

Introducing non-trophic interactions in food webs

State-of-the-art and challenges

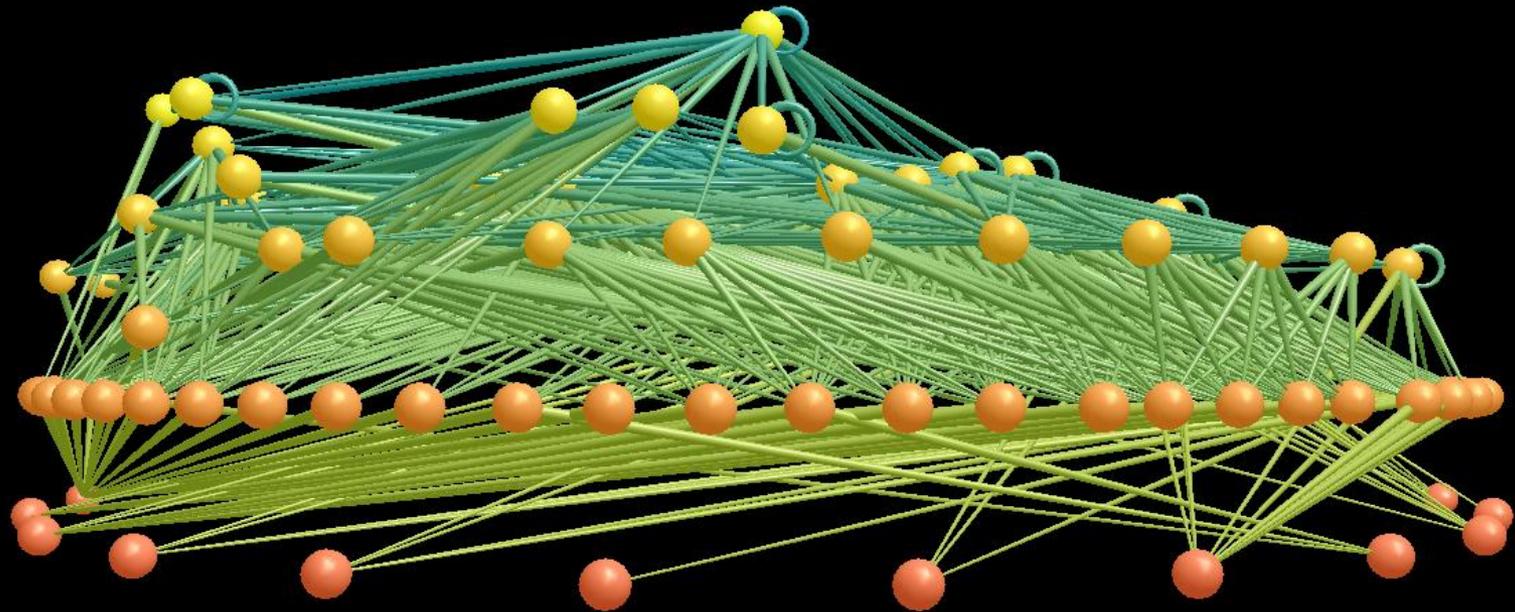
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Martinez, Bruce Menge, Carol Blanchett, Ulrich Brose



Benjamin
Cummings



Little Rock Lake Food Web (Martinez 1991)

