PREDICTING THE RECOVERY OF AQUATIC ARTHROPOD POPULATIONS USING THEIR LIFE-HISTORY TRAITS – A MODELLING APPROACH

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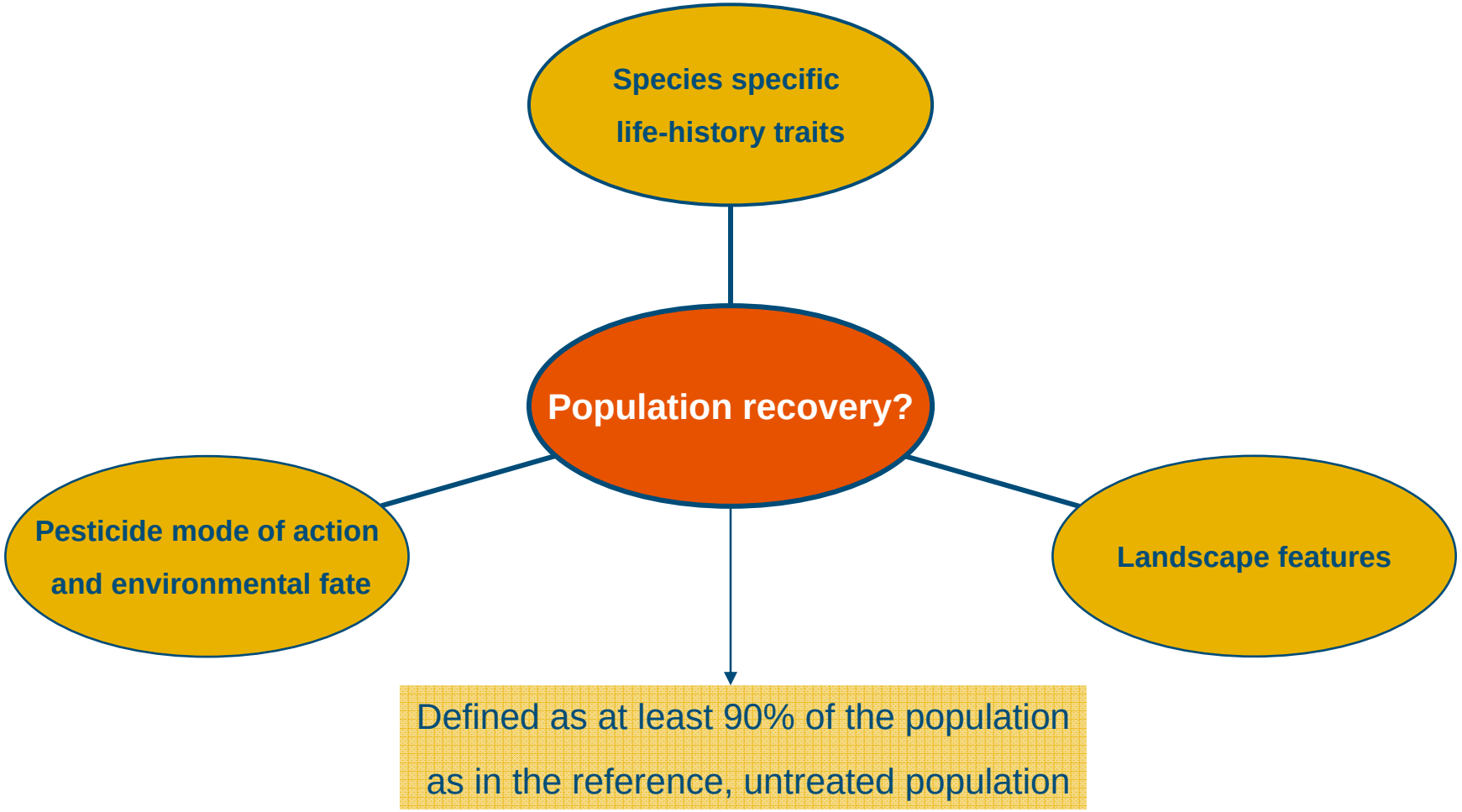
Why recovery?

- Natural and human induced disturbances
- Resilient systems tend to recover, not only resist
- Autogenic and allogenic population recovery
- Which aspects influence recovery?

The Big Question



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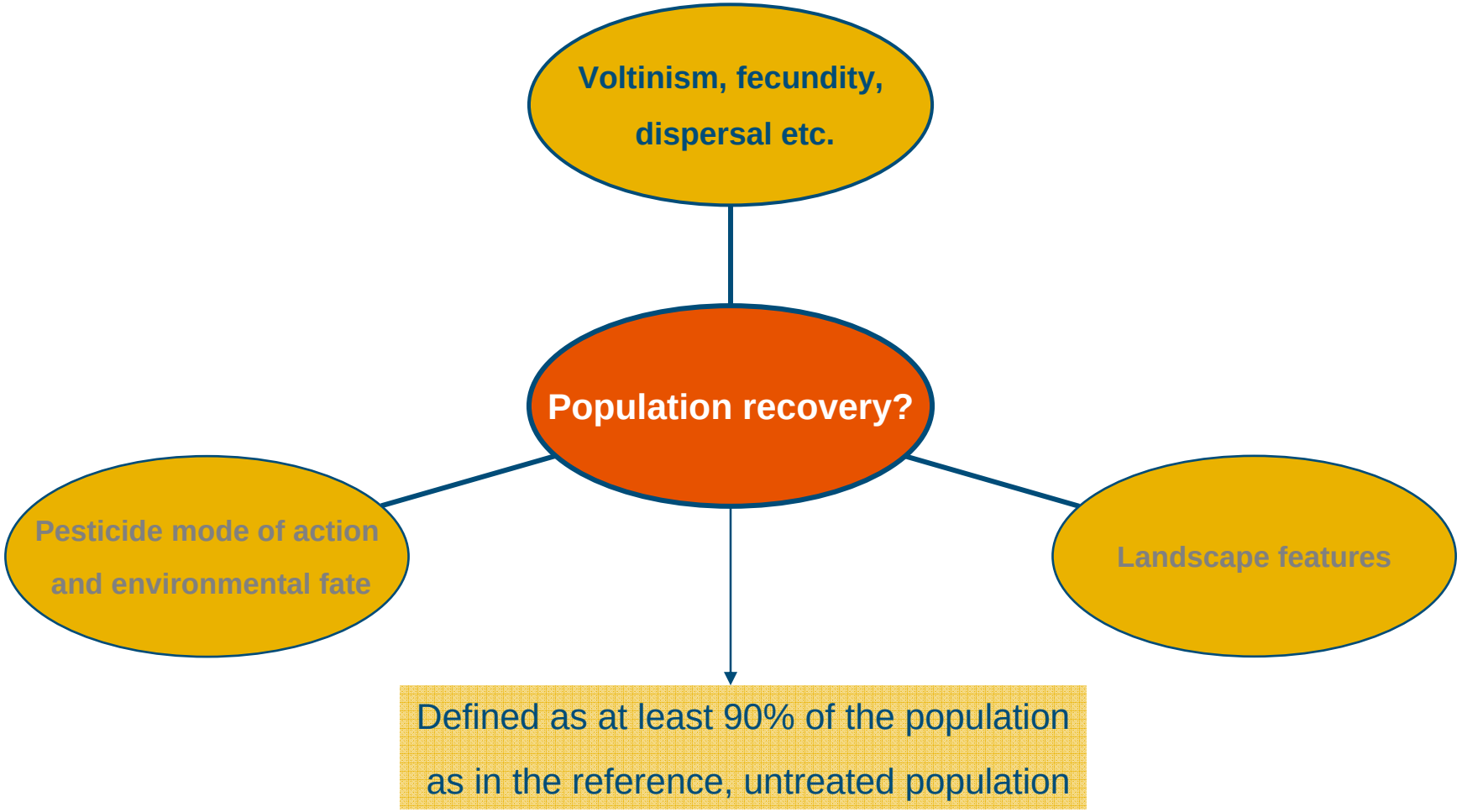

