FROM POND TO PASTURE: THE ROBUSTNESS OF A NATIONAL TROPHIC METAWEB TO HABITAT LOSS

M. Reji Chacko, C. Albouy, F. Altermatt, V. Boussange, M. Brändle, M. Gossner, H. Ho, A. Joss, F. Neff, and L. Pellissier

INTRODUCTION

- global changes can lead to species extinctions that cascade through the deletion of trophic links[1]
- species are not all equally at threat of extinction
- **how do food webs in Switzerland respond to realistic species loss scenarios?**

MATERIALS & METHODS

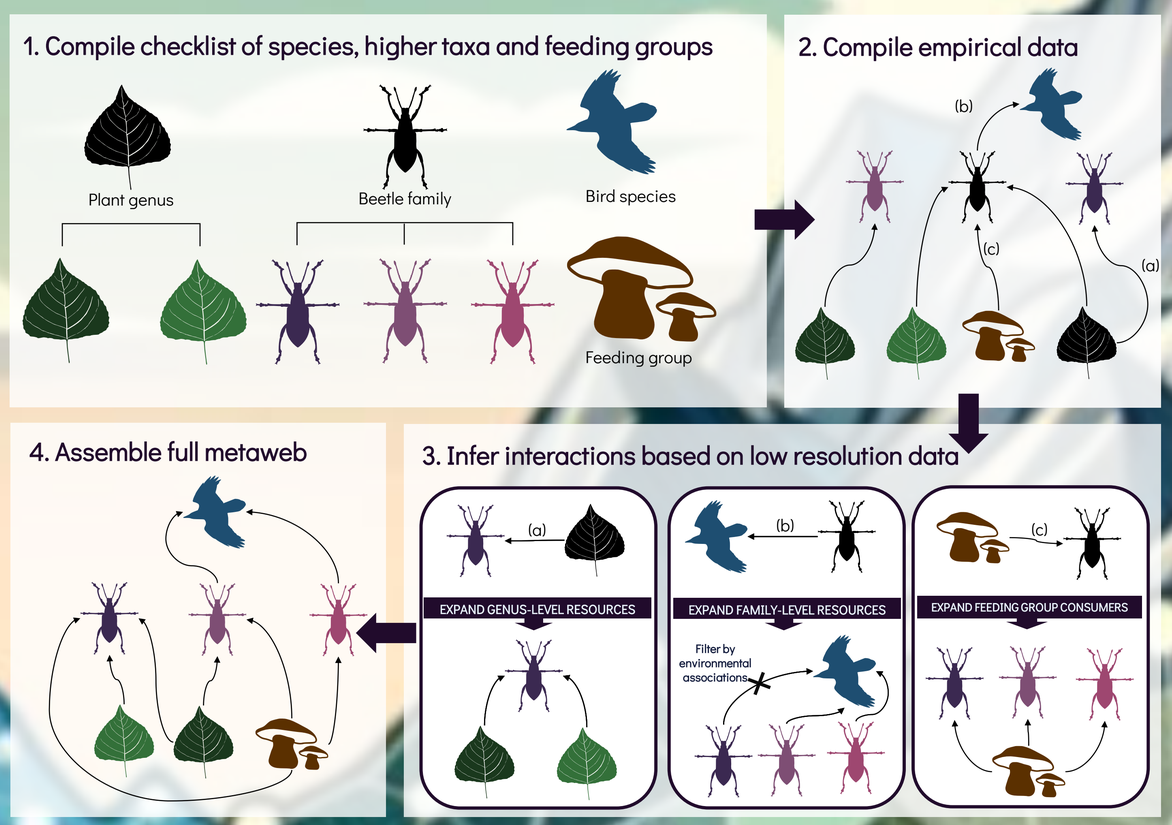
DATASETS

- **food web:** the trophiCH metaweb[2]
  - compile checklist of taxa and existing empirical trophic data
  - infer species interactions by taxonomy and geography
  - assemble full metaweb
  - bootstrap 5% subsets of the full metaweb reflecting original trophic level proportions
- **habitat associations of species:** intersect InfoSpecies[3] occurrences with Habitat Map of Switzerland[4] and from literature

