# Spatial scales of population synchrony in a two-competitors ecosystem model

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Harvesting and competition modify the spatial structure of population fluctuations of two competing species living in a stochastic environment. Here, we have obtained their characteristic spatial scales of population synchrony using a perturbative expansion around the deterministic equilibrium point [1].

Proportional harvesting always increases the spatial scale of the population synchrony of the harvested species (Figure 1). However, the effects of interspecific competition on the spatial scales are more involved, and in general depend on the environmental fluctuations, the dispersal capacities, and the growth rates of both species.

Furthermore, the strength of competition between the species may strongly modify the effects of harvesting on the spatial scaling. For example, harvesting of one species may affect the spatial distribution of unharvested and competing species.

These analytical results provide corrections to the unharvested single-species population synchrony spatial scale, which is known to be given by the environmental fluctuation spatial scale (Moran effect) [3] plus a term proportional to the quotient of the migration capacity and the rate of the return to equilibrium of the species [2].

[1] Javier Jarillo, Bernt-Erik Sæther, Steinar Engen, and Francisco J. Cao, *Effects of harvesting and strength of competition on spatial scales of population fluctuations of two competing species*, submitted (2017).

[2] Russel Lande, Steinar Engen, and Bernt-Erik Sæther, *Spatial Scale of Population Synchrony: Environmental Correlation versus Dispersal and Density Regulation*, Am. Nat. **154**(3), 271–281 (1999).

[3] Patrick Alfred Pierce Moran, *The statistical analysis of the Canadian Lynx cycle. II. Synchronization and Meteorology*, Aust. J. Zool. **1**(3), 291–298 (1953).
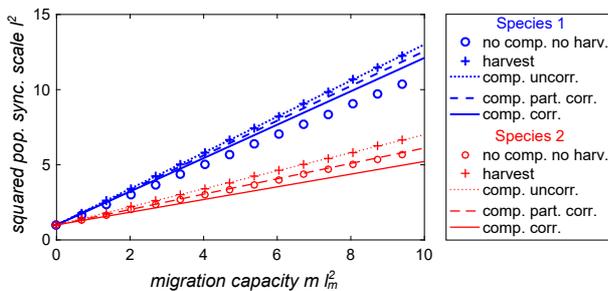
Figure 1: Square of the population synchrony spatial scale as function of the migration capacity for different cases: no competition and no harvesting (circles), only harvesting (pluses), and only competition (lines). The only competition case is represented for species with uncorrelated (dotted), partially correlated (dashed), and completely correlated (solid) environmental fluctuations. For the case with no competition and no harvesting, the squared spatial scales of population synchrony grow linearly with the migration capacity [2]. Harvesting and competition for species with uncorrelated environmental fluctuations always increase the spatial scales of both species. However, the effect of competition for species with correlated environmental noises is more involved. The curves depicted correspond to growth rates $r_1 = 1$, $r_2 = 2$; environmental fluctuations of the species with equal amplitudes, correlation functions, and spatial scales; equal competition strengths $\alpha_1^* = \alpha_2^* = 0.2$ (in the case of competition); and equal harvesting rates-growth rates ratios $\beta_1/r_1 = \beta_2/r_2 = 0.2$ (in the case of harvesting). Figure from Ref. [1].

If the environmental fluctuations are uncorrelated between the competing species, competition always increases the spatial scale of synchrony in the population fluctuations of both competitors. In contrast, if the environmental stochasticity is strongly correlated between the species, competition may increase the spatial synchrony of one or both species (Figure 1).