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

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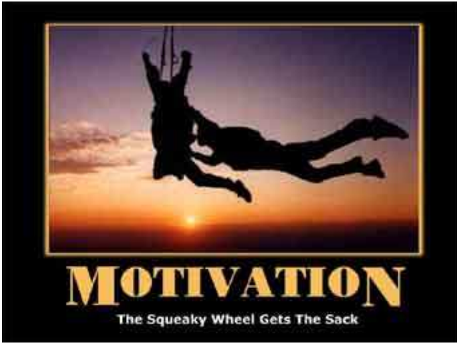
23 Sep 2013

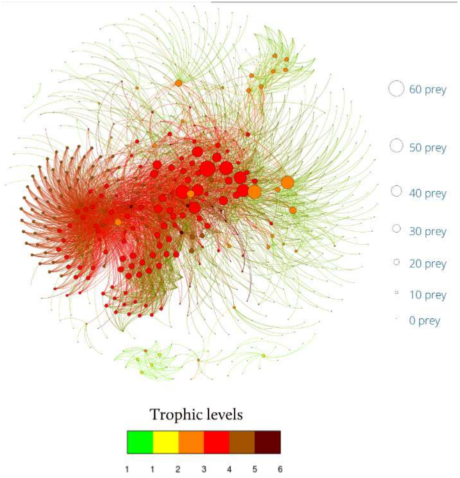
Summary

MOTIVATION



MOTIVATION

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



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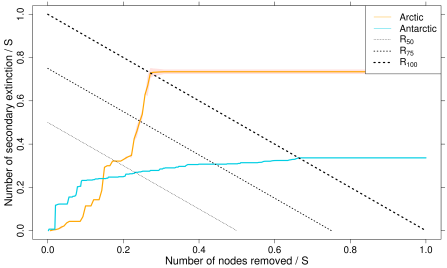
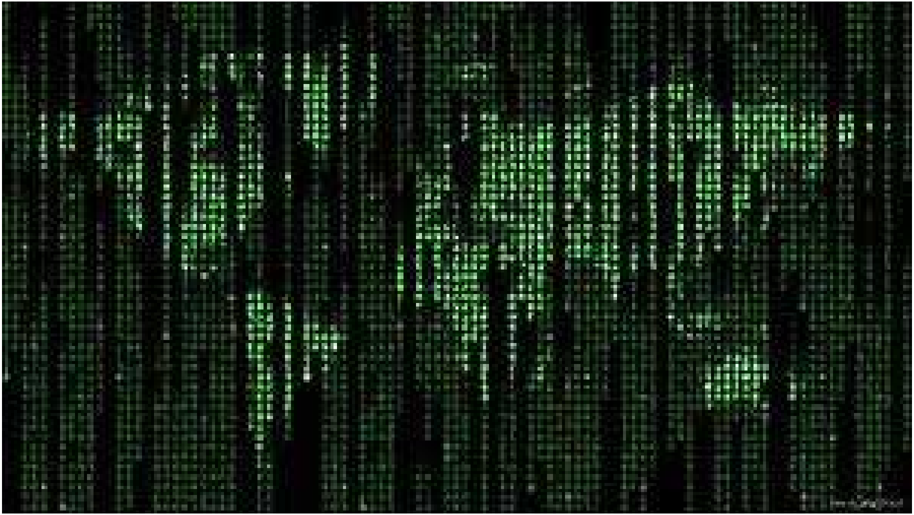