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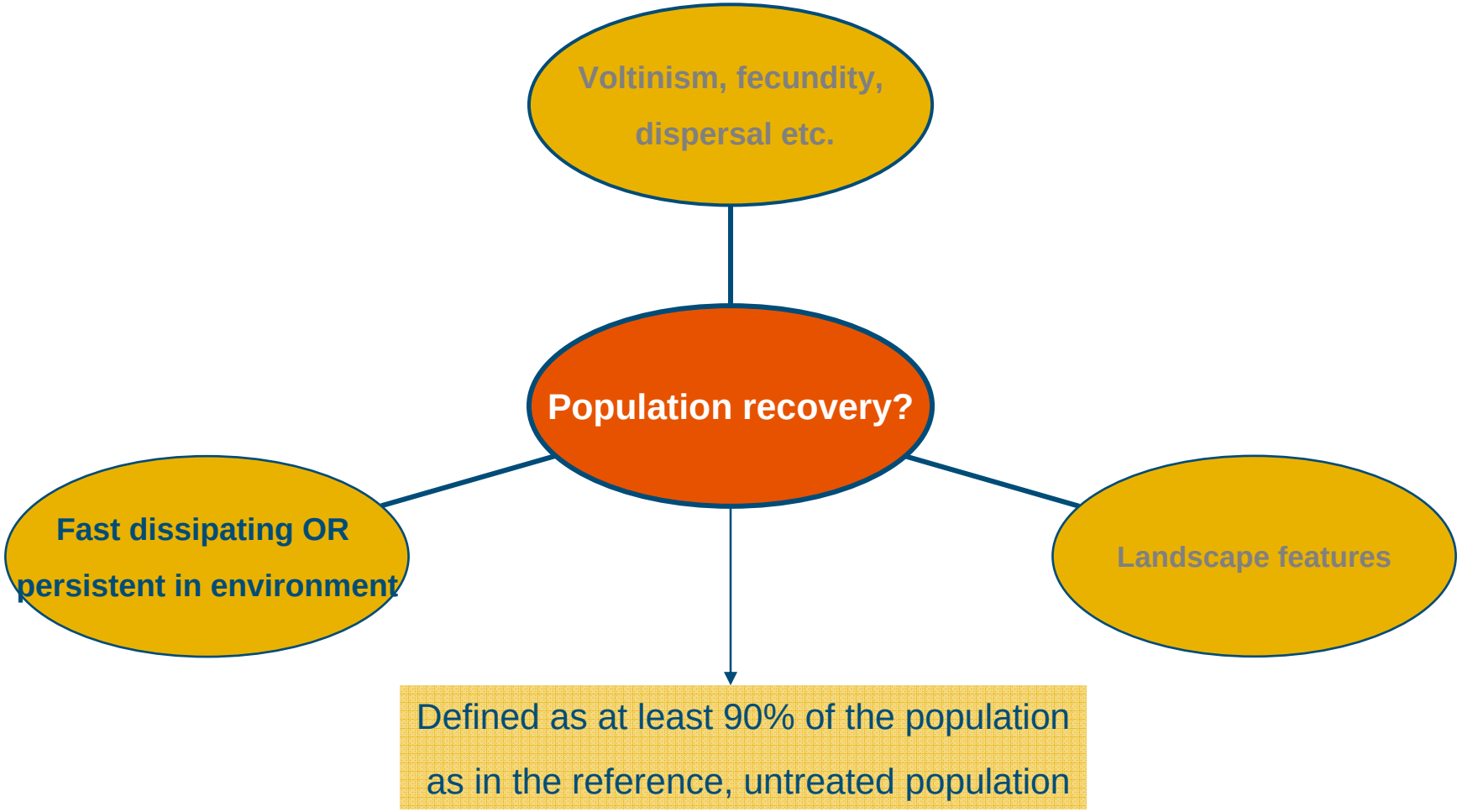

