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Rémi Duflot, Stéphanie Aviron, Aude Ernoult

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# A mensurative experiment to study effects of landscape heterogeneity on biodiversity

Rémi DUFLOT – PhD Student

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[duflot.remi@gmail.com](mailto:duflot.remi@gmail.com)

## Co-authors

Supervisors:

- Françoise BUREL
- Stéphanie AVIRON
- Aude ERNOULT

Master student trainees:

- Flore BALLAUD
- Romain GEORGES



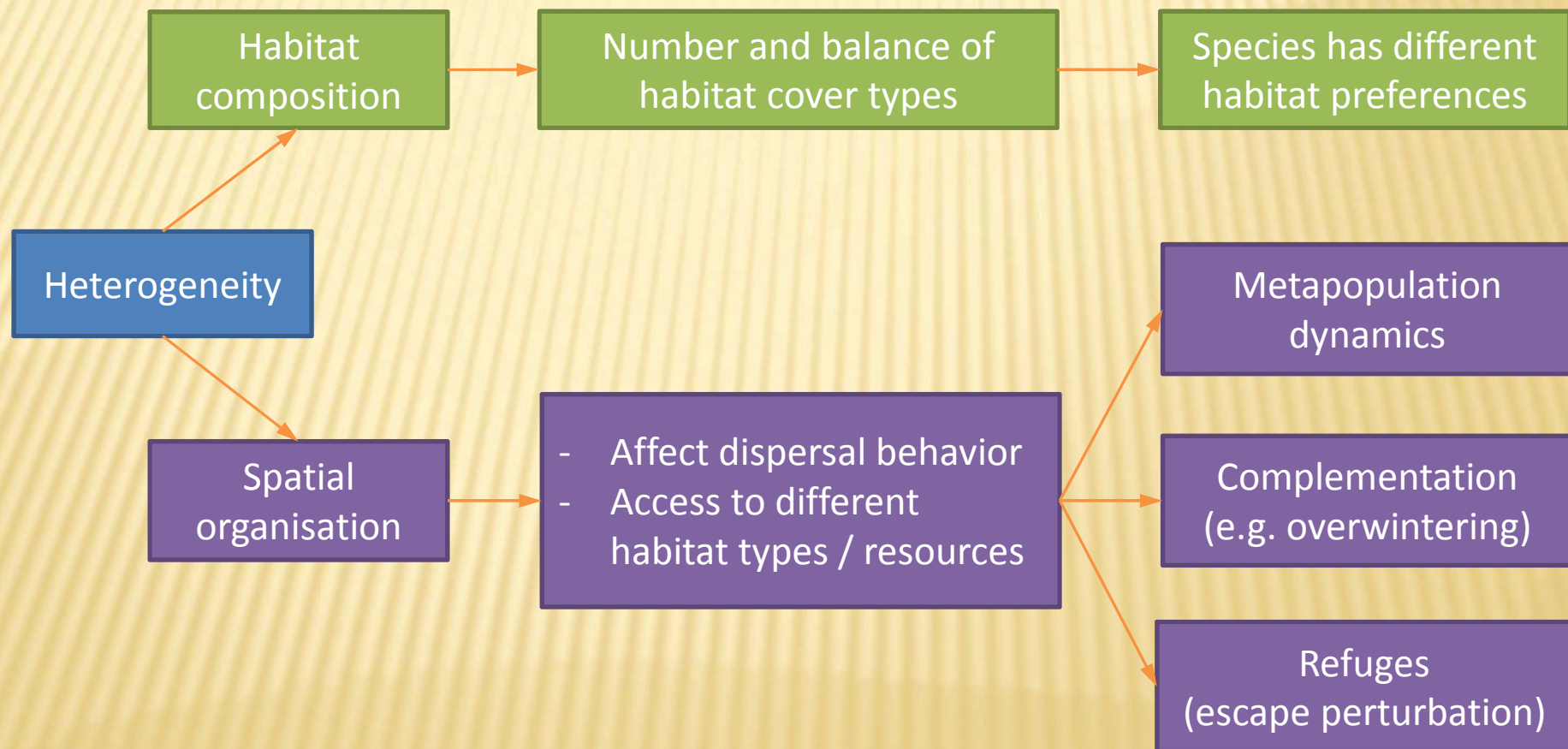
## Presentation outlines

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- 1/ Introduction of conceptual framework
- 2/ The experimental method
- 3/ Preliminary results

# Heterogeneity and diversity

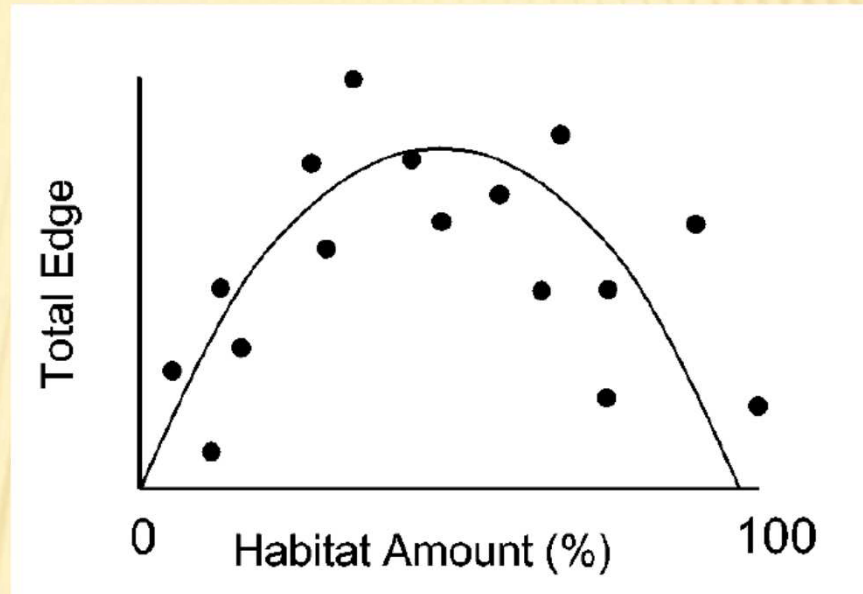
Landscape heterogeneity is a key factor in maintaining biodiversity in agricultural landscapes