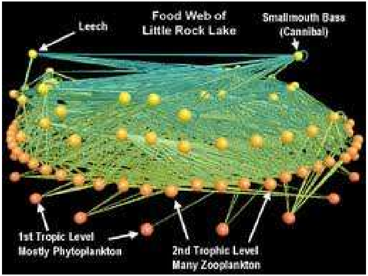
MOTIVATION

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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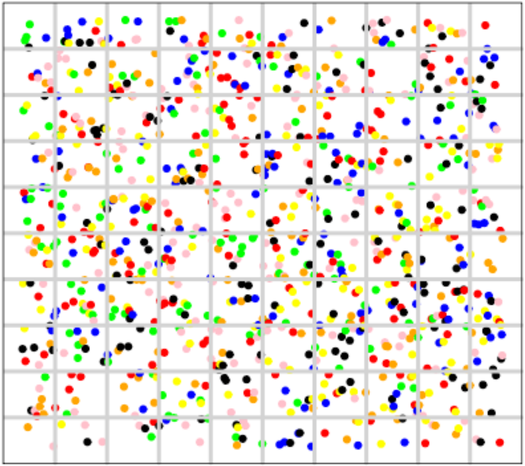
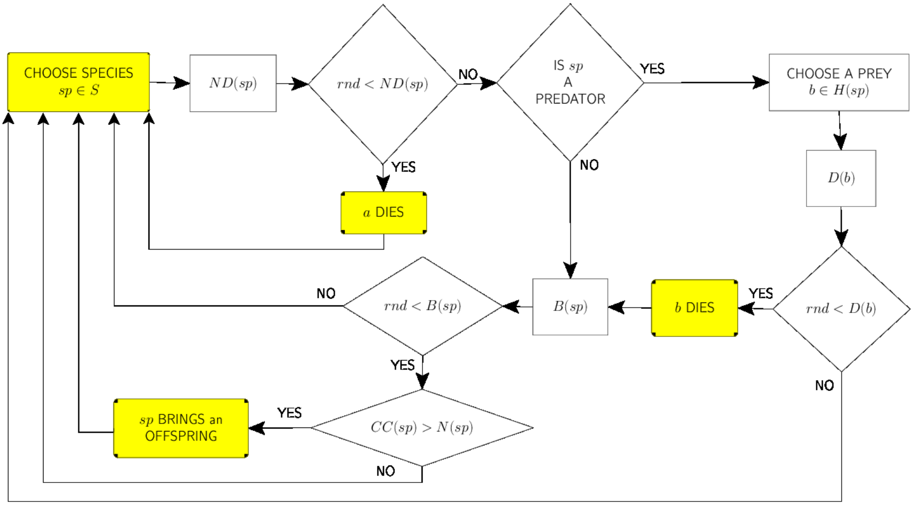


PREDATION DYNAMICS

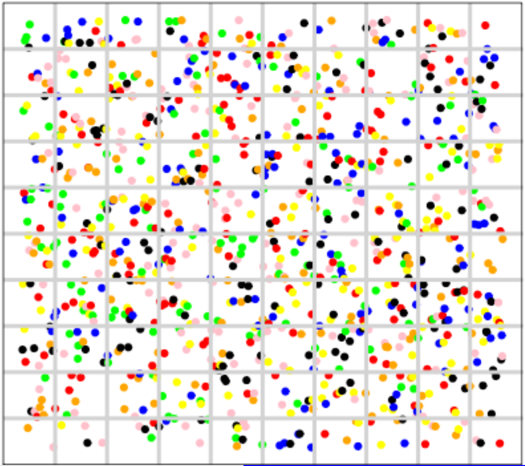


MIGRATION DYNAMICS

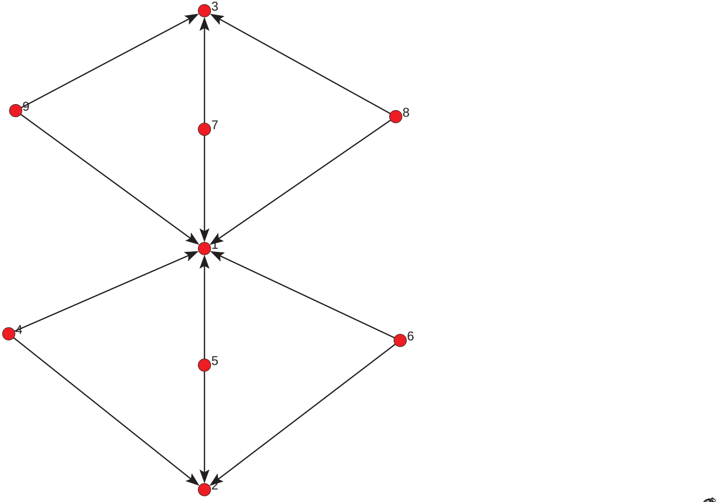
A diffusion dynamic of individuals from its grid cell towards neighbor grid cells based on the *quality of life*: **differences in the number of predators and preys** in each site.

