

A self-organized individual based predation and migration model to access aspects of the resilience of ecosystems

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SUMMARY

1 MOTIVATION

2 THE MODEL

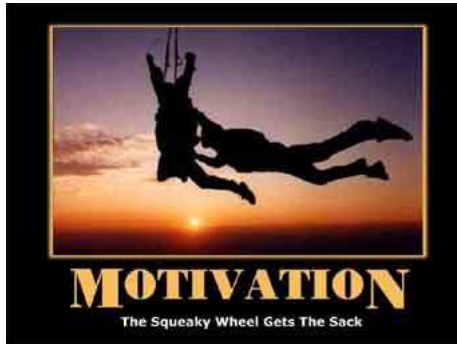
- The Model
- Predation
- Migration

3 SIMULATIONS

- Steady State
- Resilience study
- Space of Parameters
- Metabolic Theory of Ecology

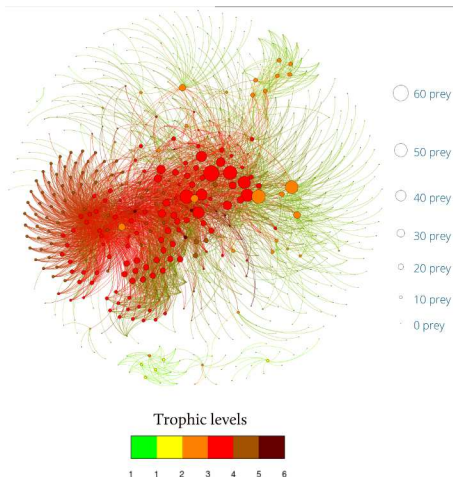
4 CONCLUSIONS

MOTIVATION



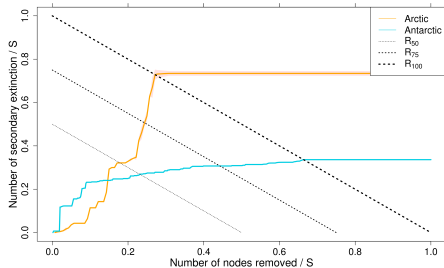
MOTIVATION

- Many aspects about the vulnerability of food webs to disturbances in species can be studied by topological and robustness analysis.



MOTIVATION

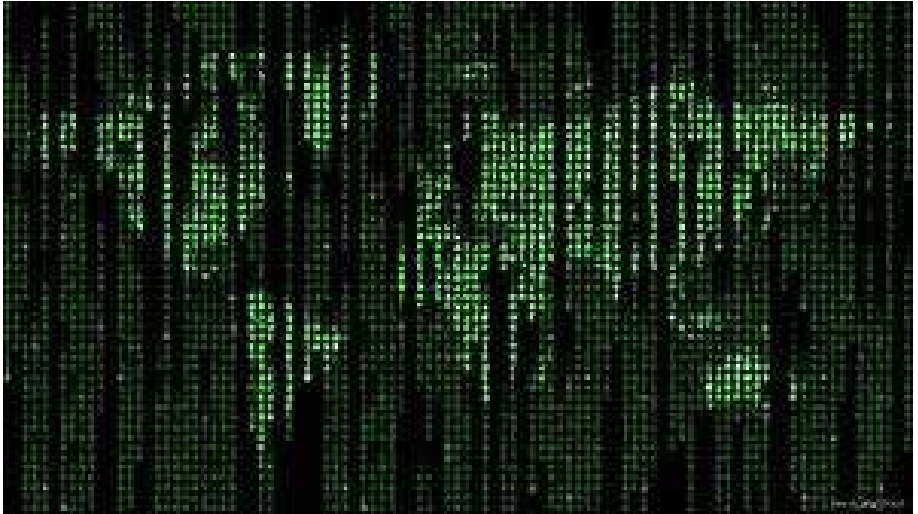
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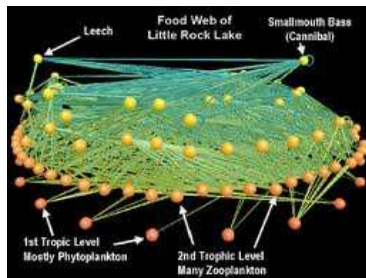
MOTIVATION

However, those approaches don't achieve the consequences of **individual level disturbances in the stability of ecosystems**. In this direction, we proposed the creation of an *Individual Based Predation and Migration model*.