SIMULATIONS

- simulate loss of species associated with threatened habitats (grassland, wetland, agroecosystems, aquatic)
- simulate sequential loss of species from rare to abundant
- track metrics along the extinction sequence

THE TROPHICH METAWEB

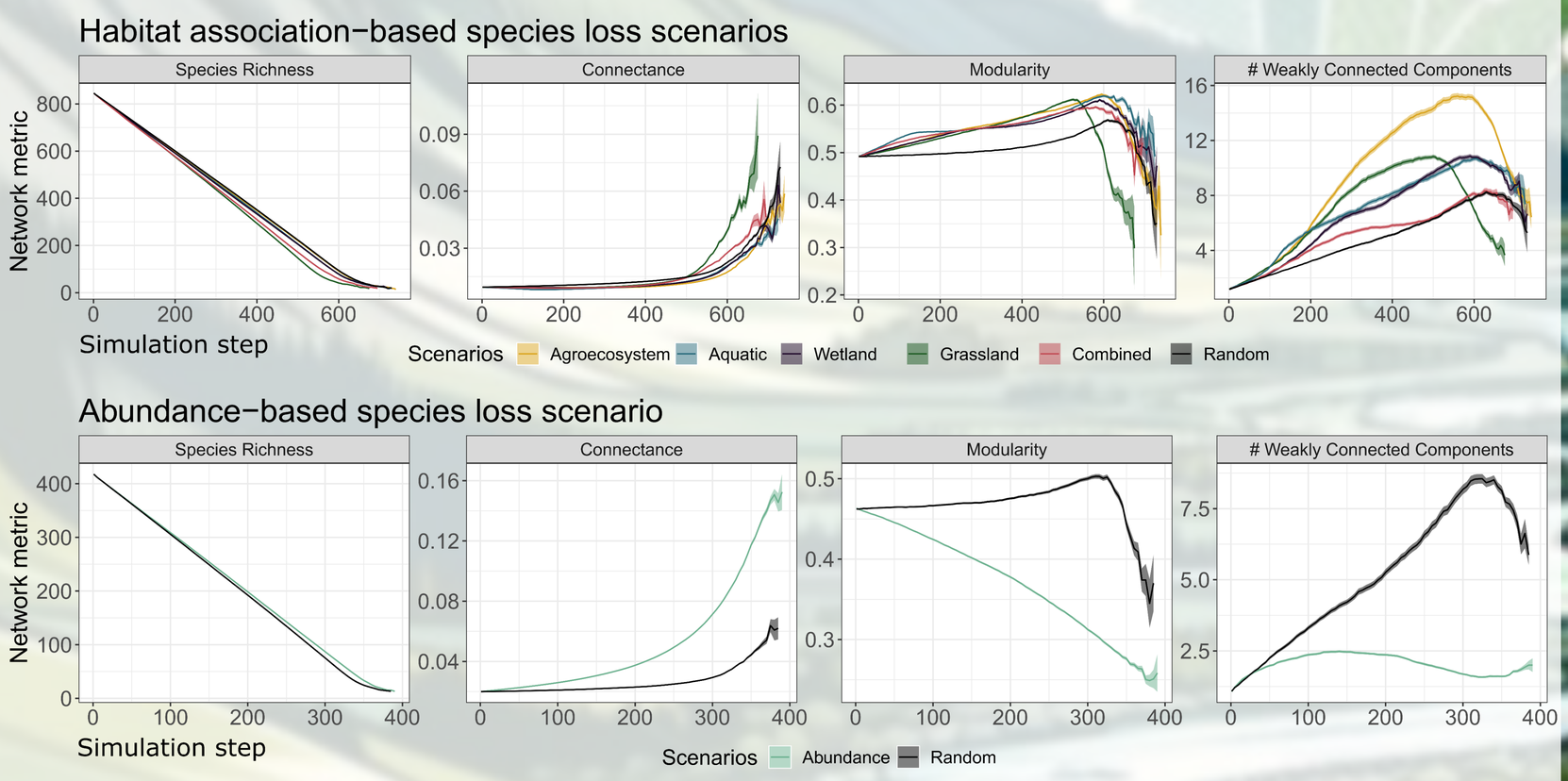


22 959 PLANTS AND ANIMALS

125 FEEDING GROUPS (FUNGI, ETC)

1 115 132 INTERACTIONS

RESULTS



TAKE HOME MESSAGE

- for all simulations, connectance and modularity increase, followed by a phase where the network integrity starts to break down, with increase in #WCC indicating fragmentation.
- targeted attacks on grassland-associated species, especially, leads to faster species loss while agroecosystems experience more fragmentation.
- more abundant species responsible for most functions, and loss of rare species is less detrimental than random loss, but this may be due to data bias **(more in supplementary!)**