RESULTS

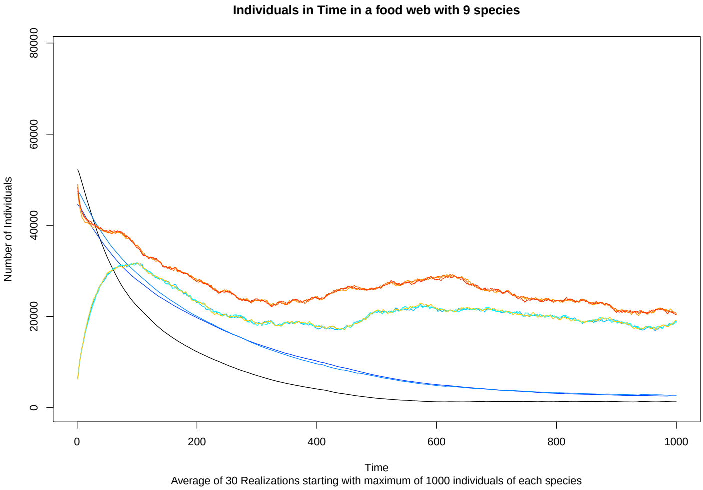
We populate each grid cells of the landscape with a random number of individuals of different species. The trophic relationships among the species are defined by a food web.