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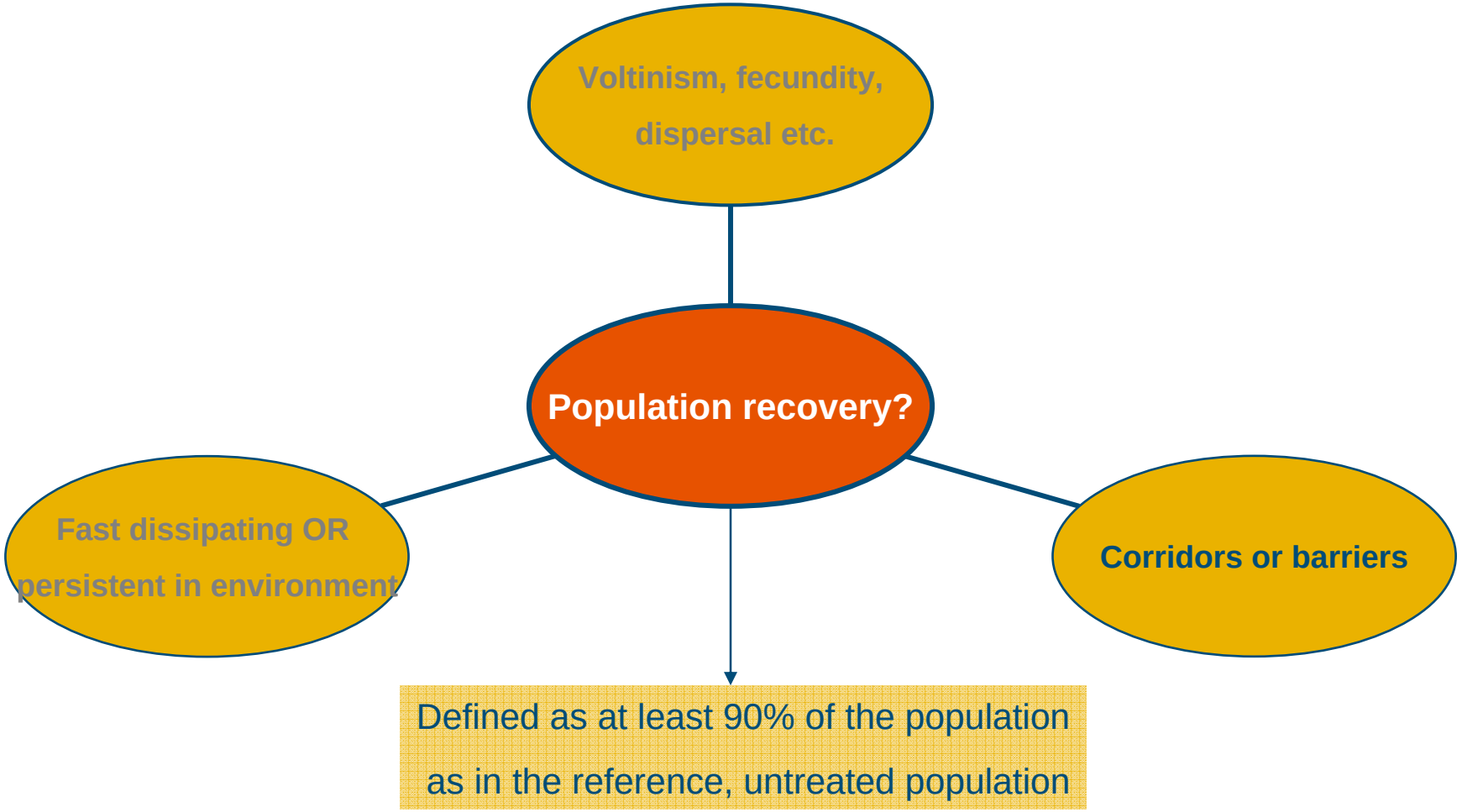
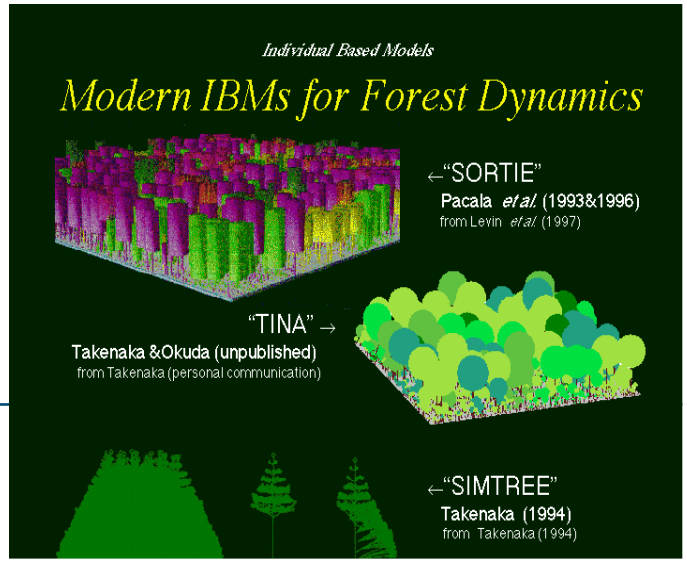


How ?

Individual-based models (IBM)

- Individual/agent is the basic element of the population, natural variability ensured
- Ability to mechanistically model chemical effects on phys. processes and behavior
- Transition to the population level through tracking individuals, their offspring and environment (book-keeping process)
- Potential for explicit space consideration
- High degree of realism and accuracy, on expense of generality



Individual-based model

- Individual female
  - Movement in explicit spatial setting
    - Patch to patch movement
    - Long distance drift
    - Flying!
  - Growth in size
  - Mortality
    - Background
    - Density dependent
    - Pesticide induced
  - Reproduction

Population model - Individual-based model (IBM)

Individual female

Movement in explicit spatial setting

Growth in size

Mortality

Reproduction

Move only 1/3 of the day

Some adults can move up to 10 meters

Some adults move to a nearby ditch

Population model - Individual-based model (IBM)

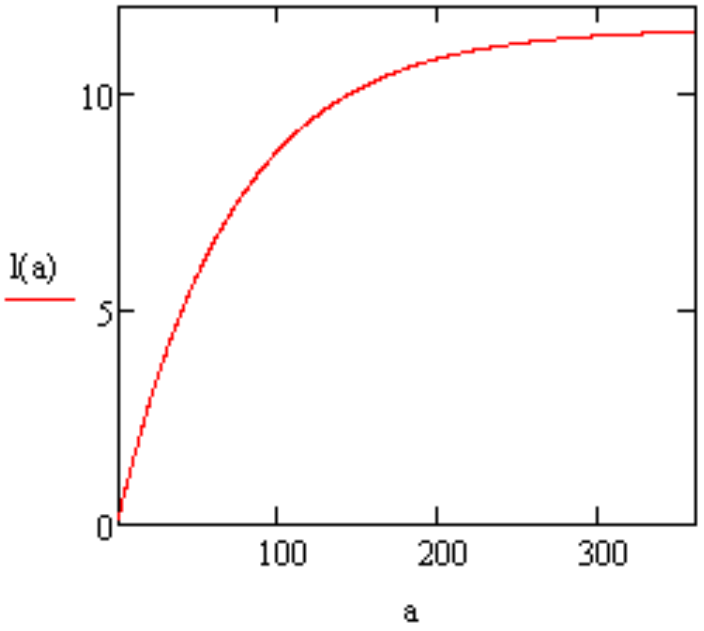
Individual female

- Movement in explicit spatial setting
- **Growth in size**
- Mortality
- Reproduction