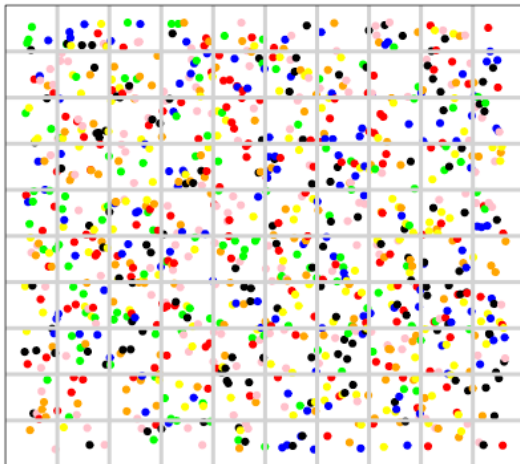
THE MODEL



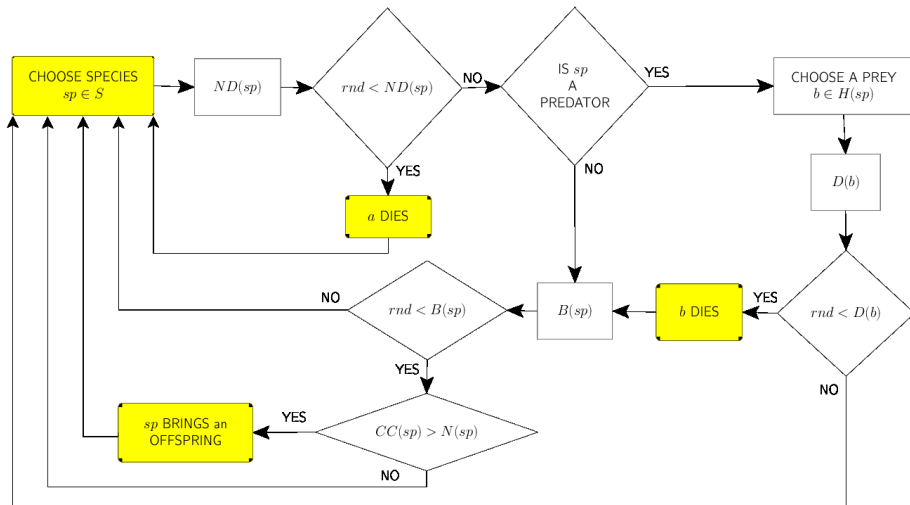
To study predator-prey and migration dynamics in a landscape.



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PREDATION DYNAMICS



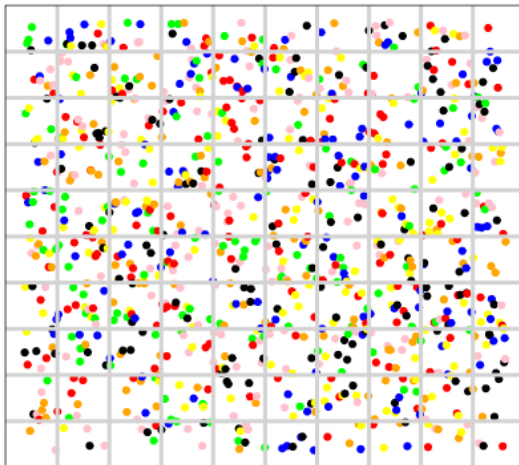
MIGRATION DYNAMICS

A diffusion dynamic of individuals from its grid cell towards neighbor grid cells based on the *quality of life*: **differences in the number of predators and preys** in each site.