Species interact in many different ways



Andrea bee pollinating a rose

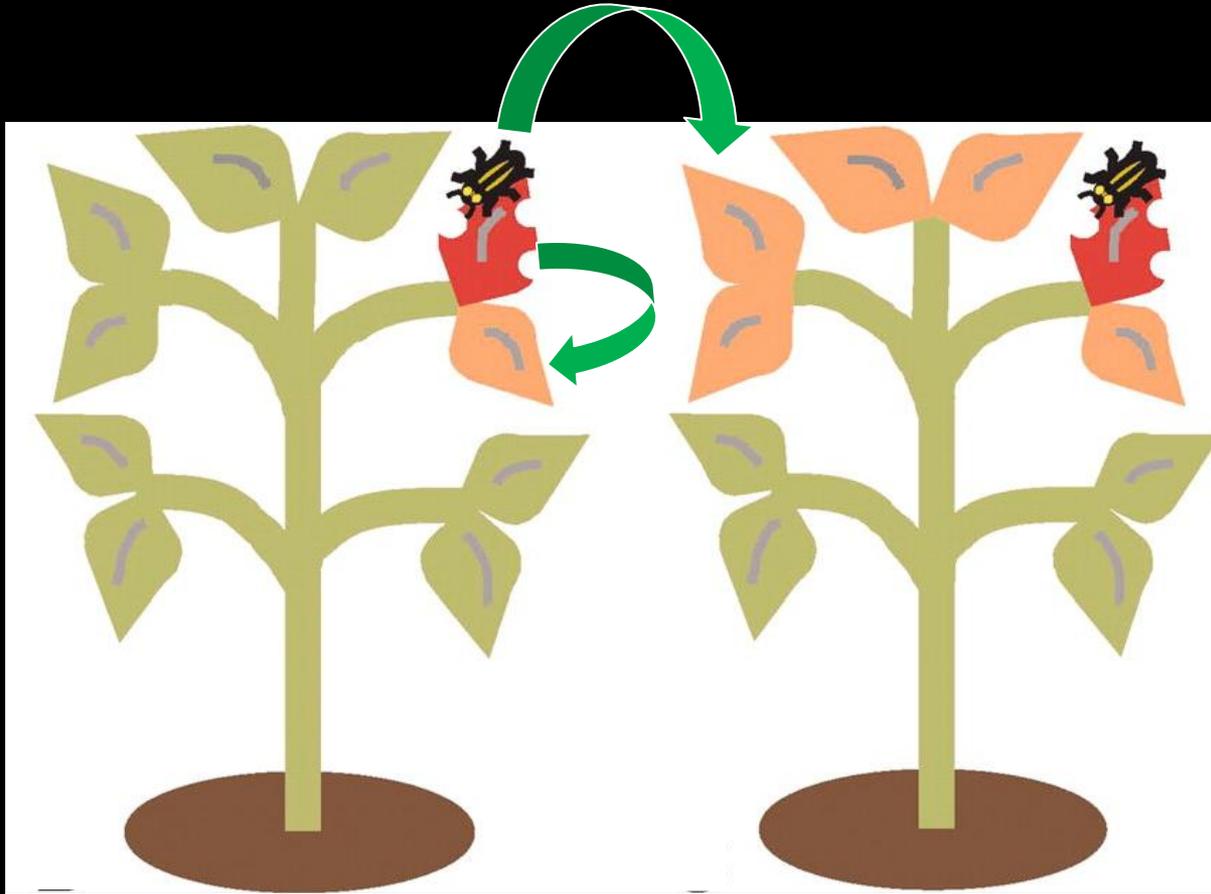


Cooperative hunting in lions



Aphids release alarm pheromones to warn related individuals of predation

Herbivory-induced compounds



Priming in plants

Non-trophic interactions (NTI) are:

present

abundant

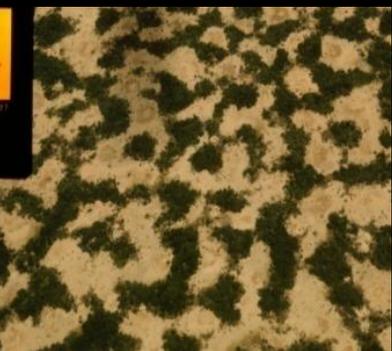
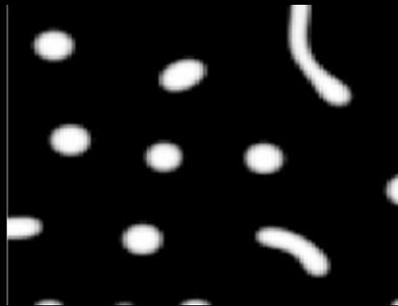
could play an essential role for community structure and
ecosystem functioning







For drylands, studies have shown that:



Facilitation:

- increases the total biomass
- increases the species diversity
- plays a role in the response of drylands to perturbations

Despite this potential importance:

Non-trophic interactions have been mostly ignored by theoreticians

or at best studied in isolation from other types of interactions

Why?

Thought to be rare? Destabilizing?

Lack of quantitative data?

Lack of a theoretical framework

Global change...

How do complex systems including trophic and non-trophic, positive and negative interactions, respond to external changes?

→ Need of a theoretical framework which combines trophic and non-trophic interactions

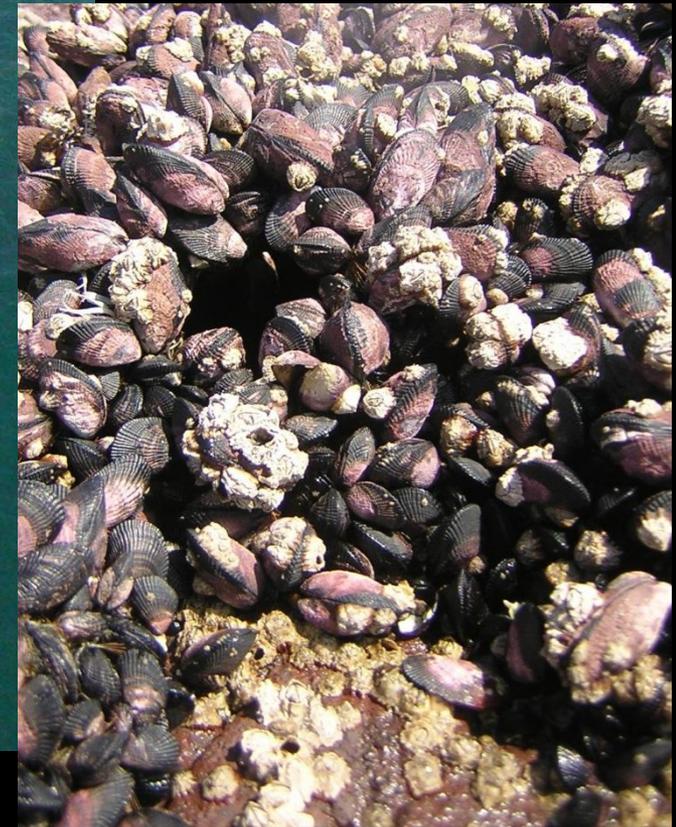
Questions

How do trophic and non-trophic interactions map into each other?