REFERENCES

[1]Valiente-Banuet, A., Aizen, M. A., Alcántara, J. M., Arroyo, J., Cocucci, A., Galetti, M., García, M. B., García, D., Gómez, J. M., Jordano, P., Medel, R., Navarro, L., Obeso, J. R., Oviedo, R., Ramírez, N., Rey, P. J., Traveset, A., Verdú, M., & Zamora, R. (2015). Beyond species loss: The extinction of ecological interactions in a changing world. *Functional Ecology*, *29* (3), 299–307. https://doi.org/10.1111/1365-2435.12356

[2]Reji Chacko, M., Albouy, C., Altermatt, F., Boussange, V., Brändle, M., Campell, F., Casanelles Abella, J., Ellis, W., Fopp, F.,Gossner, M., Ho, H.-C., Joss, A., Kipf, P., Neff, F., Petrović, A., Prié, V., Tomanović, Ž., Zimmerli, N., & Pellissier, L. (2023). *trophiCH - a food web for Switzerland* (1.0) [..Csv]. EnviDat. https://doi.org/10.16904/ENVIDAT.467 **[in prep]**

[3] InfoSpecies. (n.d.). Retrieved 23 June 2023, from https://www.infospecies.ch/de/

[4]Price, B., Huber, N., Ginzler, C., Pazúr, R., & Rüetschi, M. (2021). The Habitat Map of Switzerland v1. *Envidat*. 10.16904/envidat.262.

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Ecosystems Landscape Evolution

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1. HABITAT-ASSOCIATED SPECIES LOSS

- habitat loss, fragmentation, and pollution have historically emerged as significant drivers of species loss in Switzerland
- the Habitat Red List of Switzerland emphasises the high vulnerability of aquatic ecosystems, wetlands, and agroecosystems, and grasslands, which are classified as the most threatened habitats
- **understanding how these habitat changes target species dependent on them is crucial for comprehending potential real-world extinction cascades.**

PROBABILITY DISTRIBUTION

- we create four potential scenarios, where species are removed preferentially according to their degree of association with threatened habitats (grasslands, agroecosystems, wetlands and aquatics)

EXAMPLE (THREATENED CLASS: GRASSLAND)

- for each species we compute the proportion of the threatened habitat (here. grassland) to the total number of habitats, in which a node is present
- then we build probability classes based on the unique combinations of threatened habitat over number of habitats.
- proportions for species i, where i=1...*n*:
  a_1 = 1/1 = 100% (Grassland)
  a_2 = 1/2 = 50% (Agroecosystem + Grassland) & (Forest + Grassland)
  a_3 = 1/3 = 33% (Grassland + Forest + Agroecosystem)
  a_4 = 0/3 = 0% (Agroecosystem + Forest), (Forest) & (Agroecosystem)
- next, we want species which are not present in the threatened habitat (grassland), to have a removal-probability $p > 0$
- specifically, we define y = p({habitats \ grassland})
- as probabilities of removal from different classes must sum up to 1:

$$\sum_{i=1}^{n} p_i = 1$$

- the single probabilities are equal to:

$$p_1 = \frac{1 + x}{\sum_{i=1}^{n}(a_i + x)}$$

$$p_2 = \frac{0.5 + x}{\sum_{i=1}^{n}(a_i + x)}$$

$$p_3 = \frac{0.33 + x}{\sum_{i=1}^{n}(a_i + x)}$$

$$p_4 = \frac{min_p rop + x}{\sum_{i=1}^{n}(a_i + x)}$$

- where *x* is the term that enables to have a target probability of y (p({habitats\grassland})) for the class where the proportion of the threatened habitat is equal to zero: $a_4 = 0$
- We then solved the following equation to solve for x:

