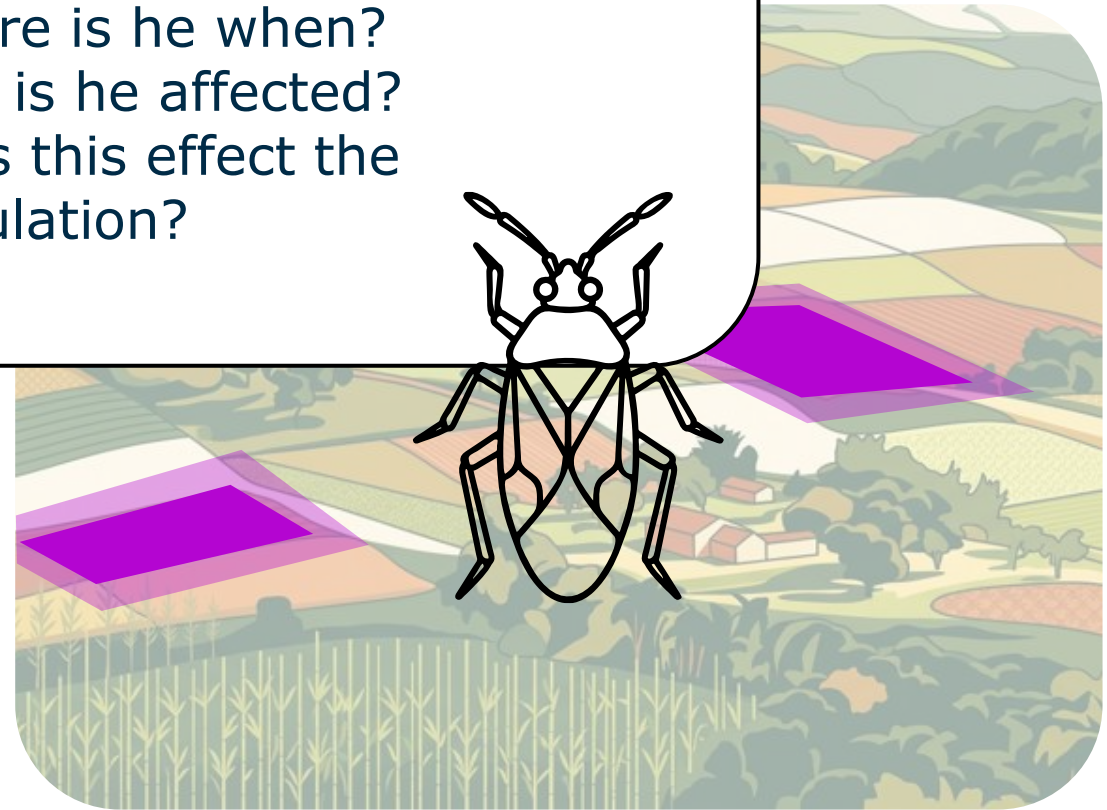


Effect on a leaf-dwelling arthropod?

- Actual individual exposure?
- Where is he when?
- How is he affected?
- Does this effect the population?
- ...

Effect quantification

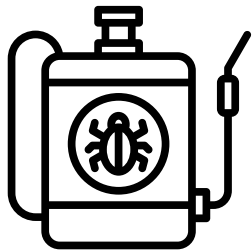
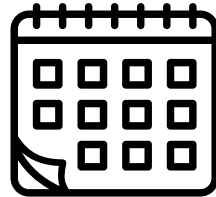
- Lab experiments
- Standard species
- Comparison with fate concentrations
- Safety factors
- ...



From fate to effect

Fate modelling concentrations

- Where?
- When?
- How much?

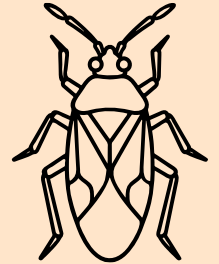


Effect and species models

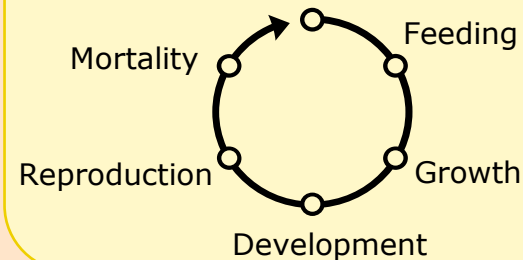
(Sub-)lethal
Pesticide effects



Pirate bug
Orius laevigatus



Dynamic energy budget (DEB) life cycle



Individual-based landscape behaviour

Movement

Overwintering

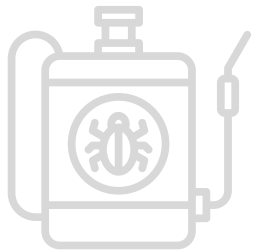
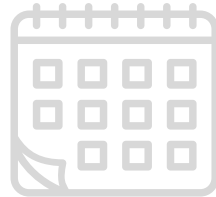
Pest
consumption

Habitat
preferences

Current work

Fate modelling endpoints

- Where?
- When?
- How much?