Von Bertalanffy growth function

$$l(a) = l_{\max} \cdot (1 - e^{-k \cdot a})$$

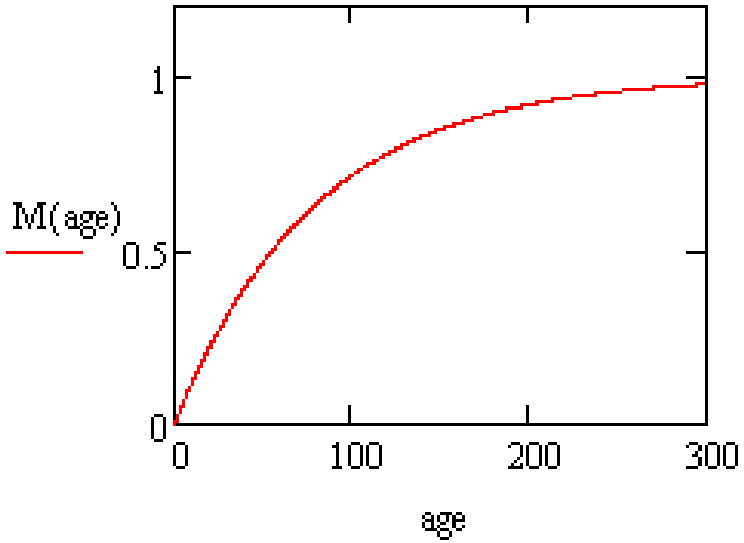
Deterministic and density dependent



Population model - Individual-based model (IBM)

Individual female

- Movement in explicit spatial setting
- Growth in size
- **Mortality**
  - **Background**
  - Density dependent
  - Pesticide induced
- Reproduction



Population model - Individual-based model (IBM)

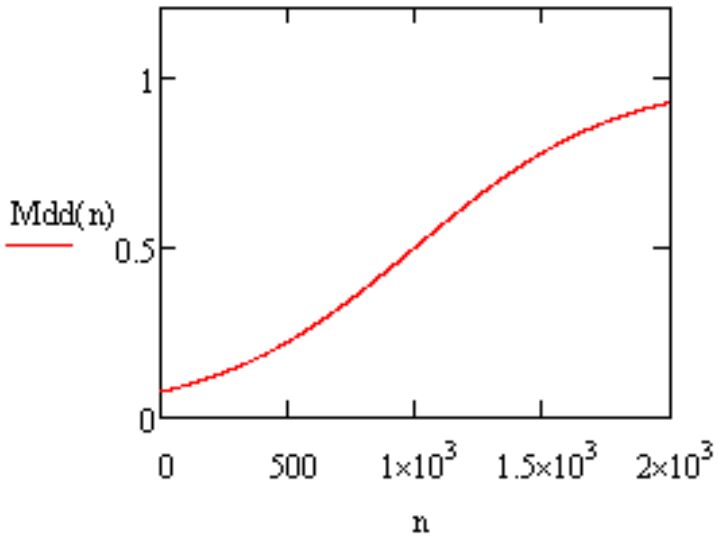
Individual female

Movement in explicit spatial setting

Growth in size

Mortality

Reproduction



Background

Density dependent

Pesticide induced

Population model - Individual-based model (IBM)

Individual female

Movement in explicit spatial setting

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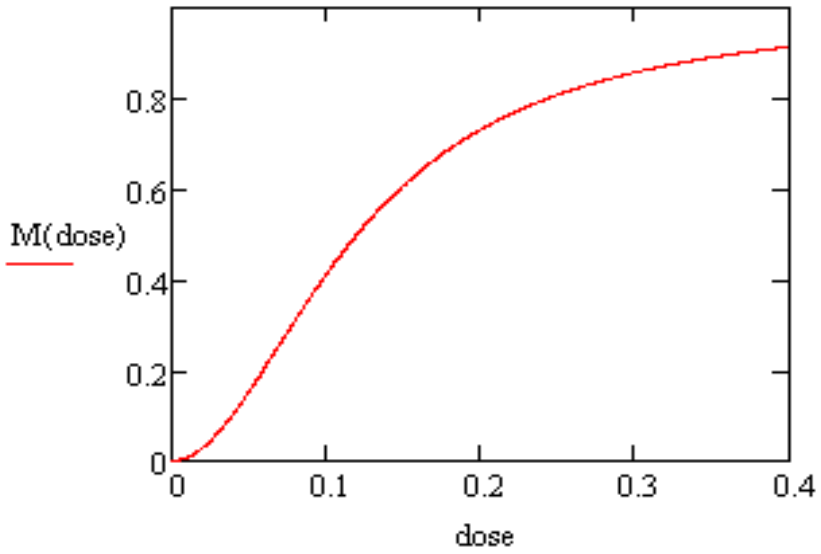
Reproduction



Background

Density dependent

Pesticide induced

Population model - Individual-based model (IBM)

