

Background

Precision farming has the potential to reduce the impact of pesticides on the environment. Particularly, a more precise use of pesticides can result not only in a reduced pesticide load, but also in a spatially heterogeneous application pattern on the field scale. Accordingly, the effect of the pesticide on populations of non-target species might change. Spatially explicit effect modelling is a valuable tool for environmental risk assessments (ERA) of pesticides, which can also be applied when considering precision applications. Models allow a practical and cost-effective investigation of a multitude of application and exposure patterns, having the potential to optimize precision application patterns further, and increase understanding of actual effects on non-target in-field species populations like the common vole (*Microtus arvalis*).



Purpose: This hypothetical case study investigates the impact of spatially heterogeneous pesticide applications in agricultural fields on common vole populations



Scenarios and simulation settings

- We applied RIFCON's individual-based and spatially explicit population model *eVole* 3.1, which is frequently used in ERA for small mammals to understand the risks of pesticide applications on a field to landscape scale.
- We compared schematic precision application patterns of a pesticide, including spot and patch treatments.

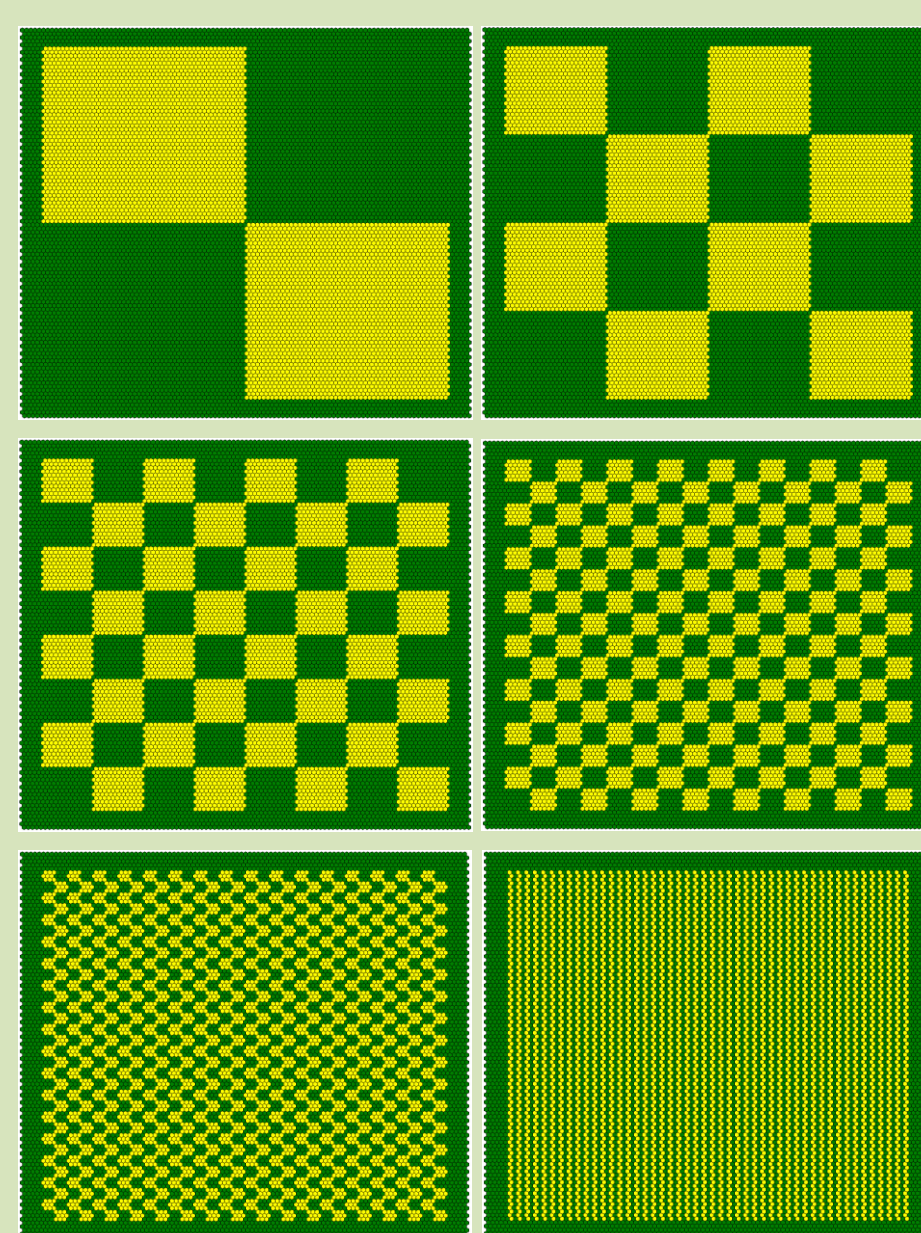


Figure 1: Different degrees of fragmentation in model landscapes (green: application free area; yellow: area with pesticide application).

