



Competitive niche: Way of population regulation

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Niche theory, what is it?

Statements to specify:

- Species partition an abstract “niche space” of the ecological possibilities among themselves.
- They are able to coexist, i.e. to avoid competitive exclusion, exactly because they partition that space.

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❖ Niche theory, what is it?

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Statements to specify:

- Species partition an abstract “niche space” of the ecological possibilities among themselves.
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Questions to answer:

- What is the niche space to partition?
- How to define the niche of a species within that space?
- What is the precise relation between niche partitioning and coexistence?



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Statements to specify:

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Ways of niche segregation to deal with:

- functional (e.g. resource partitioning)
- spatial/habitat (e.g. environmental gradient)
- temporal (e.g. successional)



Overview of the lecture

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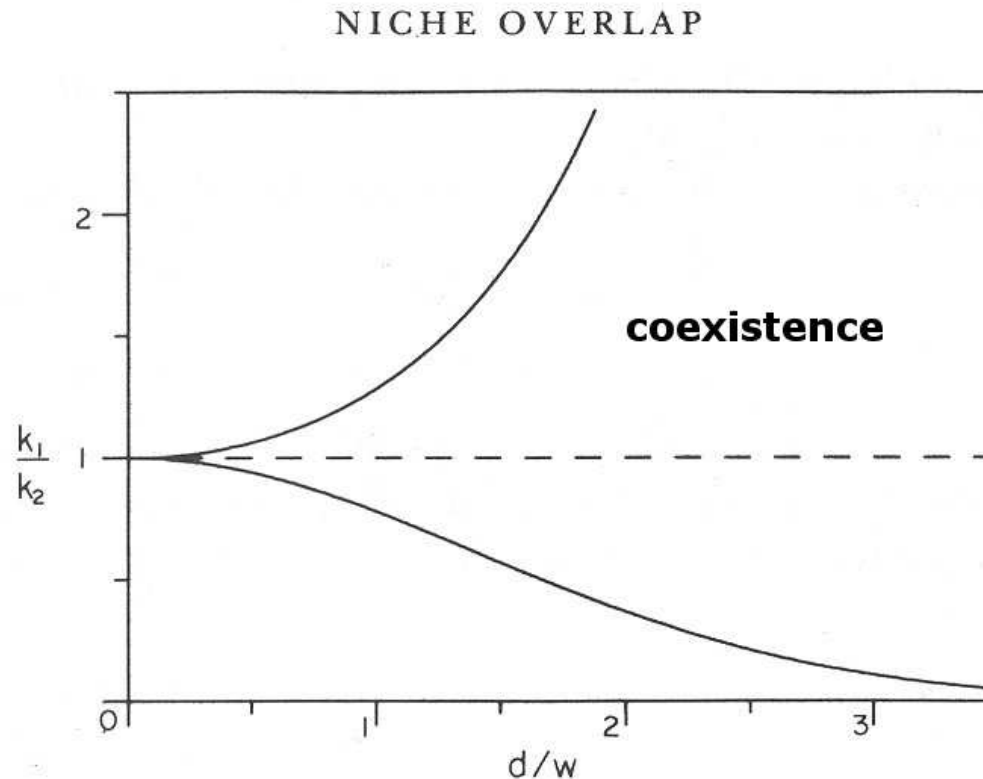


FIGURE 6.4. The resource spectrum shapes (characterized by k_1/k_2) which allow a 2-species equilibrium configuration, as a function of degree of niche overlap, d/w . The permissible range of shape parameters lies between the two solid curves. The dashed line indicates the shape which equalizes the two equilibrium populations. See text for further details.

Robert M. May (1973)

Stability and complexity

in model ecosystems

p. 158



Robust coexistence

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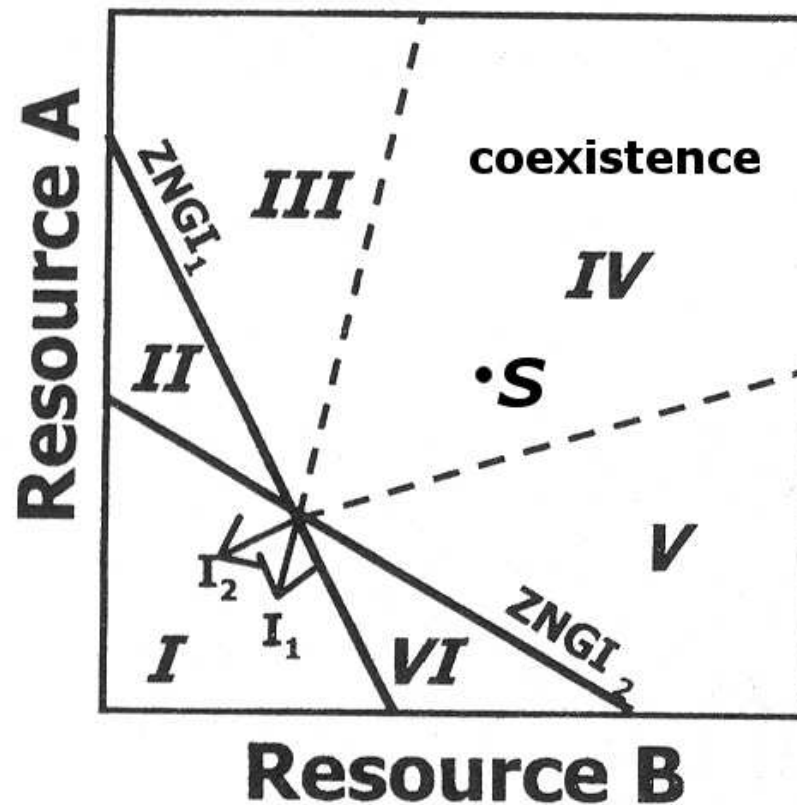
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Tilman's model