Individual female

Movement in explicit spatial setting

Growth in size

Mortality

Reproduction

- **Only adults can reproduce**

-**2 onsets of reproduction, around mid April (3 weeks) and mid June (2 weeks)**

-**Number of offspring is size-dependent, max is determined by the user**

-**Once they reproduced,**

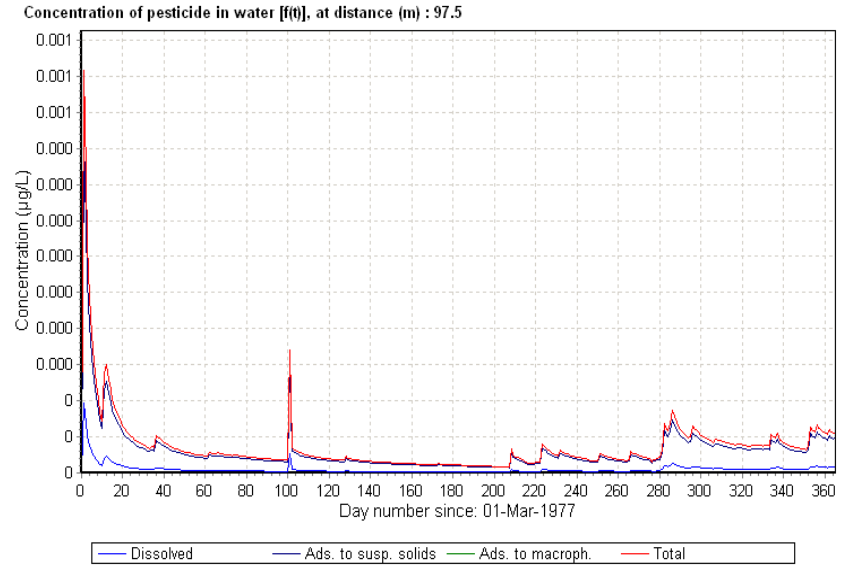
adults die shortly after

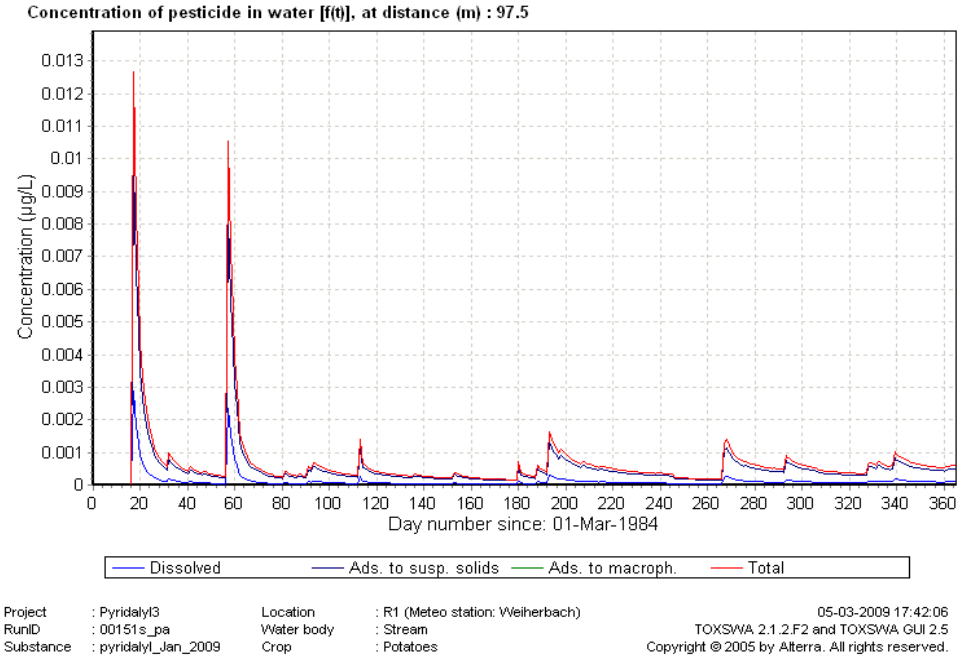
-**None get the chance to reproduce twice**

Pesticide fate

- fate model for calculating environmental concentrations in a ditch

-1 and 2 applications of an insecticide





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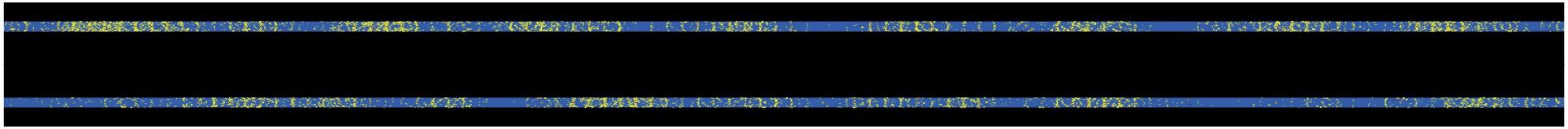
Landscape

- simple explicit consideration of space

-Ditch consists of 100 patches in a row

-Spatial heterogeneity through different carrying capacity of patches

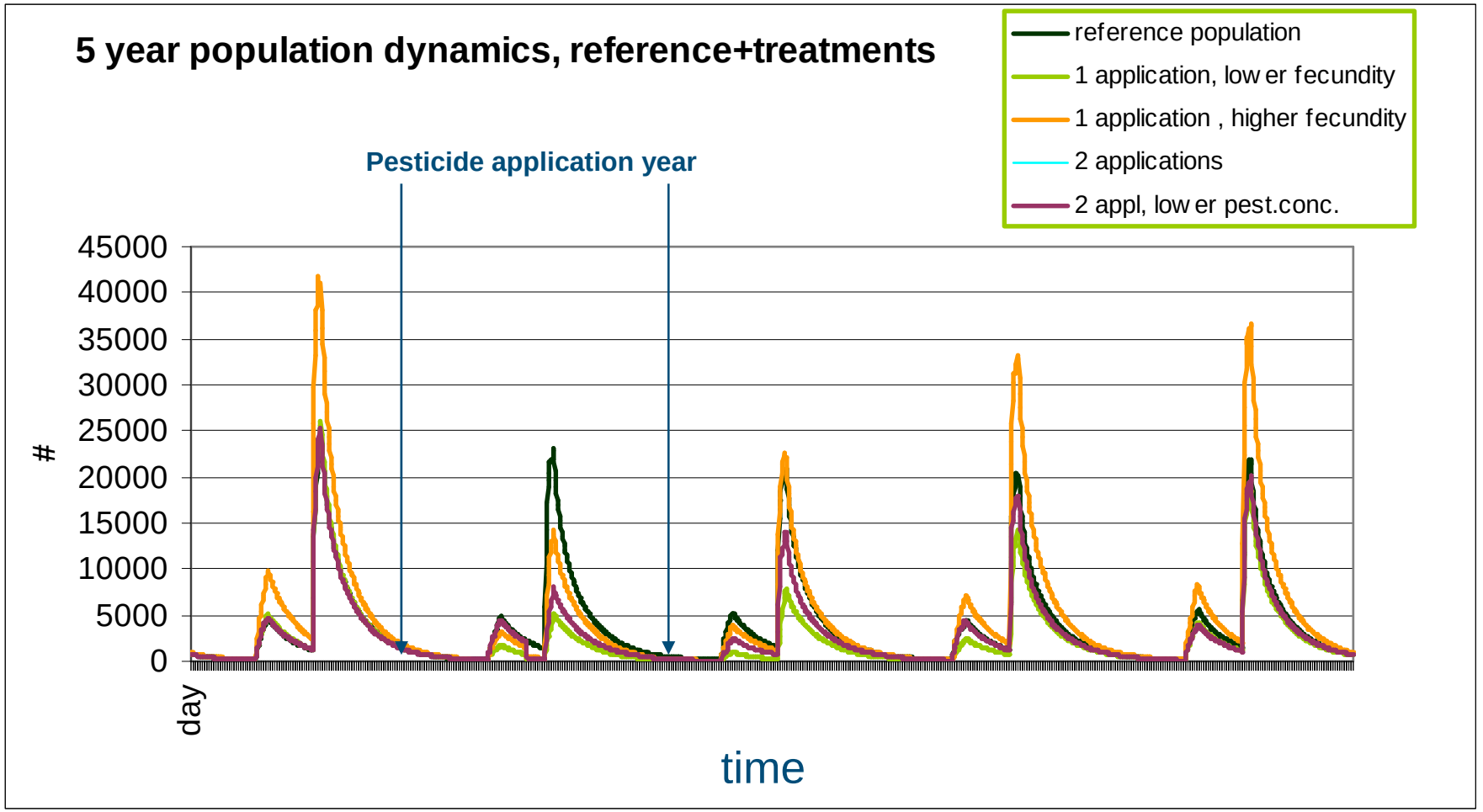


Scenarios

1. Bivoltine cycle; fully aquatic
2. Bivoltine cycle + recolonizers ; fully aquatic
3. Bivoltine cycle with a flying stage and a 2 ditch system

- Pesticides are applied in the third year of the simulation, at 1st March (60 days in the simulation)
- Second application at 1st May (day 120)