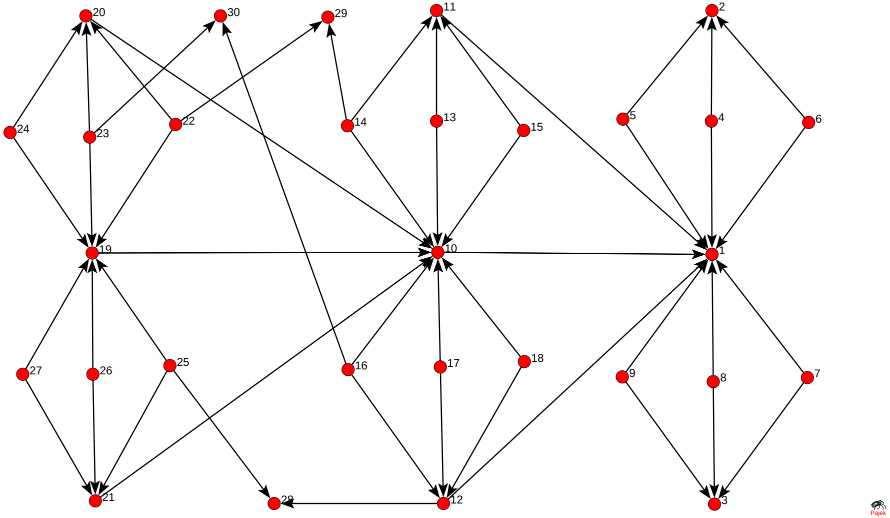
9 species food web



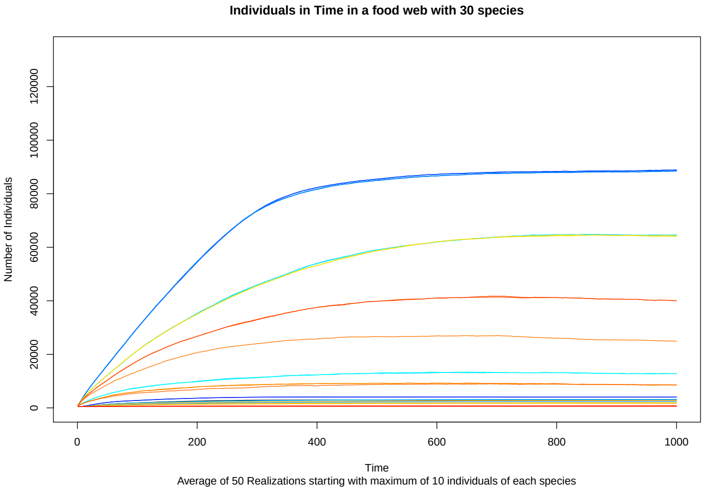
MAXIMUM START = 100 AND 1000 INDS.



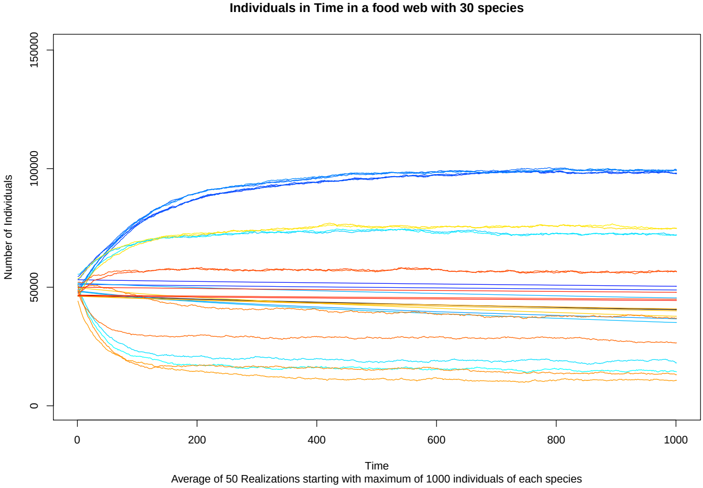
30 SPECIES FOOD WEB



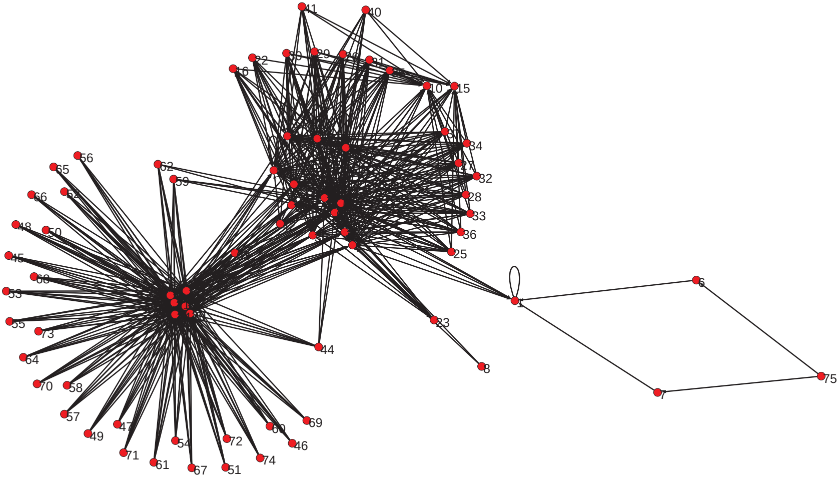
MAXIMUM START = 10 INDS.



MAXIMUM START = 1000 INDS.