*(Benton et al., 2003; Tscharntke, 2005; Le Roux, 2008; Fahrig, 2011)*

# Separating composition and spatial organisation

- Landscape composition and spatial organisation are correlated  
(*Fahrig, 2003*)



- Heterogeneity is often:
  - evaluated by the proportion of habitats
  - without accounting for spatial organisation
  - or using a measure correlated with habitat amount
- The heterogeneity of crop mosaic has been poorly studied
  - > might influence species that use crops during their life cycle

# Semi-natural habitat (SNH) and boundaries

-> Two important structures for biodiversity in agricultural landscapes

## Semi-natural habitats (Billeter, 2008):

Key role in biodiversity conservation

Habitats and corridors

Refuges

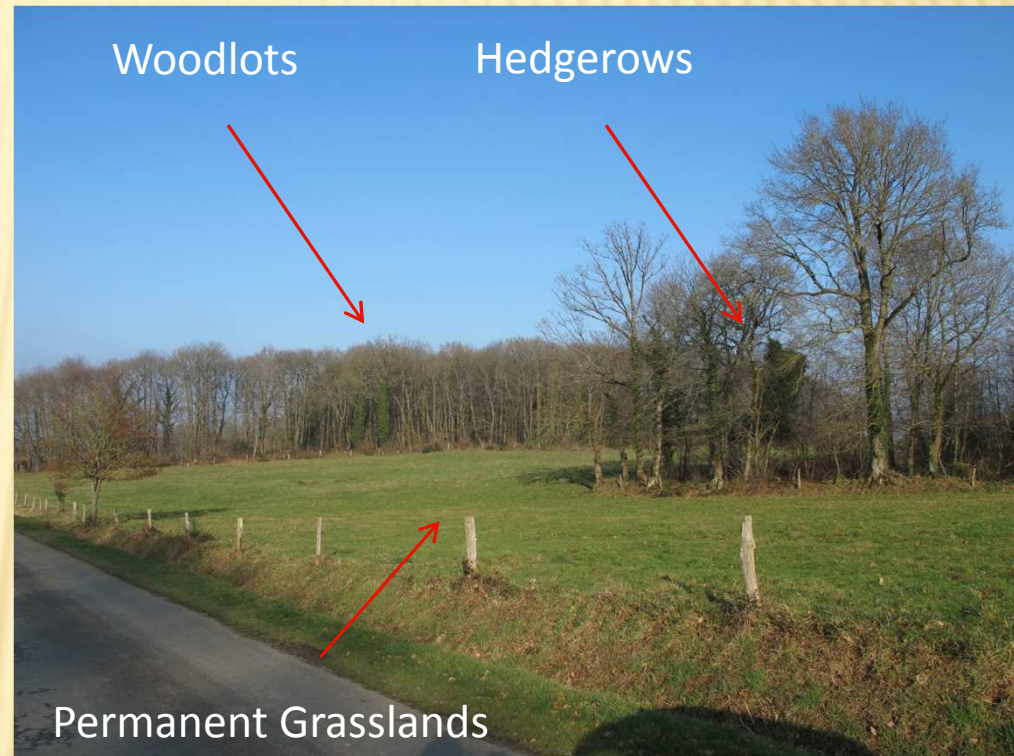
Sources to re-colonize disturbed habitat

## Boundaries:

Movement between patches

A measure of spatial heterogeneity

Three types of boundaries - Crop / Crop  
- SNH / SNH  
- Crop / SNH



Question: How important are boundaries between SNH and cultivated land in maintaining biodiversity of agricultural landscapes ?

# Creating a double gradient

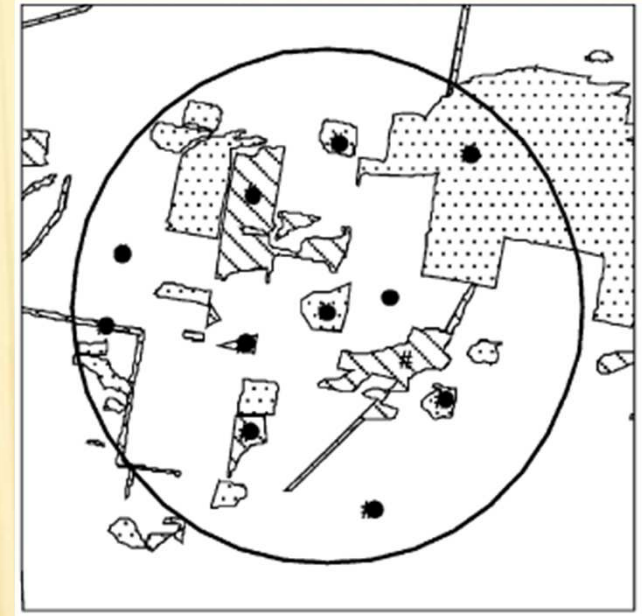
-> Aim: an experimental design without correlation between % SNH and boundaries length

## Need to:

1/ Work at landscape scale (“whole mosaic”)

2/ Sample several patches and habitat types / landscape  
-> Measure diversity at landscape scale = Gamma diversity

3/ Select landscapes according to the landscape parameters to be tested



Measure other parameters of the total heterogeneity: Effect of crop mosaic?

