

# **A (not so) gentle introduction to ecological networks**

**Timothée Poisot**

Université du Québec à Rimouski

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# Why should I care about networks?

- ▶ A good way to harness complexity
- ▶ A solid mathematical foundation
- ▶ Elegant algorithms
- ▶ That guy is going to talk about them for, like, two hours...

# What is a network?

A mathematical approach

A *graph* is a **representation** of a **set of objects** where some pairs of objects are **connected** by **links**.

Or more formally,  $G = (V, E)$ , a *graph*  $G$  is an ordered pair of *vertices*  $V$  linked together by *edges*  $E$ .

Each element of  $E$  is a two-element subset of  $V$ .

The *order* of a graph is  $|V|$ , and its *size* is  $|E|$ .

# What is a network?

## An example

In an omnivory scenario, one top predator  $P$  consumes both an intermediate consumer  $C$  and a primary producer  $R$ . The intermediate consumer also consumes the producer.

This network is specified by

$$G = (\{P, C, R\}, \{\{P, C\}, \{P, R\}, \{C, R\}\})$$

Or for brevity

$$G = (\{P, C, R\}, \{PC, PR, CR\})$$

# What is a network?

## Edge direction

Edges can be *directed* (arcs, directed edges) or not. An edge between a vertex and itself (cannibalism) is a *self-loop*.

In an **undirected graph**, there are at most  $|V|(|V| - 1)/2$  edges if there are no *self-loops*.

In a **directed graph**, there are at most  $|V|(|V| - 1)$  edges if there are no *self-loops*.

**Exercise:** What is the maximal size of a graph of order  $n$  if there are self-loops?

# Number of partners

The number of vertices *receiving* a link from a focal vertex are called its **successors**

The number of vertices *establishing* a link towards a focal vertex are called its **predecessors**

The *total* number of edges connected to a focal vertex is this vertex **degree**

# Where is the ecology in all that?

- graph** The whole community, *i.e.* the populations and their interactions
- vertices** The composition of the community (species present)
- edges** The interactions between the populations

# Where is the ecology in all that?

Exemple of “networkable” systems

- ▶ Trophic systems
- ▶ Plant–pollinators
- ▶ Hosts–parasites
- ▶ Mutualism
- ▶ Social interactions

Any system in which the **same ecological interaction** happens several time in a community can (should) be studied using network theory



# Connectance

Connectance is the *proportion of possible interactions realized*

The order of an ecological network is usually called  $S$ , and its size  $L$

In a network with directed edges and self-loops, the connectance is  $C_o = L/S^2$

**Exercise:** What is the expression of the connectance for directed/undirected networks with/without self-edges?

# Number of partners

The number of (*e.g.*) preys of a predator is its **generality**  
(number of successors)

The number of (*e.g.*) predators of a prey is its **vulnerability**  
(number of predecessors)

# Number of partners

```
1 web = read.table('web.dat')
2 generality = rowSums(web)
3 vulnerability = colSums(web)
4 degree = generality + vulnerability
```

# The niche model of food webs