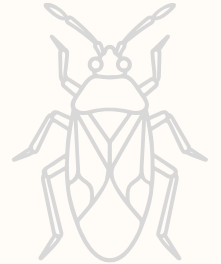


Effect and species models

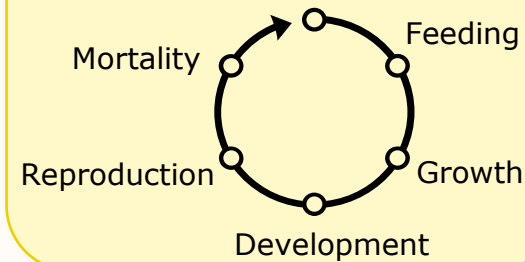
(Sub-)lethal
Pesticide effects



Pirate bug
Orius laevigatus



**Dynamic energy budget
(DEB) life cycle**



**Individual-based landscape
behaviour**

Movement

Overwintering

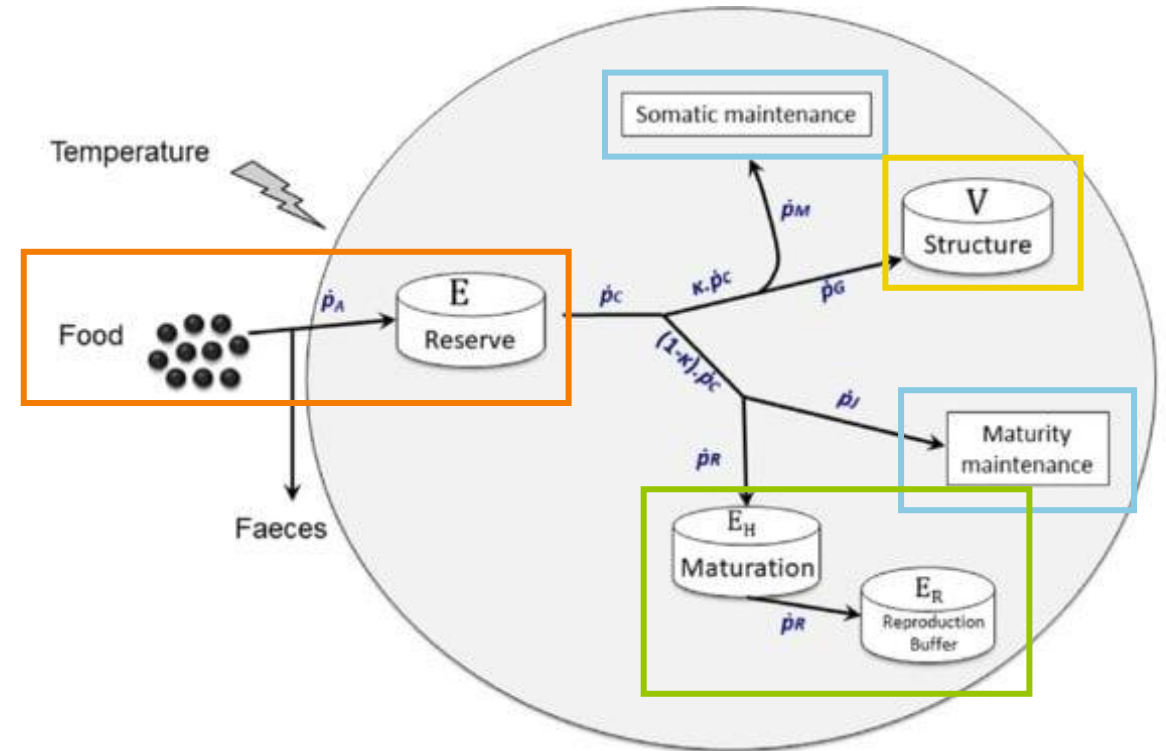
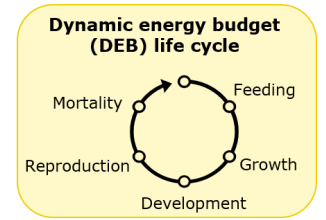
Pest
consumption

Habitat
preferences

Bashkir et al. (*submitted*)

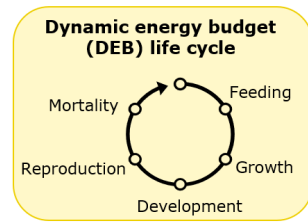
What is DEB theory?