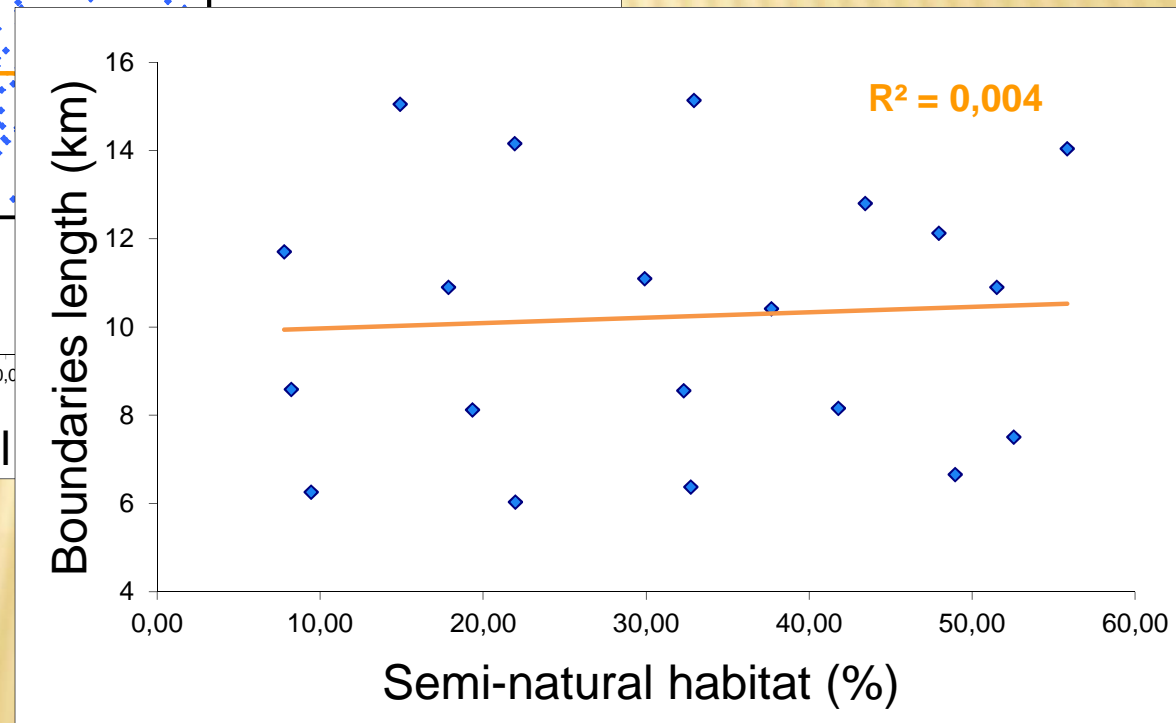
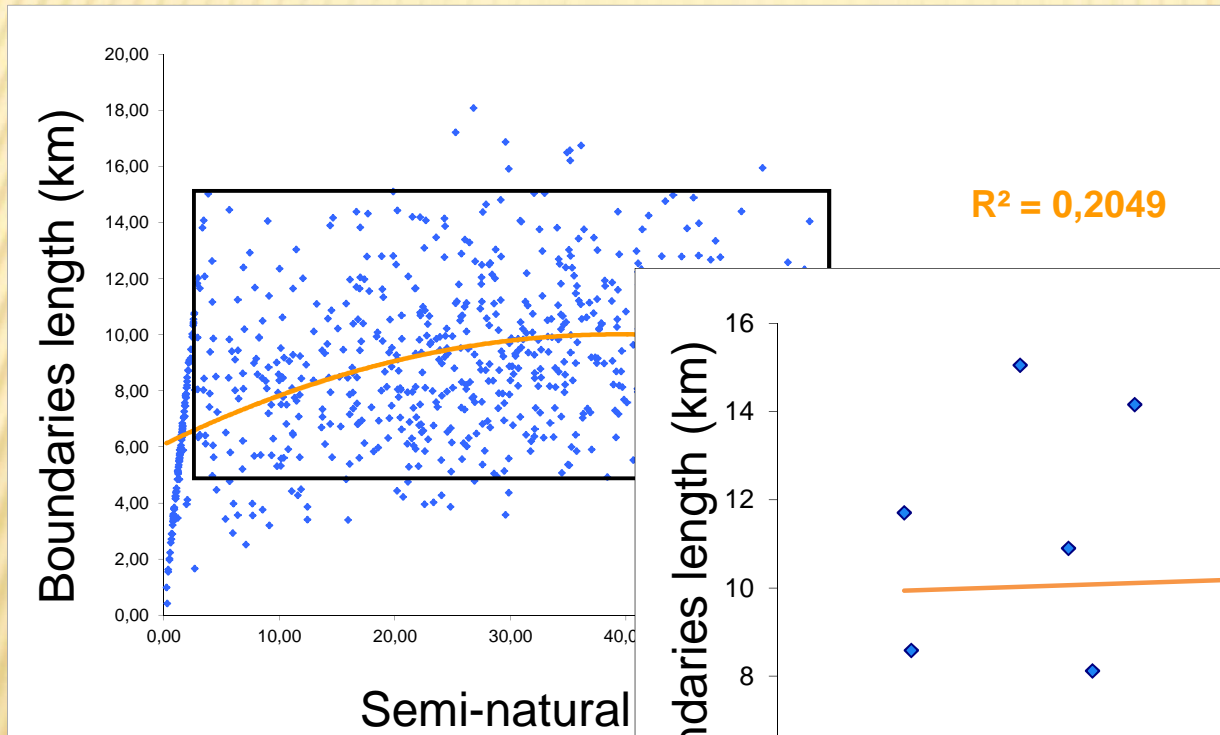
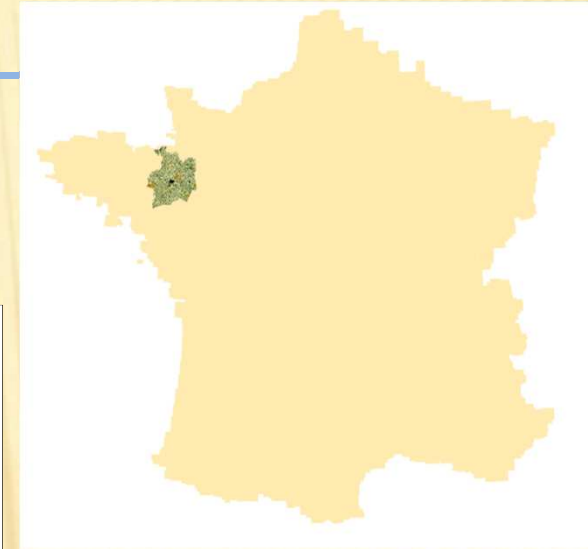
- Cover of crop types
- Total heterogeneity