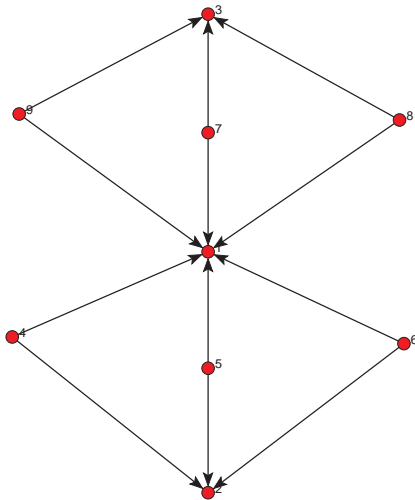
RESULTS



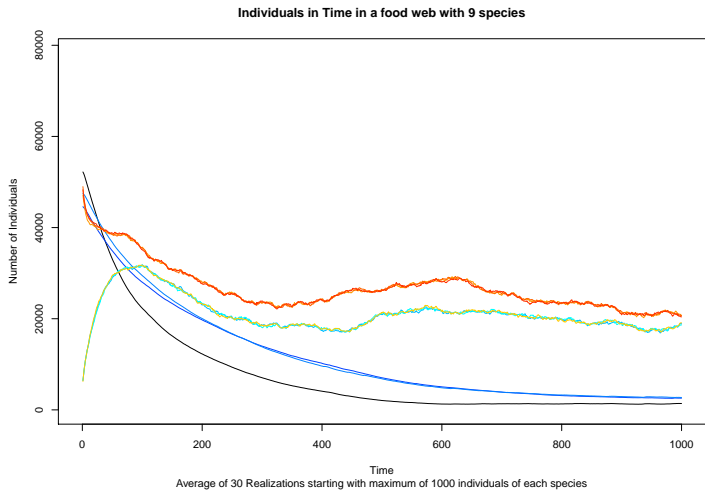
We populate each grid cells of the landscape with a random number of individuals of different species. The trophic relationships among the species are defined by a food web.



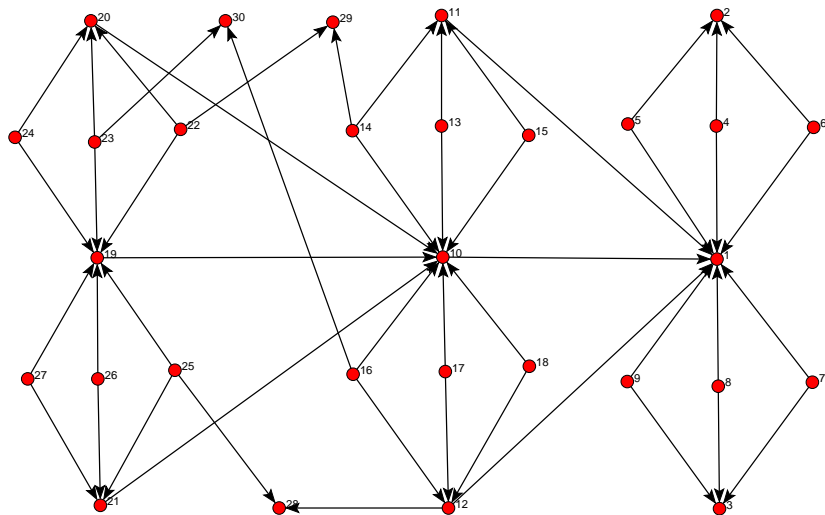
9 SPECIES FOOD WEB



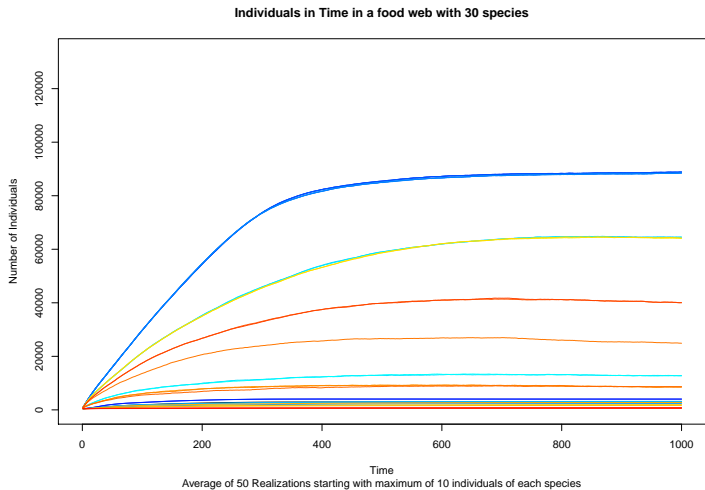
MAXIMUM START = 100 AND 1000 INDS.



