Feasibility and Resilience in Randomly Assembled Communities

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The stability of ecological communities is essential for the maintenance of natural ecosystems. However, stability has many different aspects which interplay is not straightforward.

We constructed random interaction matrices using ecologically relevant parameters and investigated the effects of ecological variables on the **Feasibility and Resilience** of the community.

We assumed generalized Lotka-Volterra Dynamics:

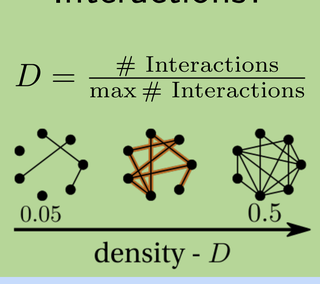
$$\frac{\mathrm{d}\vec{X}}{\mathrm{d}t} = \mathrm{diag}(\vec{X})\left(\vec{r} + \mathbf{A}\vec{X}\right)$$

How many Populations?

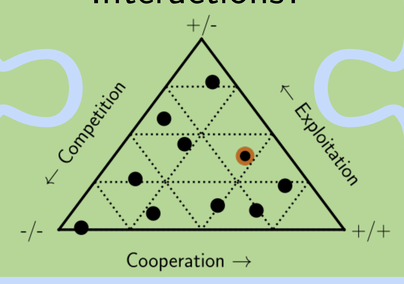
$N = 50$

How many Interactions?

$D = \frac{\#\ \text{Interactions}}{\max \#\ \text{Interactions}}$

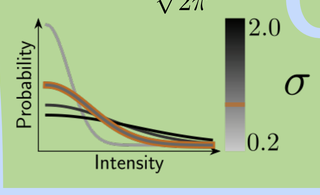


Which Interactions?



How intense?

$P(x) = \frac{e^{-\frac{x^2}{2\sigma^2}}}{\sqrt{2\pi}}$



... we randomize...

40 000 different choice of parameters

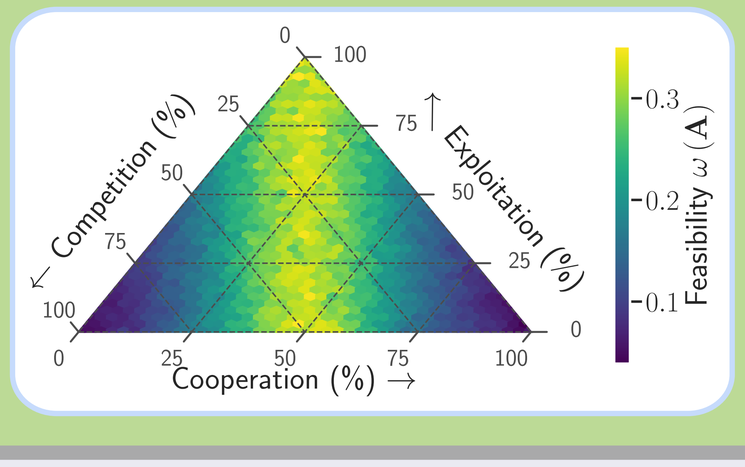
10 replicates for each choice

.... 400 000 simulations

Matrix of Interaction

$$\begin{bmatrix} -1. & -0.3 & 0. & \cdots \\ -1.6 & -1. & 0.8 & \cdots \\ 0. & 0.03 & -1. & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

Communities with Equal Proportions of Competitive and Cooperative Interactions are More Feasible



Feasibility: An ecological community is feasible in a given set of (a)biotic conditions if its underlying dynamics have an equilibrium point under which all populations have positive abundances (Song et al. 2018).

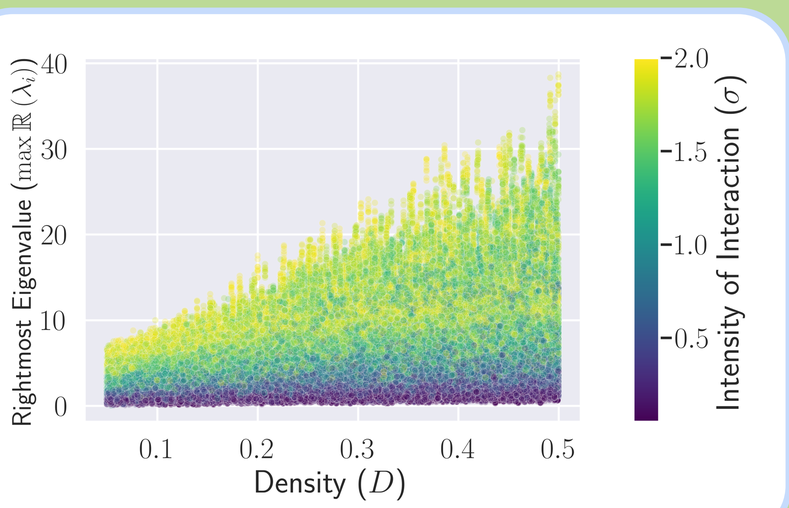
We measure feasibility as the average probability ($\omega(\mathbf{A})$) that a randomly chosen species has positive abundance at the equilibrium if the populations' growth rates are randomly distributed.