75 SPECIES FOOD WEB



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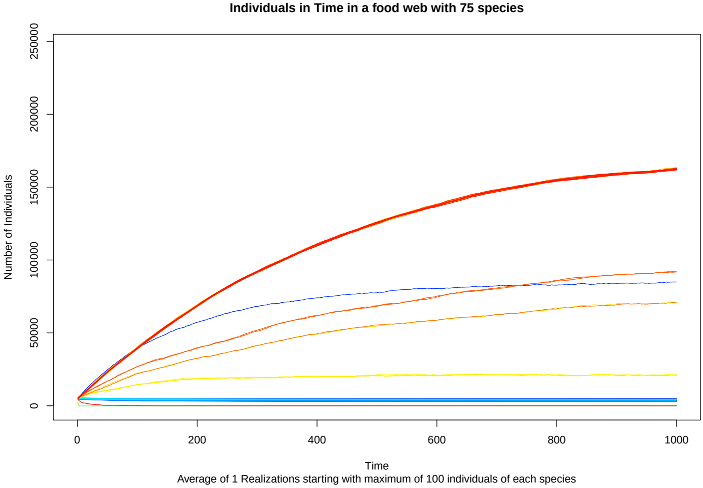
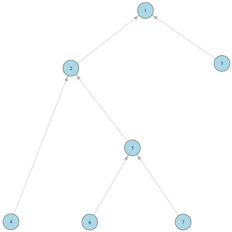
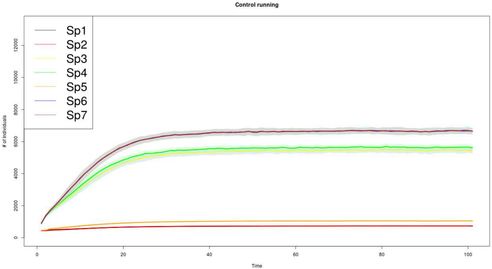


STABILITY OF THE FOOD WEBS

Expressing the parameters that govern the dynamics as functions of densities, aparently, we introduce correlations between Bp, Dp, NDp. 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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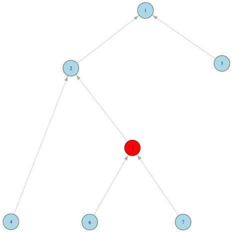
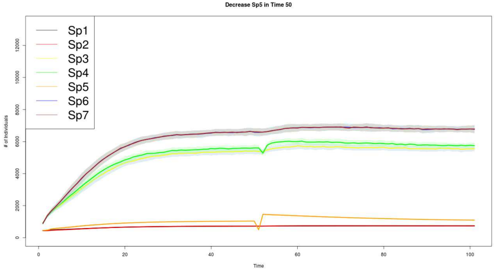
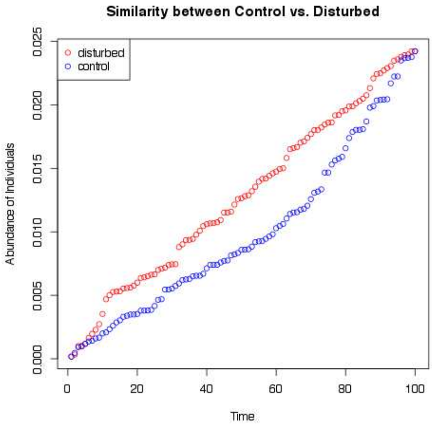
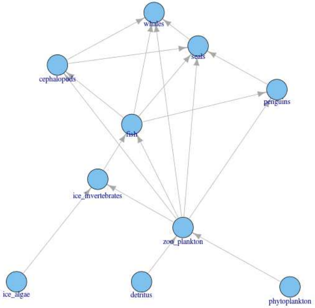