Results – 1. bivoltine, fully aquatic cycle



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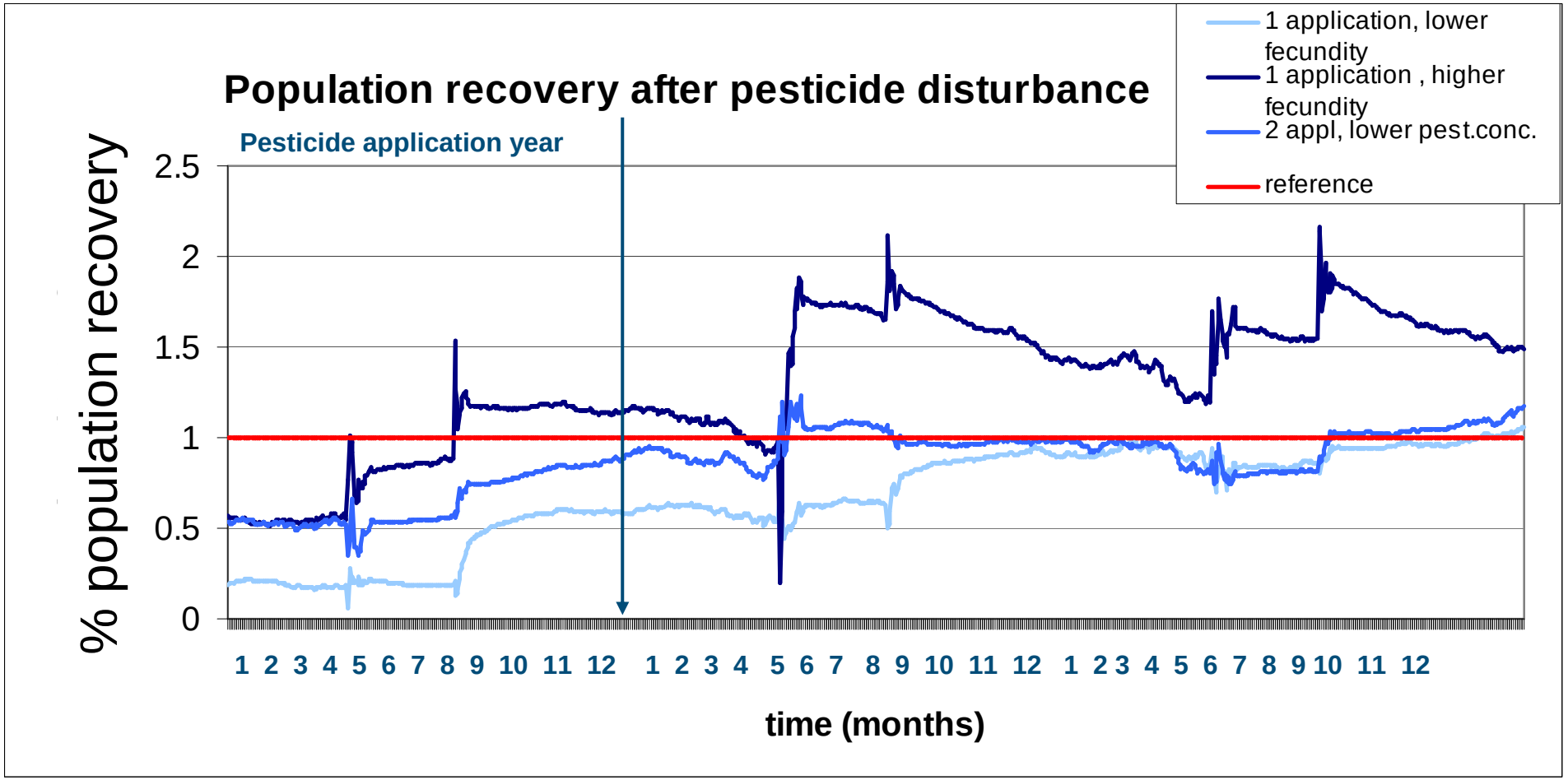
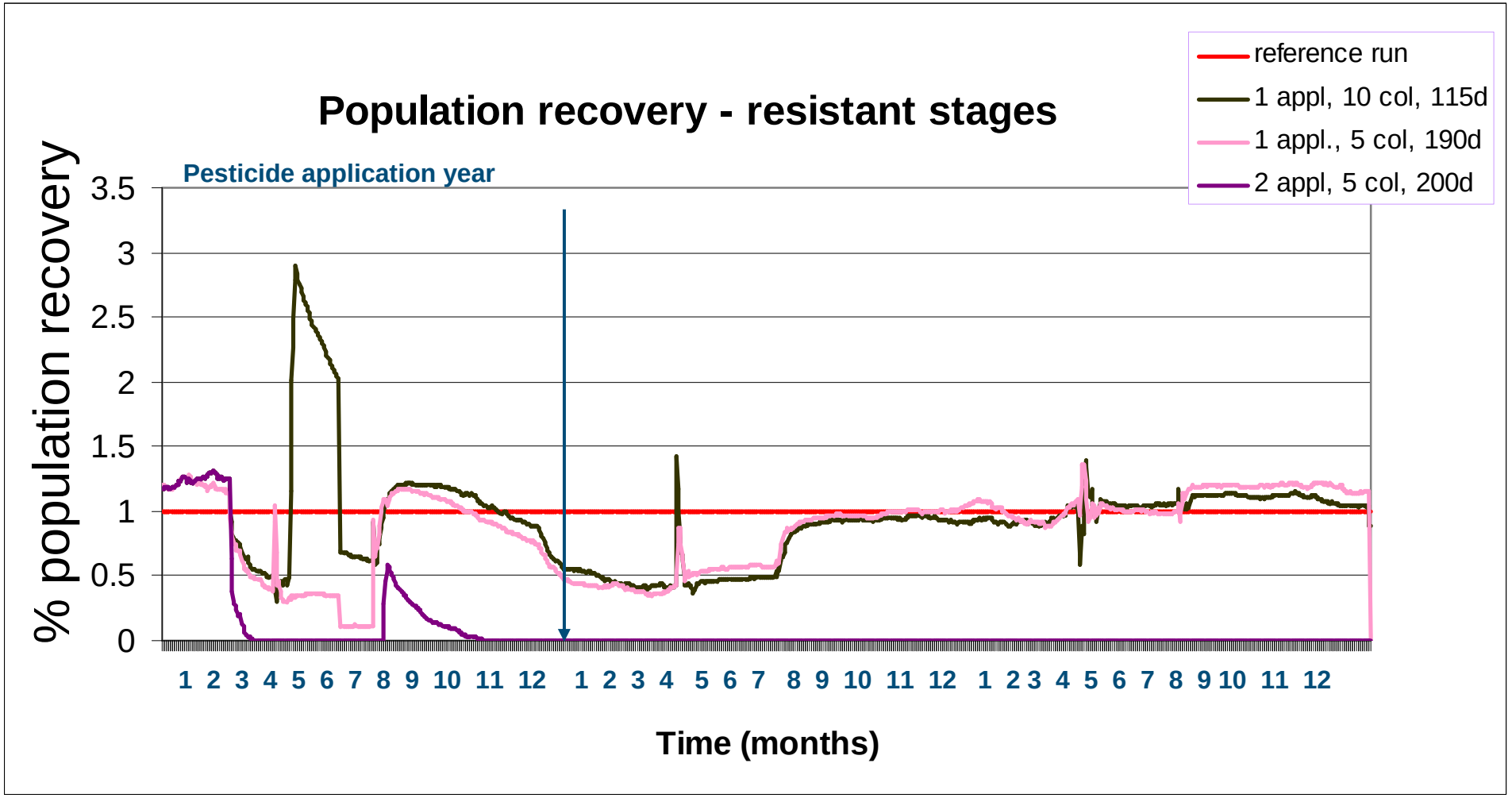
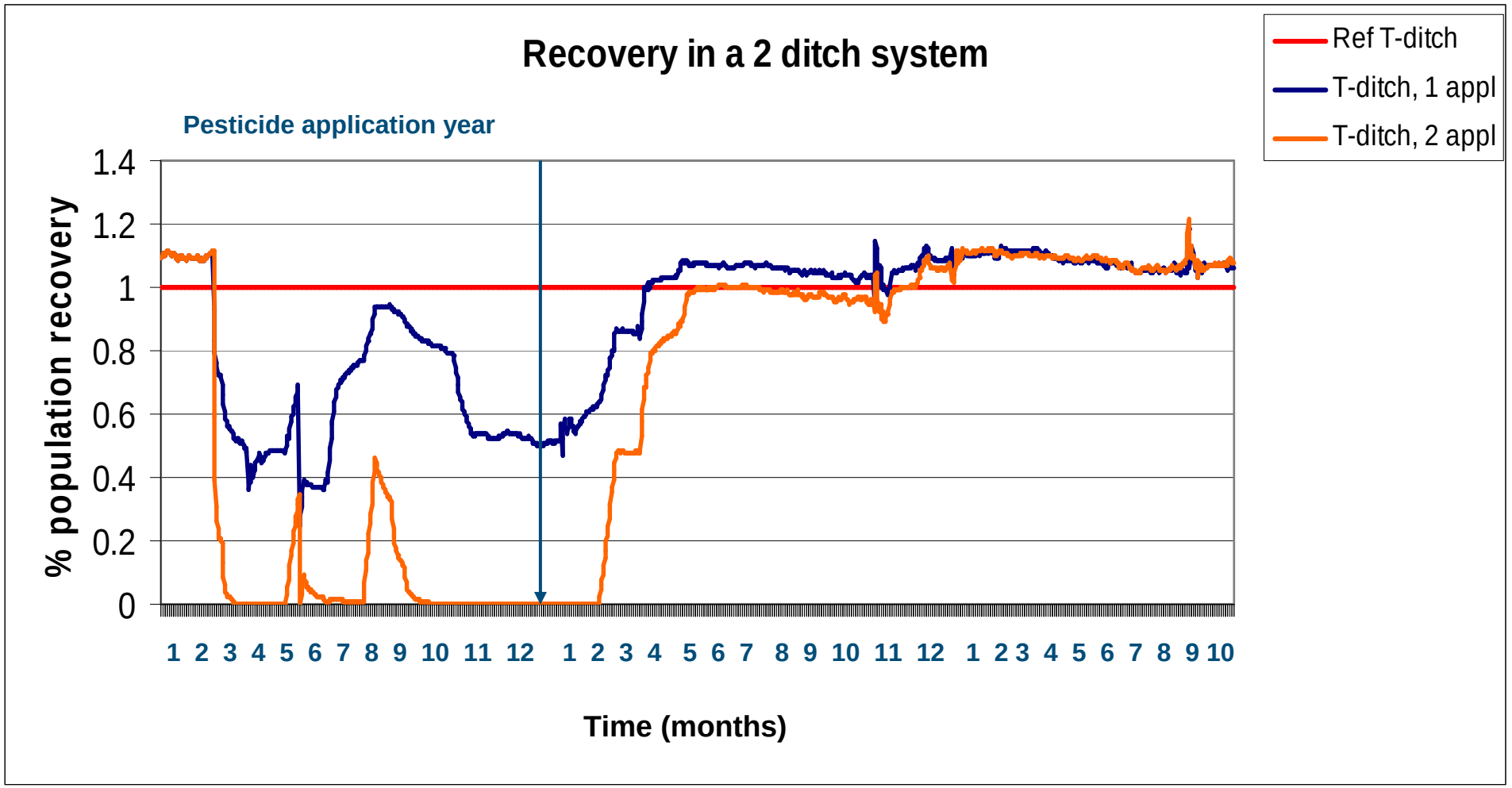


