

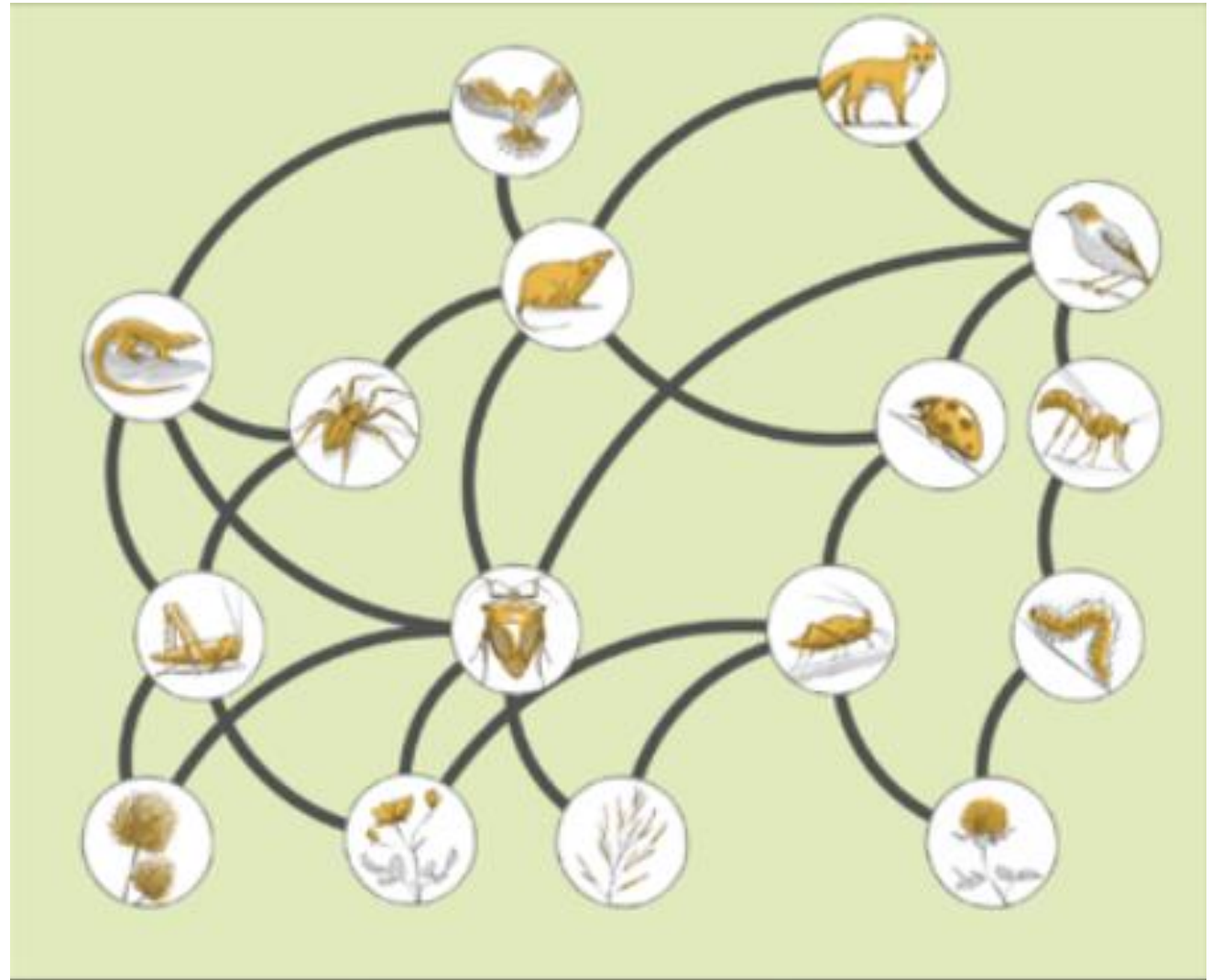
# The internet of nature: integrating food webs with information flow

Ulrich Brose, Myriam Hirt,  
Remo Ryser, Benjamin Rosenbaum,  
Emilio Berti, Benoit Gauzens,  
Andrew Hein, Samraat Pawar,  
Kenneth Schmidt, Kate Wootton,  
Sonia Kéfi



## Food webs

- describe species communities
- linked by their trophic interactions

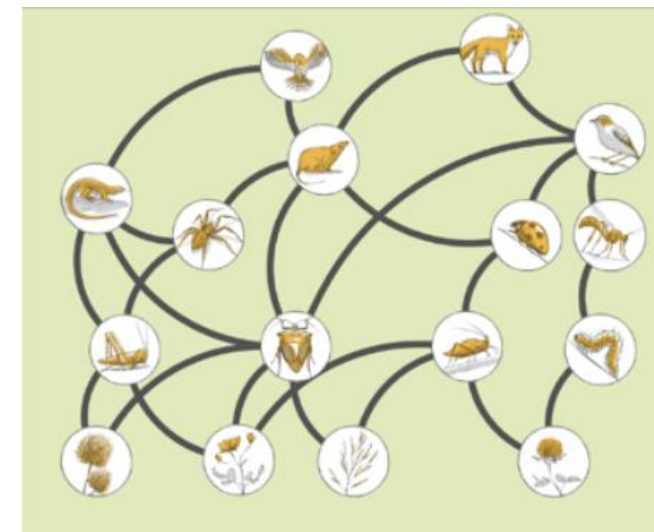


## Food webs

- provide insights into

# Size, foraging, and food web structure

Owen L. Petchey\*<sup>†</sup>, Andrew P. Beckerman\*, Jens O. Riede<sup>‡</sup>, and Philip H. Warren\*



