Land-Use Intensity and Ecosystems Stability

Joana F. V. Canelas, Henrique M. Pereira

German Center for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig
Deutscher Platz 5a, 04103 Leipzig - Germany

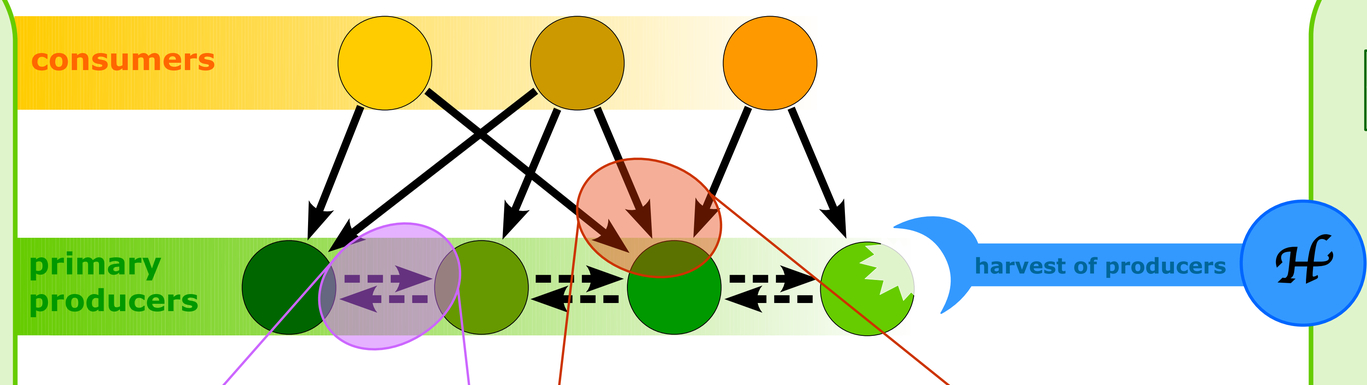
the ecological network model

the dynamics

$$\frac{\Delta \vec{Y}}{\vec{Y}} = \vec{K} + \boldsymbol{M} \cdot \vec{Y} - \vec{H}$$

$$\begin{bmatrix} \frac{\Delta \vec{P}}{\vec{P}} \\ \frac{\Delta \vec{C}}{\vec{C}} \end{bmatrix} = \begin{bmatrix} \vec{r} \\ -\vec{d} \end{bmatrix} + \begin{bmatrix} \frac{-\vec{r}\,\boldsymbol{\alpha}}{\vec{k}} & -\boldsymbol{A} \\ \boldsymbol{B}\,\boldsymbol{A}^{T} & \boldsymbol{0} \end{bmatrix} \cdot \begin{bmatrix} \vec{P} \\ \vec{C} \end{bmatrix} - \begin{bmatrix} \vec{h} \\ \vec{0} \end{bmatrix}$$

$\frac{\Delta \vec{Y}}{\vec{Y}}$ — population densities; $\vec{K}$ — intrinsic growth; $\boldsymbol{M}$ — adjacency matrix; Y; $\vec{H}$ — harvest vector



interactions

competitive
- limiting similarity -

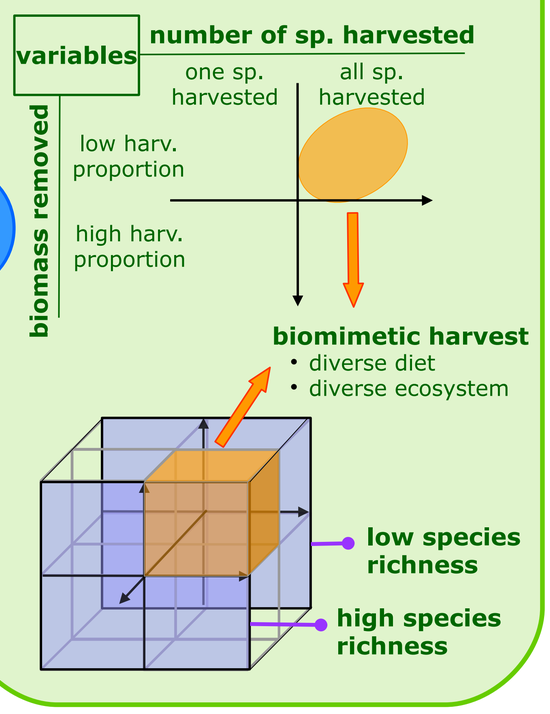
$$\boldsymbol{\alpha} = \begin{bmatrix} 1 & \alpha_{12} & 0 & \cdots & \alpha_{1n} \\ \alpha_{21} & 1 & \alpha_{23} & & 0 \\ 0 & \alpha_{32} & 1 & & \vdots \\ \vdots & & & \ddots & \alpha_{n-1,n} \\ \alpha_{n1} & 0 & \cdots & & 1 \end{bmatrix}$$

trophic
- minimum potential niche model -

$$r_d(j) = X \cdot \eta(j), \quad where \; X \sim B(1, \frac{1}{2C_t} - 1)$$

$$c(j) \sim U(\frac{r_d(j)}{2}, \eta(j) - \frac{r_d(j)}{2}), \quad if \; (\eta(j) - \frac{r_d(j)}{2}) \geq \frac{r_d(j)}{2}$$

