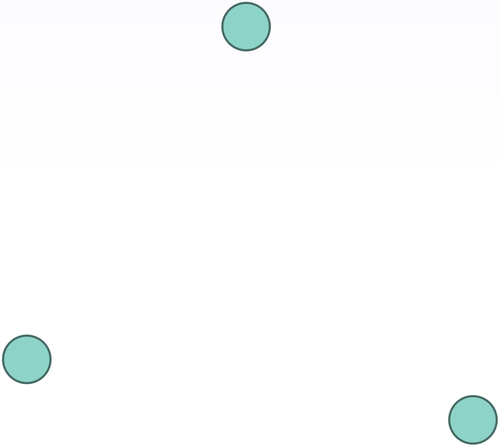
December 13, 2012

Food web motifs and the functioning of complex ecosystems

Timothée Poisot

Theoretical Ecosystem Ecology, UQAR

Biodiversity and ecosystem functioning



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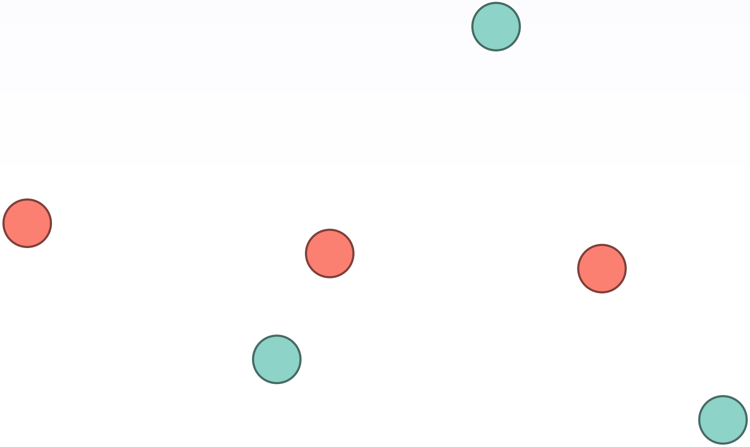

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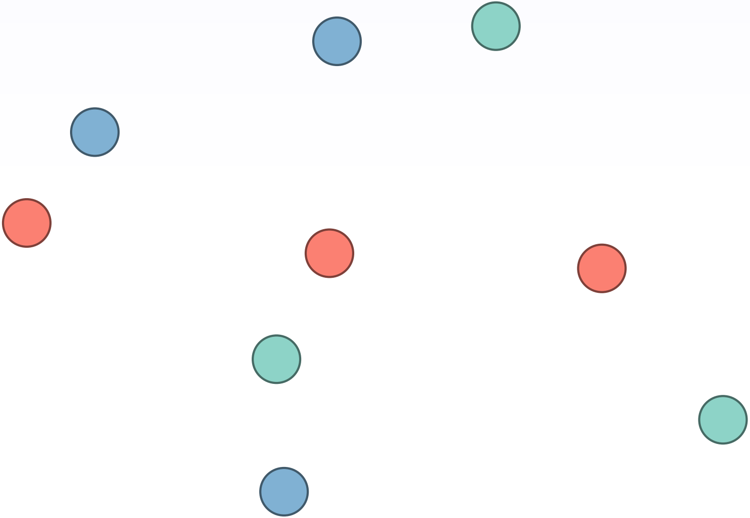

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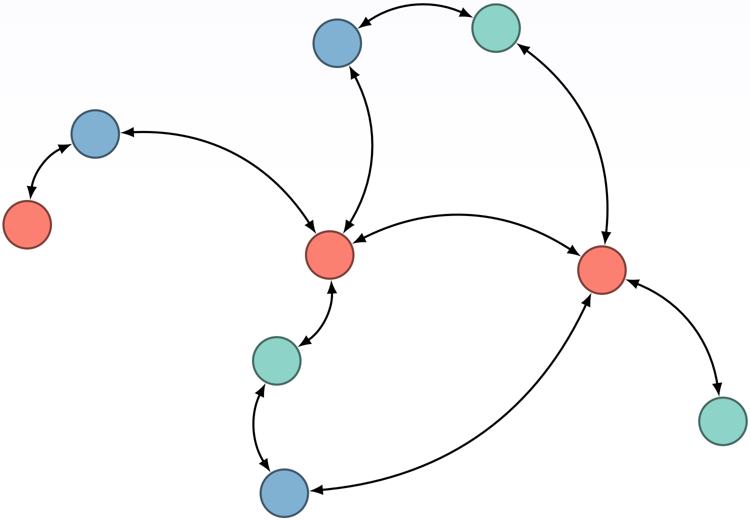
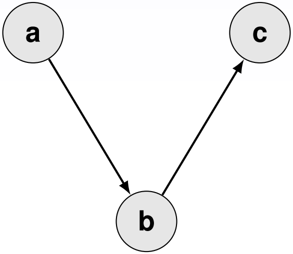