Landscape scenario:

- Grassland vegetation dynamics with two mowing events.
- Gridded landscape of 25ha in total with a variation in degree of fragmentation of treated patches within the grassland field. The total size of the treated area remains constant (Fig. 1).

Pesticide application scenario:

- Application of a hypothetical fungicide that causes a litter size reduction effect described by a log-logistic dose-response curve.
- One single application per year with a different application date per scenario (set at the first of a month from April to September, respectively).
- Application rates range from nominal to 26x increased exposure (i.e. exposure multiplication factors (EMF) of 1, 2, 4, 8, 14, 20 and 26).

Each simulation consists of 10 years of warm-up, 10 years of treatment (one single application per year), and 10 years of post-treatment.

Results

The **magnitude and duration of effects** on vole populations depend on application rate and degree of fragmentation of the precision applications (Fig. 2):

- both magnitude and duration increase with increasing application rate
- for low application rates a high fragmentation is more beneficial for the vole population in terms of effect magnitude and duration
- at high application rates a low fragmentation results in the lowest magnitude and shortest duration of effects.

Proportion of food acquired from treated habitat (Fig. 3):

- a low fragmentation separates the population mainly in two groups: individuals that consume only food from the treated area and individuals that consume no food from the treated area
- at a high fragmentation a majority of individuals consume an average proportion of their diet from the treated area.

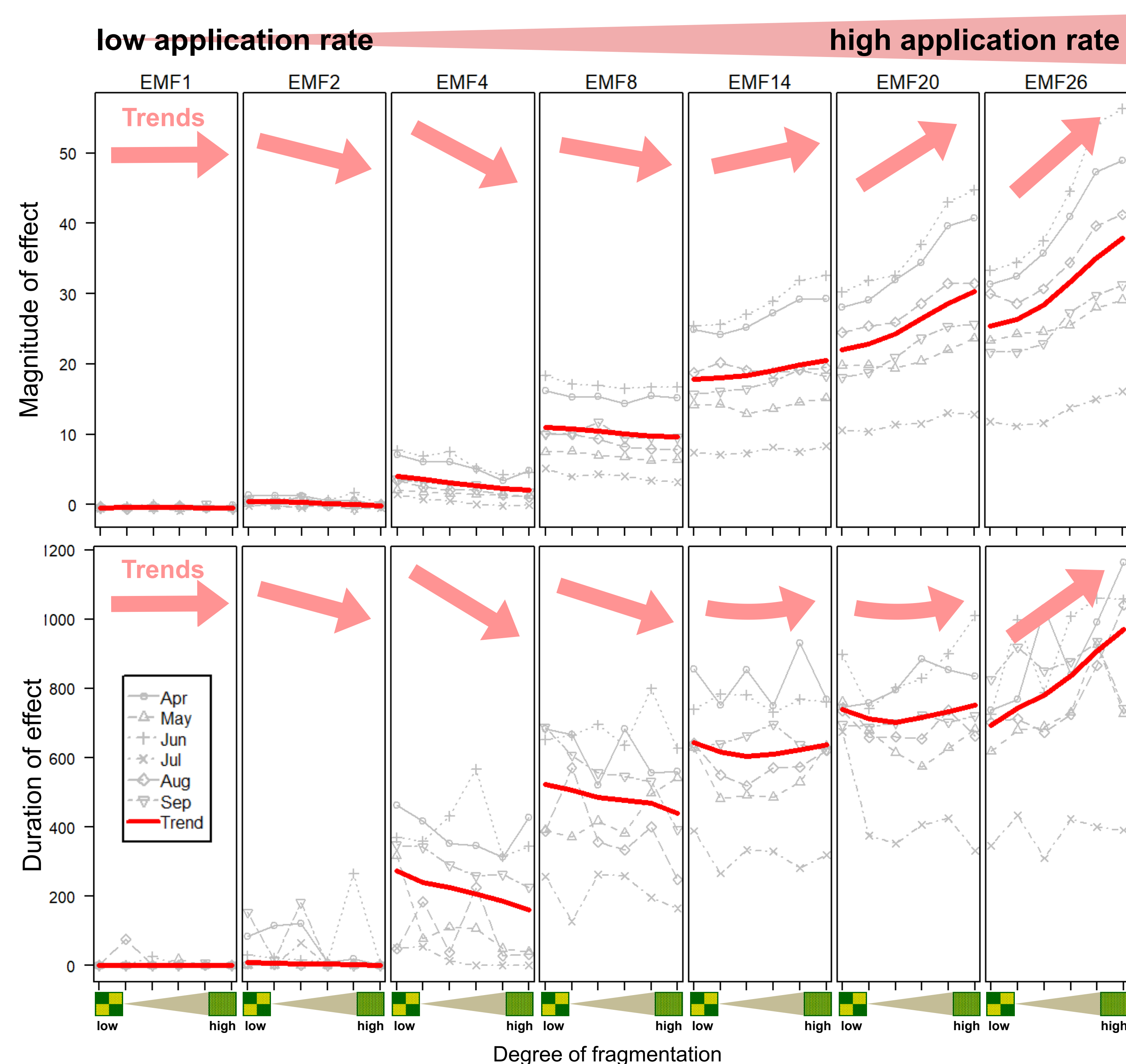


Figure 2: Magnitude and duration of the pesticide effect on the vole population depending on degree of fragmentation and application rate (i.e. exposure). Magnitude = maximum percentage difference below normal operating range (NOR); duration = days below NOR (both measures were calculated after last application).

