Structural stability = niche segregation

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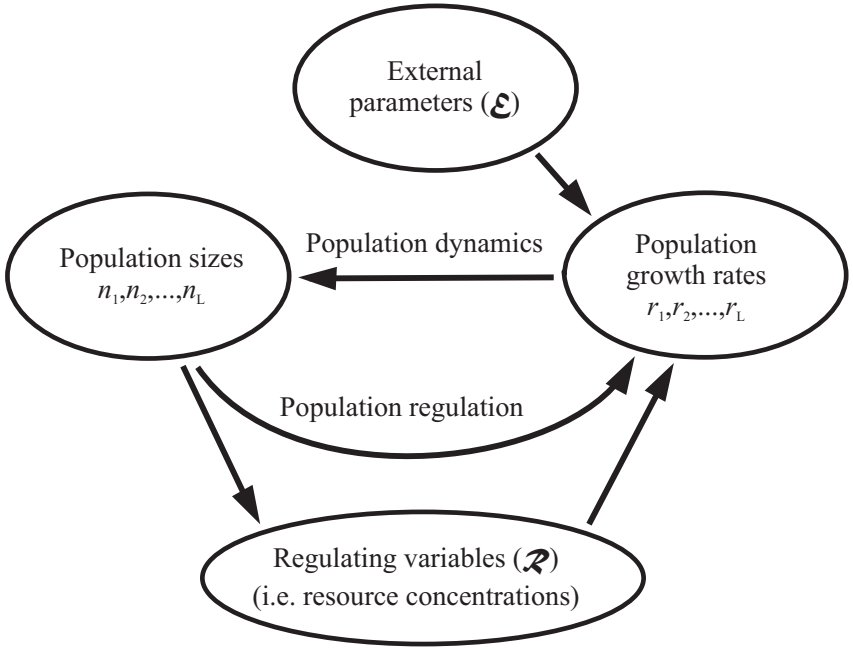
Steps from LV & classical niche to modern theory

1. Resources ⇒ Regulating variables
2. Lotka Volterra ⇒ linearization of dynamics
3. Resource utilization ⇒ impact & sensitivity
4. Limit of similarity ⇒ Robustness of coexistence



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Any model can be linearized!

Lotka-Volterra competition:

$$r_i = r_{0i} - \sum_j a_{ij} n_j$$

Generalized competition coefficient:

$$a_{ij} = -\frac{\partial r_i}{\partial n_j}$$

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Classical niche theory (*ad hoc*):

$$a_{ij} \sim \sum_k u_{ik} u_{jk}$$

Resource utilization

Proposed theory (derived):

$$-a_{ij} = \frac{\partial r_i}{\partial n_j} = \sum_k \frac{\partial r_i}{\partial \mathcal{R}_k} \frac{\partial \mathcal{R}_k}{\partial n_j} = \boldsymbol{S}_i \cdot \boldsymbol{I}_j$$

Sensitivity of Species i

Impact of Species j

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Equilibrium:

$$\boldsymbol{r}(\boldsymbol{\mathcal{R}}(\boldsymbol{n}), \boldsymbol{\mathcal{M}}) = 0$$

Perturbation:

$$\frac{\partial \boldsymbol{n}}{\partial \boldsymbol{\mathcal{M}}} = \boldsymbol{a}^{-1} \frac{\partial \boldsymbol{r}}{\partial \boldsymbol{\mathcal{M}}}$$

Robustness:

$$\det \boldsymbol{a} = \det(\boldsymbol{S}_i \boldsymbol{I}_j)$$

must be large!

⇒ Species should be different!

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   Regulating variables
2. Lotka Volterra $\Rightarrow$
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   impact & sensitivity
4. Limit of similarity $\Rightarrow$
   Robustness of coexistence