Three-species motifs: capturing complexity



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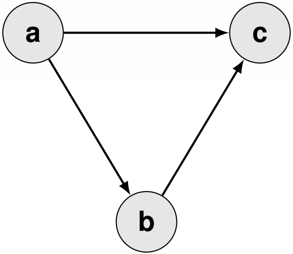

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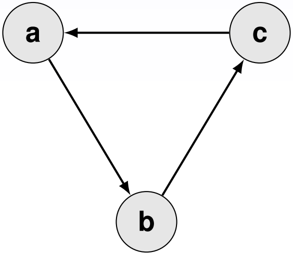

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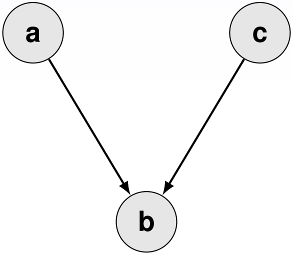

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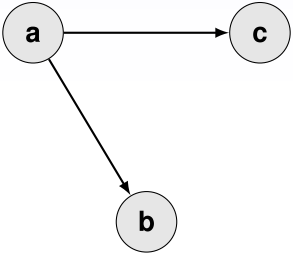

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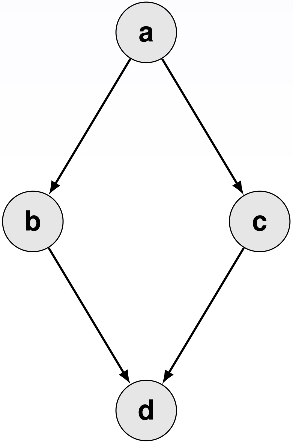

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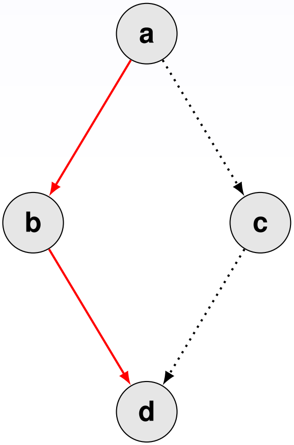

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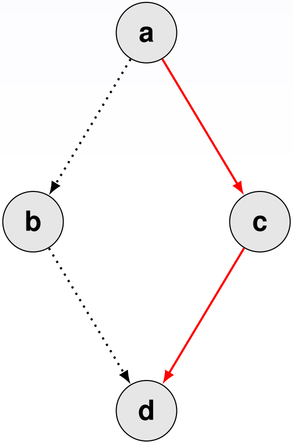

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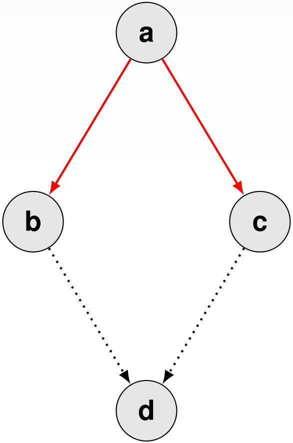

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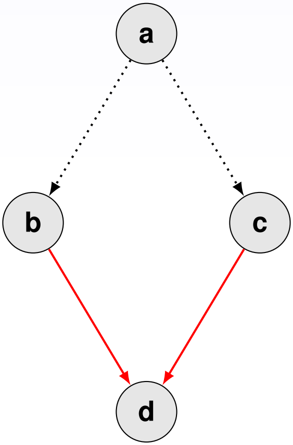
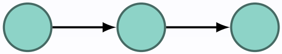
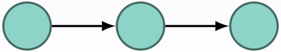