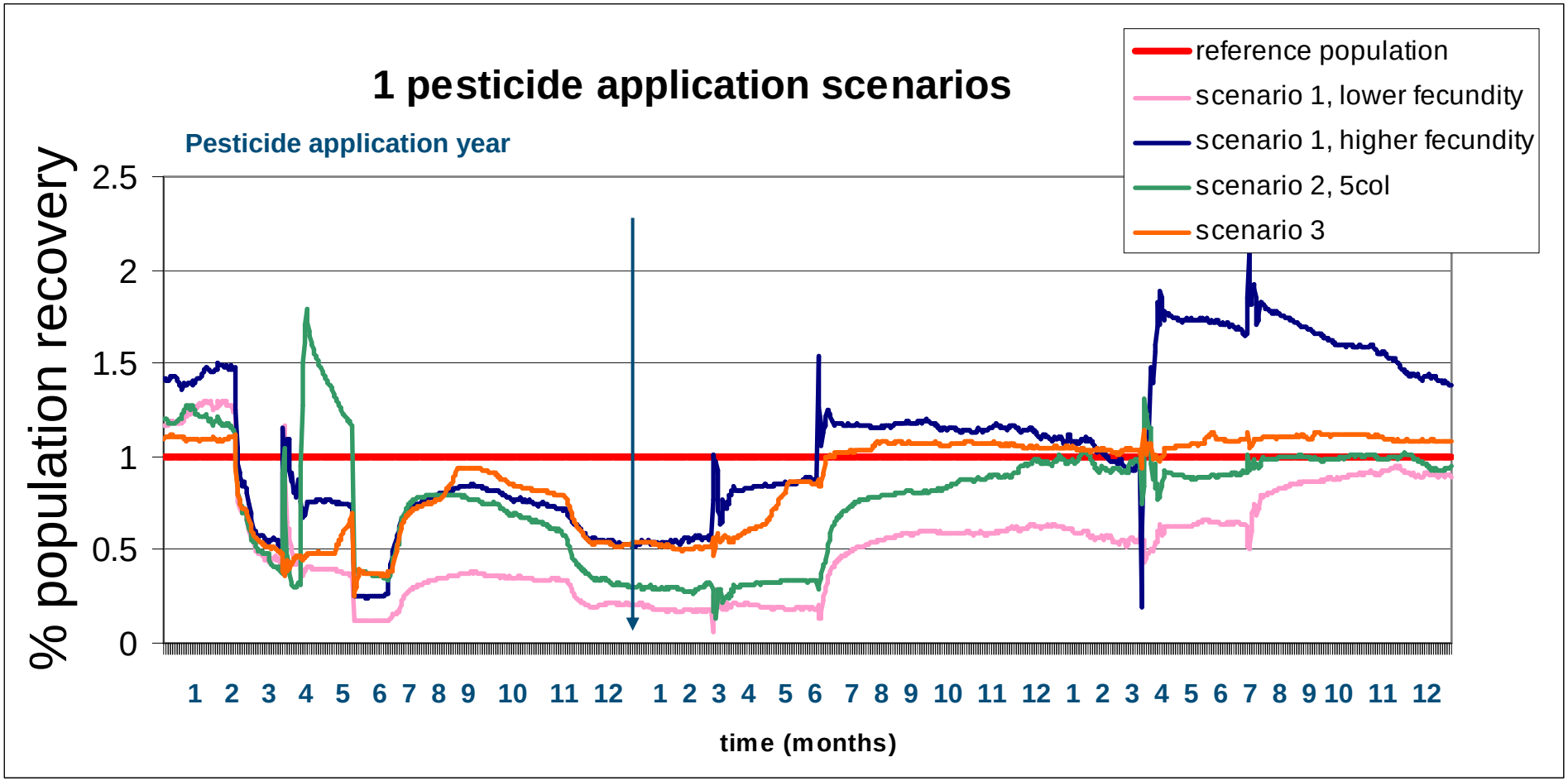
Results – 2. bivoltine, fully aquatic cycle, recolonization