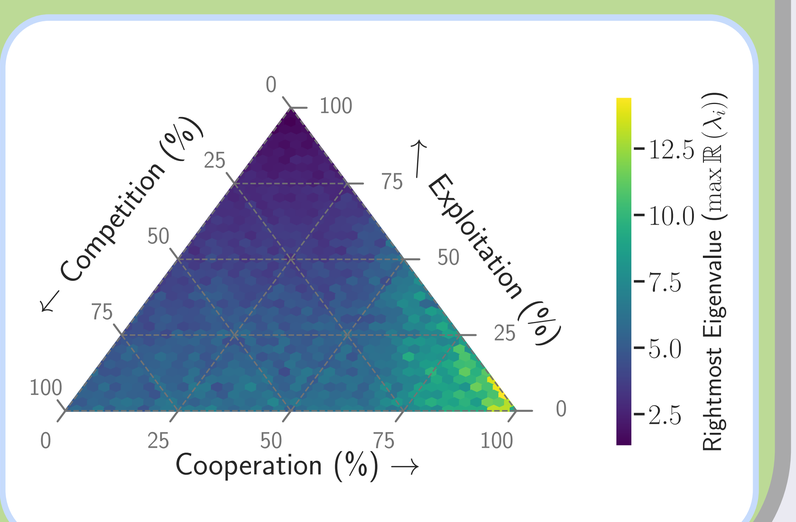
Resilience: The resilience of an ecological community is how fast the community returns to an equilibrium point after being minimally displaced from it (Hofbauer and Sigmund 1998).

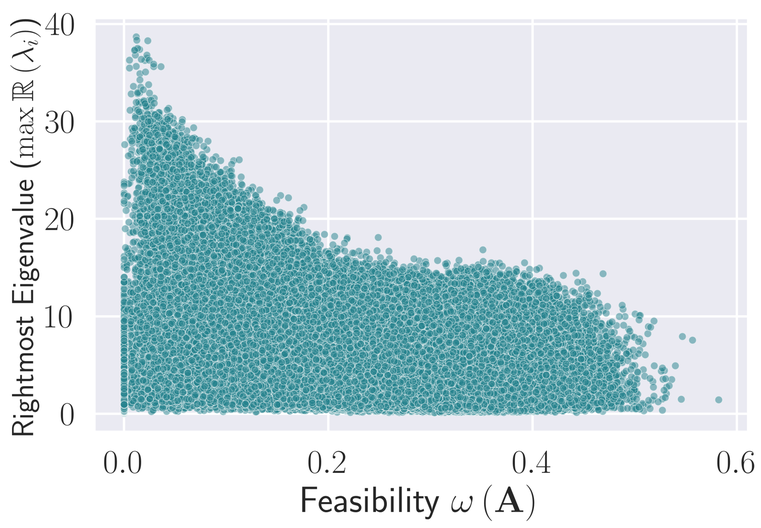
We measure resilience as the real part of the eigenvalue with the largest real part among the eigenvalues of the community matrix **M.**

The community matrix depends both on the interaction matrix and the abundance of all the populations in the equilibrium, but the resilience is primarily determined by the interaction matrix (Gibbs et al. 2018).

Communities with Lower Densities, Weaker Interactions, and More Competition/Exploitation are More Resilient







We found that Feasibility and Resilience capture distinct aspects of the stability of ecological communities, as highlighted by the variance.

Nevertheless, the least resilient communities (larger rightmost eigenvalue) were also the least feasible.

References

Gibbs, Theo, Jacopo Grilli, Tim Rogers, and Stefano Allesina. 2018. "Effect of Population Abundances on the Stability of Large Random Ecosystems." Physical Review E 98 (2): 022410. https://doi.org/10.1103/PhysRevE.98.022410.

Hofbauer, Josef, and Karl Sigmund. 1998. Evolutionary Games and Population Dynamics. http://dx.doi.org/10.1017/CBO9781139173179.

Song, Chuliang, Rudolf P. Rohr, and Serguei Saavedra. 2018. "A Guideline to Study the Feasibility Domain of Multi-Trophic and Changing Ecological Communities." Journal of Theoretical Biology 450 (August): 30–36. https://doi.org/10.1016/j.jtbi.2018.04.030.

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