$$\text{Heterogeneity} = - \sum_{q=1}^{na} Pq \times \ln(Pq)$$

(Bennett, 2006 ; Crist, 2003; Burel & Baudry, 2003)

# Selection of study sites

- > Screening of up to 8000 squared landscapes 1km x 1km:
  - Selection of 20 sites without correlation between % SNH and boundaries length





# Diversity survey

## Two study groups

- Carabid beetles
- Vascular plants

## Sampling methods

- Plants: squared plots
- Carabids: pitfall traps

## Stratified sampling design

Two replicates of five habitat types

- Woodlot
- Hedgerow
- Permanent grassland
- Temporary grassland
- Winter cereal fields (wheat)

-> 10 sampling points / landscape



# Hypotheses

- I. Percentage of SNH increases Gamma diversity
  - More suitable habitat available
- II. Boundaries length increases Gamma diversity
  - Promote exchanges between patches and habitats
- III. Important role of crops for some species
  - Crop-specialist carabid beetles, plant weeds
- IV. Heterogeneity
  - a) Heterogeneity reduces dispersal rates, limits competition and increases biodiversity
  - b) Heterogeneity limits metapopulation dynamics, fragmentation effect, decreases biodiversity



-> Heterogeneity might have different impact according to other parameters

# Preliminary results

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## Results include

- 10 sites along the gradient
  - > Landscapes that have more cereals also have more heterogeneity
- No survey of plant in wheat fields
- Only the first two trapping periods (pooled) of carabid beetles (out of 6)
  - 4 periods in May / June
  - 2 periods in September
- Gamma diversity analyzed with Multiple Linear Models
  - > % SNH / Boundaries length / % Cereals / Heterogeneity

## General overview

-> The effects of variables on species are well estimated

Coinertia RV-coefficient = 63% (carabids) / 56% (Plants)

Carabid beetles : 73 species ; 30 % appeared in less then 3 sites

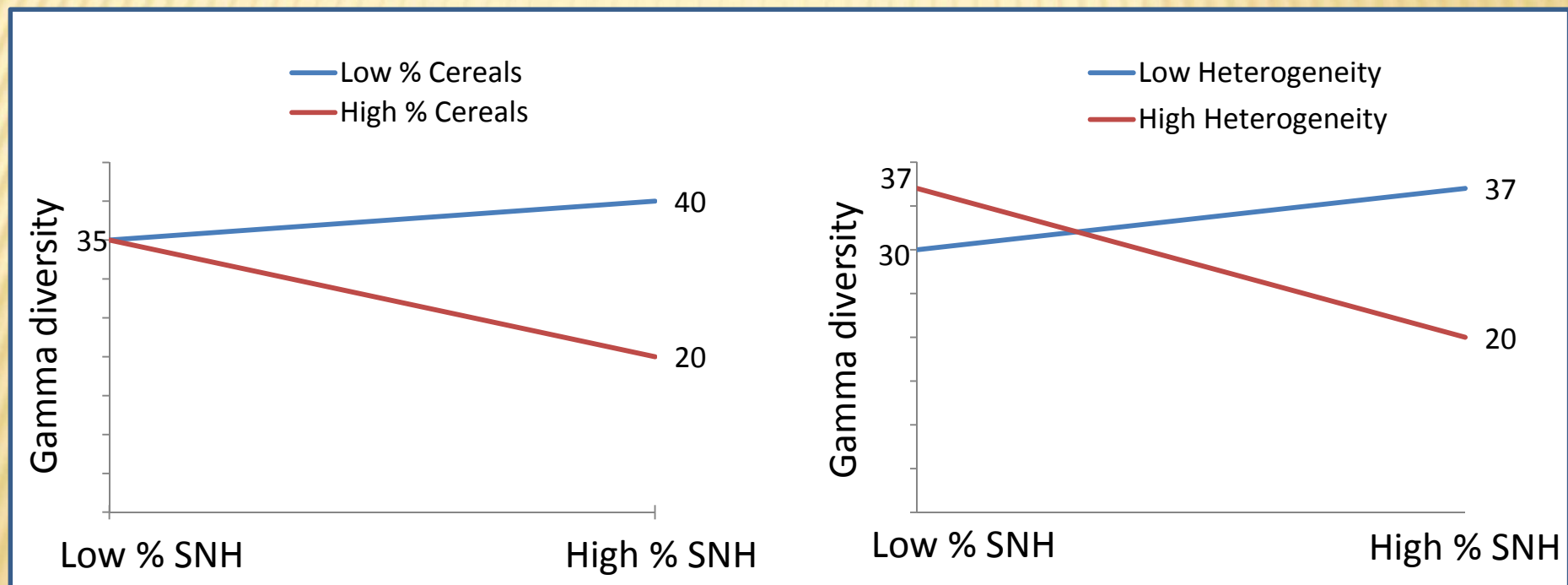
Plants: 227 species ; 52 % appeared in less then 3 sites