- Mathematical model based on mass/energy balance for the **uptake and allocation of resources** within an organism (Kooijman, 2009)
- Different **DEB variants** for different species families
- Food is taken up into a **reserve** which is then used to:
 - Pay **maintenance** cost
 - Grow** in size
 - Invest into maturation or **reproduction**

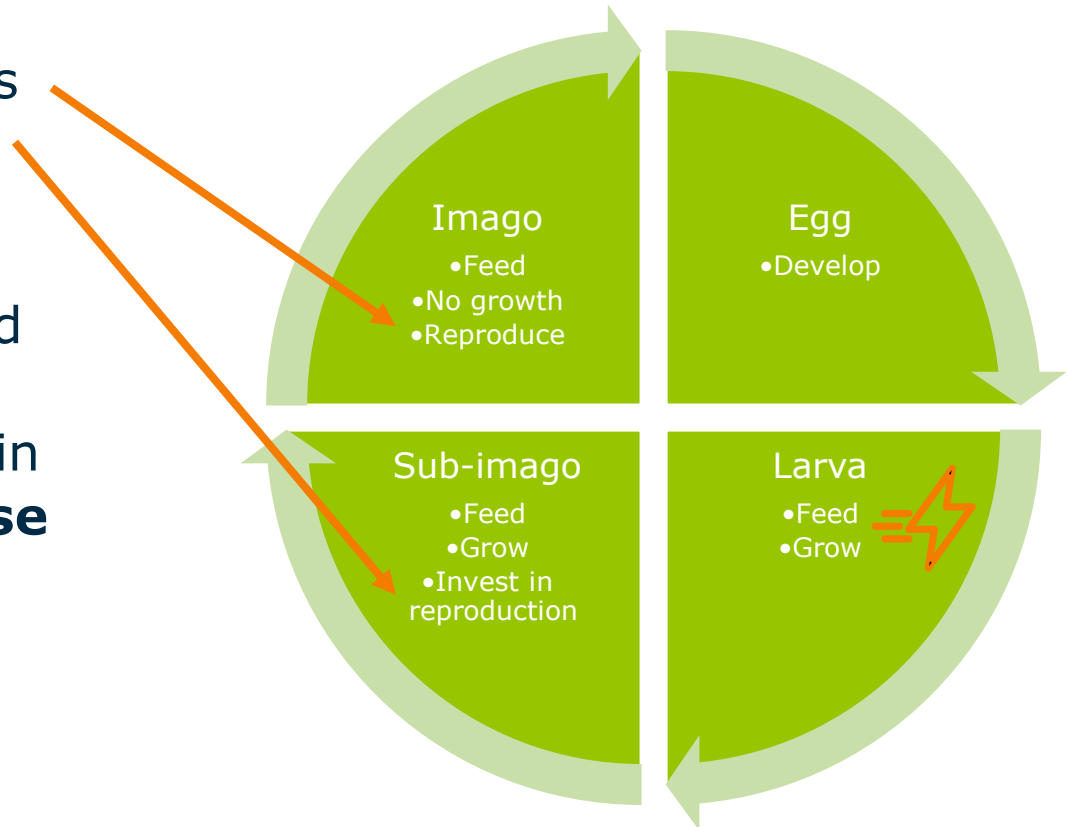


From Fabri-Ruiz et al. (2021)

DEB model for the pirate bug *Orius laevigatus*



- *Orius* requires the DEB hep variant due to its developmental behaviour
- **Four life stages** differentiated
- Data for the DEB parameters already derived (Huang & Bashkir, 2025)
- DEB parameters available for many species in the open and curated **Add-my-pet database**