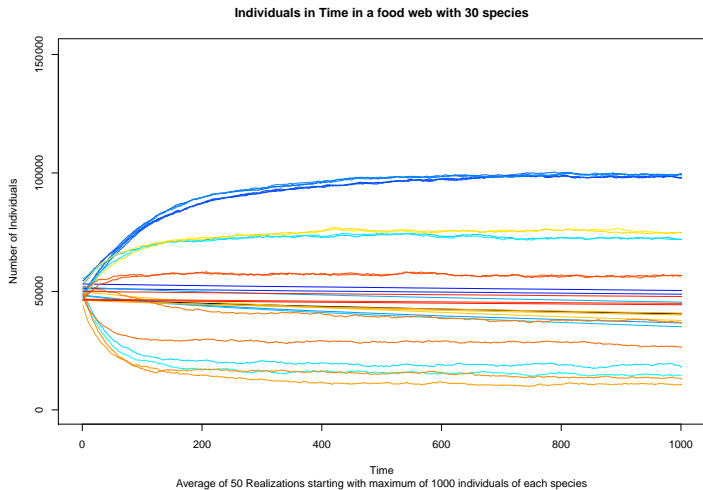
30 SPECIES FOOD WEB



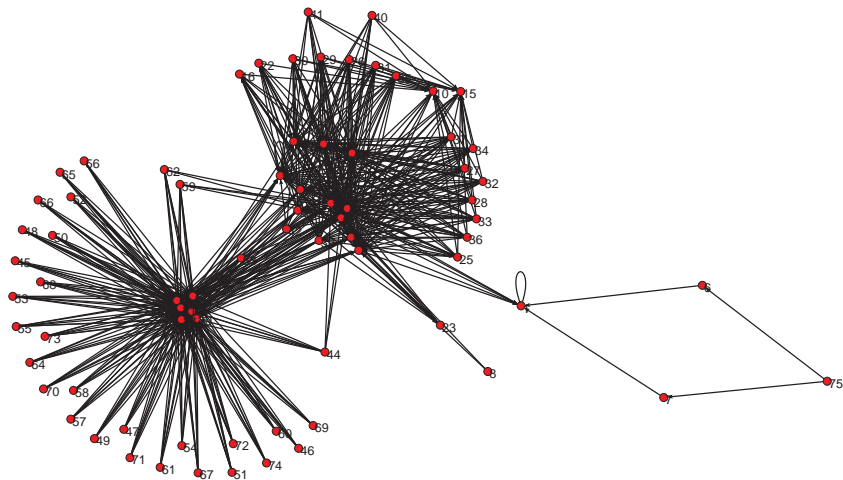
MAXIMUM START = 10 INDS.



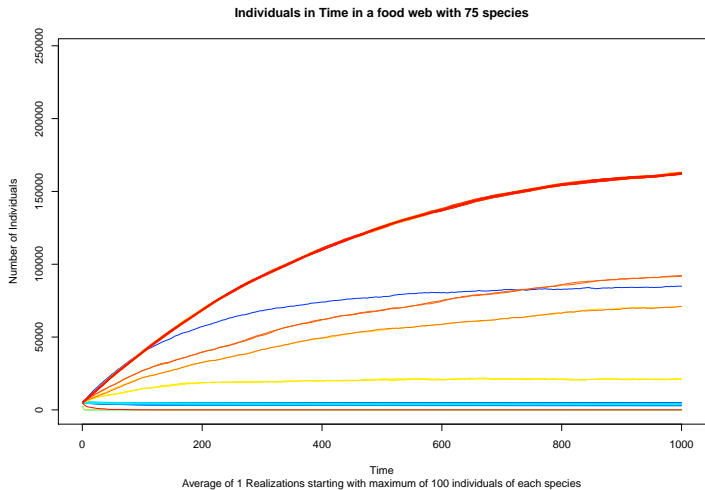
MAXIMUM START = 1000 INDS.