from:

Chase & Leibold (2003)

Ecological niches:

linking classical and

contemporary approaches



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Regulating loop

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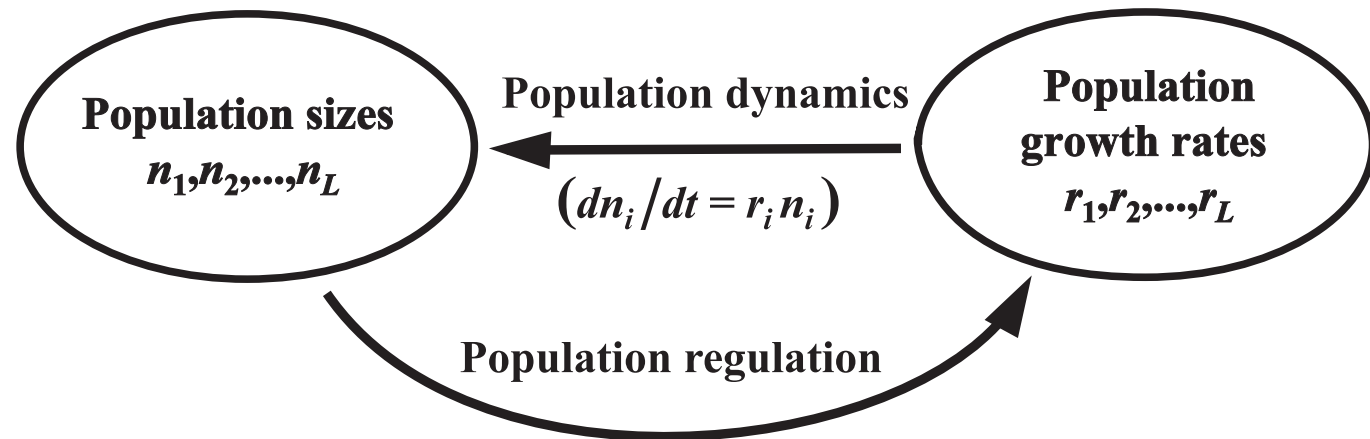
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Meszéna, Gyllenberg, Pásztor & Metz, 2006:

Competitive exclusion and limiting similarity: a unified theory. TPB **69**: 68-87



Regulating loop

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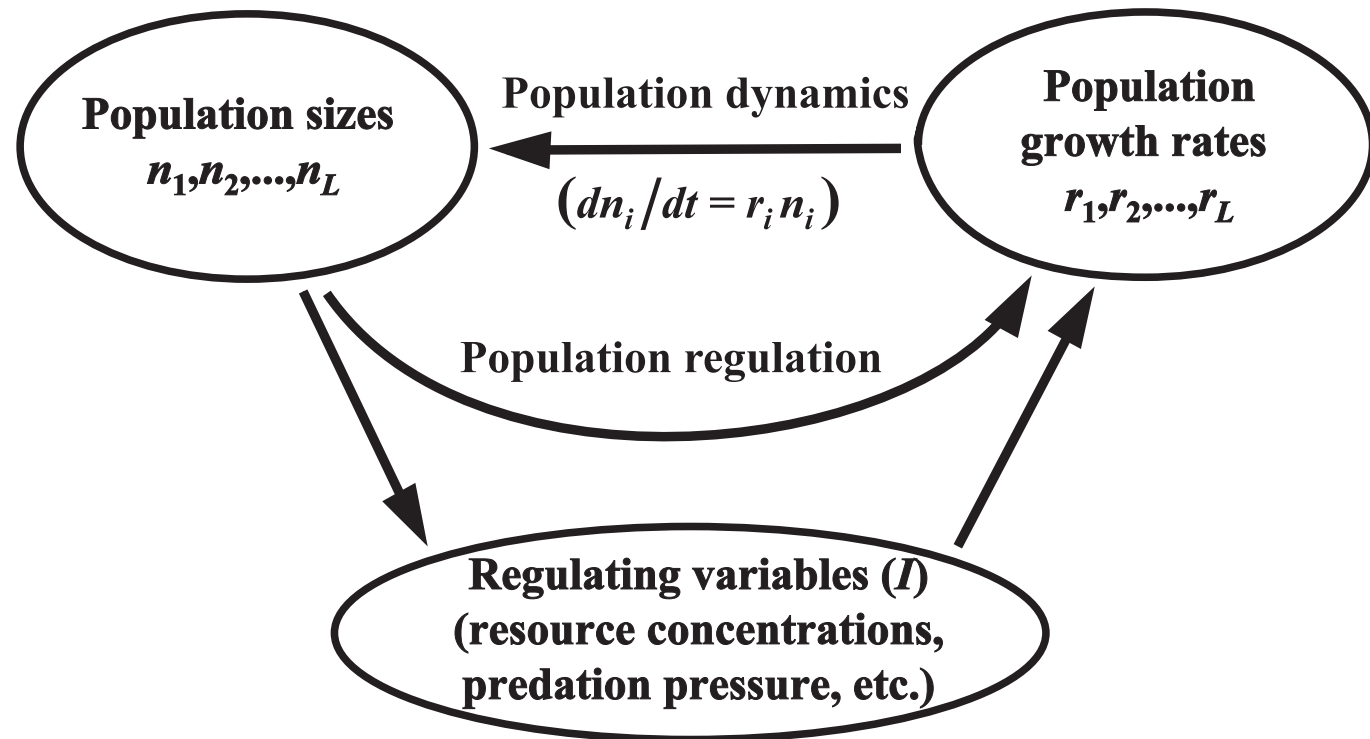
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Regulating loop