**Benguela Pelagic**

Real  
predation matrix



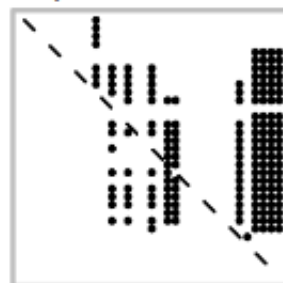
**Coachella**

Real  
predation matrix



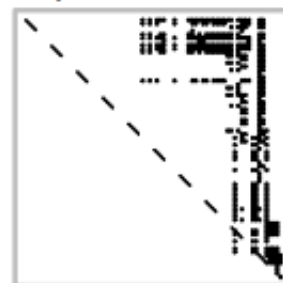
**Sierra Lakes**

Real  
predation matrix



**Tuesday Lake**

Real  
predation matrix



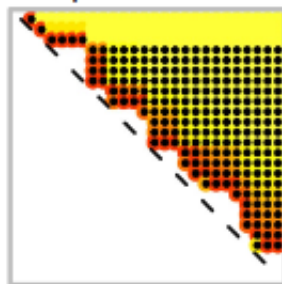
Ratio ADBM

Prop. correct = 0.57



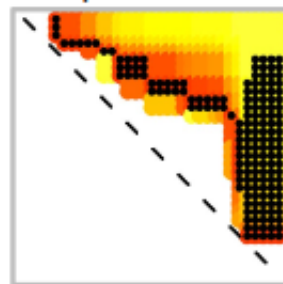
Ratio ADBM

Prop. correct = 0.65



Ratio ADBM

Prop. correct = 0.6



Ratio ADBM

Prop. correct = 0.46





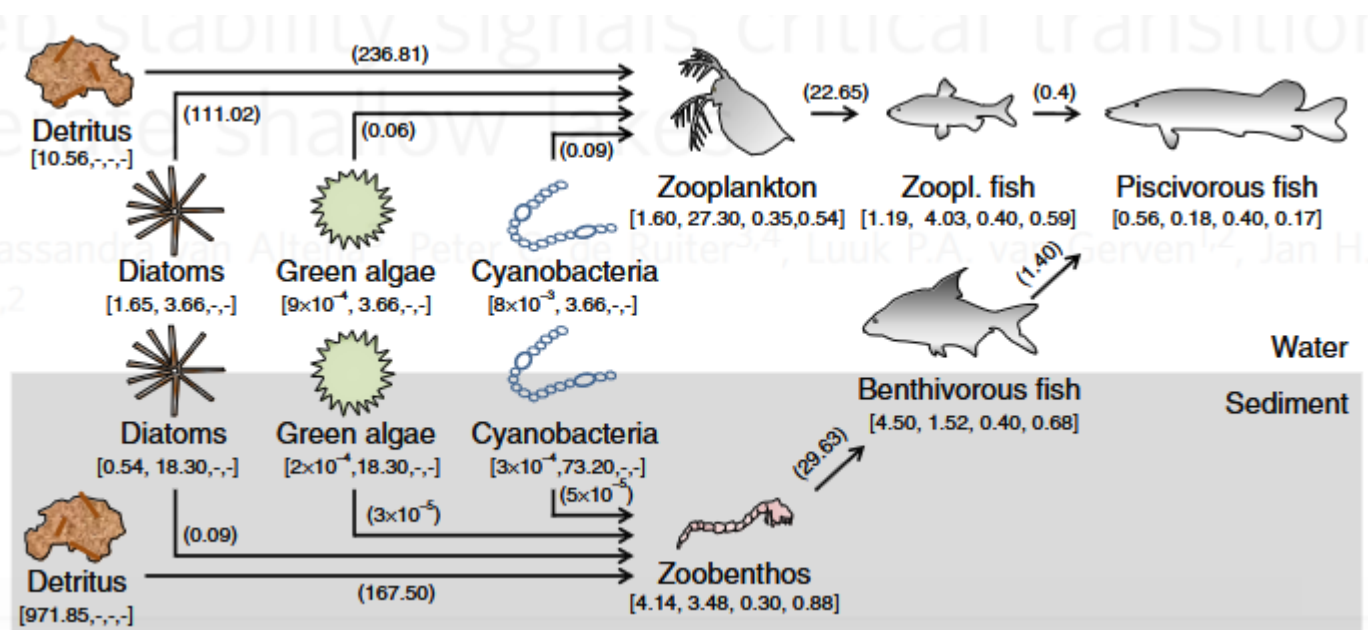
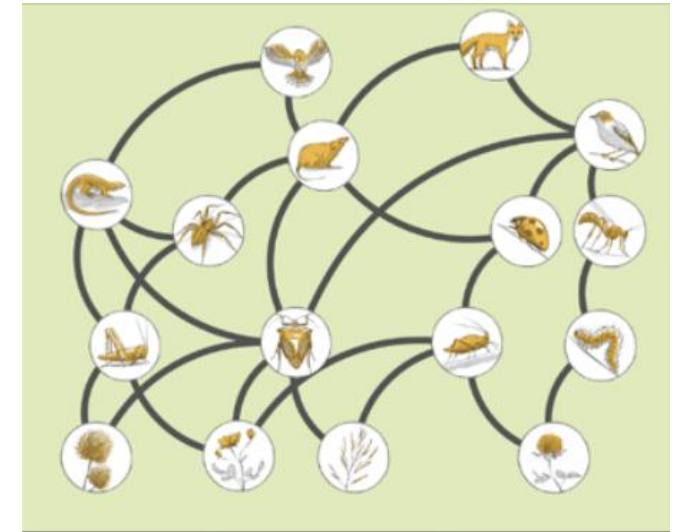