75 SPECIES FOOD WEB



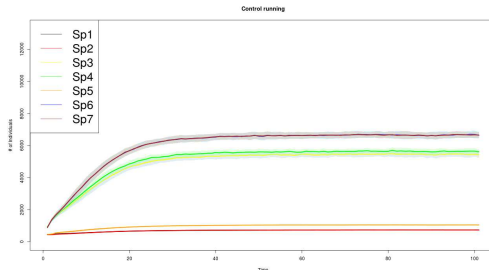
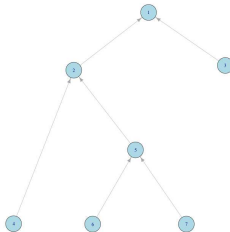
MAXIMUM START = 100 INDS.



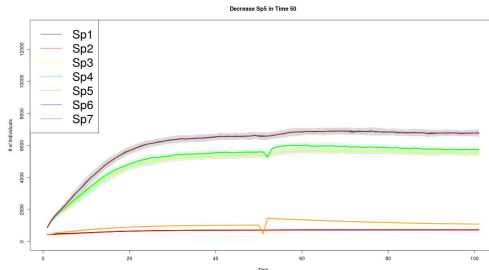
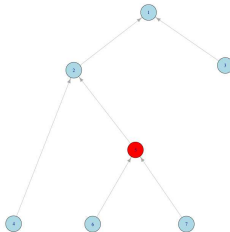
STABILITY OF THE FOOD WEBS

Expressing the parameters that govern the dynamics as functions of densities, apparently, we introduce correlations between B_p , D_p , ND_p . As a result of that, the system **self-organizes towards steady state**, independently of the initial number of individuals.

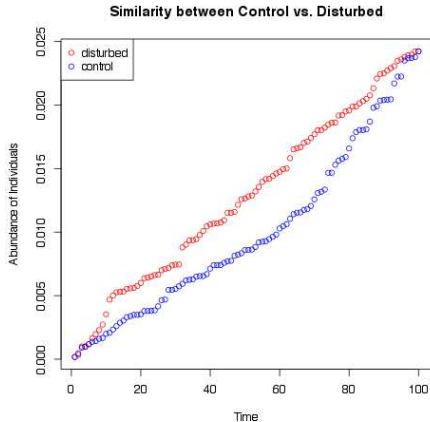
ADDING DISTURBANCE TO THE SYSTEM



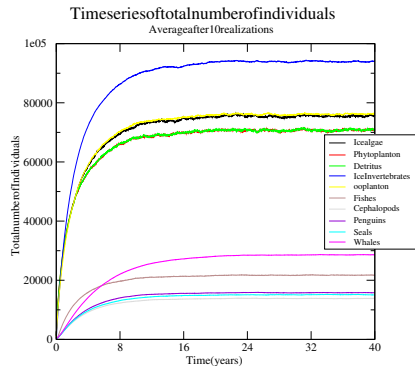
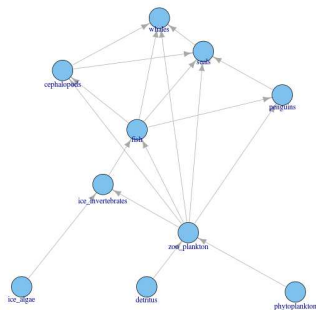
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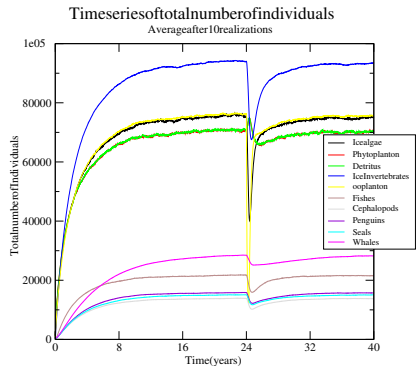
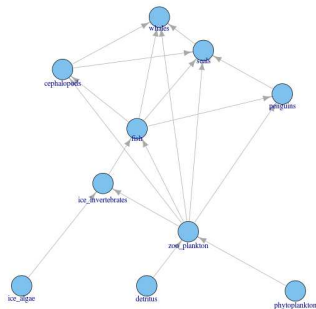
MEASURING THE DISTURBANCE