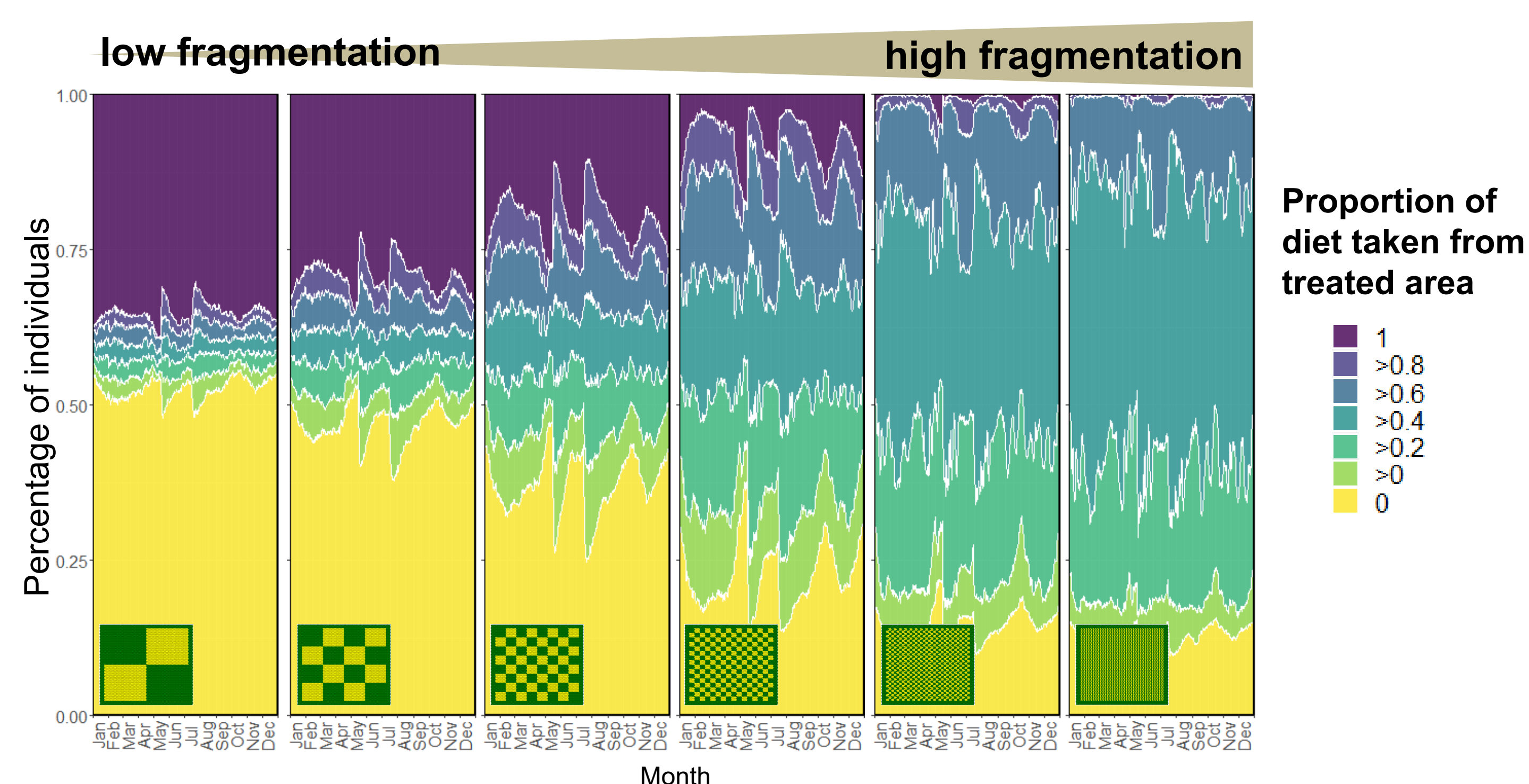


Figure 3: Distribution of the individuals' proportion of home range within treated area ranging from no diet taken from treated area (yellow) to 100% diet taken from treated area (violet).

Conclusion

- Our case study demonstrates the potential of spatially explicit effect models to investigate and optimise precision applications.
- There is a tipping point for the impact of the degree of fragmentation on exposed vole populations depending on application rate.
- The impact of the degree of fragmentation depends on the average home range size of a farmland species, which is in common voles small compared to other farmland mammals.
- Our modelling results provide cost-effective and valuable information to improve understanding of underlying mechanisms and support risk assessment and management, as well as complement field study approaches.