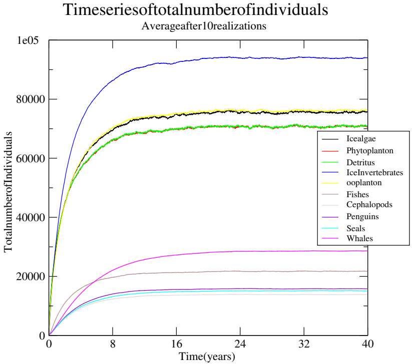


MEASURING THE DISTURBANCE

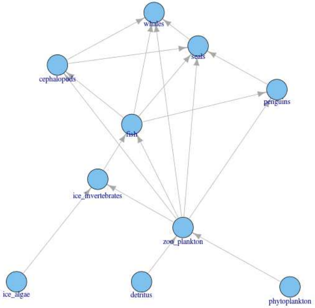


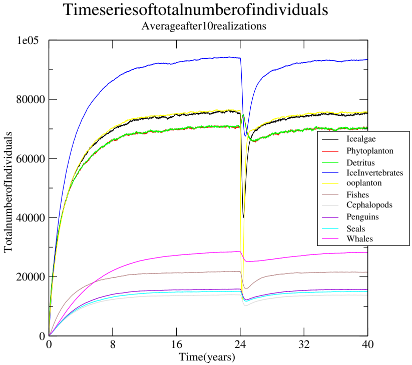
CASE STUDY: RESILIENCE OF AN ANTARCTIC FOOD WEB



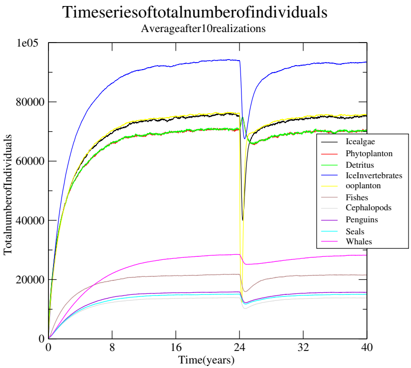


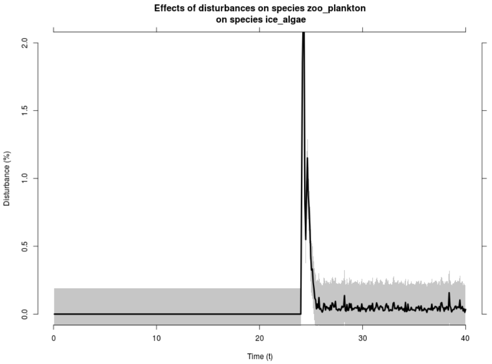
ANTARCTIC FOOD WEB: DECREASE OF ABUNDANCE OF SPECIES *Zooplankton*



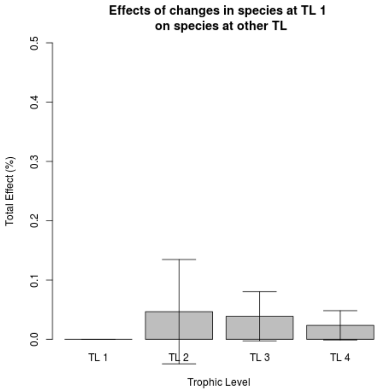


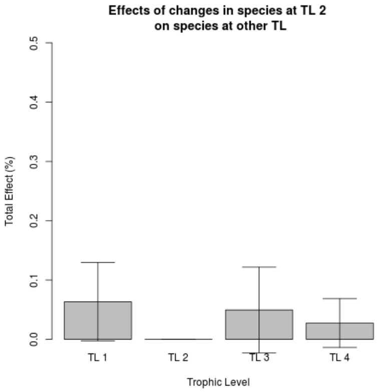
EFFECTS OF DECREASE IN *Zooplankton* IN OTHER SPECIES: *Ice Algae*