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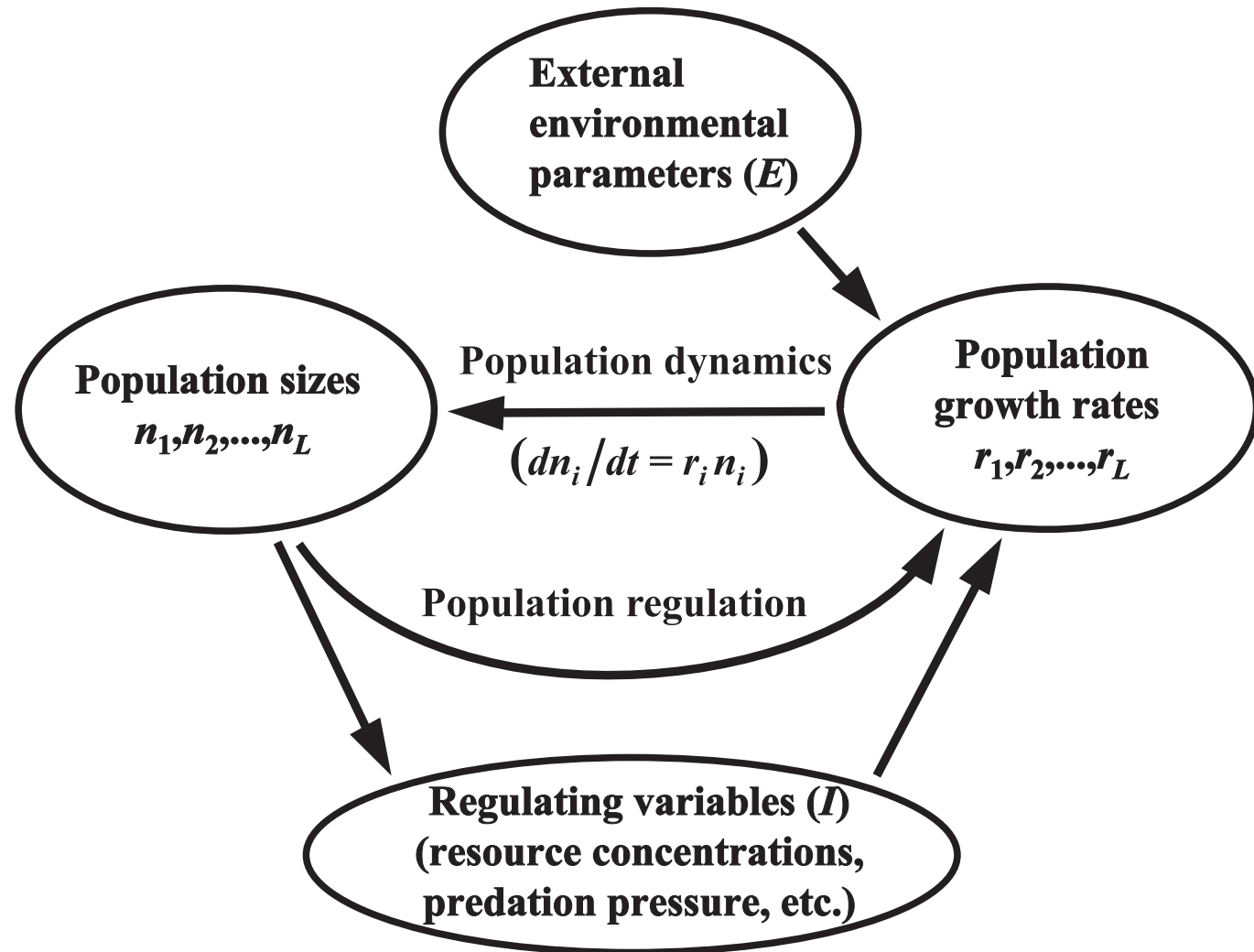
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Regulating loop

