

# A sedentary population dynamics model in fragmented habitat: Local extinction by global density effect

分断された生息域における定住性個体群動態モデル：大域的密度効果による局所的絶滅

Hiromi Seno

東北大学大学院情報科学研究科

*Graduate School of Information Sciences, Tohoku University, Sendai, Japan*

`seno.math.is@tohoku.ac.jp`

On the population dynamics in a fragmented habitat with a number of local habitats, frequently referred to as a patchy habitat, many scientific researches considered the interaction of subpopulations (local populations) inhabiting those local habitats through their mobility to make possible some direct/indirect interaction between individuals of different local habitats. If the migrants can settle in the local habitat different from the original, the mobility causes the demographic change in the local habitat. In such a case, the density effect on the population dynamics in the local habitat is influenced by the migration too.

However this is not the case of sedentary population, population with sufficiently low mobility (very slow migration process in space), or with little interaction between individuals of different local habitats. In contrast to the interaction between individuals directly affecting the population dynamics, there could be an indirect interaction between individuals of different local habitats even for the sedentary population. We may consider an influence to the individual of a local habitat from the other local populations without direct interactions between individuals of different local habitats. For example, we may take account of the environmental degradation by living activities in the habitat, or the exploitative competition for the resource diffusing over the habitat.

We shall consider a single species population dynamics model for such a sedentary population in a fragmented habitat with patchy local habitats. No migration between local habitats occurs other than temporal visits with neither relation to reproductive activity nor significant density effect to the residential individuals. Individuals of a local habitat make the maturation and reproduction in the same habitat, and so do the offsprings born there. Every individual of a local habitat undergoes a negative density effect from the others of the same local habitat: *local (negative) density effect*. It is due to the intraspecific competition within each local habitat, which has a sufficiently short spatial scale of its influence only within the local habitat. The living activity of individuals causes an influence on the environment to get degraded, while the environmental condition potentially tends to recover. The environmental degradation affects the reproduction for every individual in all local habitats: *global (negative) density effect*. This global density effect introduces a kind of indirect intra-specific reaction within the population, which has a sufficiently long spatial scale of its influence over the habitat.

We construct a simple mathematical model with a system of ordinary differential equations which describes the population dynamics of every local population with local and global density effects. The results obtained by analyzing it, we will show the possibility of the extinction of a local population due to the global density effect. We will find a case where there would be a *keystone* local habitat such that its removal, that is, the extermination of its local population induces the persistence of all other populations, whereas its existence causes the extinction of some other local populations. Further we consider how the heterogeneity of local environments in local habitats is related to the equilibrium population size in the habitat, and try to discuss the better or worse management of the habitat design for the population conservation.