$$y = \frac{min_p rop + x}{\sum_{i=1}^{n}(a_i + x)}$$

$$x = \frac{(1 - yn)}{y \sum_{i=1}^{n} a_i} - min_p rop(1 - yn)$$

- if we then set y as 5% (minimum probability class):

$$x = \frac{(1 - 0.05n)}{0.05 \sum_{i=1}^{n} a_i} - 0(1 - 0.05n)$$

$$x = 0.114375$$

- the distribution will then look as follows:

$$p_1 = \frac{1 + 0.114375}{\sum_{i=1}^{n}(a_i + 0.114375)}$$

$$p_2 = \frac{0.5 + 0.114375}{\sum_{i=1}^{n}(a_i + 0.114375)}$$

$$p_3 = \frac{0.33 + 0.114375}{\sum_{i=1}^{n}(a_i + 0.114375)}$$

$$p_4 = \frac{0 + 0.114375}{\sum_{i=1}^{n}(a_i + 0.114375)}$$

2. ABUNDANCE-BASED SPECIES LOSS

- abundant species are less likely to face extinction than rare species
- ecosystems comprise generally of a few hyperabundant species and many less abundant ones
- InfoSpecies archives decades of occurrence data for species in Switzerland, combining this with a subset of the trophiCH dataset produces a national metaweb of species with abundance information
- **understanding how the sequential loss of rare species affect network robustness provides a partial view into a real-world extinction cascade**

PROBABILITY DISTRIBUTION

- we take the inverse of the abundance of the species as the probability of extinction, as follows:

$$P_i = \frac{\frac{1}{A_i}}{\sum_{j=1}^{N} \frac{1}{A_j}}$$

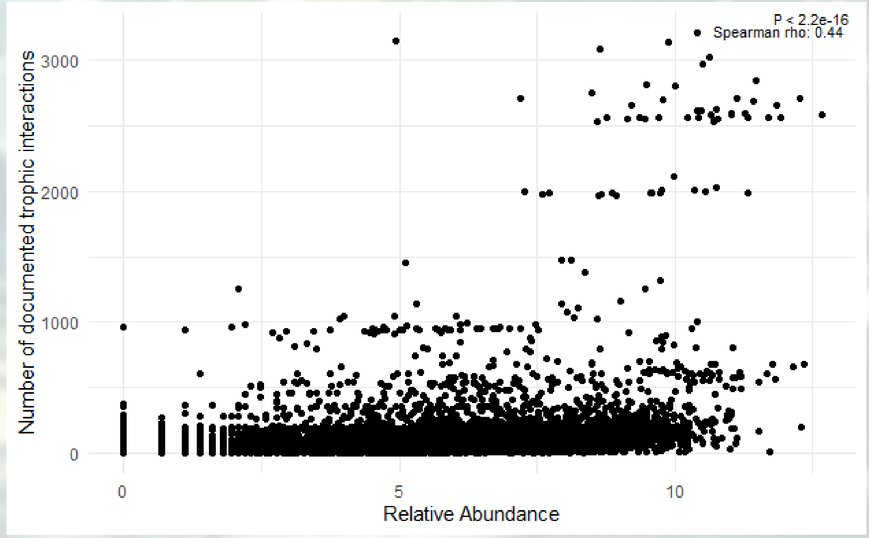
Extinction probability of species *i*

Abundance of species *i*

Number of species

3. DATA GAPS

- while the food webs seem to be more robust against a sequence of extinctions where rare species are initially lost, it is worth keeping in mind that rarer species likely have been documented with fewer interactions
- a Spearman correlation test suggests a moderate positive correlation between the number of documented interactions and relative abundance:



4. THE TROPHICH METAWEB

- the trophiCH metaweb is a dataset that catalogues empirical trophic interactions between well-documents plant and animal species in Switzerland.
- trophiCH will soon be available as a data paper, a data set (https://doi.org/10.16904/ENVIDAT.467) and as a Shiny R App, so please keep an eye out!

ABOUT



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