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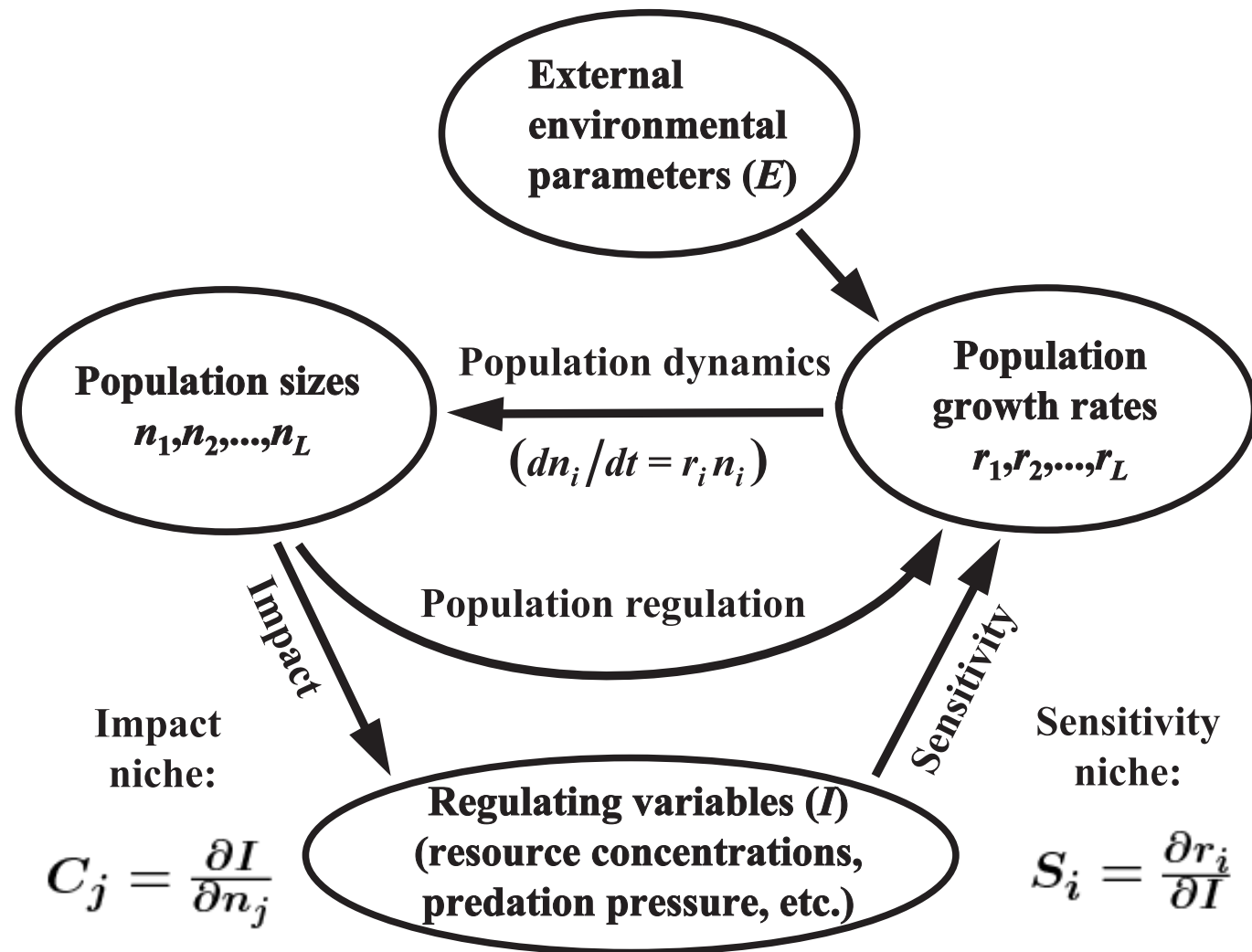
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Robust coexistence requires segregation with respect to the regulating variables.

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$$r_i(\mathbf{E}, \mathbf{I}(n_1, n_2, \dots, n_L)) = 0$$

$$\begin{aligned} \frac{d\mathbf{n}}{d\mathbf{E}} &= - \left(\frac{\partial \mathbf{r}}{\partial \mathbf{n}} \right)^{-1} \cdot \frac{\partial \mathbf{r}}{\partial \mathbf{E}} = \\ &= - \frac{\mathbf{M}}{\det \left(\frac{\partial r_i}{\partial n_j} \right)} \cdot \frac{\partial \mathbf{r}}{\partial \mathbf{E}} \end{aligned}$$

$$\begin{aligned} J &= \det \left(\frac{\partial r_i}{\partial n_j} \right) = \det (\mathbf{S}_i \cdot \mathbf{C}_j) \\ |J| &\leq \mathcal{V}_S \cdot \mathcal{V}_C \end{aligned}$$

$$\begin{aligned} \mathcal{V}_S &= |\mathbf{S}_1 \wedge \mathbf{S}_2 \wedge \dots \wedge \mathbf{S}_L| \\ \mathcal{V}_C &= |\mathbf{C}_1 \wedge \mathbf{C}_2 \wedge \dots \wedge \mathbf{C}_L| \end{aligned}$$



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Robust coexistence requires segregation with respect to the regulating variables.