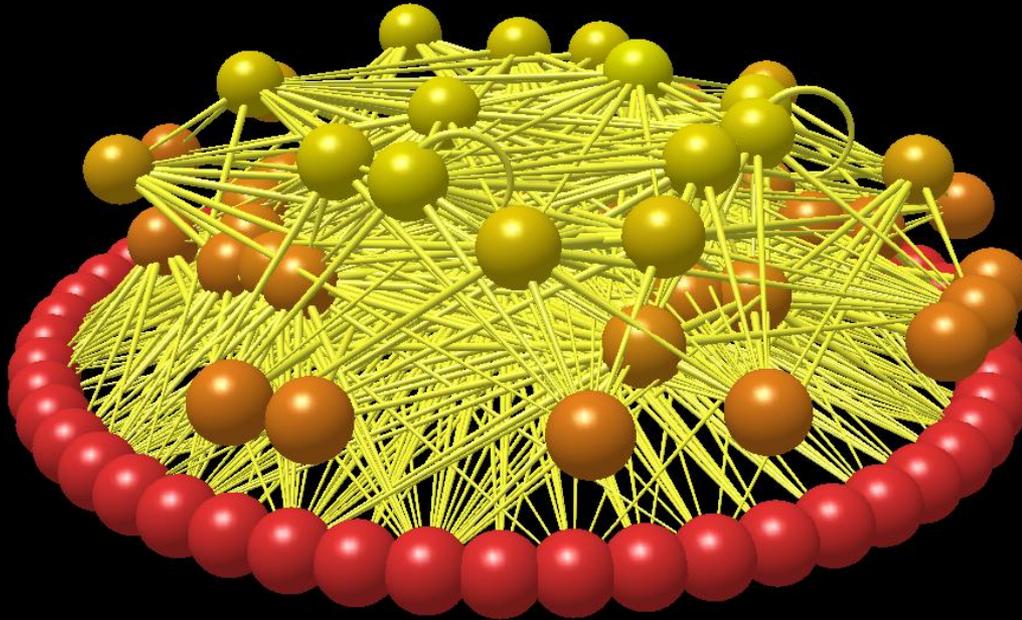
Do non-trophic interactions have a structure?

What are the dynamical consequences of integrating these interactions at the scale of the system?