HANPP
harvest intensity



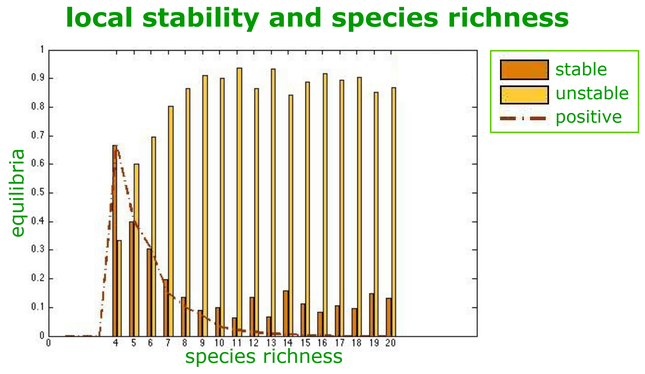
conclusions

- equilibria with **positive densities tend to be locally stable** and their frequency decrease with species richness;
- the **intensity of harvest** decrease the frequency of positive **local stable equilibria** and increase the **variability in the total biomass remaining;**
- an **homogeneous distribution of harvest** among producer species **reduce overall impacts** on ecosystem stability, as well as uncertainty on yields;
- the **communities with low richness** are prone to **more heterogeneous dynamics** in response to harvest and provide **lower yields**;
- a **biomimetic harvest** configuration may **reduce impacts** while **increasing the yields.**

results

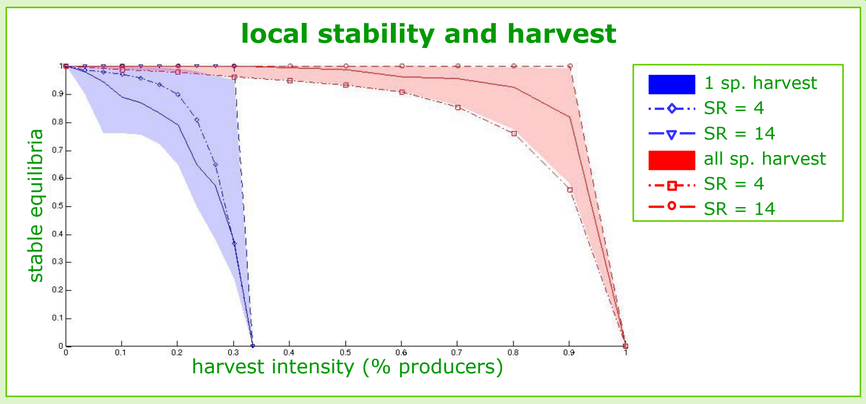
ecosystem stability

local stability and species richness



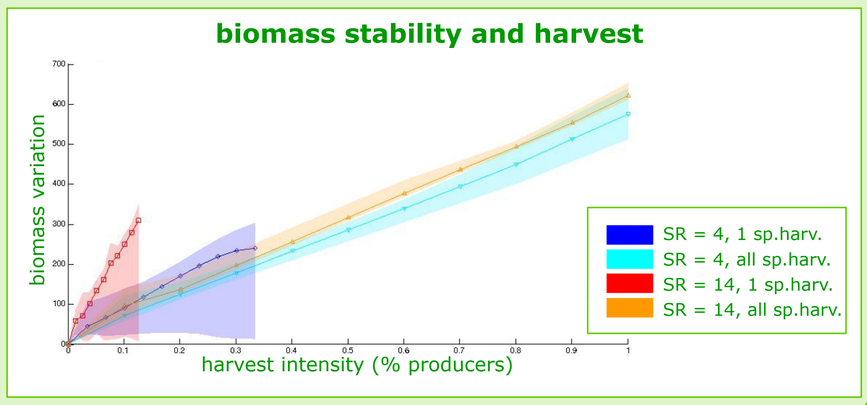
Frequency of local stable and unstable equilibria found in 1000 sample networks generated for communities with species richness from 4 to 20 species, together with the stable equilibria found with positive densities.

local stability and harvest



Frequency of local stable equilibria found on the set of previously stable configurations after the introduction of harvest. The colored areas represent the 10th and 90th percentiles across communities with different richnesses and the solid lines present the median.

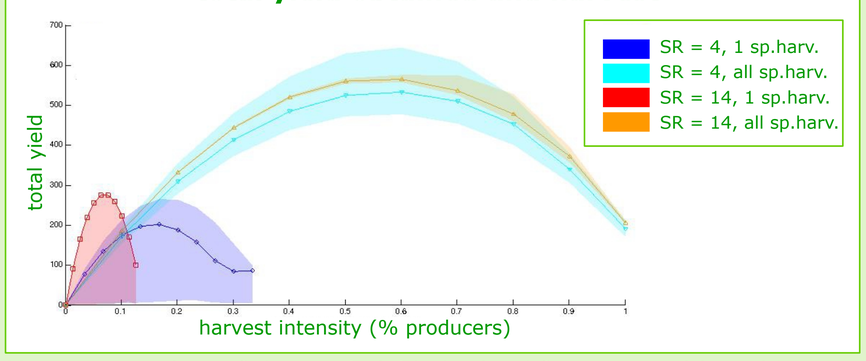
biomass stability and harvest



Standard deviation of the mean total biomass across time on the set of previously stable configurations after the introduction of harvest. The solid lines present the median standard deviation and the colored areas represent the 10th and 90th percentiles of all communities with a given richness.

ecosystem productivity

total yield obtained and harvest



Mean across time of the total yield obtained for communities with different richnesses and harvest distributions. The solid lines present the median total yield and the colored areas represent the 10th and 90th percentiles of all sample communities with a given richness. The set of communities with stable configurations before harvest is used.

bibliography

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contact: joana.canelas@idiv.de