## Food webs

- provide insights into

# Food-web stability signals critical transitions in temperate shallow lakes

Jan J. Kuiper<sup>1,2</sup>, Cassandra van Altena<sup>3</sup>, Peter C. de Ruiter<sup>3,4</sup>, Luuk P.A. van Gerven<sup>1,2</sup>, Jan H. Janse<sup>1,5</sup> & Wolf M. Mooij<sup>1,2</sup>

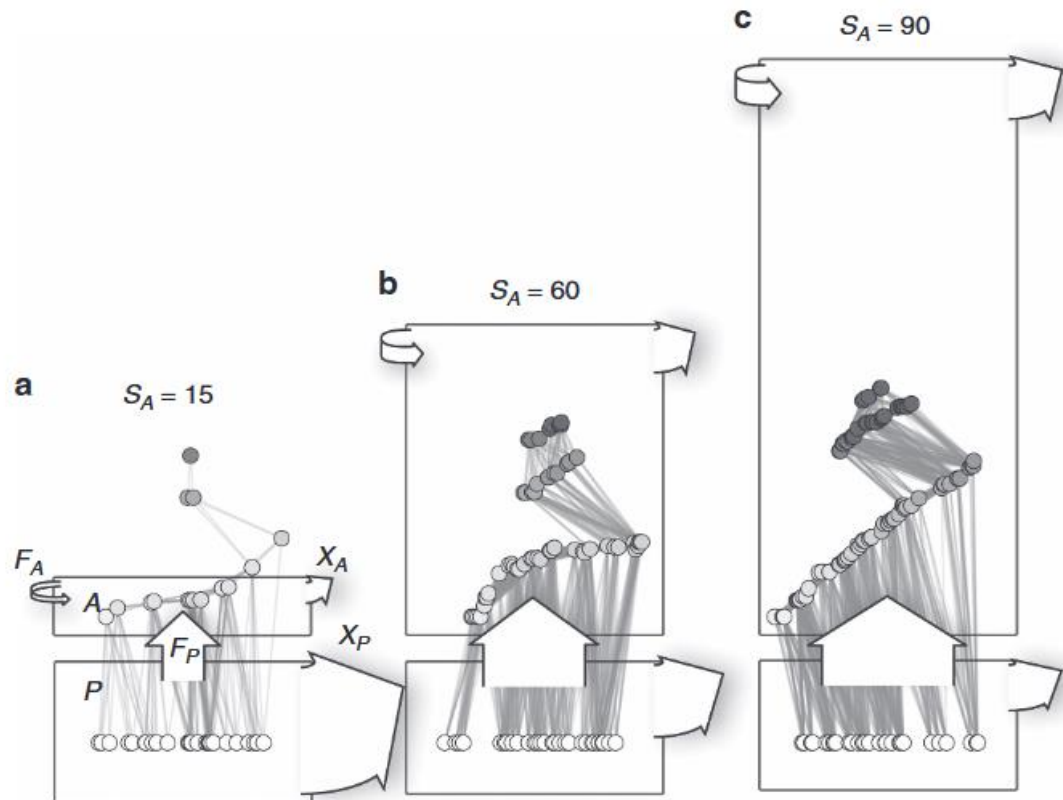
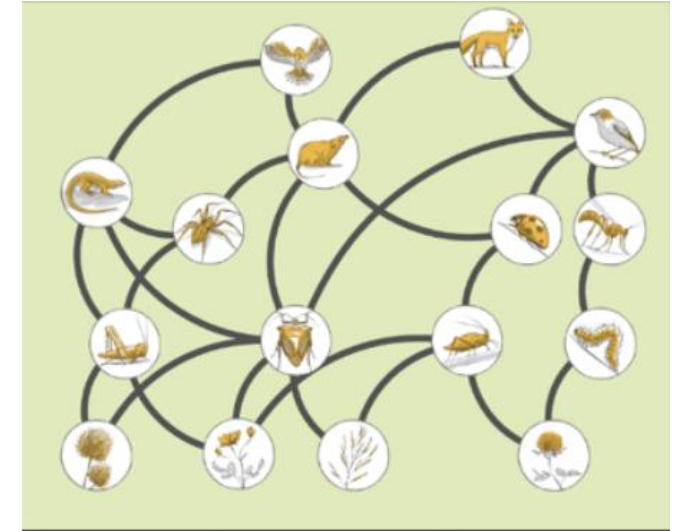