Pesticide effects

(Sub-)lethal
Pesticide effects

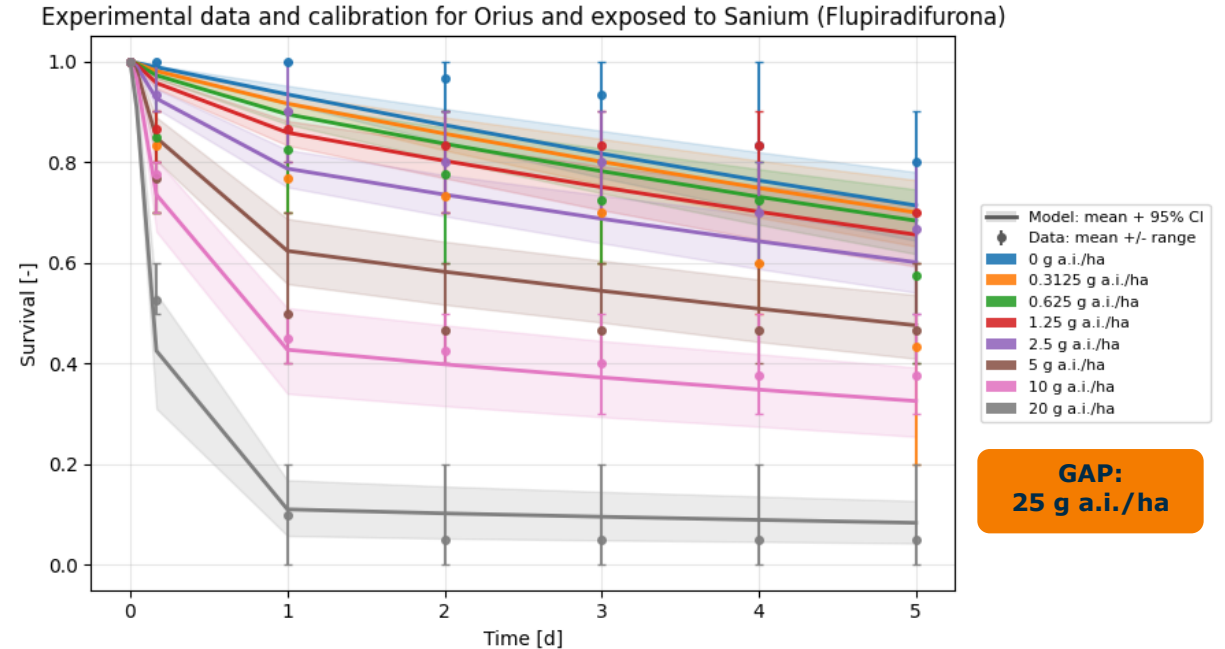


Lethal

- BufferGUTS model for terrestrial invertebrates (Bürger & Focks, 2025)
- Data for *Orius* from AENEAS project for **three insecticides** (Sarmiento et al., 2026)

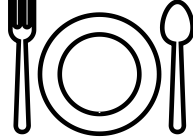
Sub-lethal

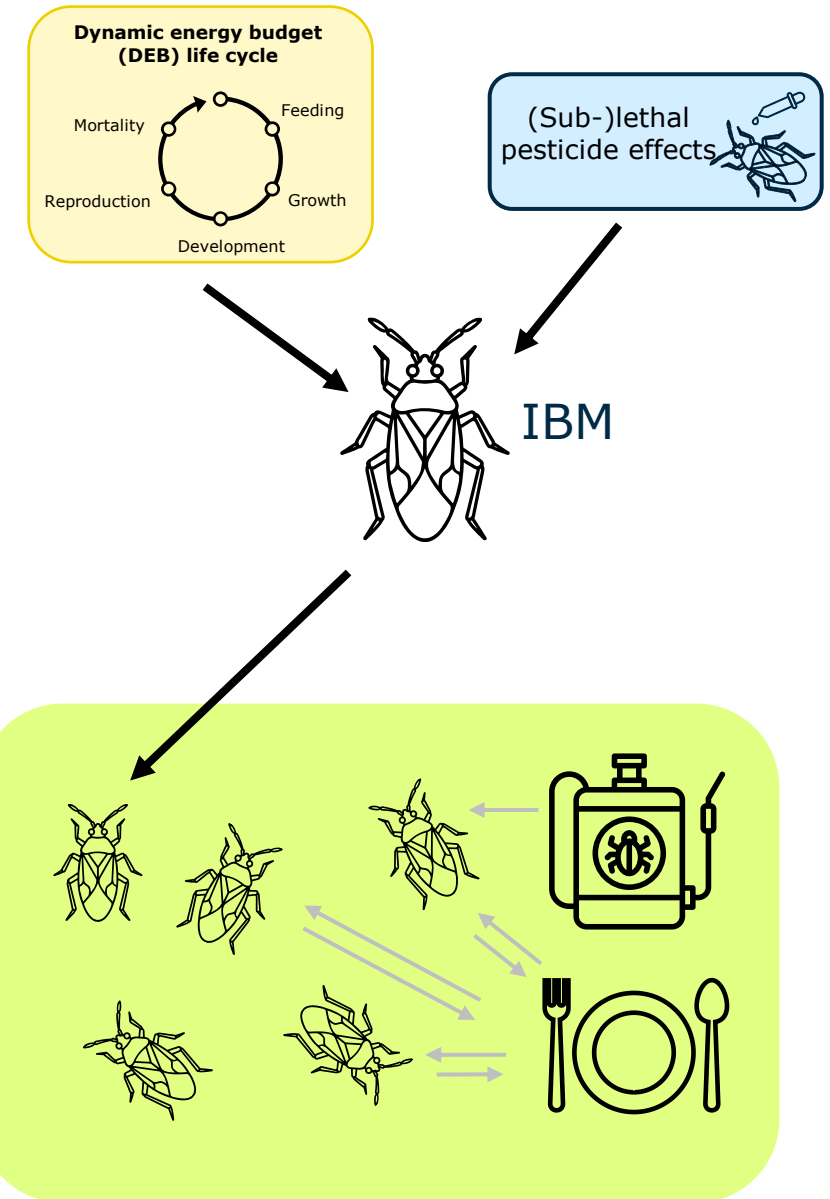
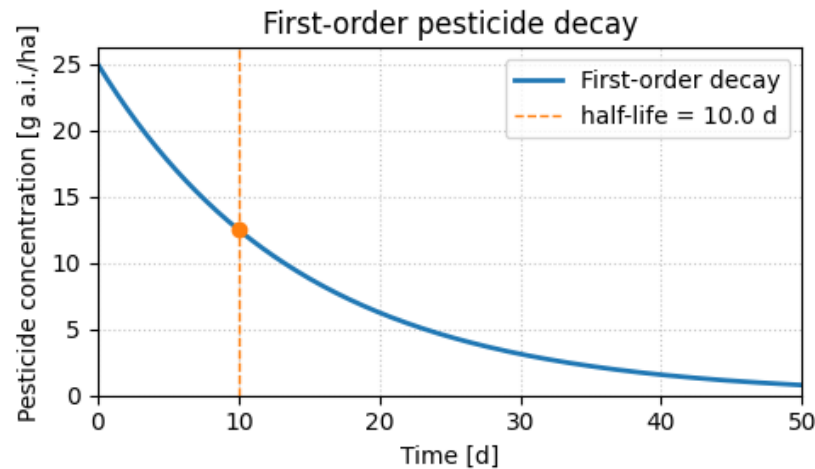
- DEB-TKTD theory for effects on growth, development, reproduction etc.
- **No sub-lethal data** available for this species
- **Not used in current version, as no data available**



