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Ecology and Genetics of insects/ Démécologie

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Landscape dynamics
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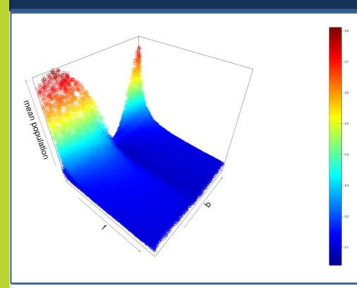
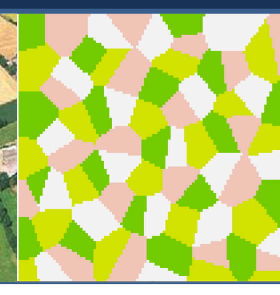
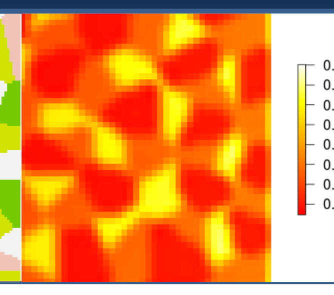
Modelling ecological processes and agricultural landscape dynamics to explore the biological for biological control

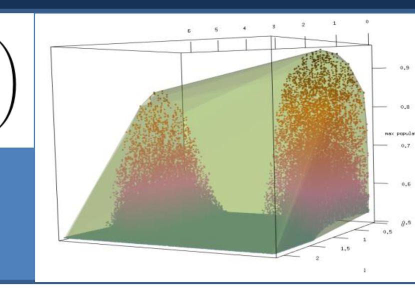






$$\frac{dN'(t')}{dt'} = N'(t')\sum_{i=1}^{M} p_i \left(1 - \frac{N'(t)}{(1 + a\cos(2\pi f't' - b - \lambda(i-1)))}\right)$$

$$\frac{\partial u}{\partial t} = \frac{\partial^2}{\partial x^2}\left(\mu(x,y)u\right) + \frac{\partial^2}{\partial y^2}\left(\mu(x,y)u\right)$$



Social-economic context

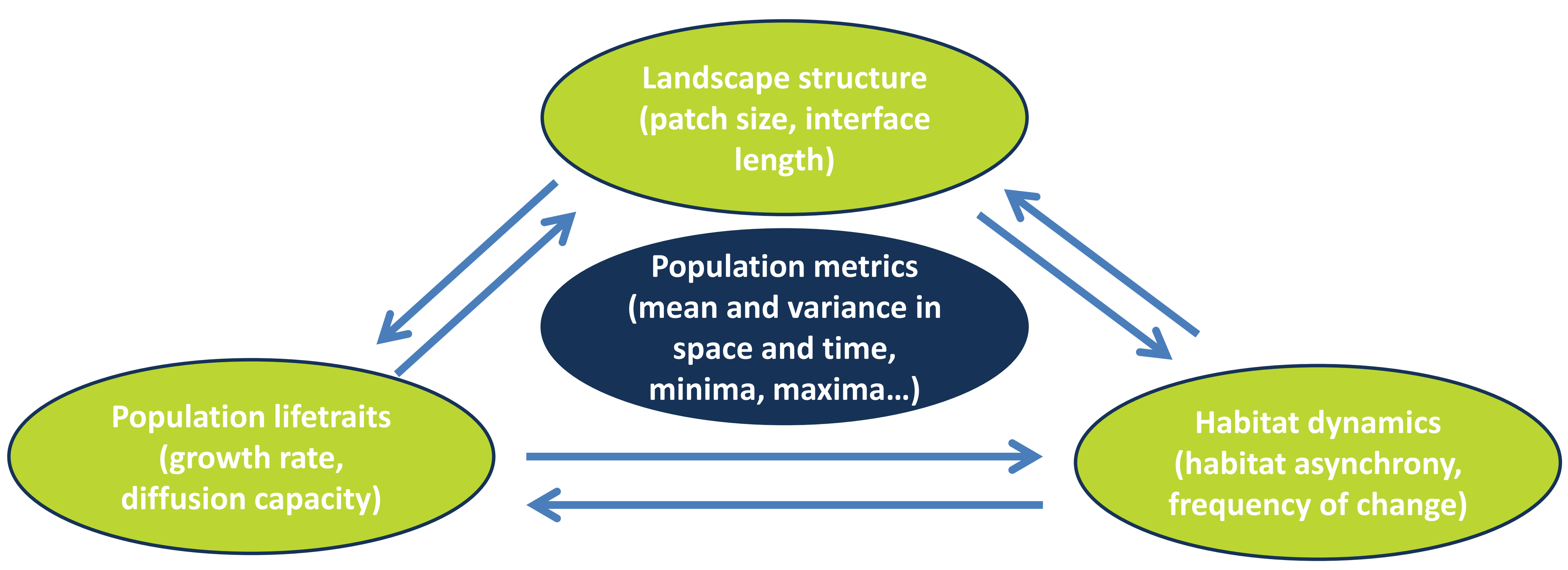
Pesticides side effects on the environment and human health call for a drastic reduction in their use. Promoting pest regulation by their natural enemies seems a promising alternative. However, much remains to be known about the link between landscape structures and insect population dynamics. In particular, the specificities of agricultural landscapes – highly heterogeneous and dynamic – and their influence on insect population dynamics remain poorly studied.

Scientific context

At the agricultural plot scale, habitat quality changes along with crop phenology. Different crops may have asynchronous habitat quality dynamics. Insect population thus have to move within the landscape to ensure resource continuity in space and time. Modeling studies linking landscape structure and population dynamics have mainly focused on static landscapes. Landscape fragmentation is seen as facilitating colonization but limiting long term persistence. We hypothesize that within a quickly fluctuating environment, increasing interface length between asynchronous patches should on the contrary favor species persistence as it allows individuals to reach a good quality habitat patch faster.

Objectives

By the means of numerical exploration of a coupled landscape/population model, we aim to link landscape structure, habitat dynamics and population life traits parameters with population metrics in space and time.



The landscape structure is generated by the tessellation of a Multitype Strauss Hardcore point pattern . An optimization process allows generating patch size and interface length gradients.

Population dynamics are modeled using a reaction diffusion model. The demographic component of the model is a logistic equation with a periodically time varying carrying capacity to take into account habitat fluctuation along with time. Parameters of the demographic model allow tuning the frequency of the habitats change and the asynchrony of habitats dynamics. Diffusion is modeled using a Fokker Planck diffusion equation.

A sensitivity analysis is conducted on the parameters of both the spatialized model and its non-spatial counterpart (mean field) to rank model parameters influences and their interactions on the population metrics.

The demographic and diffusion parameter bounds are based on the carabid beetle *P. melanarius* life-traits.

Results

Results on the non spatial model (mean field approach) highlight the importance of the frequency of habitat fluctuations. A frequently changing habitat in comparison to growth rate reduces population mean, maximum and minimum, as it does not allow the population to reach the maximum carrying capacity before the habitat quality decreases again.

Increasing asynchrony of the different habitat types has a negative impact on mean and maximum population. We expect a positive effect of asynchrony with the spatial version of the model.

Perspectives

Fokker Plank diffusion has been implemented in the model to take into account the spatial structure of the landscape.

Next step will be to run the spatial model on a gradient of landscapes differing by the interface length between asynchronous habitat to disentangle spatial and temporal components of landscape structure effects on population metrics.

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