## Food webs

- provide insights into

# Animal diversity and ecosystem functioning in dynamic food webs

Florian D. Schneider<sup>1,2</sup>, Ulrich Brose<sup>3,4</sup>, Björn C. Rall<sup>3,4</sup> & Christian Guill<sup>5,6</sup>



# Conclusion

**Food-web ecology is a predictive  
science ...  
and we are doing great!**





**Sorry to interrupt this day dream, but ...**

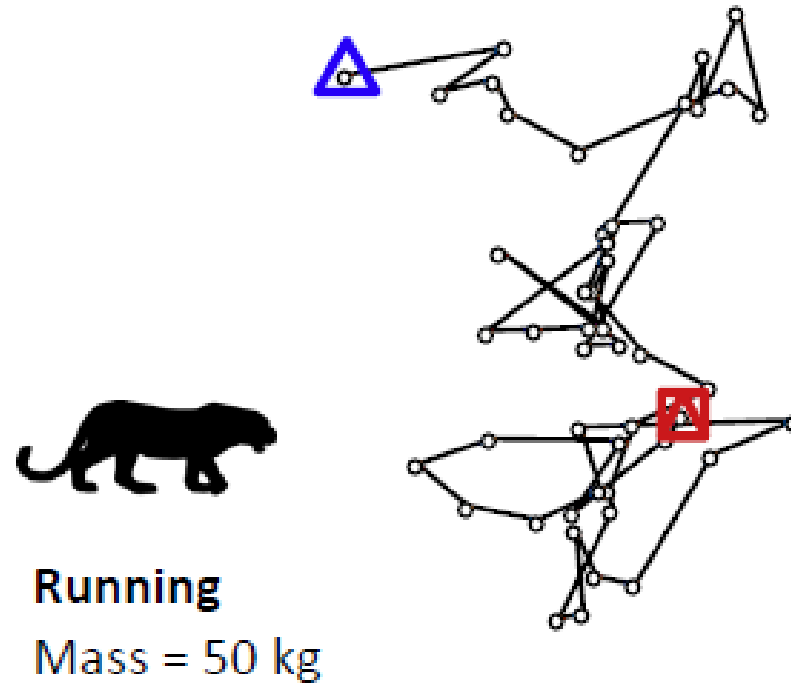
**Can we  
please stop  
this talk  
right here?**





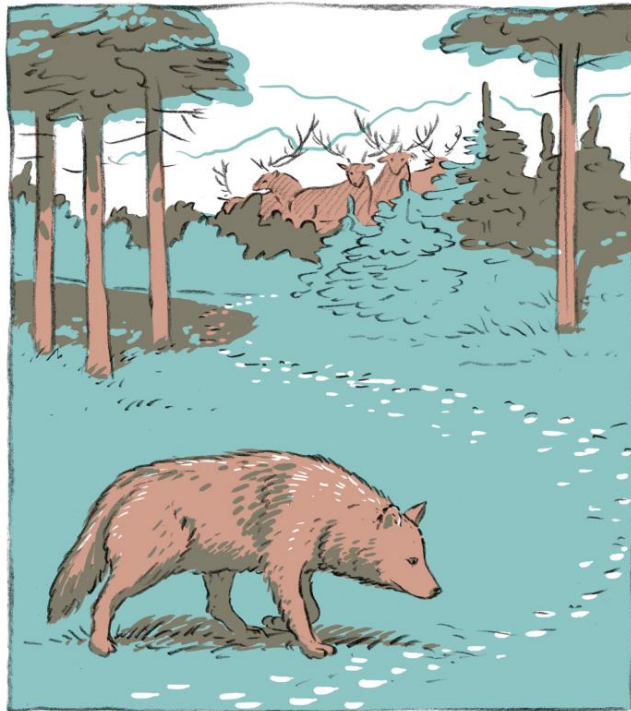
## Food web models

- Are based on the intrinsic assumption of random walks



## In nature,

- predators use information cues to inform their directed movement
- prey use information cues to avoid areas with predators