BufferGUTS model calibrated to effect data
from direct overspray experiments

Individual based model (IBM)

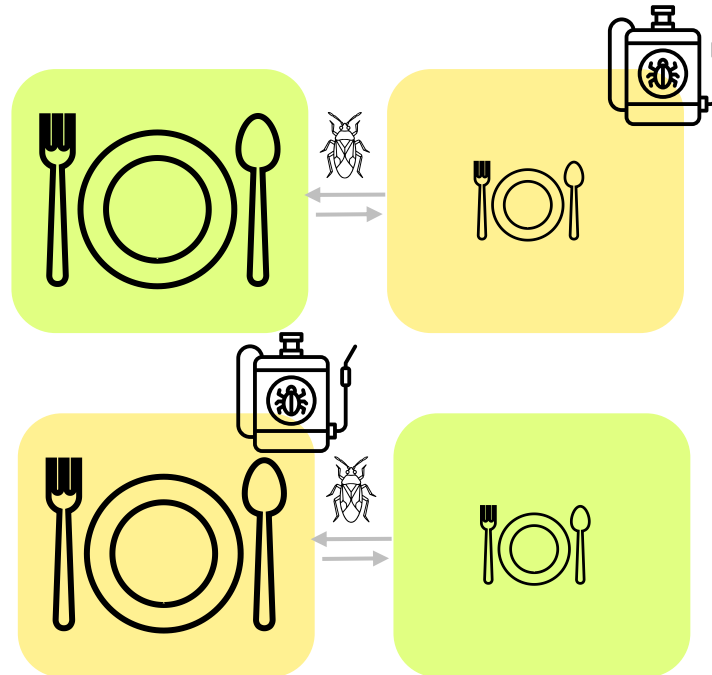
- The different submodels are **combined** into an **IBM**
- Model simulates **population** over time (1h timestep)
- Density dependence just via competition over **resource availability** in the patch 
- Simulation of **lethal pesticide effects**
(applied yearly at GAP concentration 25g a.i./ha)



