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Temporal dynamics of grasslands as sources of soil-dwelling insect pests: new insights from *in silico* experiments for pest management strategies

S. Poggi*, M. Sergent, Y. Mammeri, M. Plantegenest,
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- ▶ Wireworms are serious pest of food crops worldwide, inflicting \approx \$100M/year economic damage
- ▶ Progressive phase-out of chemical pesticides (e.g. neonicotinoids in UE, 2018) enhances crop vulnerability
- ▶ Entanglement of grassy landscape elements (favourable habitats) and crops (e.g. maize, potatoes, cereals) facilitates crop colonisation within the agricultural mosaic
- ▶ Correlative studies do not provide a sound understanding of processes underpinning crop infestation



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Premise:

- ▶ Landscape is the relevant scale to design pest resilient agroecosystems that minimise the use of pesticides

Hypothesis:

- ▶ Arrangement of land uses in space and time might efficiently contribute to pest regulation

Objectives

- ▶ Provide a mechanistic framework to study the spatiotemporal distribution of soil-dwelling insect populations within dynamic landscapes
- ▶ Examine the role of grasslands in crop colonisation by wireworms within contrasted dynamic agricultural mosaics, and infer novel spatiotemporal pest management strategies

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1. **Derive a parsimonious population dynamics model** encompassing key biological and ecological mechanisms and considering space explicitly
2. **Parameterise the model** from an extensive review of literature dealing with the biology and ecology of wireworms
3. **Model various landscape contexts** comprising grasslands and vulnerable crops characterised by their carrying capacity, providing situations with grassland in the history, the neighbourhood or the historic neighbourhood of crops

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Parsimonious, spatially explicit model

$$\left\{ \begin{array}{l} \partial_t A(x, t) = \tau(t)B(x, t, m_c) + D\Delta A(x, t) - \vec{u}(x, t) \cdot \nabla_x A(x, t) \\ \quad - \mu_A A(x, t) \\ \partial_t B(x, t, m) = -\tau(t)B(x, t, m_c) + \pi A(x, t) - c\partial_m B(t, x, m) \\ \quad - \mu_B \left(\frac{B(x, t)}{K(x, t)} \right)^\beta B(x, t, m) \end{array} \right.$$

- ▶ A, B: aboveground and belowground compartments
- ▶ **Emergence** of adults from mature larvae
- ▶ Adult random (**diffusion**) and directed (**advection**) motions
- ▶ **Oviposition**
- ▶ Larval development along a maturity dimension (**maturation**)
- ▶ Adult **mortality** and larval density-dependent mortality

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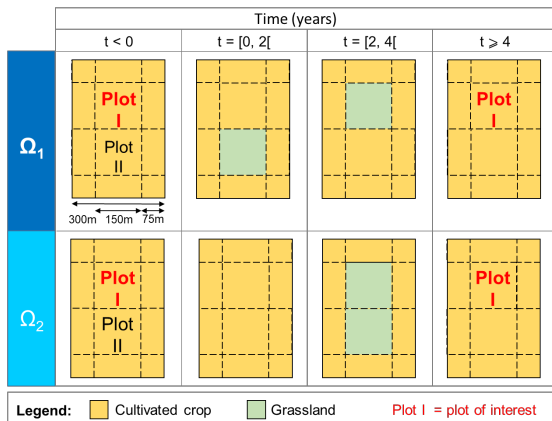
4 contrasted models of landscape context:

- A. Homogeneous crop ($K_C=120$ ind/m²) cultivated over 2 years
- B. Grassland in the plot history: a 5-year cultivated area following a 5-year grassland ($K_G=2000$ ind/m²)
- C. Grassland in the plot neighbourhood : a 10-year heterogeneous area consisting of 2 adjacent plots, one cultivated and the other unmanaged
- D. Grassland in both plot history and neighbourhood

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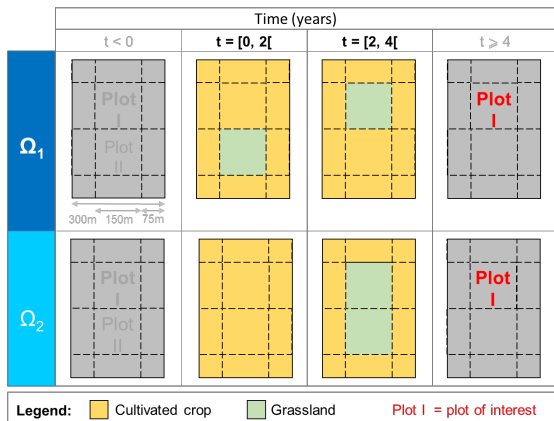
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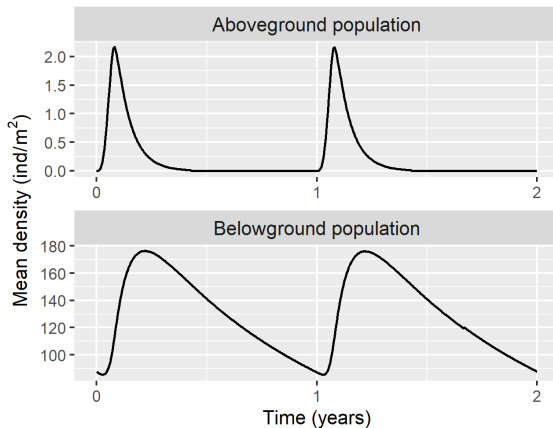


- ▶ 2 dynamic landscapes (Ω_1 and Ω_2) exhibiting the same duration of land use types (*composition*) but contrasted configurations over time.

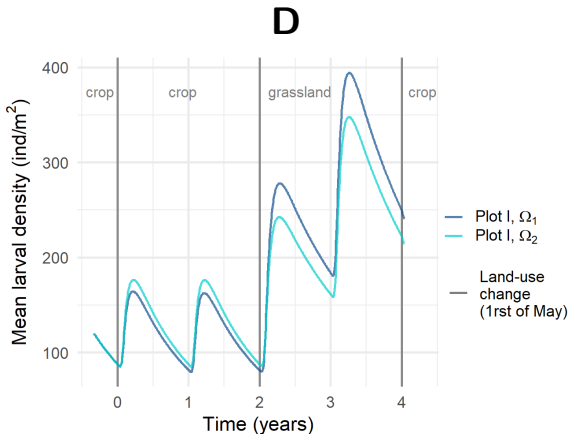
D



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A

- ▶ Stationary dynamics
- ▶ Oviposition
- ▶ Adult emergence
- ▶ Mortality

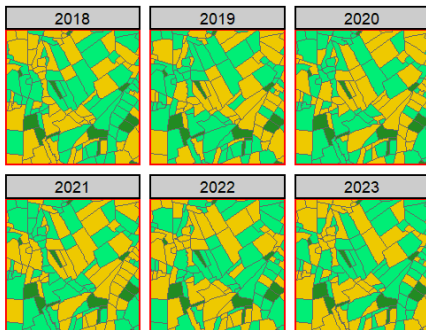


- ▶ $\approx 11\%$ difference in larval density at the end of the scenario (year 4)
- ▶ Results from contrasted scenarios of diffusive and advective motions over time

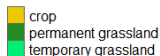
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- Exploration of suppressive patterns in realistic agricultural landscapes (i.e. generated under agronomic constraints at the farm or landscape scales)



Land use type:



Thank you for your attention!