Chilean web



Trophic network



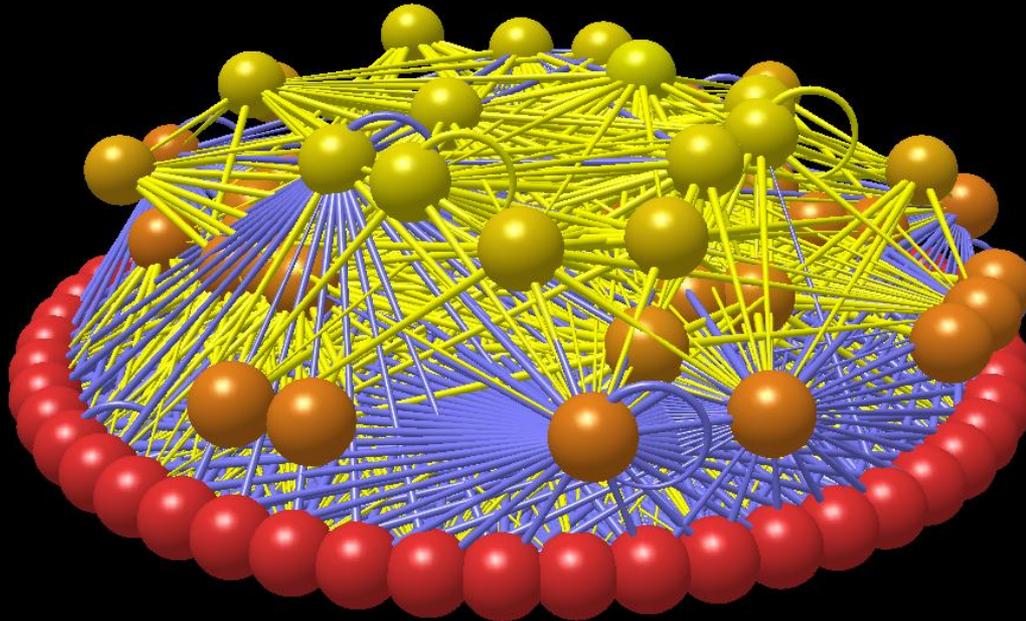
109 species

$C = 0.10$

2404 TI

19 TI per species

Trophic + non-trophic network



72 species have at
least 1 NTI

5738 NTI

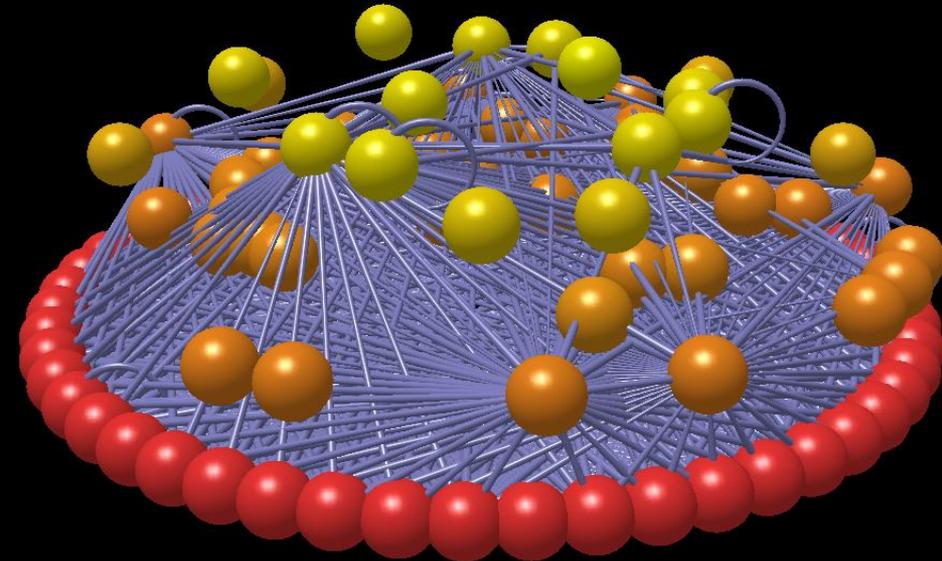
2404 TI

53 TI per species

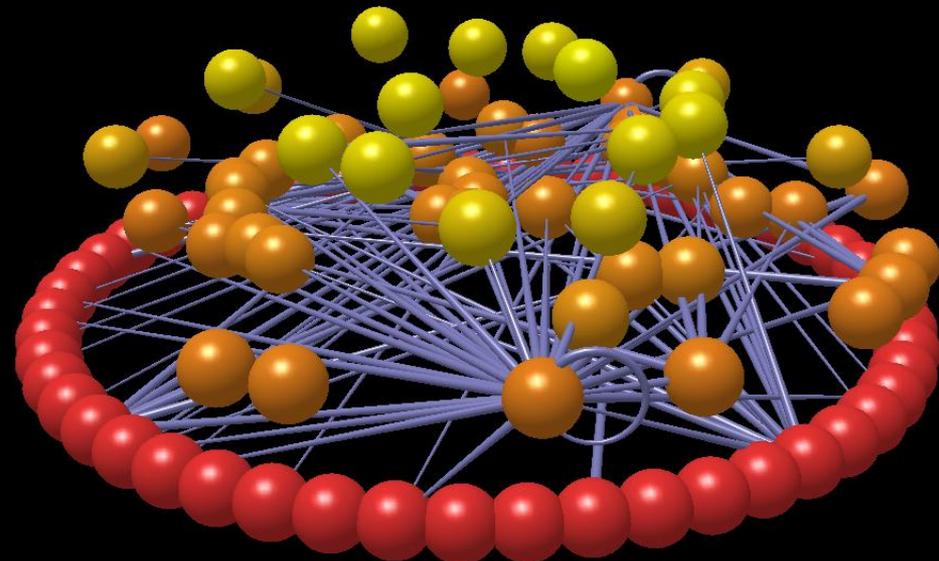
19 TI per species

Negative NTI network

Positive NTI network



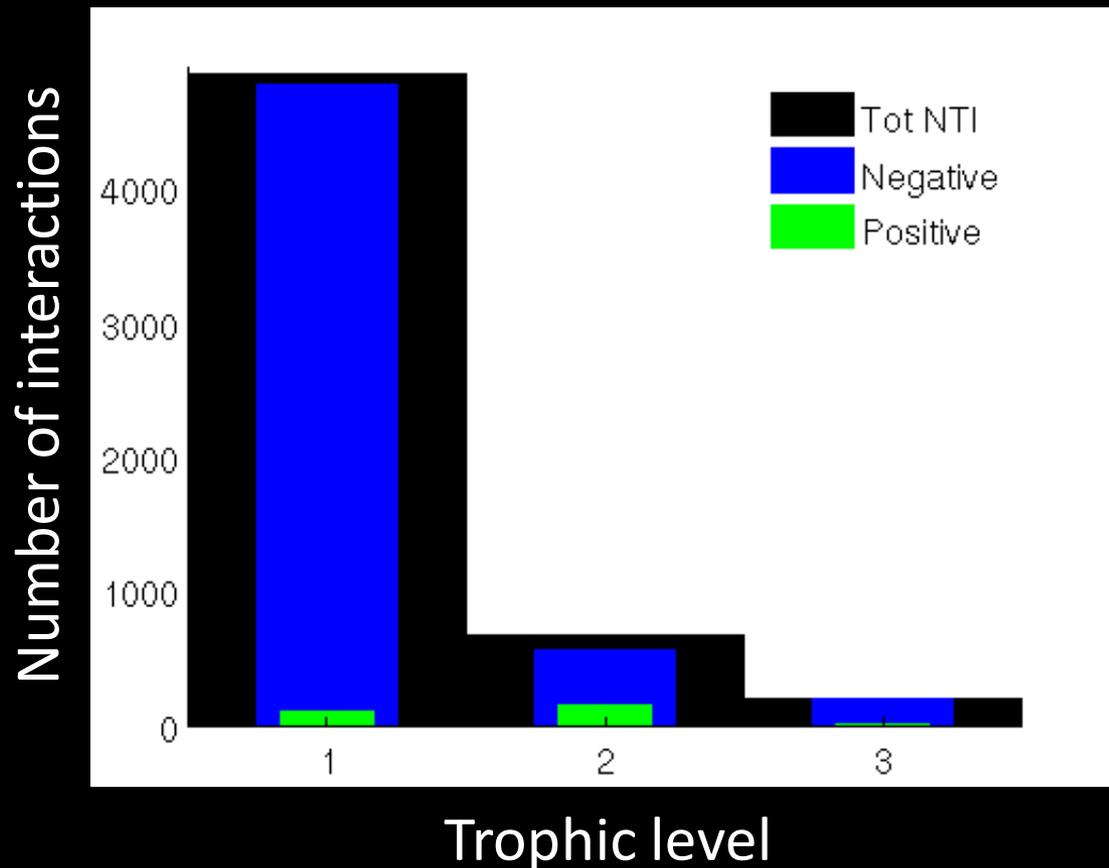
5540 negative NTI
72 species involved



260 positive NTI
69 species involved

Non-trophic interactions per trophic level

# of species:	52	47	10
Total:	4859	676	203



Are the NTI randomly distributed throughout the web?

Are NTI more frequent at the base of the web?

Randomized webs

→ Keep constant:
the # of NTI links
the structure of the trophic web

→ Redistribute the NTI links randomly (100 times)

For each trophic level:

$$\text{Z-score} = (\text{NTI}^* - \langle \text{NTI} \rangle) / \text{sig}$$

NTI in the
data set

Mean # NTI in
random webs

std in random
webs



Results

NTI are not randomly distributed throughout the web

	Trophic level 1	Trophic level 2	Trophic level 3
NTI total	336	-277	-57
NTI neg	347	-288	-58
NTI pos	-17	25	-8

What are the functional consequences (presence, abundance and localisation)?

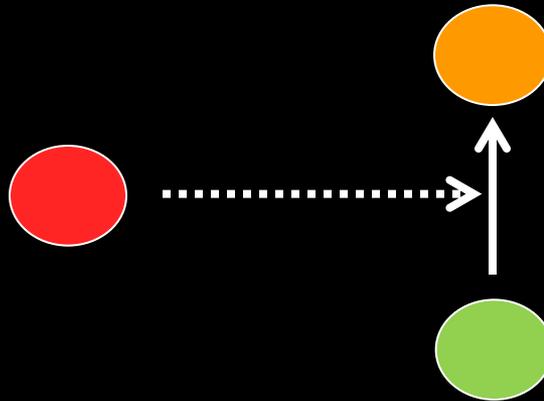
Modeling

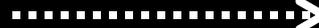
How to integrate the great diversity of NTI in current food web models?

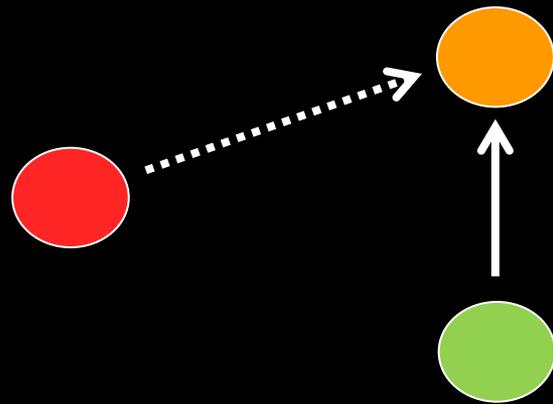
→ An option: use modeling options to create categories of interactions that could be modeled in a similar way

Former modeling approaches of NTI within food webs

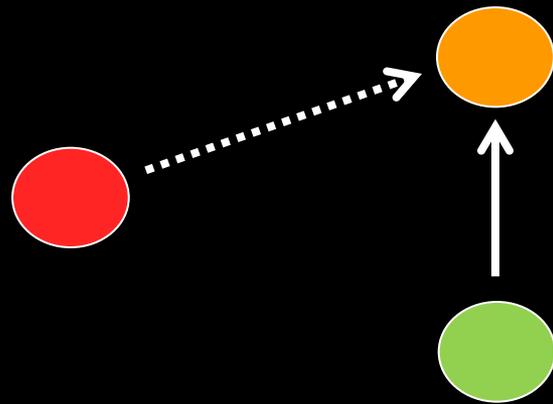
Modification of trophic interactions
Arditi et al. 1995, Goudard and Loreau 2007