Therefore, the niche space should be identified with the **set** of regulating variables.

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Segregation is measured by differentiation of the impact and the sensitivity niches.

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Therefore, the niche space should be identified with the **set** of regulating variables.

Segregation is measured by differentiation of the impact and the sensitivity niches.

Therefore, the niche of species i should be identified with the pair (C_i, S_i) .

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- ❖ Spatial segregation
- ❖ Functional & spatial segregation
- ❖ Temporal segregation

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Spatial segregation

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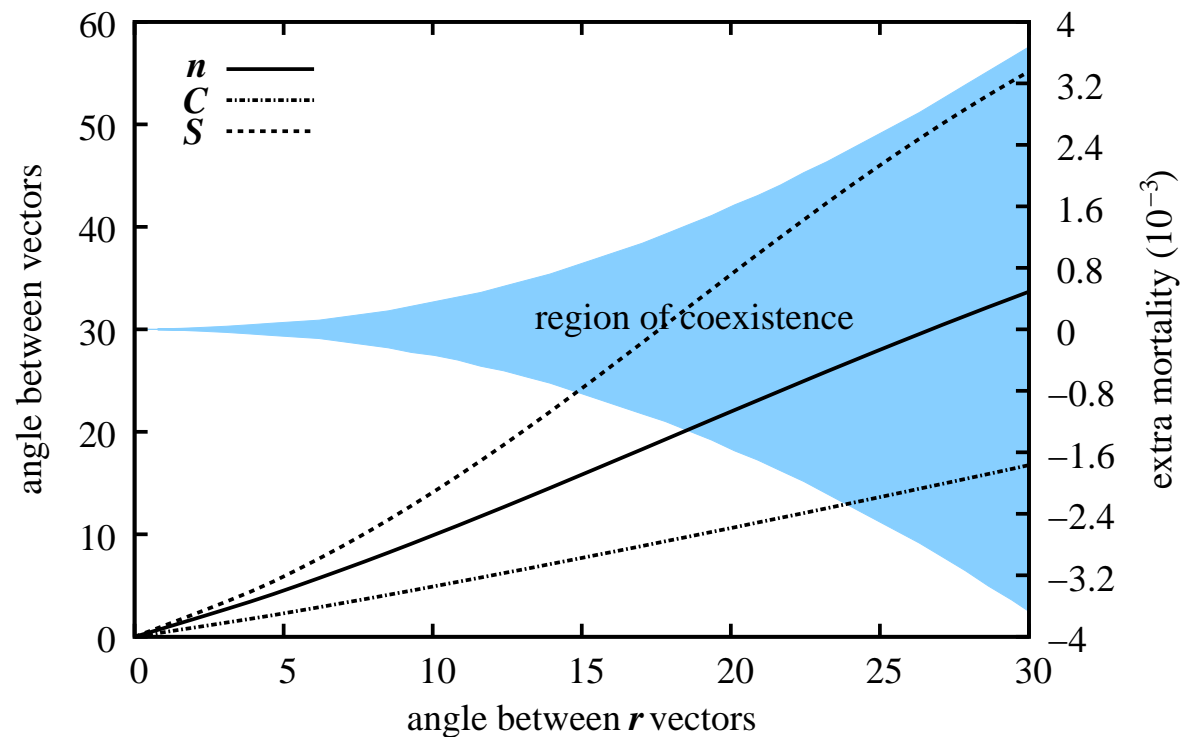
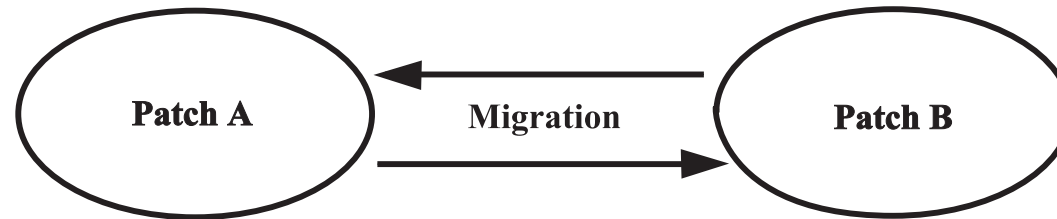
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Szilágyi & Meszéna:

