Ecography

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Supplementary material

Appendix 1

Model and simulation methods

We calculated population density profiles ρ along the propagation direction y as the average density profiles for non-reproductive (ρ_{1}) and reproductive individuals (ρ_{2}).

$$\rho_1\ (y,t)=\frac{1}{L_x}\sum_{x=1}^{Lx}\left[\Theta(a_{x,y}(t))-\Theta(a_{x,t}(t)-t_m)\right]$$

$$\rho_2\ (y,t)=\frac{1}{L_x}\sum_{x=1}^{Lx}\Theta(a_{x,y}(t)-t_m)$$

where $a_{x,y}$ is the age of an invader located at a cell whose coordinates in the grid are (x,y) and Θ (x) is given by

$$\Theta(x)\begin{cases}1\ if\ \ x>0,\\0\ if\ \ x\le 0\end{cases}$$

ρ_1 and ρ_2 give us the average density profiles for non-reproductive and reproductive individuals respectively.

Interactive case

To work with several species we incorporate interactions between them by coupling the cellular automata through dynamical interacting rules. A species can colonise a new grid cell, or outcompete another during the interacting process. Unless a particular resource is explicitly considered, competition occurs in an ample sense as competition by space. The interacting rules are the following:

a) A given cell cannot be occupied by individuals of different species at the same time.

b) In an empty cell we compute the probability of colonisation by different species and compare them with independent random numbers sorted for each one. If only one species succeeds the dynamics are that of a single species. If more than one species succeed the winner is sorted with some probability that depends on the particular set of species under consideration. If all the species make a similar use of the environmental resources then the winner is sorted with equal probability among the occurring species at the cell.

c) If different species make different use of the environmental resources then new parameters are incorporated into the model. Consider for instance the case of two species, where one of them has an especial ability to establish in shallow soils and rock crevices compared to the other. We introduce a soil state parameter c_i for each cell $_i$, which can take the values 0 and 1, representing a rocky ground and a deep soil cell, respectively. These parameters are sorted with some spatial distribution at the beginning of the simulation and kept fixed through it. We introduce the following competition rule: if c_i = 1 the winner is sorted with equal probability but, if ci = 0, then the species with the especial ability soil occupation always succeeds in colonising the cell. For more details please see Cannas et al. (2003).

References

Cannas, S. A. et al. 2003. Modelling biological invasions: species traits, species interactions and habitat heterogeneity. – Math. Biosci. 183: 93–110.

Marco, D. and Páez, S. 2000. Invasion of *Gleditsia triacanthos* in *Lithraea ternifolia* montane forests of central Argentina. – Environ. Manage. 26: 409–419.

Marco, D. E. et al. 2002. Species invasiveness in biological invasions: a modelling approach. – Biol. Invasions 4: 193–205.

Marco et al. 2008. Comparable ecological dynamics underlie early cancer invasion and species dispersal, involving self-organizing processes. – J. Theor. Biol. 256: 65–75.

Table A1. Values of life history parameters for the species considered in the model. Life history traits included are: d, mean seed dispersal distance, t_{max}, maximum longevity, q, annual adult survival probability, t_m, age of reproductive maturity, n, mean seed production, f_g, mean germination probability, P_n, juvenile survival probability, and t_j, average age of saplings in the juvenile bank.

Parameter	*L. ternifolia*	*F. coco*	*G. triacanthos*	*L. lucidum*	*U. minor*
d (lattice units)	1	1	3	6	5
t_{max} (yr)	140	40	75	75	200
q	0.98	0.93	0.96	0.96	0.96
t_m (yr)	20	5	7	6	15–30
n (seeds/plant)	6000	6000	14000	15000	14000
f_g	0.01	0.2	0.2	0.4	0.2
P_n	0.3	0.5	0.4	0.8	0.4
t_j (yr)	0	0	5	5	0

Sources: Marco and Paez (2000), Marco et al. (2002, 2008), Cannas et al. (2003).

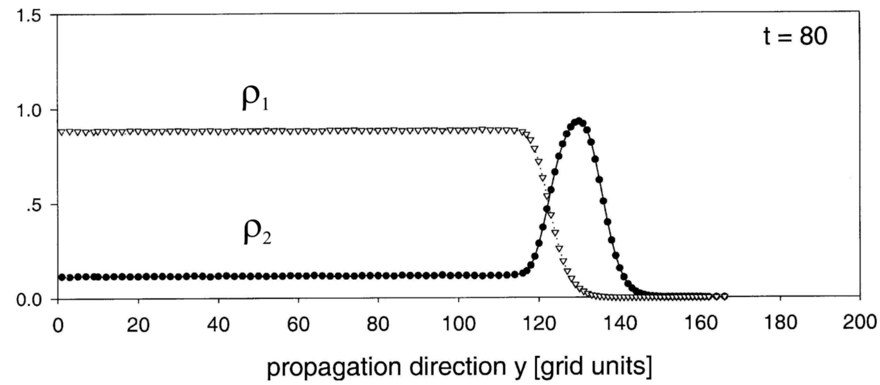

Figure A1. Average population density profiles for *G. triacanthos* spread in a rectangular simulation area of width Lx ¼ 100 at t = 80 yr. ρ_1 = non-reproductive individuals, ρ_2 = reproductive individuals, showing the travelling wave structure.