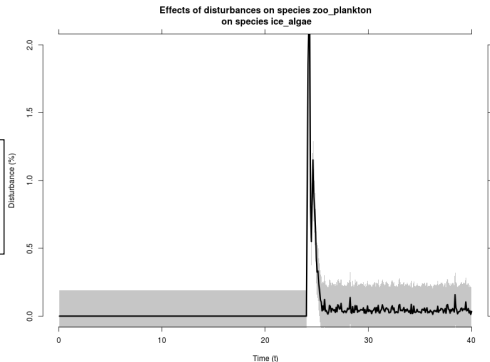
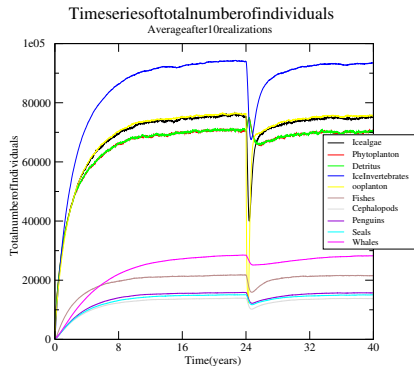
CASE STUDY: RESILIENCE OF AN ANTARCTIC FOOD WEB



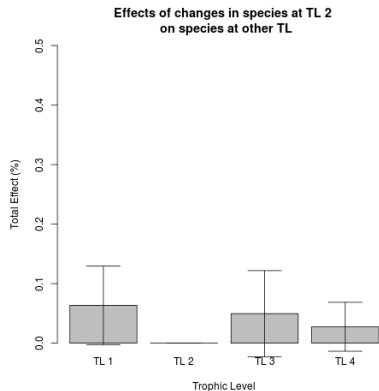
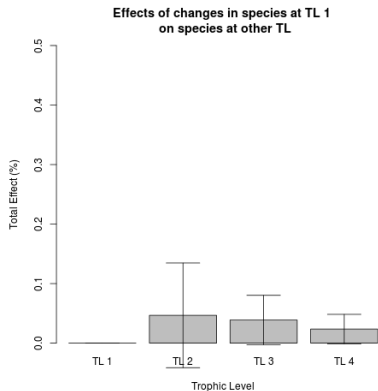
ANTARCTIC FOOD WEB: DECREASE OF ABUNDANCE OF SPECIES *Zooplankton*



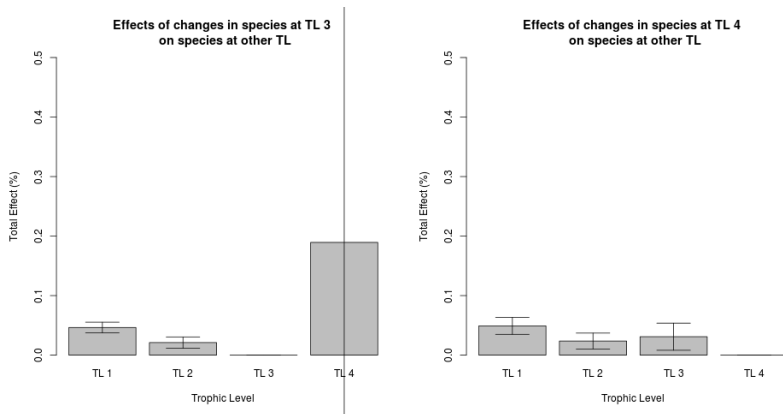
EFFECTS OF DECREASE IN *Zooplankton* IN OTHER SPECIES: *Ice Algae*



DECREASE IN ABUNDANCE OF SPECIES: EFFECTS AMONG TROPHIC LEVELS



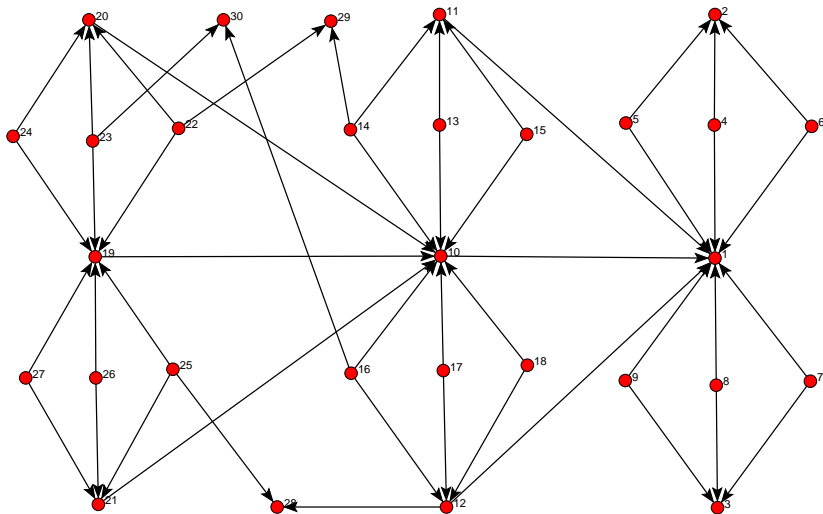
DECREASE IN ABUNDANCE OF SPECIES: EFFECTS AMONG TROPHIC LEVELS