DECREASE IN ABUNDANCE OF SPECIES: EFFECTS AMONG TROPHIC LEVELS





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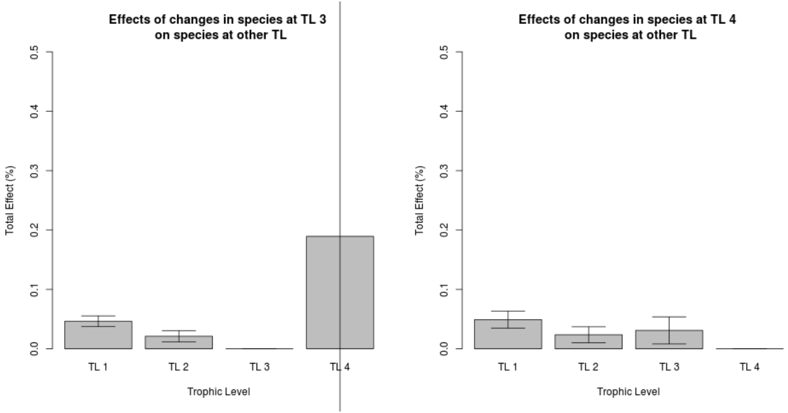
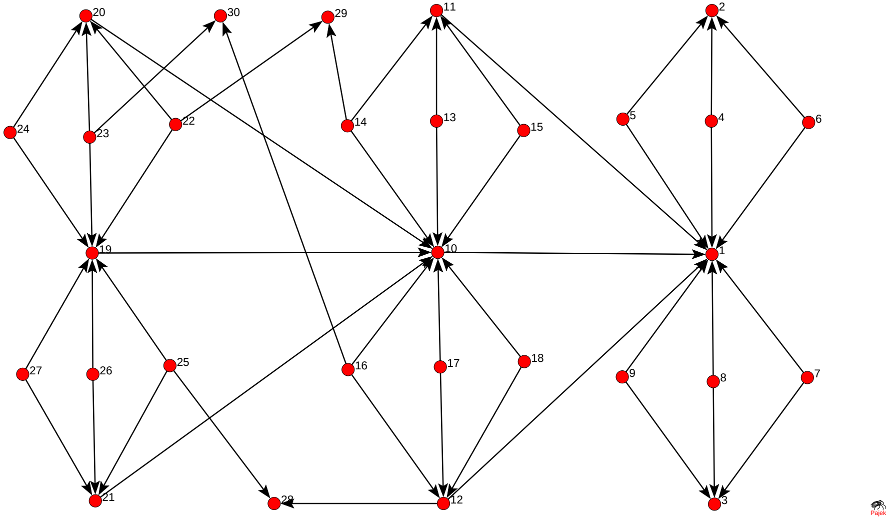


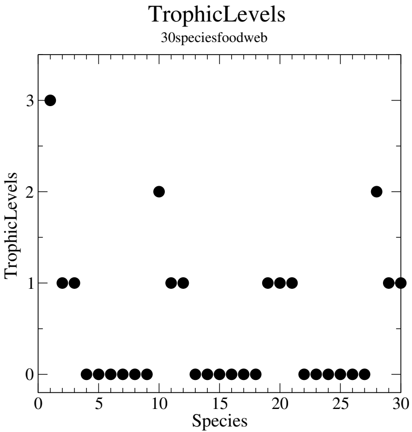
STUDYING RESILIENCE OF ECOSYSTEMS

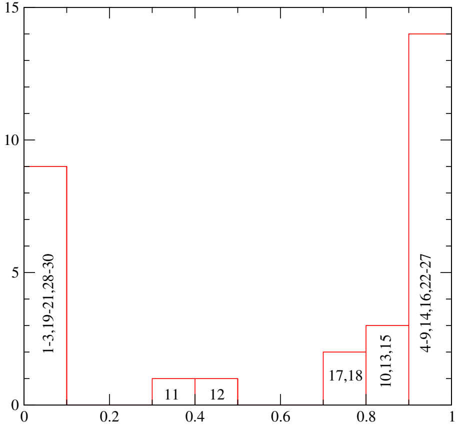
The model allow the addition of disturbances in the abundance of the species studied. By comparing the distribution of abundance of species in a **control run** and in different **disturbed run** we can infer characteristics about the resilience of the studied ecosystems.