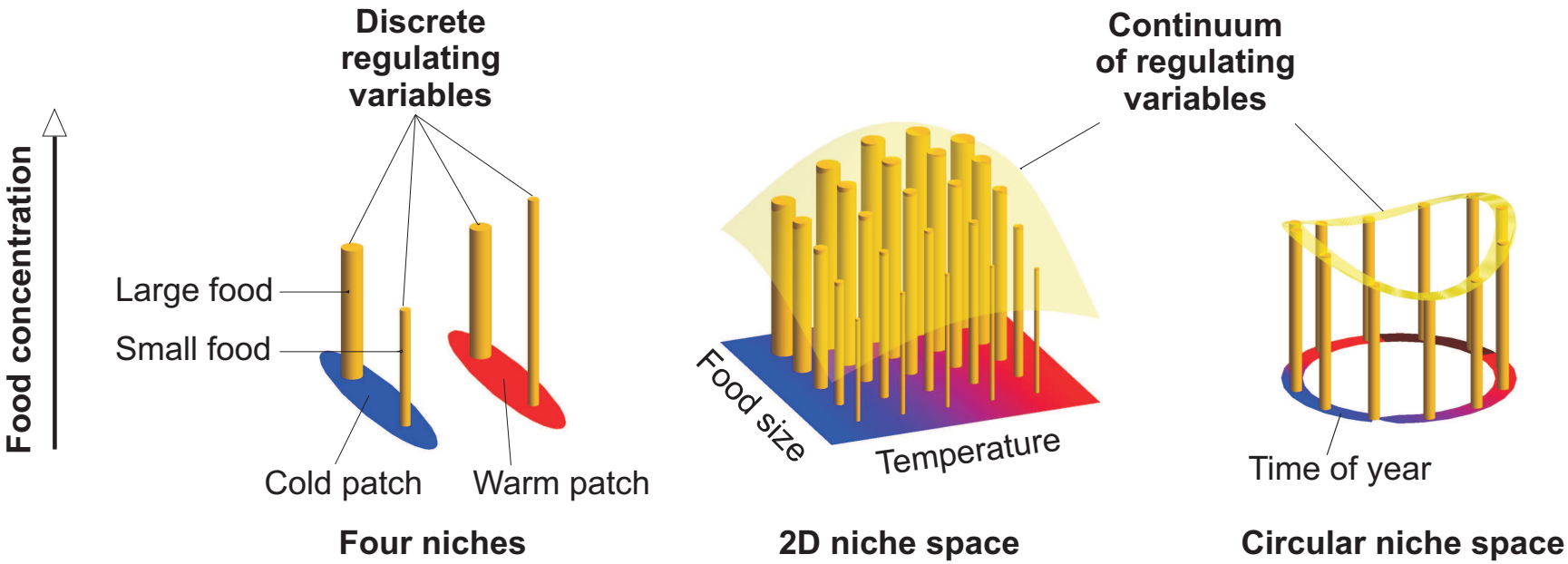
Larger similarity in
*I*mpact or *S*ensitivity
$\Downarrow$
Weaker robustness
of coexistence

No absolute limit of similarity!

Coexistence of a continuum is
struturally unsable!

