

# Heterogeneous landscapes and the role of refuge on the population dynamics of a specialist predator and its prey

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Received 10 February 2003; accepted 20 August 2003  
Evolutionary Ecology 17: 349–369, 2003.

**Abstract.** How, and where, a prey species survives predation by a specialist predator during low phases of population fluctuations or a cycle, and how the increase phase of prey population is initiated, are much-debated questions in population and theoretical ecology. The persistence of the prey species could be due mainly to habitats that act as refuges from predation and/or due to antipredatory behaviour of individuals. We present models for the former conjecture in two (and three) habitat systems with a specialist predator and its favoured prey. The model is based on dispersal of prey between habitats with high reproductive output but high risk of predation, and less productive habitats with relatively low risk of predation. We illustrate the predictions of our model using parameters from one of the most intriguing vertebrate predator-prey systems, the multi-annual population cycles of boreal voles and their predators. We suggest that cyclic population dynamics could result from a sequence of extinction and re-colonization events. Field voles (*Microtus agrestis*), a key vole species in the system, can be hunted to extinction in their preferred meadow habitat, but persist in sub-optimal wet habitats where their main predator, the least weasel (*Mustela nivalis nivalis*) has a low hunting efficiency. Re-colonization of favourable habitats would occur after the predator population crashes. At the local scale, the model suggests that the periodicity and amplitude of population cycles can be strongly influenced by the relative availability of risky and safe habitats for the prey. Furthermore, factors like intra-guild predation may lead to reduced predation pressure on field voles in sub-optimal habitats, which would act as a refuge for voles during the low phase of their population cycles. Elasticity analysis suggested that our model is quite robust to changes in most parameters but sensitive to changes in the population dynamics of field voles in the optimal grassland habitat, and to the maximum predation rate of weasels.

Key words: field vole, functional response, habitat selection, least weasel, predation, refuge, specialist