-> Our results are sensitive to rare species

# Gamma Diversity / Carabid beetles

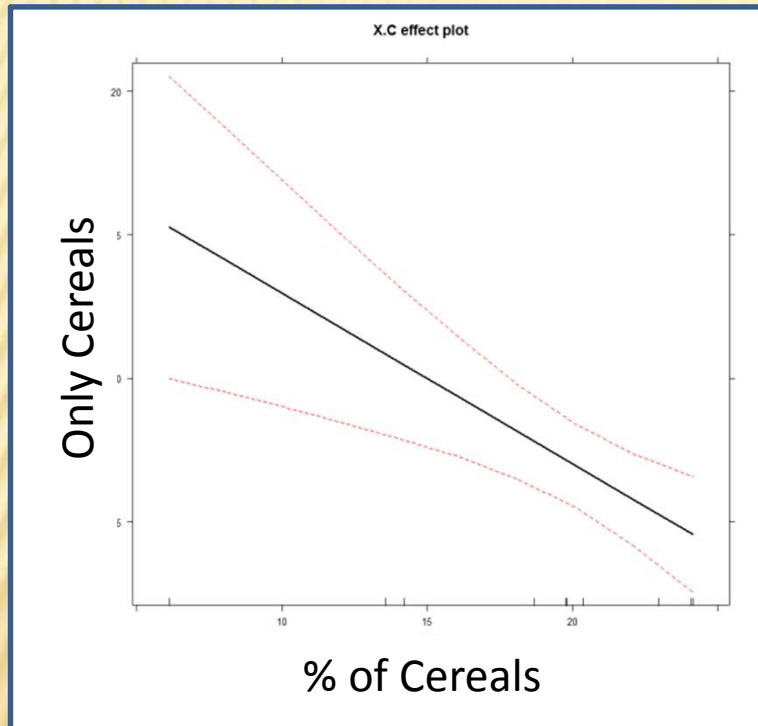
-> No effect of boundaries length on Gamma Diversity

-> The effect of % SNH depends greatly on the % of cereals and heterogeneity levels

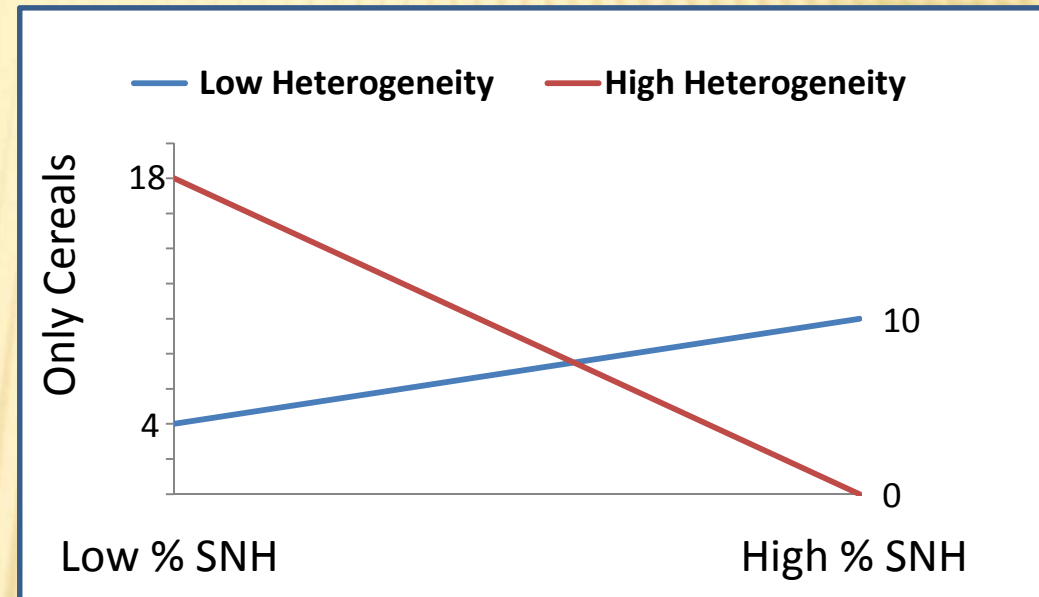


\* Estimated values from Multiple Regression analysis

# Species present only in cereal habitats



## Interaction % SNH x Heterogeneity



The number of species present only in cereal fields decreases with decreasing % of Cereals

Interaction % SNH x Heterogeneity has the same pattern as for the Gamma diversity