Dynamical meaning of first-order motifs



Linear food chain

Dynamical meaning of first-order motifs



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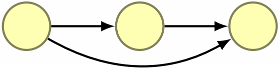
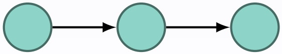


Omnivory

Dynamical meaning of first-order motifs



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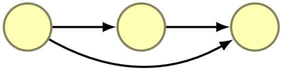
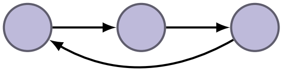
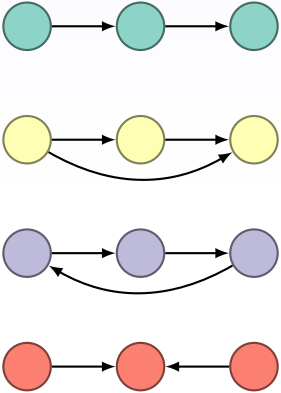


Omnivory



Trophic loop

Dynamical meaning of first-order motifs



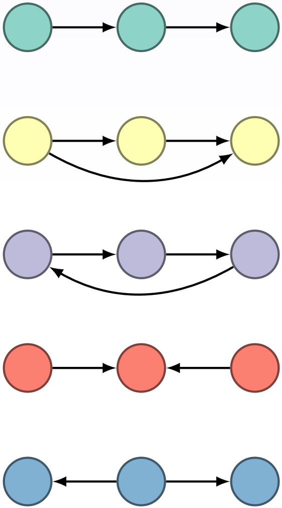
Linear food chain

Omnivory

Trophic loop

Exploitative competition

Dynamical meaning of first-order motifs



Linear food chain

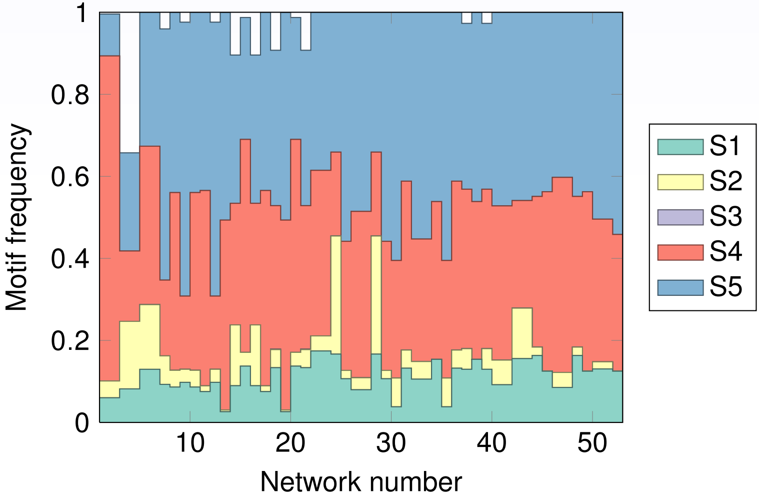
Omnivory

Trophic loop

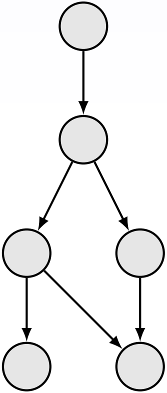
Exploitative competition

Apparent competition

Variation in motif composition

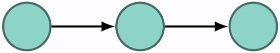


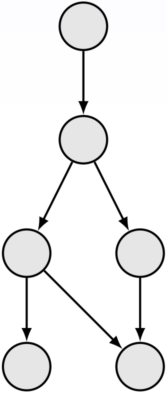
The question



The question

$N(S1) = 5$





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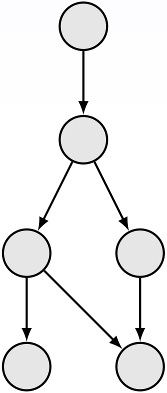

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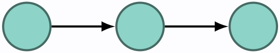
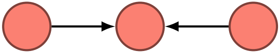


$N(S4) = 1$



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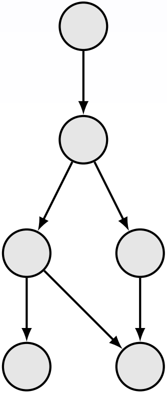
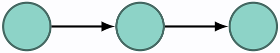
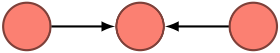