Prey



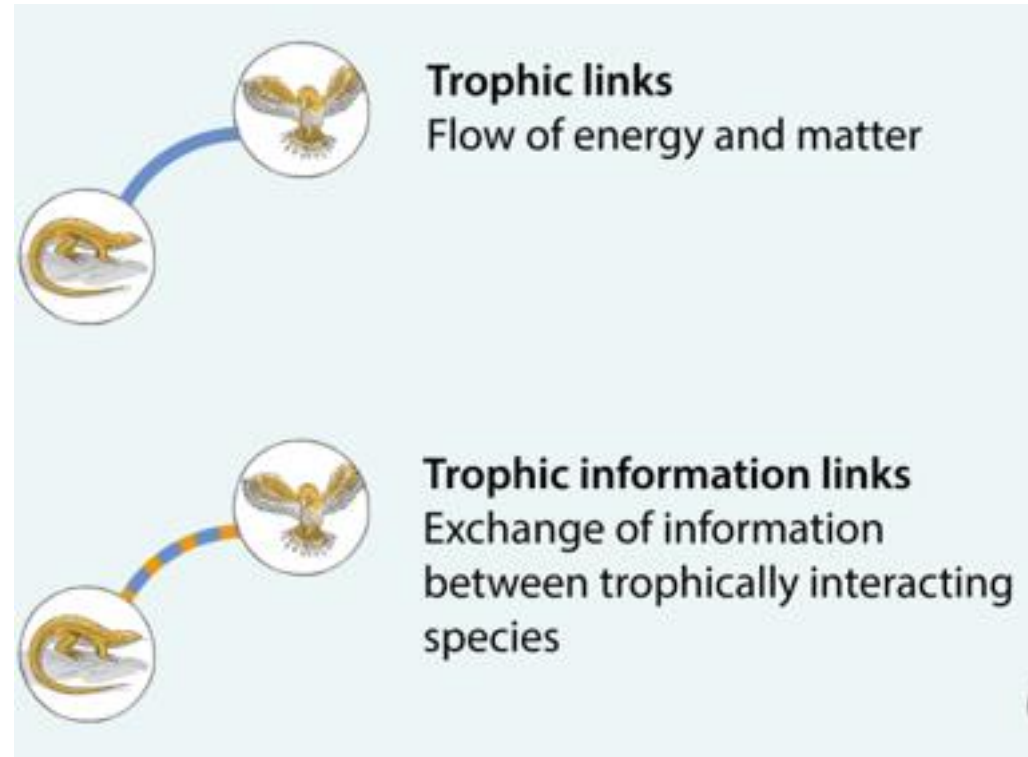
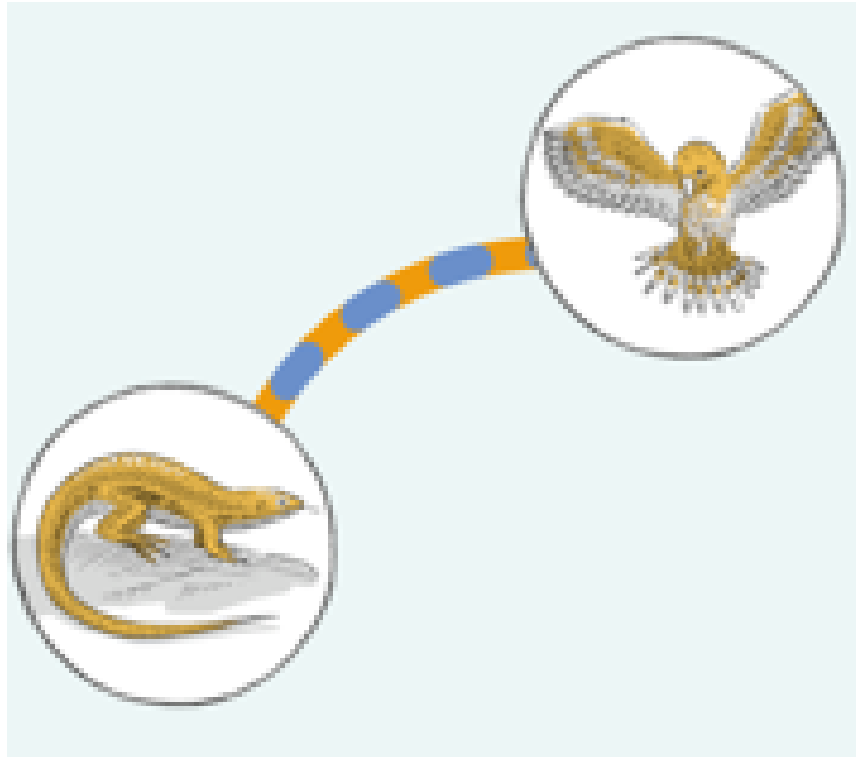
Predator



Unintentional signal by prey

## In nature,

- the interactions between predator and prey are better characterized by a mixture of matter flow (trophic) and information flow links



→ PhD by Jingyi Li



... fortunately published:

Ecology Letters / Volume 27, Issue 9 / e14522

LETTER |  Open Access |   

## Decoding Information Flow and Sensory Pollution: A Systematic Framework for Understanding Species Interactions

Jingyi Li , Ulrich Brose, Benjamin Rosenbaum, Remo Ryser, Emilio Berti

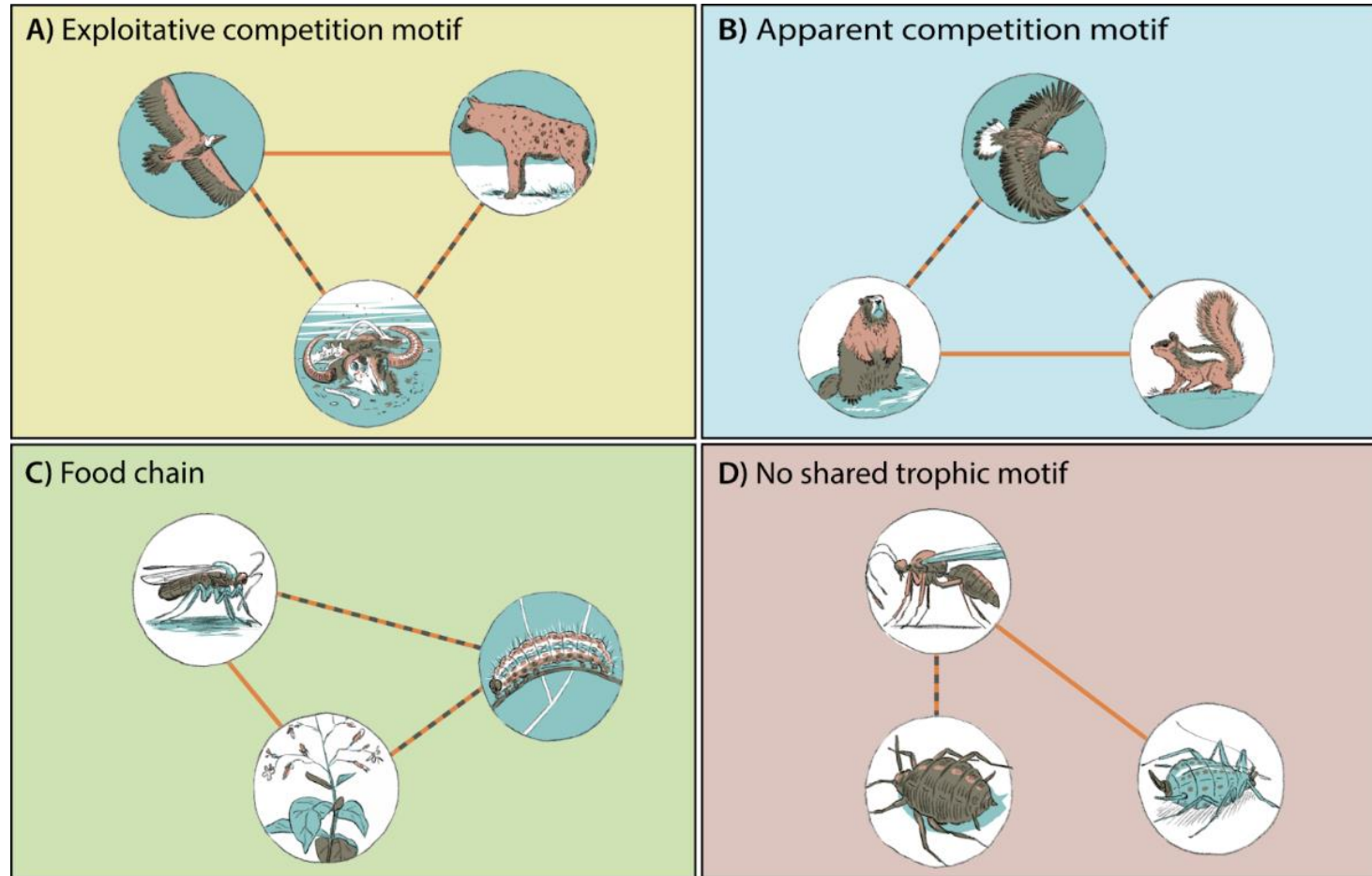
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<https://doi.org/10.1111/ele.14522>