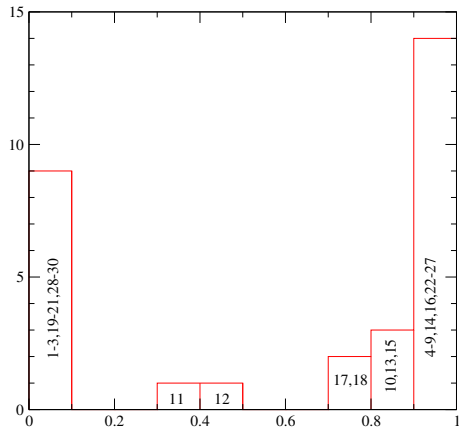
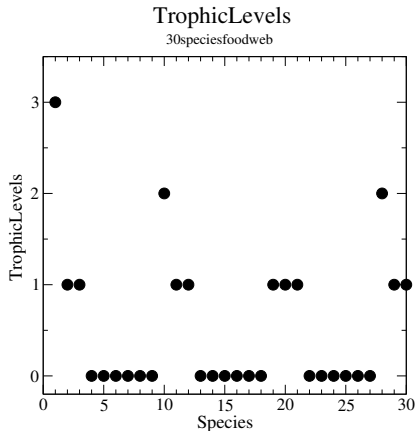
STUDYING RESILIENCE OF ECOSYSTEMS

The model allow the addition of disturbances in the abundance of the species studied. By comparing the distribution of abundance of species in a **control run** and in different **disturbed run** we can infer characteristics about the resilience of the studied ecosystems.

SPACE OF PARAMETERS: 30 SPECIES FOOD WEB



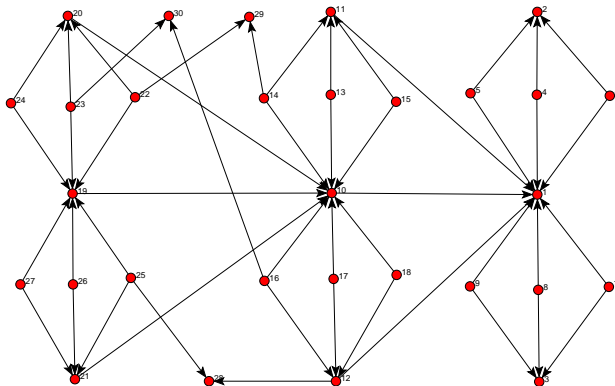
30 SPECIES FOOD WEB: SPACE OF BP



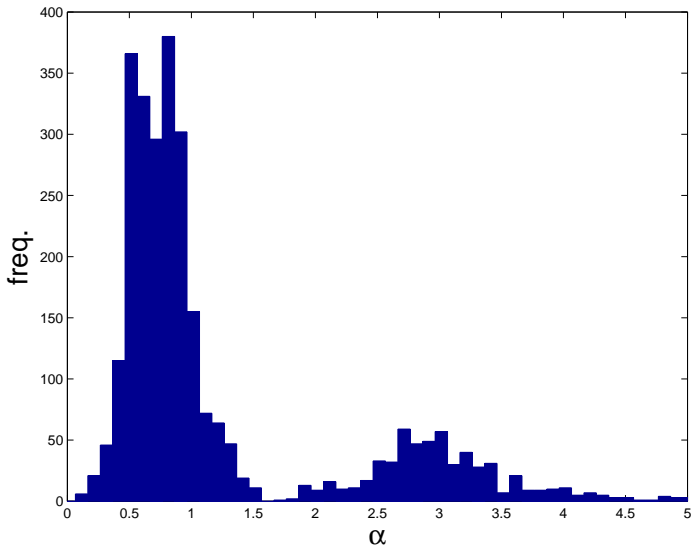
BP OF A 30 SPECIES FOOD WEB

Aparently, in a **steady site**, the lower species' **trophic level** the higher species' **birth probability**.