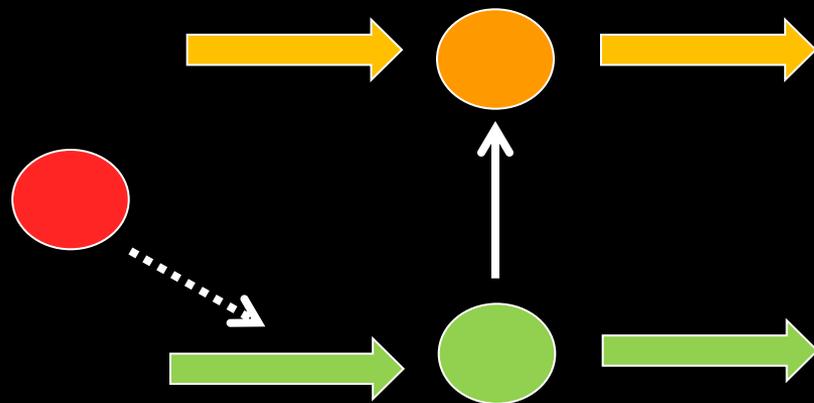


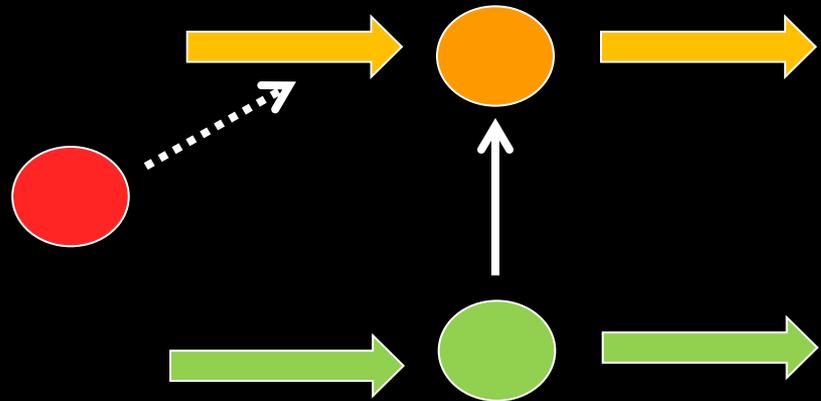


Reproduction



Reproduction,
mortality







NTI on links



NTI on nodes



NTI on input/output
of matter
(open systems)



NTI on links

Modification of trophic interactions

Handling time

Capture efficiency



NTI on nodes

Mortality

Establishment

Growth rate

Reproduction



NTI on input/output of matter (open systems)

Immigration/Emigration

Incoming/outcoming flow of a resource

The relevant parameters become functions
of the NTI species

$$M = M(N_i, N_j, \dots)$$



Function of the
biomasses of the NTI
species

Exemple of a general equation

Biomass of i



mortality



$$\frac{dN_i}{dt} = \sum_k c_k e_i f_{ki}(N_k) N_i - m_i N_i - \sum_j c_j f_{ij}(N_i) N_j$$

k: prey of i

j: pred of i

Exemple of a general equation

Biomass of i



mortality



$$\frac{dN_i}{dt} = \sum_k c_k e_i f_{ki}(N_k) N_i - m_i N_i - \sum_j c_j f_{ij}(N_i) N_j$$

k: prey of i

j: pred of i

Functional response:

$$f_{ki} = \frac{N_k}{N_{k0} + N_k}$$

Exemple of results for facilitation

One species

Plant

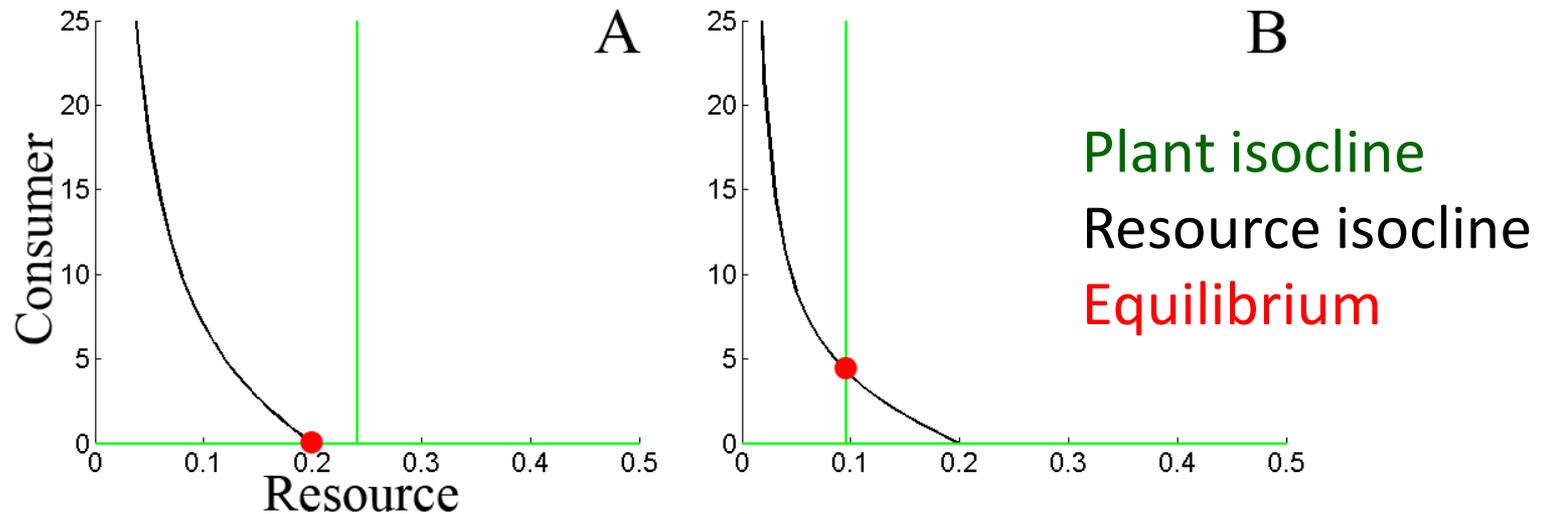
$$\frac{dC}{dt} = ce \frac{R}{R + R_o} C - mC$$

