Research topic: **The structure of aquatic food webs – analysis of weighted empirical networks.**
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Institute: Instytut Badań Systemowych PAN
Discipline classification: Information and Communication Technology
Recruitment form: interview
Number of candidates: 2
Description:
Species extinctions are compromising ecosystem functioning and services around the globe. The effects of species loss propagate over food webs (trophic networks). Food webs are graphs that represent feeding relationships, encoding matter flows as links between groups of species in an ecosystem. Previous research has been limited by reliance on purely theoretical models, few food webs, and only binary networks. In binary networks links have weights 0 or 1, while in weighted networks they quantify the actual flow of matter.

A newly compiled database of 243 geographically diverse weighted empirical food webs allows a much better understanding of their real structure. Dr. Mateusz Iskrzyński and Dr. Karol Opara from the Systems Research Institute of the Polish Academy of Sciences collaborated with scientists from the International Institute for Applied Systems Analysis (IIASA) and an ecologist, Prof. Ursula Scharler (UKZN Durban, South Africa). They analysed the food web vulnerability to species extinctions comparing whole ecosystems.
The goal of the research is a detailed description of the food web structure based on the database of 243 food webs. It would require:
1. statistical analysis of the values of network structure indicators at both node and ecosystem level,
2. analysis of network motifs (statistics of subgraphs consisting of 3 nodes),
3. construction of a theoretical model generating weighted, directed networks with properties consistent with empirical food webs.
It would be worthwhile to study how the vulnerability of an individual node to the effects of removal of another node depends on node-level structural properties. Also, the dependence of structural indicators on aggregation (joining) of nodes is worth pursuing.
We expect skills in programming (familiarity with Python is welcome), mathematical modeling and statistical data analysis.

Suggested reading:

- a popular introduction https://www.mdsg.umd.edu/topics/food-webs/food-web
- Ulanowicz, Robert E. Quantitative methods for ecological network analysis, *Computational Biology and Chemistry*, 28 (5–6), 321-339 (2004),
- Kazanci, C. & Ma, Q. System-wide measures in ecological network analysis. *Dev. Environ. Model.* 27, 45–68 (2015),
- Lau, M. K., Borrett, S. R., Baiser, B., Gotelli, N. J., and Ellison, A. M. Ecological network metrics: opportunities for synthesis. *Ecosphere* 8 (8), (2017)
- Milo, R. et al.. Network motifs: simple building blocks of complex networks. *Science,* 298, 824-827 (2002),
- Williams, R., Martinez, N. Simple rules yield complex food webs. *Nature* 404**,** 180–183 (2000),
- Dunne, Jennifer A., Williams, Richard J., Martinez, Neo D., Food-web structure and network theory: The role of connectance and size., *PNAS* 99 (20), (2002)
- Bramon Mora, B., Gravel, D., Gilarranz, L.J. *et al.* Identifying a common backbone of interactions underlying food webs from different ecosystems. *Nat Commun* **9,** 2603 (2018)
- Dominguez-Garcia, V. et al. Unveiling dimensions of stability in complex ecological networks. *PNAS* 116 (51), 25714-25720 (2019)