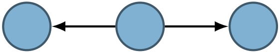
$$N(S1) = 5$$



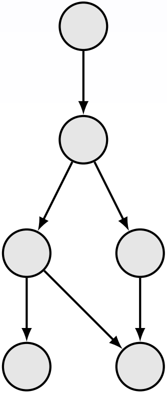
$$N(S4) = 1$$



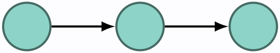
$$N(S5) = 2$$



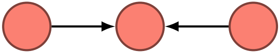
The question



$N(S1) = 5$



$N(S4) = 1$



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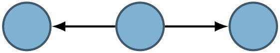
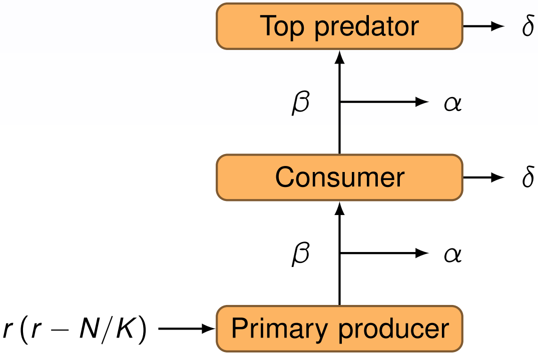


Functioning ?

The model

$$\frac{dN_i}{dt} = N_i \left[r \left(1 - \frac{N_i}{K} \right) - \sum_{j \in pred} \alpha N_j \right] \quad (1)$$

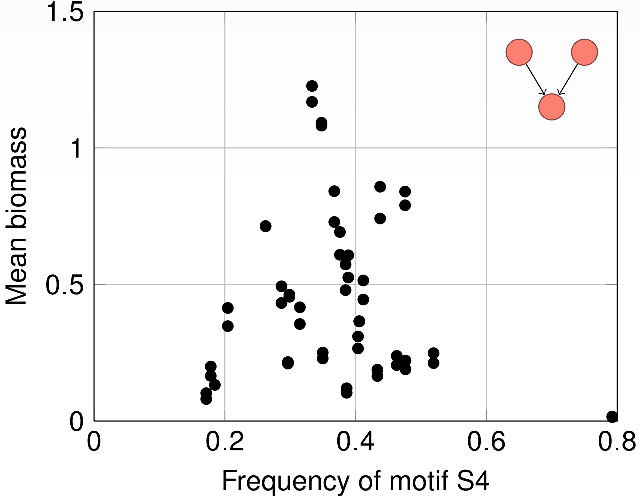
$$\frac{dN_i}{dt} = N_i \left[\sum_{j \in prey} \beta N_j - \sum_{j \in pred} \alpha N_j - \delta \right] \quad (2)$$


Top predator
δ
β
α
Consumer
δ
β
α
$r\,(r - N/K)$
Primary producer

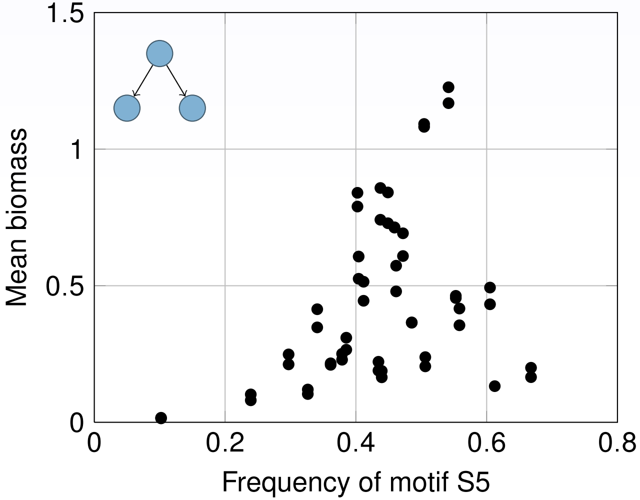
Simulations

- Each species starts with $N_i \in [0, 1]$, at random
- We run the system well over equilibrium (10^4 time steps)
- We record the total biomass of the system
- Repeat 10 times for each of the 180 webs
- Average over the 10 replicates presented in the figures