Two-patch model of spatial niche segregation. *Evol. Ecol.*, *in press*



Spatial segregation

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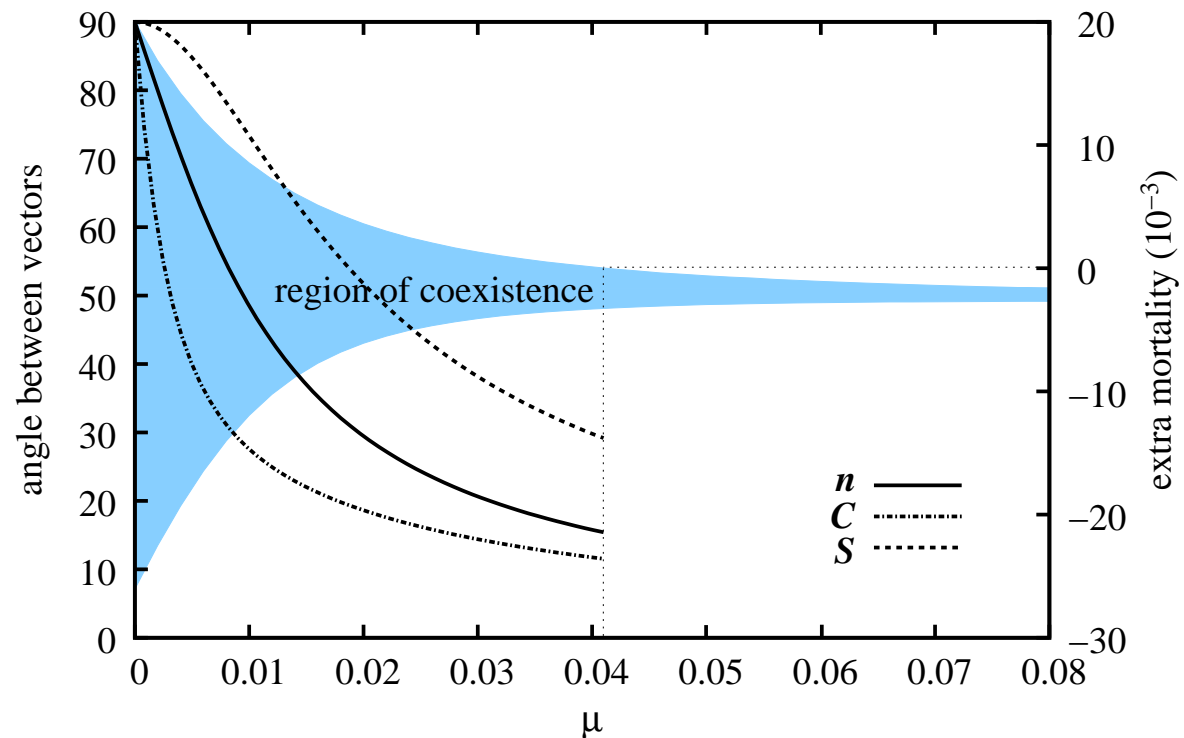
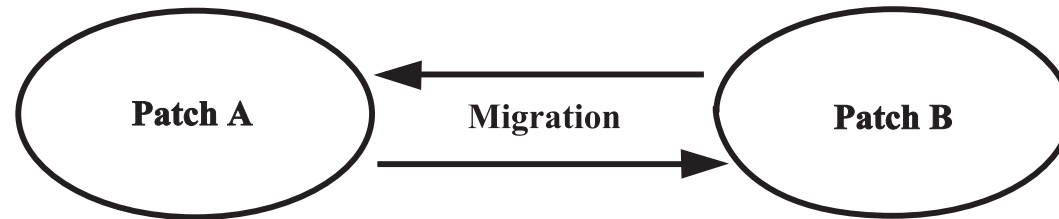
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Functional & spatial

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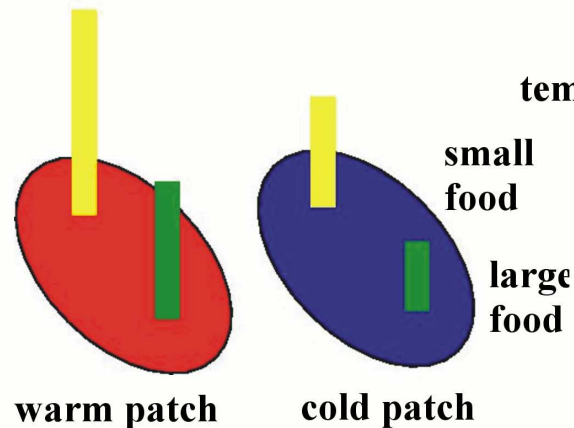
❖ Spatial segregation