Scenarios

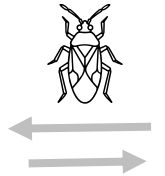


Pesticide application



Investigation

Effect of **migration**



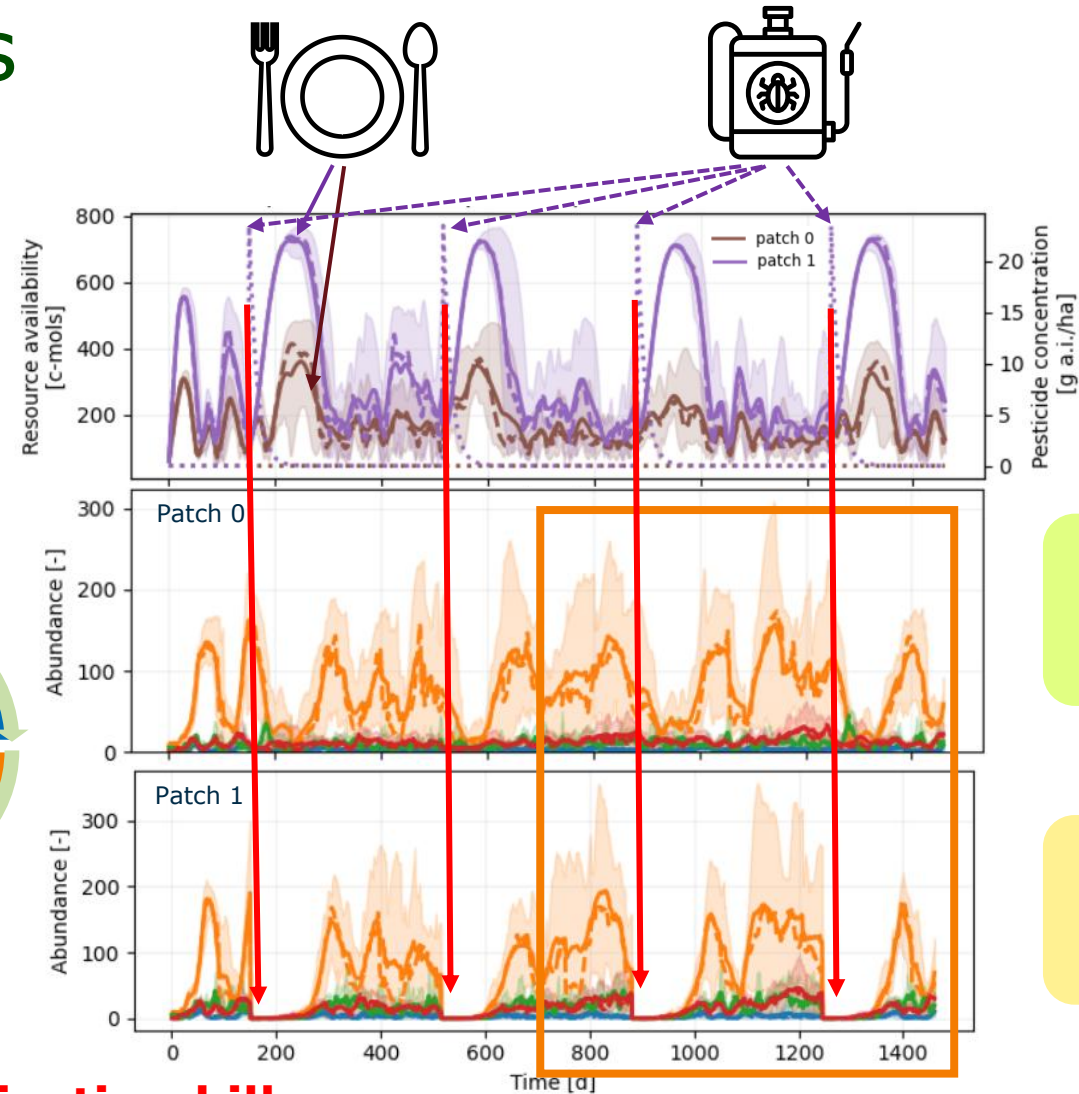
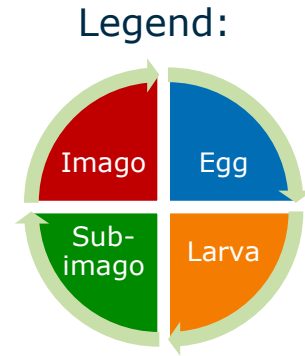
Effect of **resource availability**