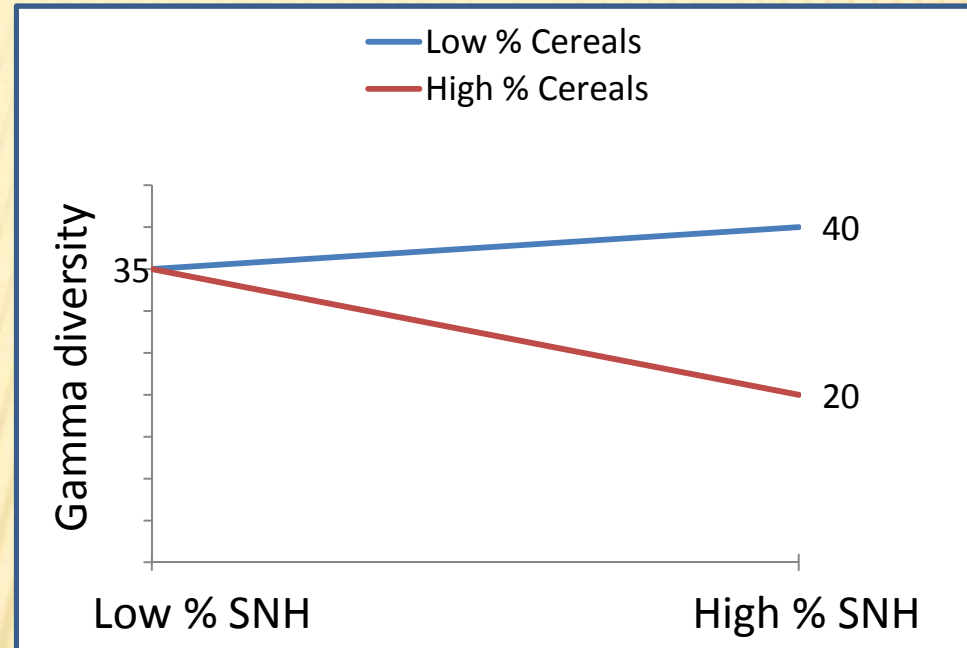
\* Estimated values from Multiple Regression analysis

# Gamma Diversity / Carabid beetles

Positive effect of Heterogeneity



Negative effect of % Cereals



Negative effect of % Cereals



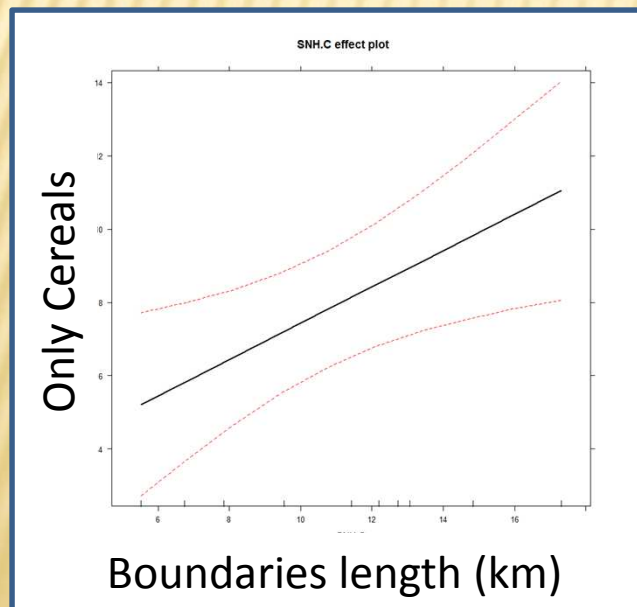
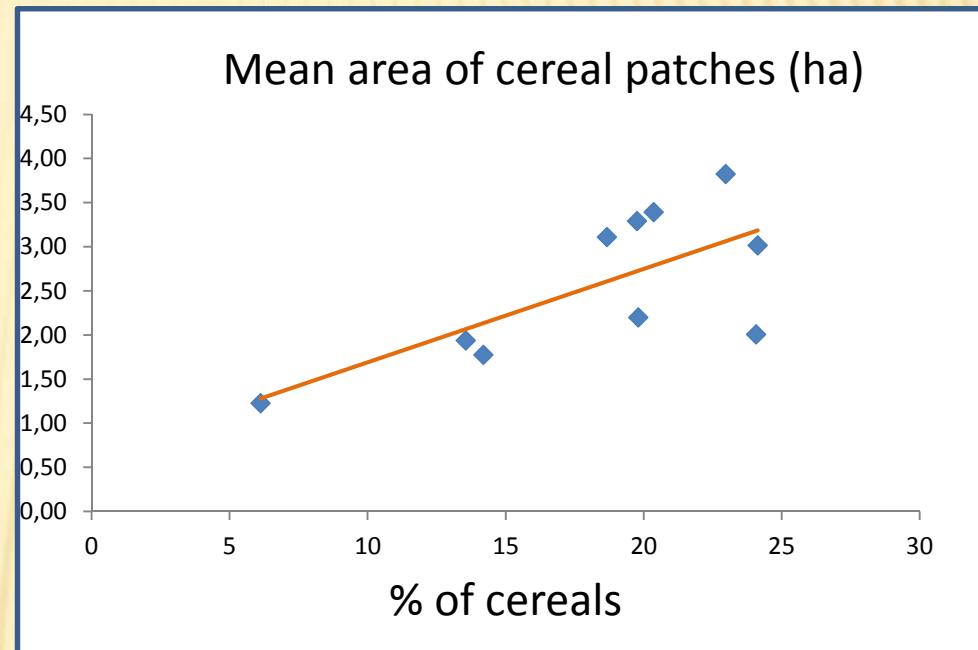
-> Gamma diversity variation is related to the number of species present only in cereals

At low % SNH the negative effect of % Cereals balance the positive effect of heterogeneity