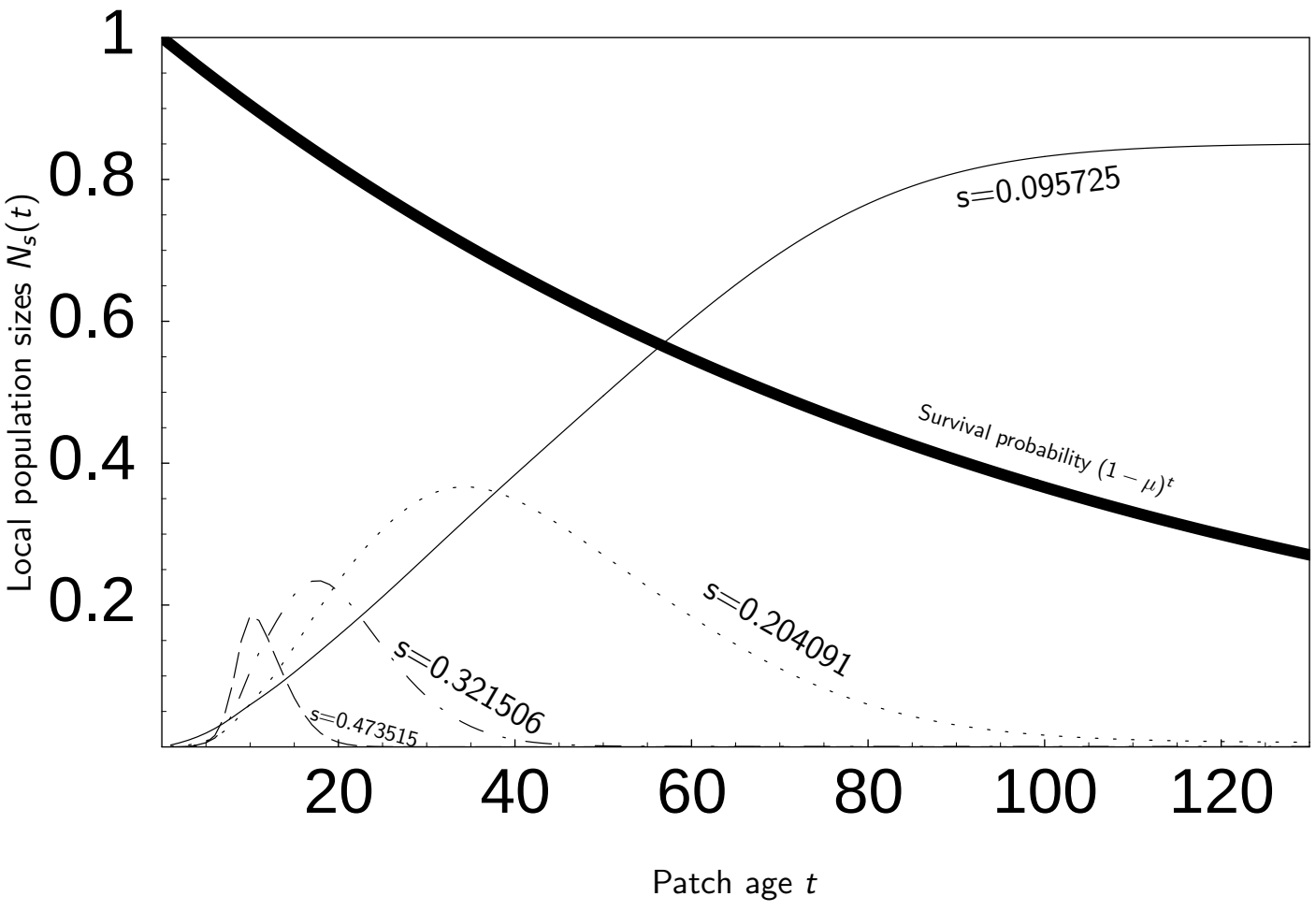
Niche space: Ways of niche segregation

Varieties for niche space:

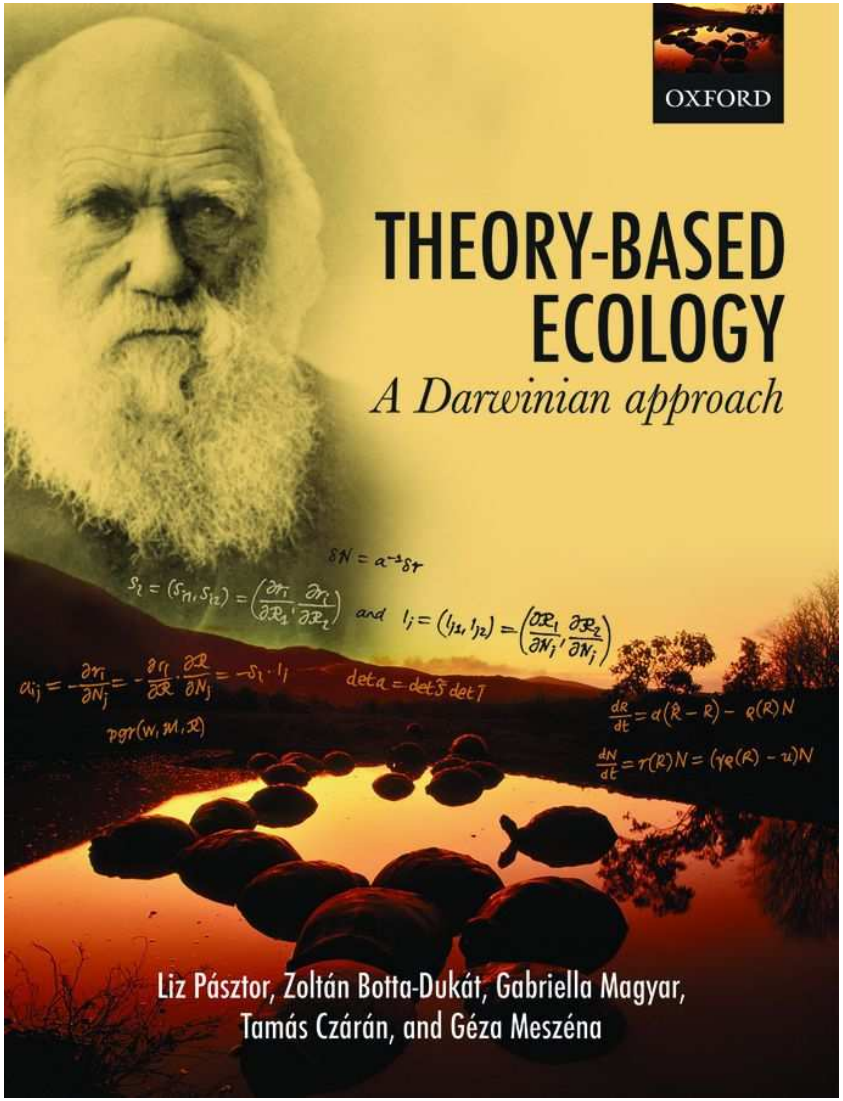


Niche space: *index set* of regulating variables.
Not necessarily an Euclidean space of a few dimension!

Species succession within a patch



Theory-Based Ecology: A Darwinian approach



Principles

1. Exponential growth
2. Growth regulation
3. Inherited variability
4. Finitness – stochasticity
5. Competitive exclusion
6. Coexistence
7. Constraints – trade-offs

My take

Ecosystem = a random assemblage of random species?

NO!

Species are adapted to their own niches
– determined by the community.