Appendix S1: Malthusian growth in two patches

The equation system (1) can be rewritten as:

$$\frac{d(N_1+N_2)}{dt}=r_1N_1+r_2N_2, \qquad \text{(A1a)}$$

$$\frac{d(N_1-N_2)}{dt}=(r_1N_1-r_2N_2)-2\beta(N_1-N_2). \qquad \text{(A1b)}$$

As $\beta\to\infty$, the mixing time scale becomes much faster than the demographic time scale. In the RHS of the second equation (A1b), the first term becomes negligible in front of the second one. Using $x=N_1-N_2$, this equation (A1b) becomes approximately

$$\frac{dx}{dt}=-2\beta x,$$

whose solution $x=x_0\,\mathrm{e}^{-2\beta t}$ tends to $x=0$, i.e., $N_1=N_2$. Replacing this solution $N_1=N_2=N_T/2$ into eq. (A1a) gives immediately eq. (2).

Appendix S2: Logistic growth in two patches

As in Appendix S1, the equation system (3) can be rewritten as:

$$\frac{d(N_1+N_2)}{dt}=r_1N_1+r_2N_2-\frac{r_1}{K_1}N_1^2-\frac{r_2}{K_2}N_2^2, \qquad \text{(A2a)}$$

$$\frac{d(N_1-N_2)}{dt}=\left(r_1N_1-r_2N_2-\frac{r_1}{K_1}N_1^2-\frac{r_2}{K_2}N_2^2\right)-2\beta(N_1-N_2). \qquad \text{(A2b)}$$

As explained in Appendix S1, the system can be simplified to a single equation when $\beta\to\infty$. With $N_1=N_2=N_T/2$, eq. (A2a) becomes:

$$\frac{dN_T}{dt}=\frac{r_1+r_2}{2}N_T-\frac{r_1}{K_1}\frac{N_T^2}{4}-\frac{r_2}{K_2}\frac{N_T^2}{4}, \qquad \text{(A3)}$$

which can be brought to the standard logistic form (4–5).

Appendix S3: Verhulst growth in two patches

As in Appendices S1 and S2, the equation system (8) can be rewritten as:

$$\frac{d(N_1+N_2)}{dt}=r_1N_1+r_2N_2-\alpha_1N_1^2-\alpha_2N_2^2, \tag{A4a}$$

$$\frac{d(N_1-N_2)}{dt}=\left(r_1N_1-r_2N_2-\alpha_1N_1^2-\alpha_2N_2^2\right)-2\beta(N_1-N_2). \tag{A4b}$$

As explained in Appendices S1 and S2, time scale arguments lead to a single equation when $\beta\to\infty$. With $N_1=N_2=N_T/2$, eq. (A4a) becomes:

$$\frac{dN_T}{dt}=\frac{r_1+r_2}{2}N_T-\frac{1}{2}\cdot\frac{\alpha_1+\alpha_2}{2}N_T^2, \tag{A5}$$

which can be written in the standard Verhulst form (9).