Resource

$$\frac{dR}{dt} = I - dR - c \frac{R}{R + R_o} C$$

Exemple of results for facilitation

One species



Case without facilitation
Isoclines of the model

Exemple of results for facilitation

One species

Plant

$$\frac{dC}{dt} = ce \frac{R}{R + R_o} C - mC$$

Resource

$$\frac{dR}{dt} = I - dR - c \frac{R}{R + R_o} C$$

Plants increase the resource access for others
(drylands)

Exemple of results for facilitation

One species

Plant

$$\frac{dC}{dt} = ce \frac{R}{R + \frac{R_o}{C + 1}} C - mC$$

Resource

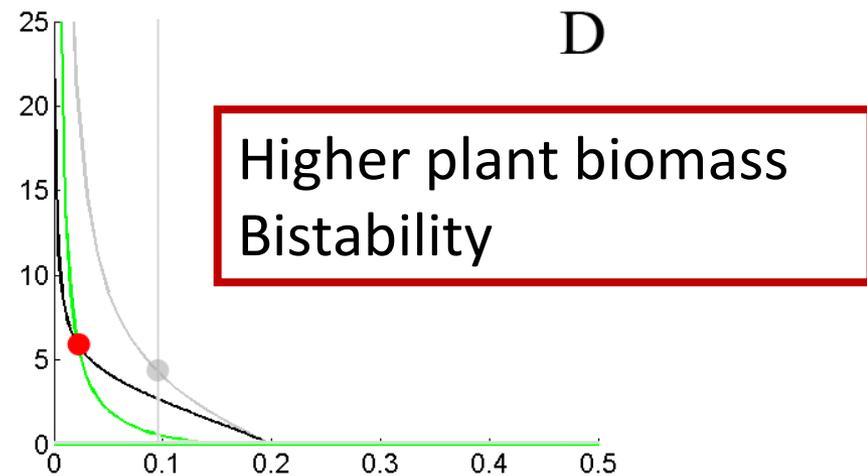
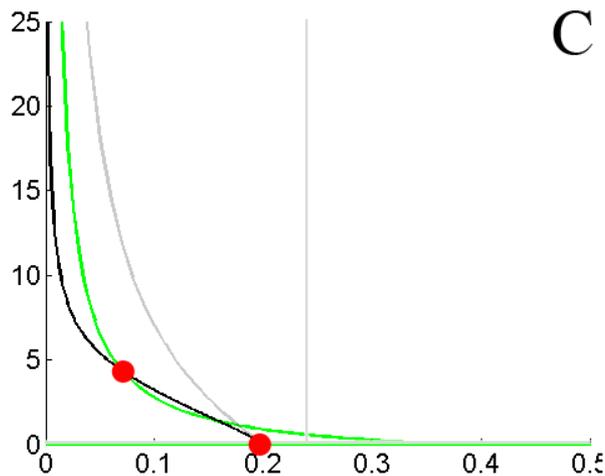
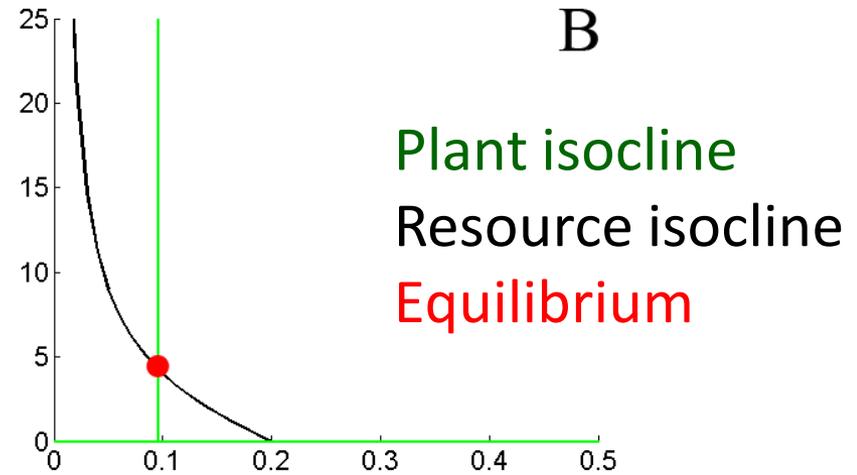
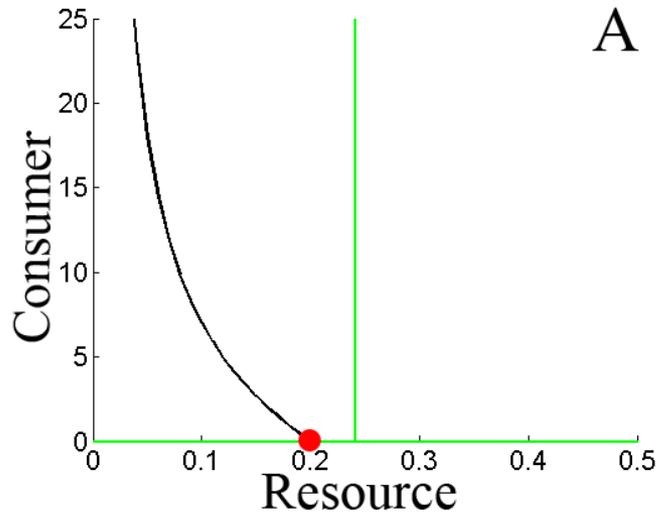
$$\frac{dR}{dt} = I - dR - c \frac{R}{R + \frac{R_o}{C + 1}} C$$