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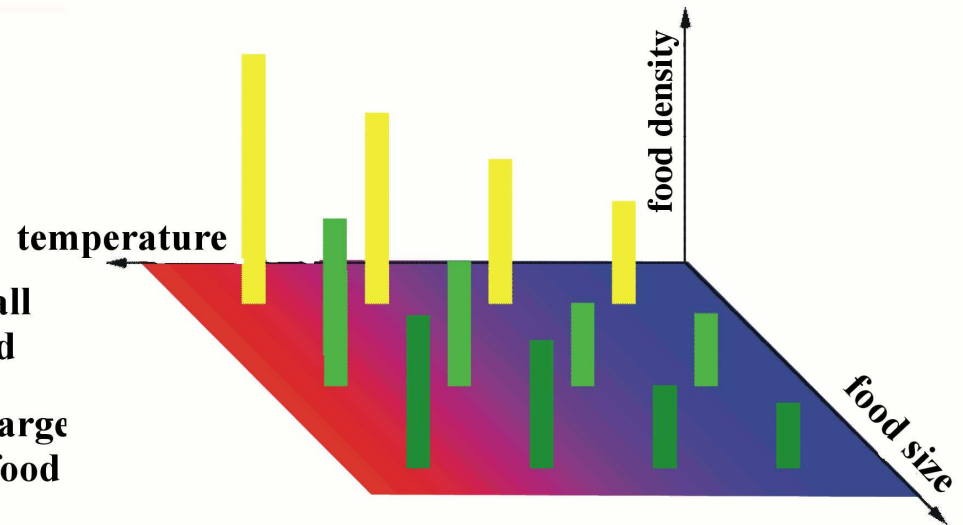
❖ Temporal segregation

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Discrete



Continuous



4 elements ← niche space → 2D continuum

RED-BLUE: temperature (spatial segregation)

YELLOW-GREEN: food size (functional segregation)

Do not confuse the niche space with the space of regulating variables!

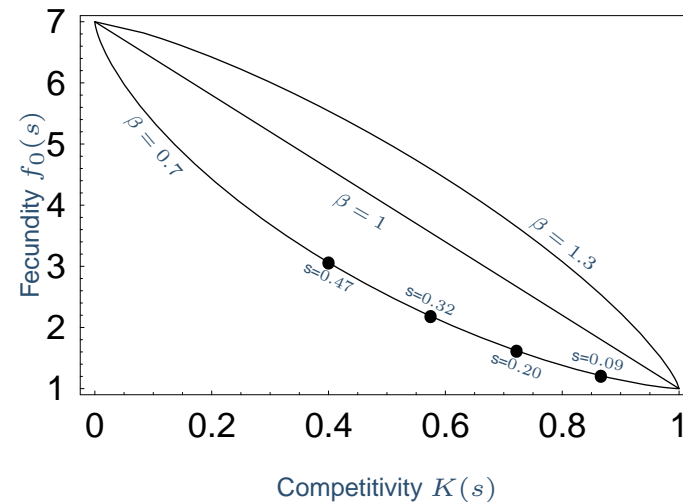


Temporal/successional

Structured metapopulation:

local population size has a dynamics also!

Random local catastrophes with rate μ .



Strategy: s

Trade-off:

Competitiveness: $K(s) = (1 - s)^{1/\beta}$

Fecundity: $f_0(s) = 1 + \gamma s^{1/\beta}$

Density dependent fecundity:

$$f\left(s, \sum N\right) = f_0(s) \exp\left(-\frac{\sum N}{K(s)} \ln f_0(s)\right)$$

Parvinen & Meszéna:

Disturbance-generated niche-segregation in a structured metapopulation model. *in prep.*



Local succession

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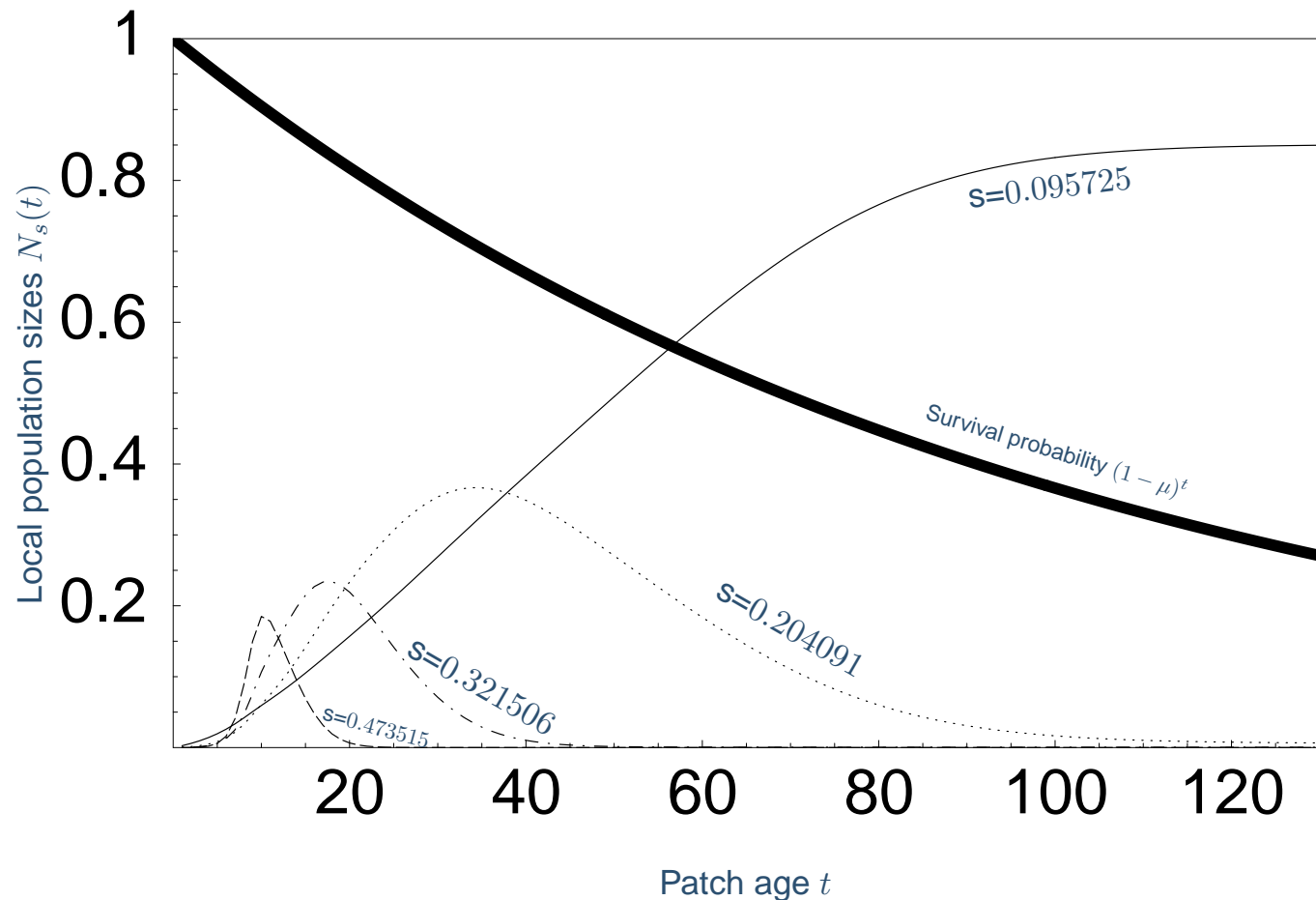
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Regulating variable: local density – for all patch ages.
Niche axis: patch age.