Under control and **pesticide** conditions



Modelling results



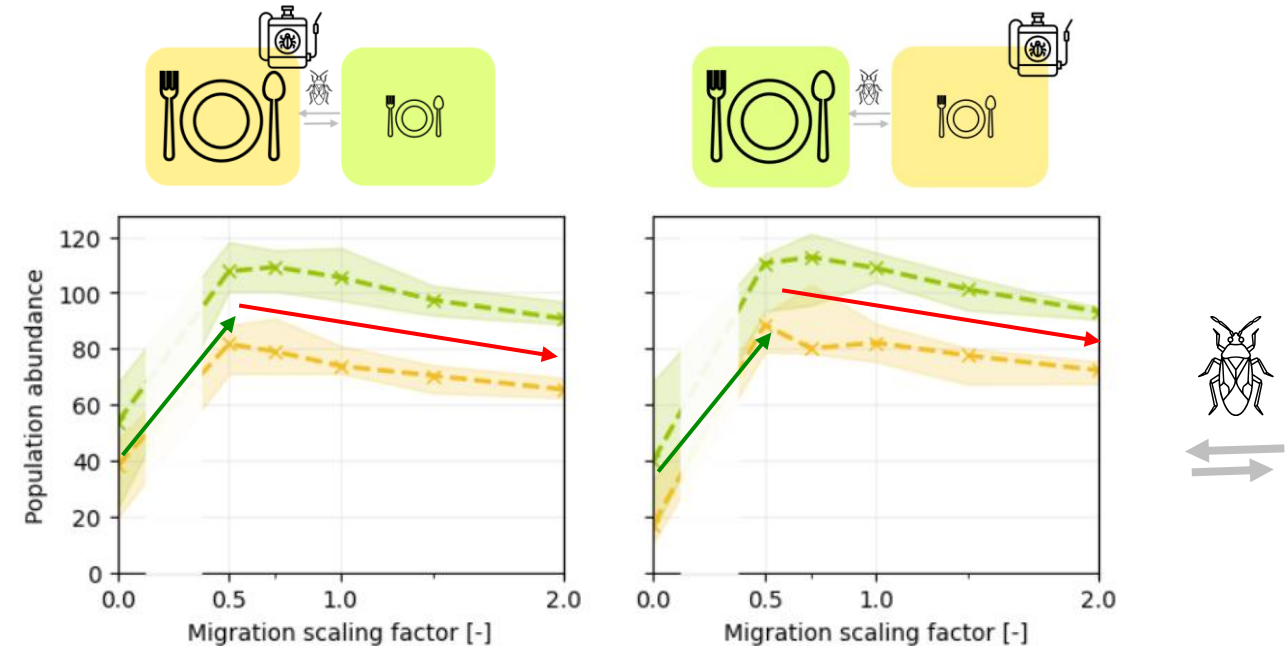
**Pesticide application kills
population in the sprayed field**