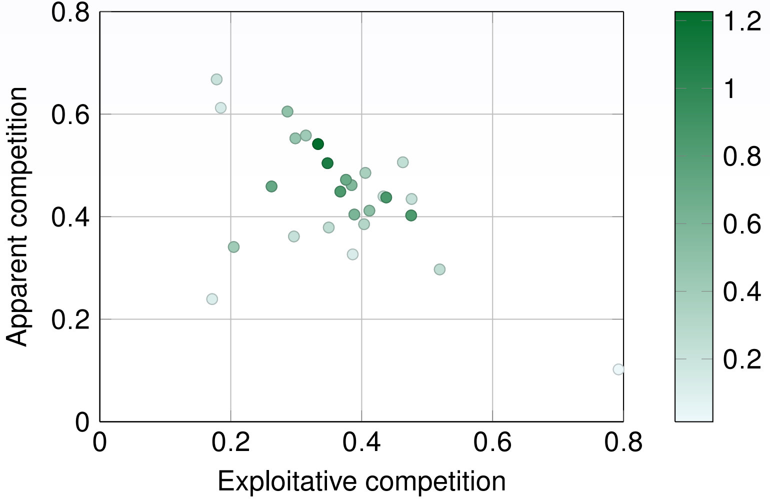
Exploitative competition



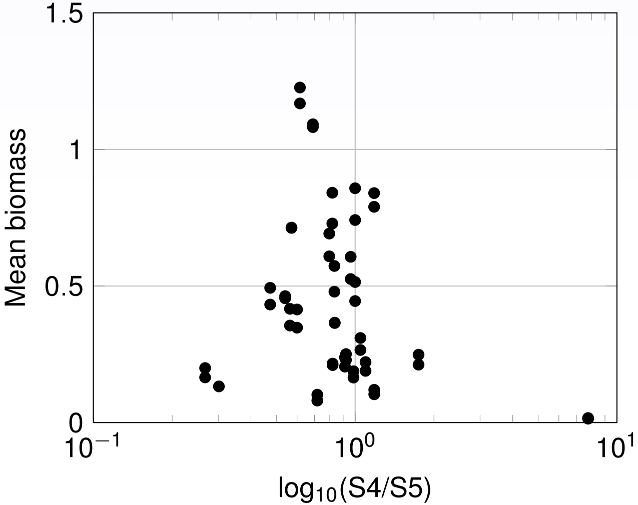
Apparent competition



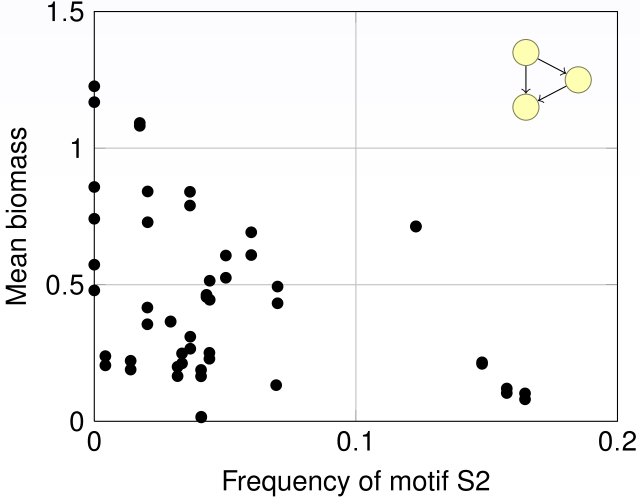
Types of competition



Competition type ratio



Omnivory decreases biomass production



Synthesis of the results – biomass production

Motif	Df	F value	Pr(>F)
Expl. comp. (S4)	1	1287.82	***
Omnivory (S2)	1	112.18	***
Lin. chain (S1)	1	91.22	***
Loop (S3)	1	26.41	***
App. comp. (S5)	1	11.69	***
Residuals	1774		$R^2 = 0.46$

Synthesis of the results – productivity

Motif	Df	F value	Pr(>F)
Expl. comp. (S4)	1	1013.00	***
Lin. chain (S1)	1	258.20	***
Omnivory (S2)	1	42.69	***
App. comp. (S5)	1	2.28	0.13
Loop (S3)	1	0.53	0.46
Residuals	1103		$R^2 = 0.54$

Biomass production and productivity