At high % SNH the negative effect of % Cereals is dominant

\* Estimated values from Multiple Regression analysis

# Cereals Negative Effects



More cereals = larger cereal patches

-> lower boundary / area ratio

-> Boundaries influence the number of species present only in cereals

# Heterogeneity Effects

Cereal-specialist carabid beetles usually have high dispersal abilities



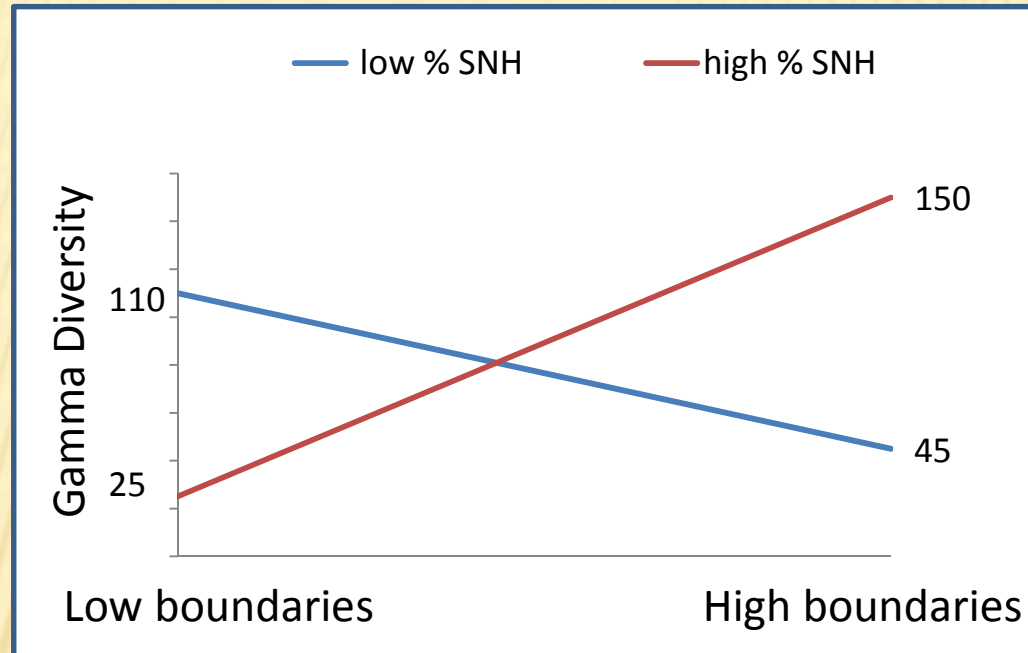
Huston, 1994. The coexistence of species on changing landscapes  
-> high competition and low diversity

Heterogeneity increases -> less dispersal -> less competition  
(explains results for low % SNH)

Heterogeneity increases -> more fragmentation -> less complementation / refuges...  
(explains results for high % SNH)



# Gamma Diversity / Flora



- > At high % SNH : boundaries are favorable (hypothesis : enhanced dispersal)
- > At low % SNH : boundaries are unfavorable (hypothesis : Fragmentation effect)

The direct effect of SNH on plant diversity is not reliable because of lack of replicates

\* Estimated values from Multiple Regression analysis

# Next steps of the research

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1/ Make analysis with:

- 20 landscapes
- all trapping periods
- Include flora data of cereal fields

2/ Improve the understanding of results by studying  $\alpha$  and  $\beta$  diversity

3/ Study differences between functional groups

- various habitat preferences
- various dispersal abilities

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International Association  
for Landscape Ecology