Plants increase the resource access for others
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Exemple of results for facilitation

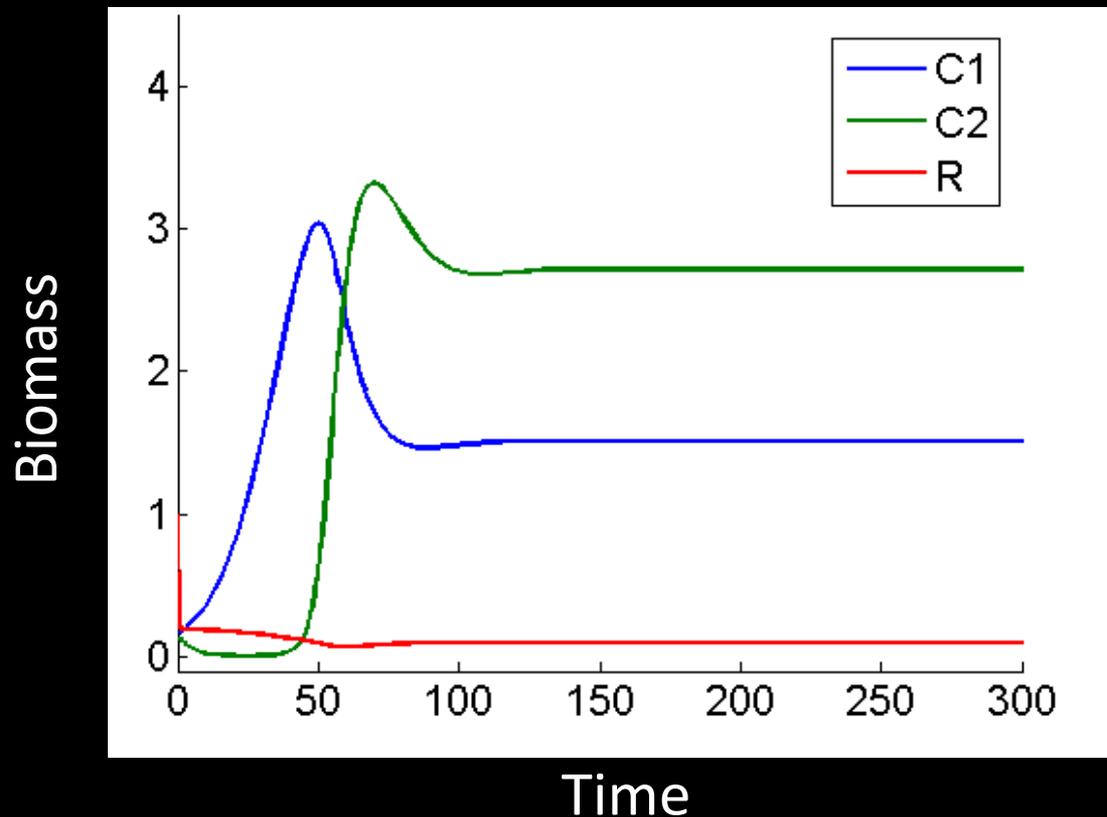
One species

Facilitation



Two plant species, 1 resource

Result: coexistence occur when the most competitive species facilitates the other



Introducing non-trophic interactions can change the
outcome predicted by classical theory

quantitatively

qualitatively

Many species
Many types of interactions

understand the functioning of these systems and
predict their response to perturbations...

→ need to take all these types of interactions into
account

What's missing to go further?

Type of NTI in the webs and their distributions

Quantification of the NTI links? Which currency?

Reliable/validated theoretical framework

→ What are the functional consequence at the scale of the web (presence, abundance, location, type)?

→ Do the effects observed on mini-modules scale-up?

Thanks for your attention

Acknowledgements

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