**Population size in last
two years of simulation**



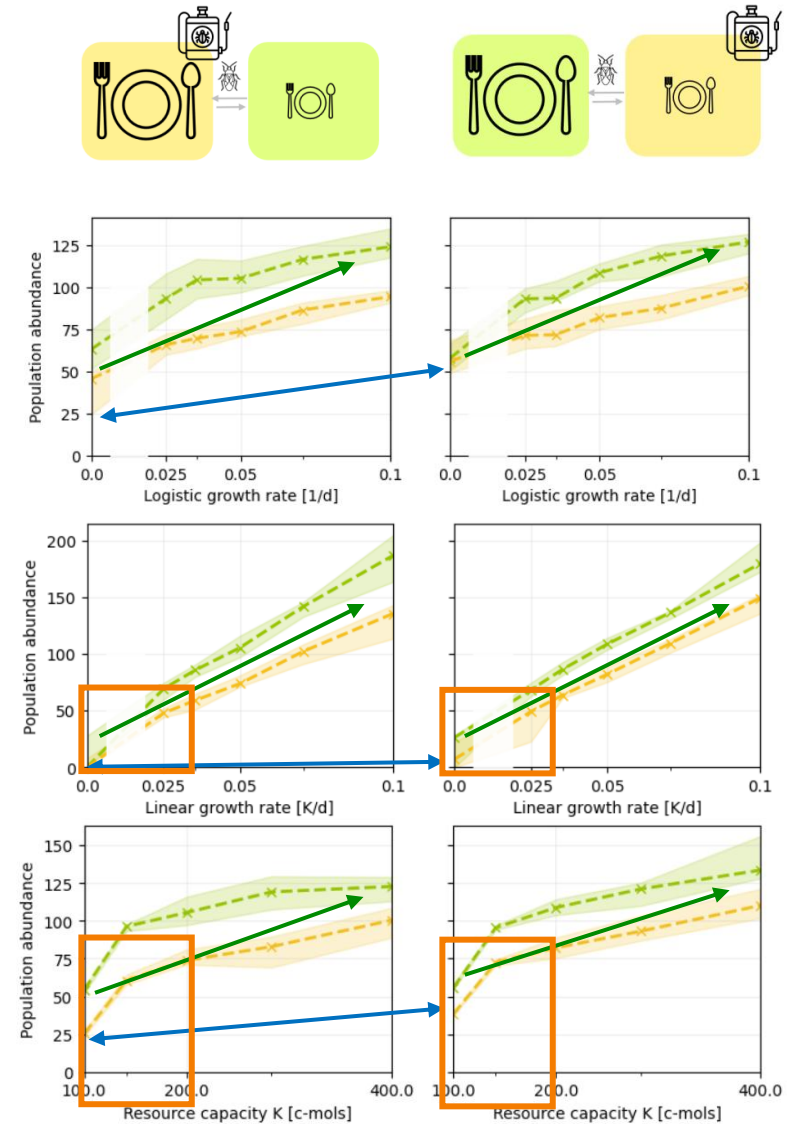
Effect of migration

- Each lifestage has its own **probability** of **migrating** from one patch to the other
- Migration independent of patch conditions
- Some migration highly beneficial
- Slight downward trend with more migration
- Migration between patches enables **recolonization**

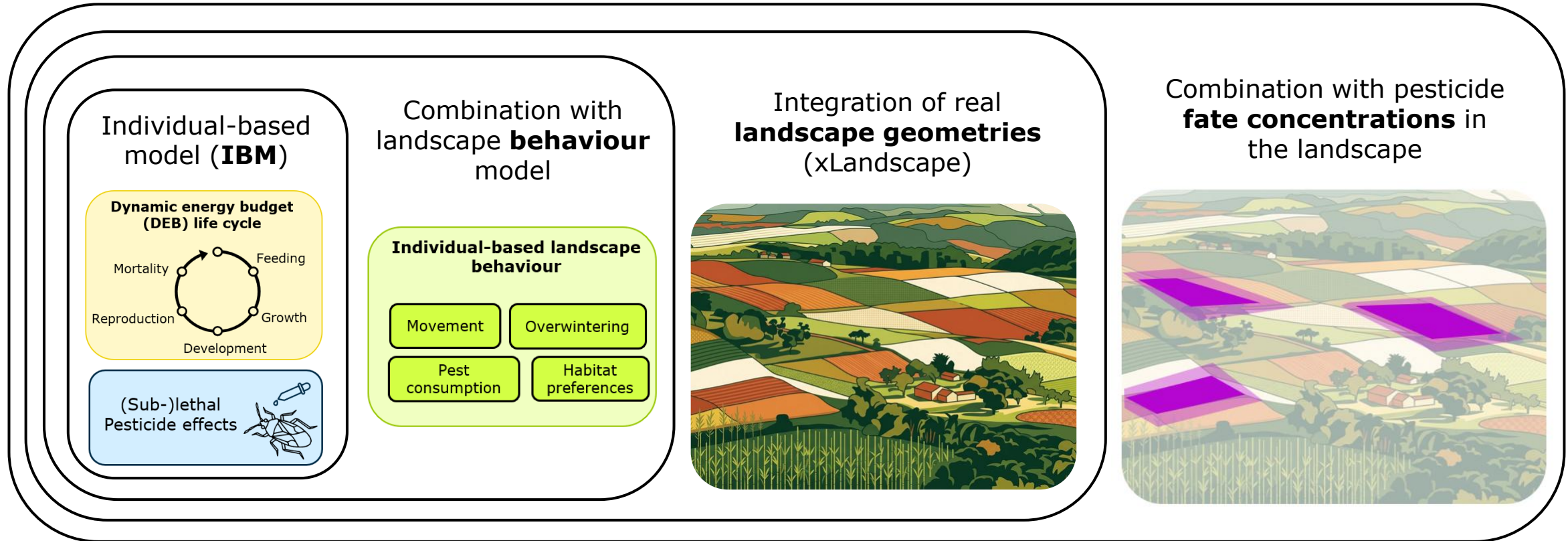


Effect of resource availability

- Resource availability is determined by three factors:
 - Logistic resource growth (**prey**) 
 - Linear resource growth (**pollen**) 
 - **Resource capacity** (overall resource potential of the landscape patch) 
- More is more
- Pesticide application in resource-rich patch has higher effects
- Be cautious in **resource poor** areas with **no alternative** resources



Next steps



Take-homes

- We are building a **landscape effect model** for a **leaf-dwelling arthropod** that is capable of:
 - Simulating **resource** uptake and **energetics**
 - (Lethal) **pesticide effects**
 - Field & landscape **population**
 - Landscape **behaviour**
- **Recolonisation** important factor to repopulate sprayed areas
- Requires **healthy** and unaffected **off-field populations**
- Interesting to see the results once combined with real landscape geometries and **fate model concentrations** for e.g. adjacent off-field strips



Thank you for the attention!

I want to thank **Dana**, **Annika** and **Bas** for their input and help with designing and developing the model!



Happy to answer questions now, later at the symposium or via email: **leo.buerger@wur.nl**

Sources

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<https://doi.org/10.2903/sp.efsa.2026.EN-10191>