SPACE OF PARAMETERS: 30 SPECIES FOOD WEB



30 species Food Web: Space of Bp

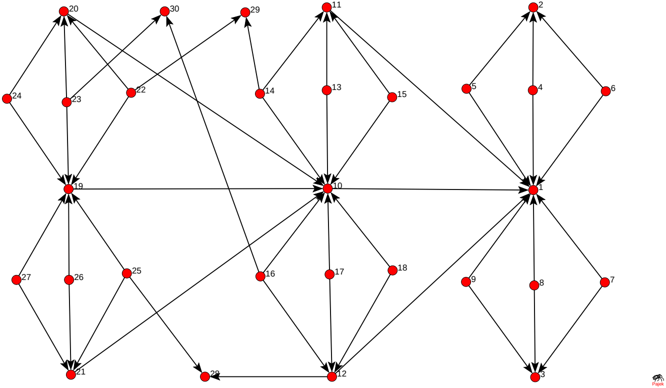




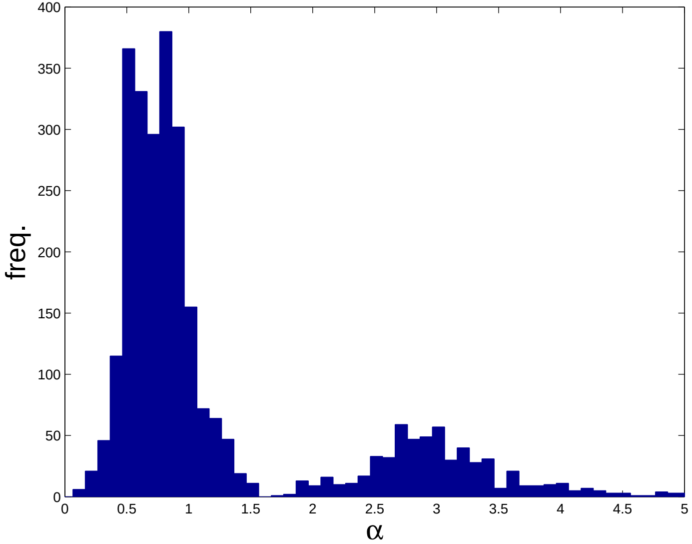
Bp of a 30 Species Food Web

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

- $N \sim M^{-\frac{3}{4}}$ [1]
- $B \sim M^{-\frac{1}{4}}$ [2]
- $N \sim B^{3}$

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.

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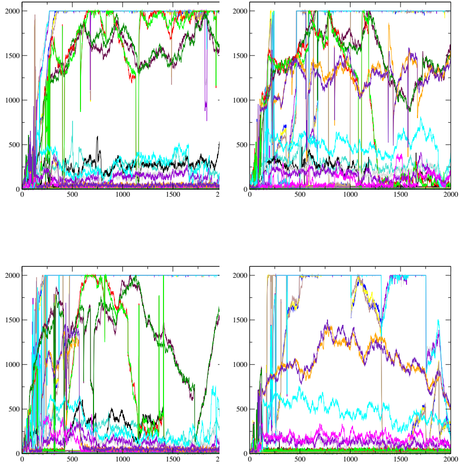
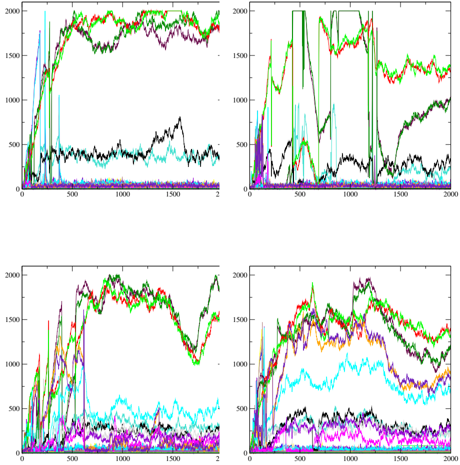
UNESTABLE SITES: $N \sim B^1$



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



METHABOLIC THEORY OF ECOLOGY

Aparently, 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 Bp, Dp, NDp. 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 Iteractions*.

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THANNK YOU FOR YOUR ATTENTION!