Région  
**BRETAGNE**

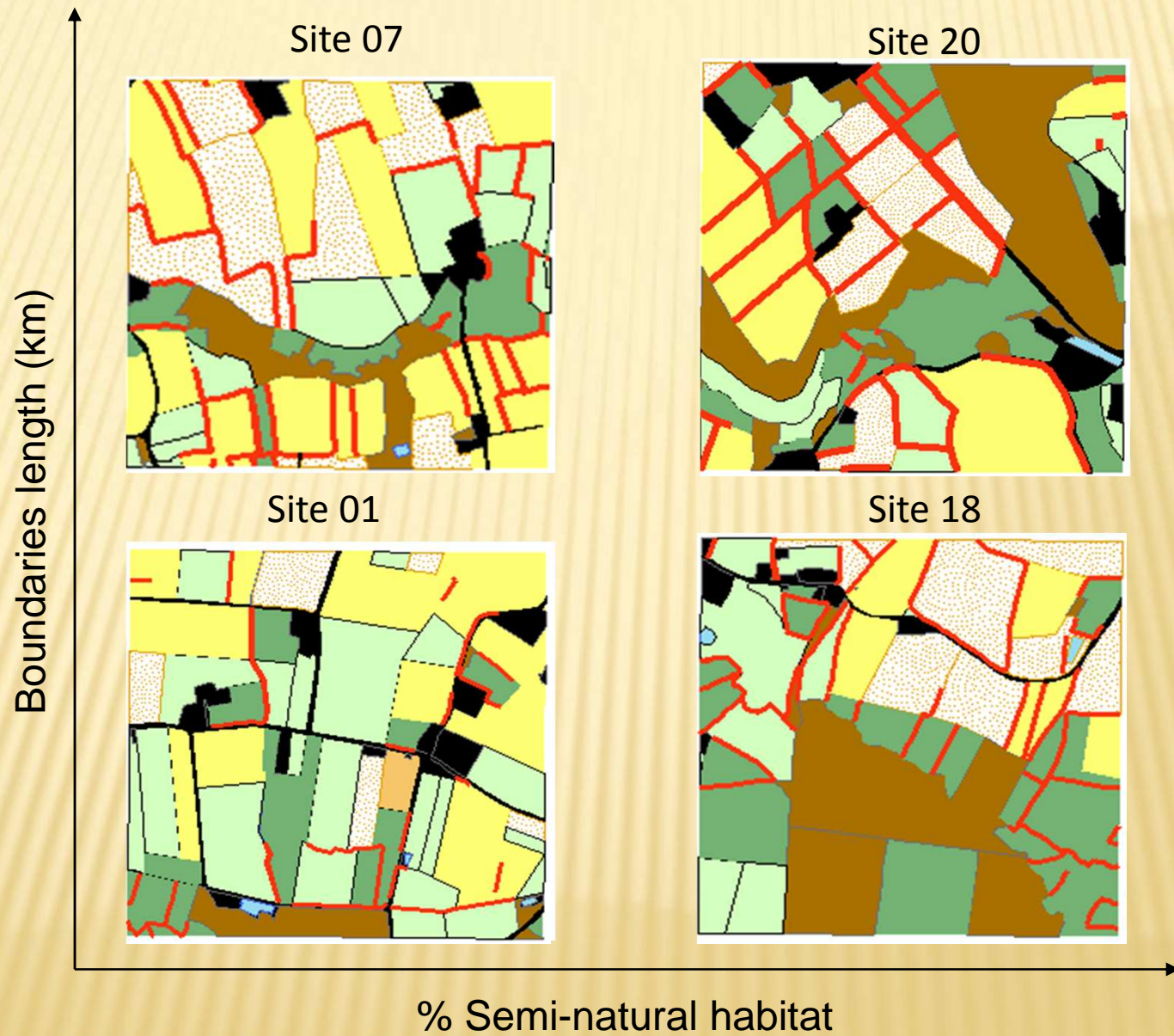
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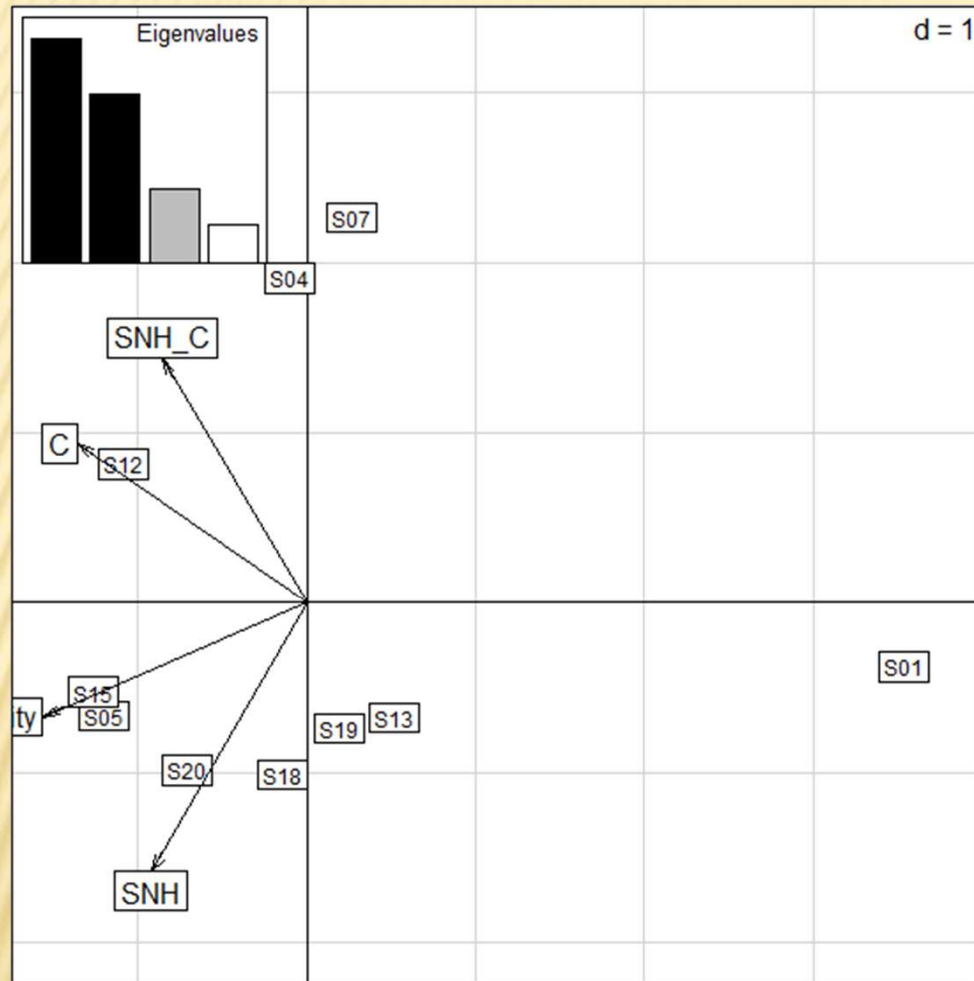
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# Heterogeneity Effects

		Actual Physical Heterogeneity of the Environment	
		LOW	HIGH
Mobility/Perception/Size of Organism	LOW	Effective Heterogeneity: LOW Competition Intensity: HIGH Species Diversity: LOW	Effective Heterogeneity: HIGH Competition Intensity: LOW Species Diversity: HIGHEST
	HIGH	Effective Heterogeneity: LOW Competition Intensity: HIGH Species Diversity: LOWEST	Effective Heterogeneity: LOW Competition Intensity: HIGH Species Diversity: LOW

Huston, 1994





PCA on environmental variables

Axis 1 : 44%

Axis 2 : 33% (cumulated 77%)

Heterogeneity and Cereals are the main variable of Axis 1.

Site S01 has low X.C and low Heterogeneity

S04 et S18 medium / medium

S15, S05 and S11 have high X.C and high heterogeneity

(07/13/19/20)

-> The effect of heterogeneity and cereals are partially mixed