Results – 3. bivoltine, flying stage

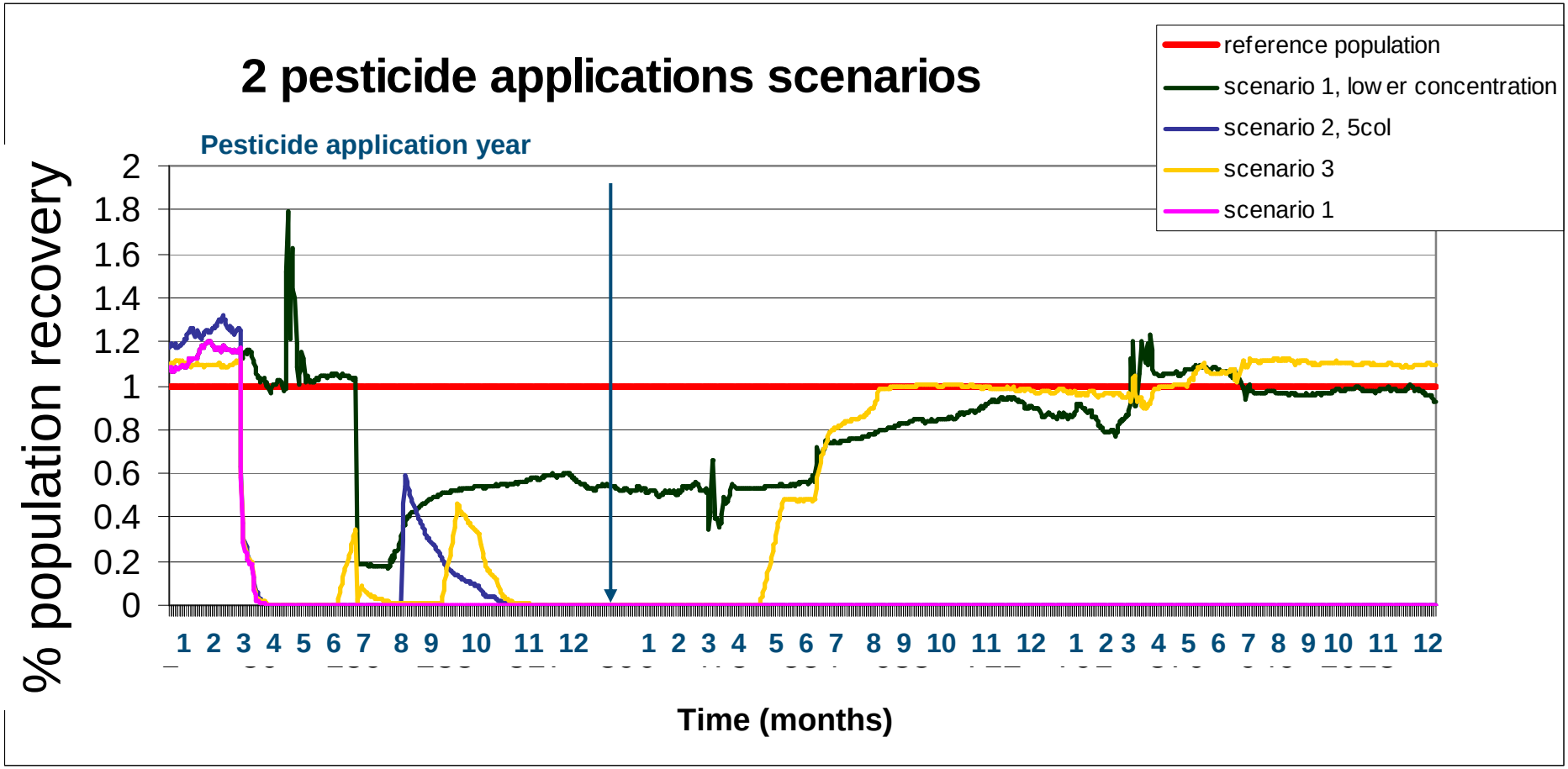


Results – overall



In 1 application scenarios, full recovery (as defined) is possible only in organisms with very high fecundity and in the 2 ditch scenario; around 6-7 months after the pesticide application year

Results – overall



In 2 application scenarios, full recovery (as defined) is possible only in the 2 ditch scenario; more than 9 mo after the pesticide application year

Future outlook

- More species with different life-history traits
- Look into sublethal effects and timing of applications
- Integration of toxicokinetic-toxicodynamic models (individual level)
- Coupling with a landscape-level fate model for different chemicals
- Experimental validation of model output

Thank you all for your attention