## In nature,

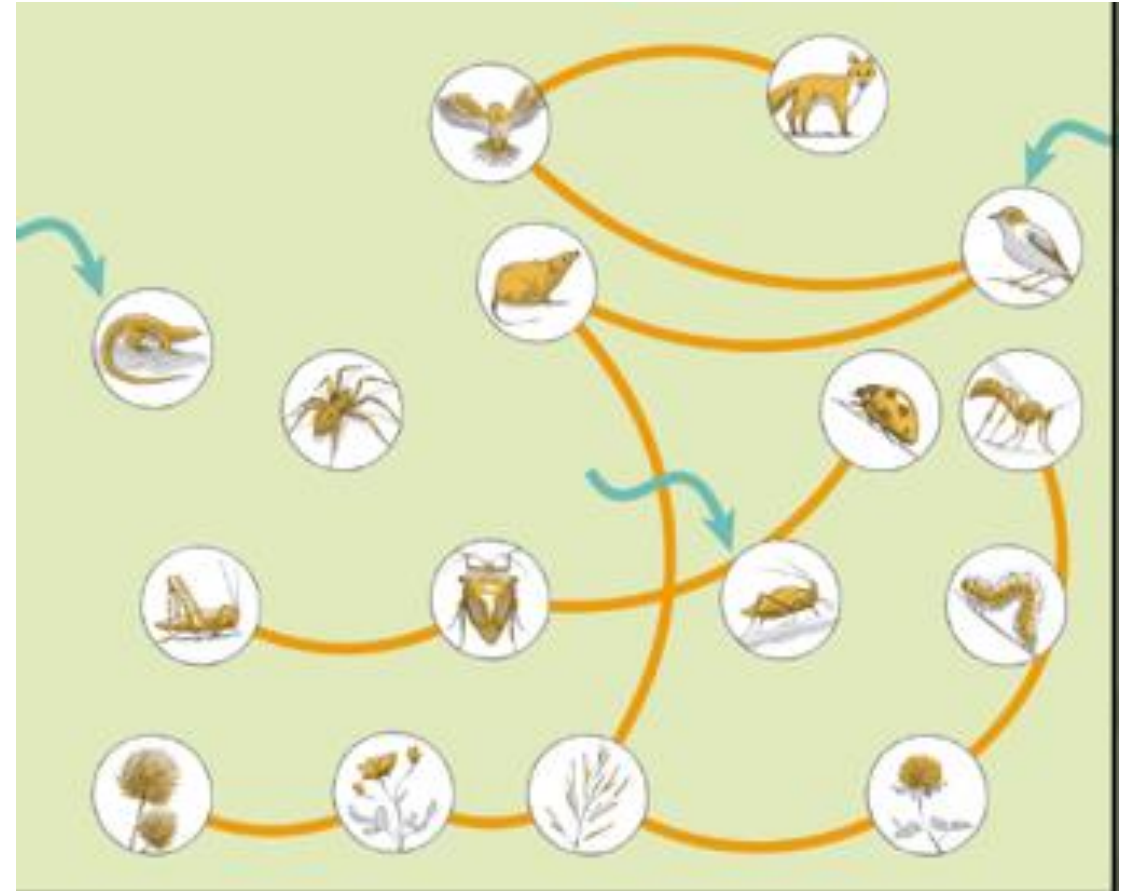
- information is exchanged between species that are not in trophic interactions



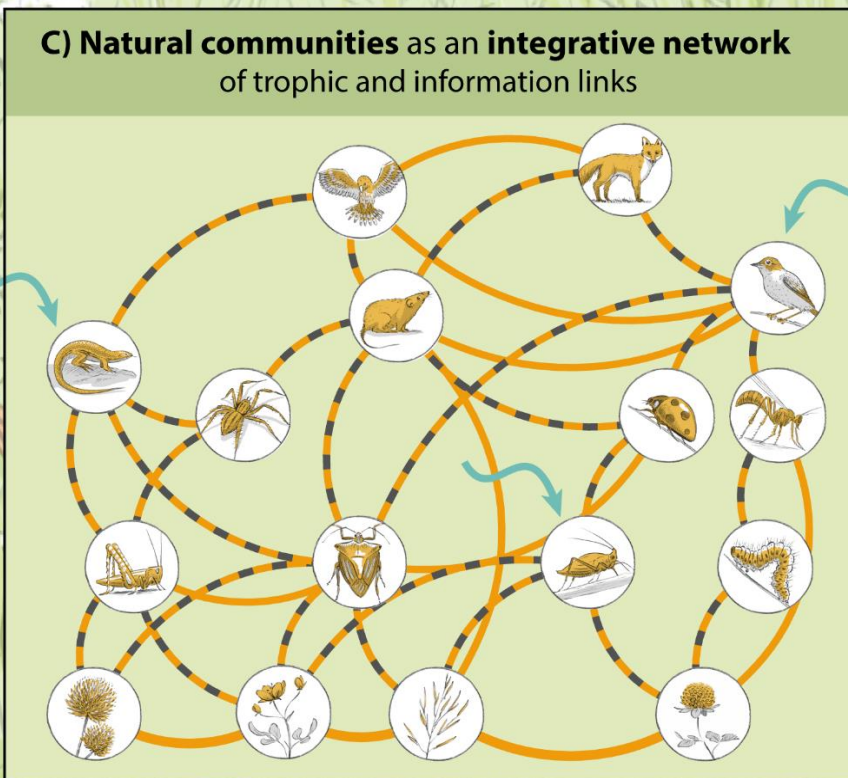
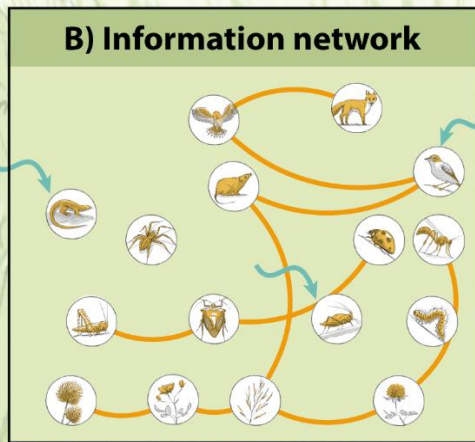
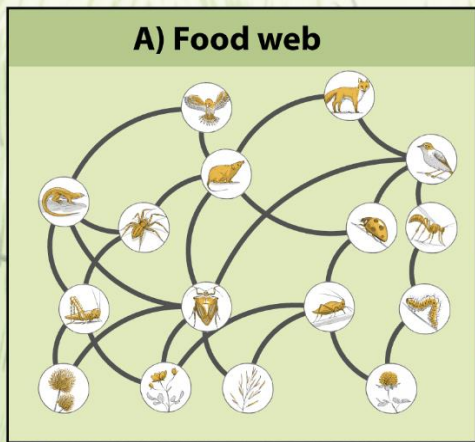
--- Trophic (information) links  
— Pure information links

## Information flow,

- is ubiquitous,
- composes an “internet of nature”







## Food webs and information flow networks

- should be integrated.
- Understanding the flow of matter through trophic links without information flow links is similar to predicting the flow of goods in human economies without the internet.