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What is niche space?

The *set* of the regulating factors.
(Discrete, or continuous, not only resources!)



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What specifies the niche of a species?

The way the population is regulated:
the pair of impact and sensitivity niches (C_i, S_i) .



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What is the condition for coexistence?

Robust coexistence requires the segregation of the niches.
Large niche-overlap makes the coexistence unlikely.



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Generality

Discrete and continuous, competitive and non-competitive interactions, equilibrium and non-equilibrium are handled together!



Morale

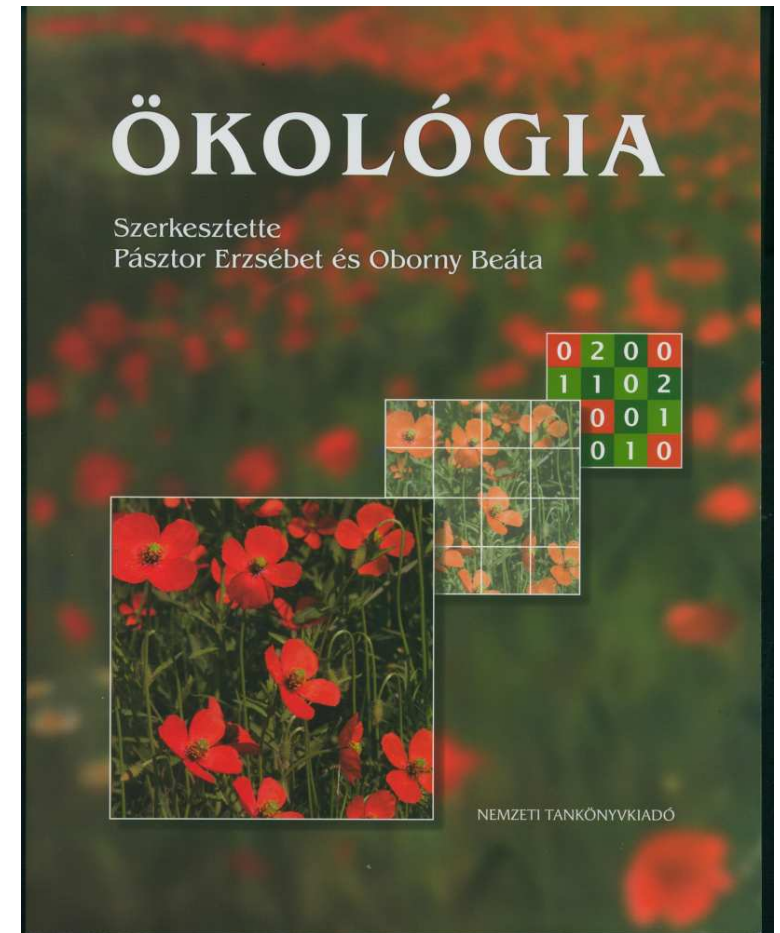
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It is possible to have a consistent view of ecology, based on first principles.





Thanks to

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- György Barabás
- Mats Gyllenberg
- Hans Metz
- Péter Szabó
- Dávid Völgyes