METABOLIC RATE: FOR A FOOD WEB WITH 30 SPECIES



METABOLIC RATE: $N \sim B^\alpha$ (FOR EACH SITE)



METABOLIC THEORY OF ECOLOGY

$$\bullet \quad N \sim M^{-\frac{3}{4}} \quad [1]$$

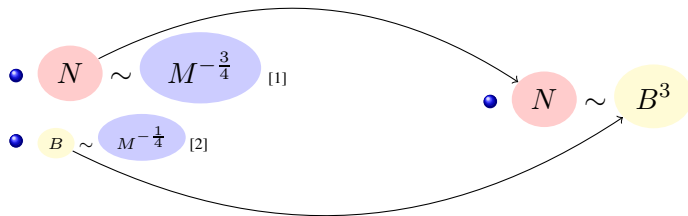
$$\bullet \quad B \sim M^{-\frac{1}{4}} \quad [2]$$

$$\bullet \quad N \sim B^3$$

1 - **Brown, J. H. , Gilloly, J. F. Allen, A. P., Savage V. M., and West G. B.** (2004). Toward a metabolic theory of ecology. *Ecology*, 85:1171-1789.

2 - **West, G. B., Brown, J. H.** (2005). The origin of allometric scaling laws in biology from genomes to ecosystems: towards a quantitative unifying theory of biological structure and organization. *J Exp Biol*, 208:1575-1592.

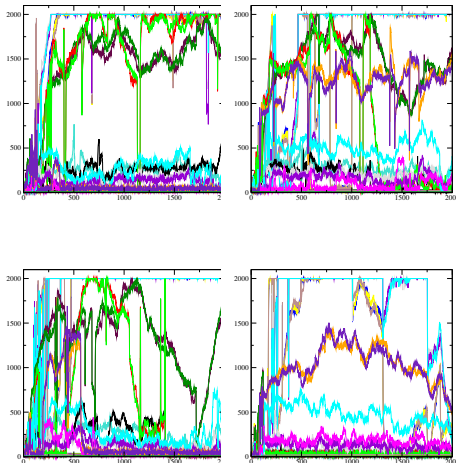
METABOLIC THEORY OF ECOLOGY



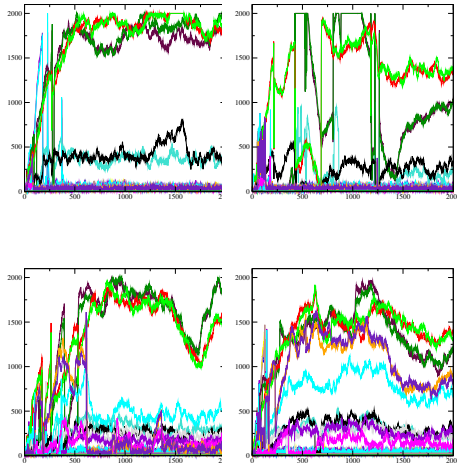
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UNESTABLE SITES: $N \sim B^1$



STEADY STATE ACHIEVED SITES: $N \sim B^3$



METHABOLIC THEORY OF ECOLOGY

Apparently, there is a relation between a steady state achievement and the assessed α ($N \sim B^\alpha$) in the site.

CONCLUSIONS



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Expressing the parameters that govern the dynamics as functions of densities, we introduce correlations between B_p , D_p , ND_p . As a result of that, the system **self-organizes towards steady state**, independently of the initial number of individuals.

The model allow the comparison of dynamics of the simulated systems under different disturbed situation: (e.g.: loss of habitat; changes in niche of species; loss of connectivity between sites; invasive species; extinction of species; etc).

Aparently, in a **steady site**, the lower species' **trophic level** the higher species' **birth probability**.

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The model is general enough to allow the inclusion of biotic and abiotic iterations.

The model can be nested to niche models, and then provide a *Niche Model with Biotic Interactions*.

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THANK YOU FOR YOUR ATTENTION!