<b>Trophic links</b>	<b>Information links</b>
— Flow of energy and matter	— <i>Pure information links</i> Exchange of information between species not engaged in trophic interactions
	— <i>Trophic information links</i> Exchange of information between trophically interacting species
	— <i>Environmental information links</i> Information received from the environment

**Food webs and information flow are two layers of natural ecological networks**

**... but is this integration important?**

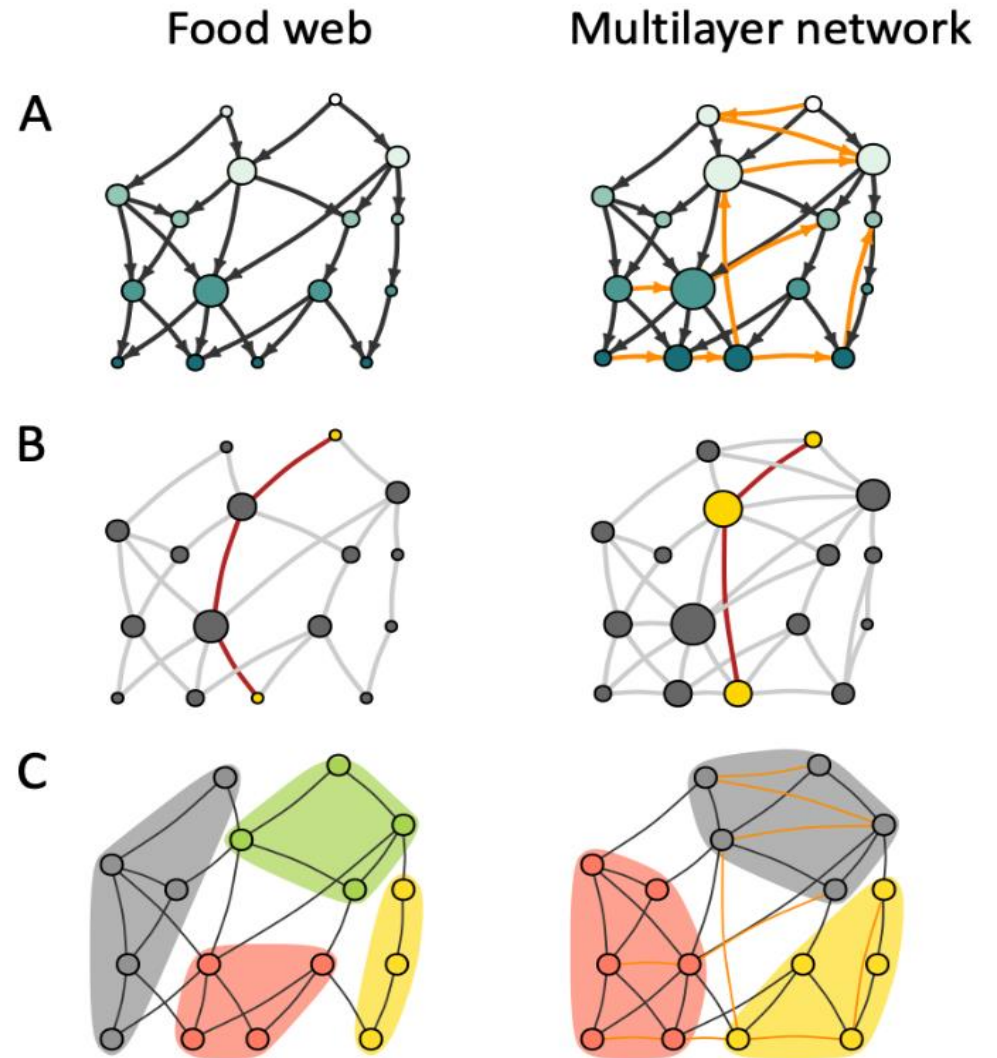


# Consequences of integrating food webs and information flow layers

Network structures are different  
→ Important for network ecology

Paths between pairs of species become shorter  
→ Important for disturbance propagation

Species are clustered in different modules  
→ Important for coupling of populations





# Integrating food webs with information flow

- Information flow among species is ubiquitous
- Information flow is driving species behavior, movement and interactions
- Integrating information flow in food webs will improve the prediction accuracy



# Integrating food webs with information flow

→ Collaboration is needed:

- Sophisticated multilayer network theory
- Empirical examples of food webs with added information flow (expert guesses)





# Thank you!

Myriam Hirt, Sonia Kéfi,  
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