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# Increased drought of the mediterranean climate and biotic interactions: functional consequences on plant communities in a shrubland ecosystem

Natalia RODRIGUEZ-RAMIREZ <sup>1\*</sup>, Nicolas MONTES <sup>1</sup>, Christine BALLINI <sup>1</sup>

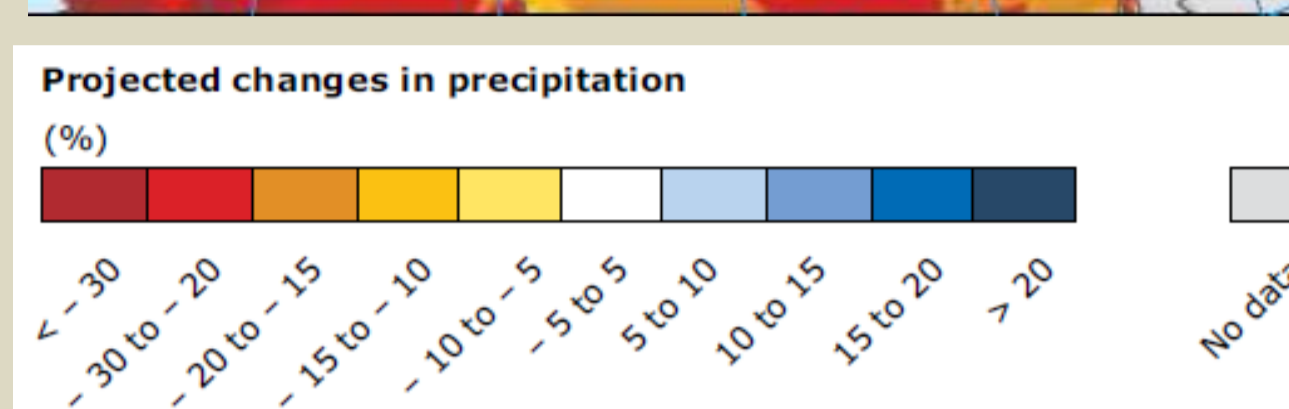
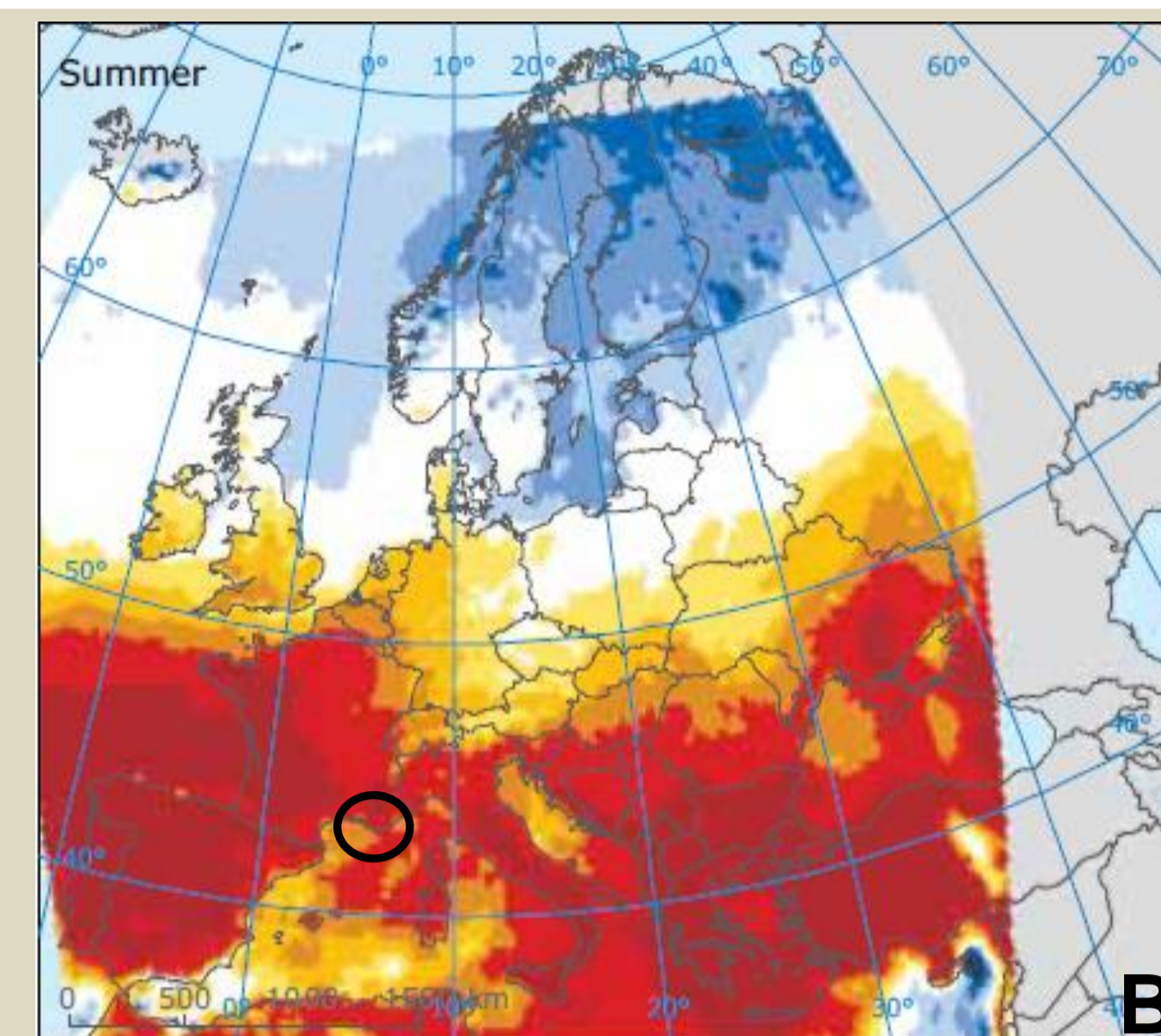
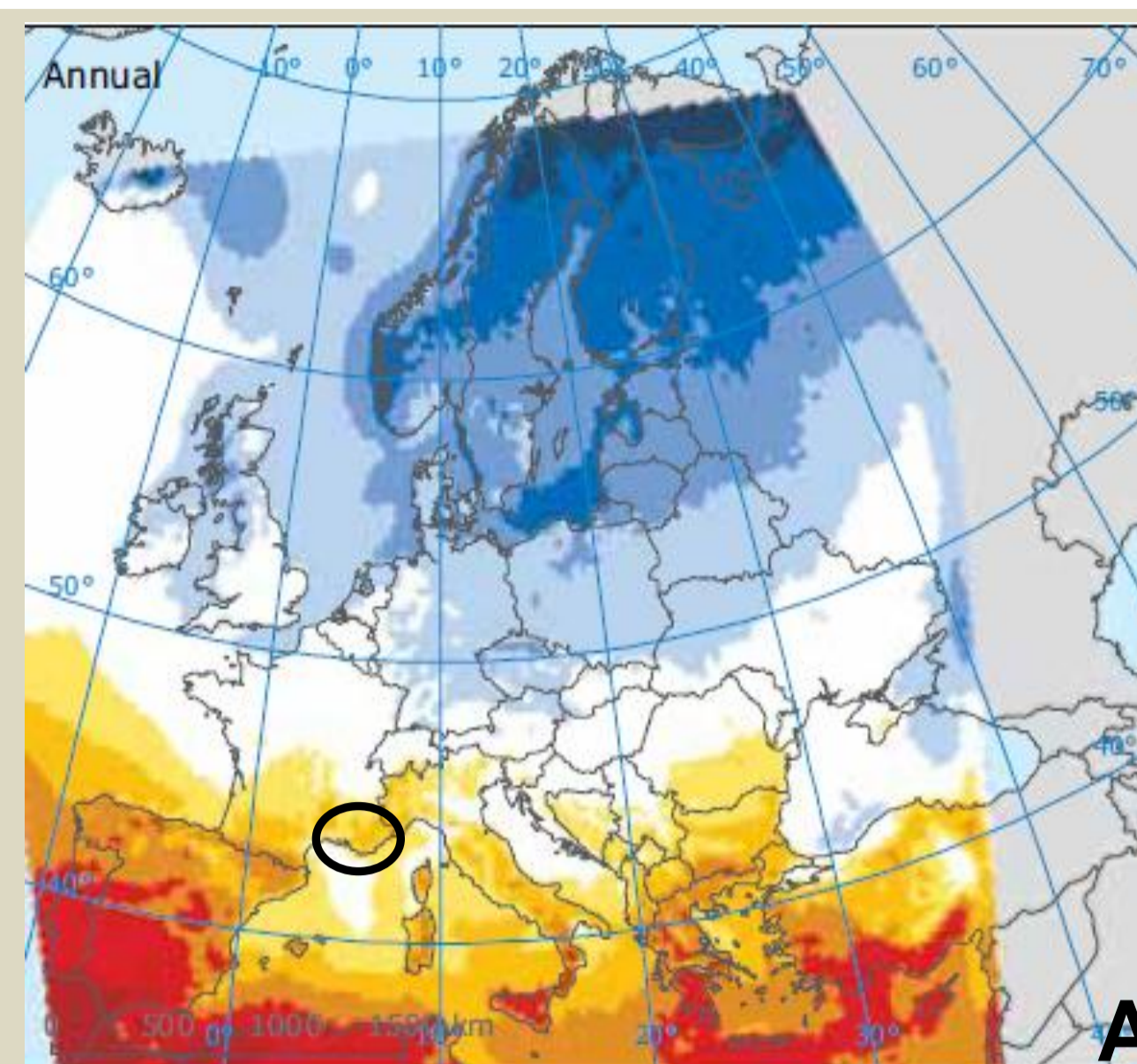
<sup>1</sup>- Aix-Marseille Université, Institut Méditerranéen de Biodiversité et Ecologie marine et continentale-IMBE



## Introduction

Climate Change is predicted to be particularly pronounced on the Mediterranean basin. With up to 40% decrease in summer precipitation and temperature 2° C to 5° C higher by 2080-2099 than in the 1980-1999 (EEA,2012), important changes on biodiversity and plant-plant interactions are expected on this century (Lloret *et al.* 2009, Quézel et Médail, 2003).

The aim of the **CLIMED project** (*Climate change effects on Mediterranean biodiversity and consequences for ecosystem functioning*) is to link predicted the decrease of precipitation to changes in biodiversity across multiple trophic levels (plants, litter, soil and their fauna), and quantify their feedback on the ecosystem functioning and environmental services using an experimental approaches



Predicted changes (%) of annual (A) and summer (B) precipitation between 1961-1990 and 2071-2100. (EEA, 2012)

## How will the projected diminution of precipitations (-40%) affect the Mediterranean Schrubland vegetation ?

More precisely what effects on:

### Diversity and community structure

- Diversity indices
- Non destructive quantification of biomass production
- Interspecific relationships

### Functional traits and functional diversity:

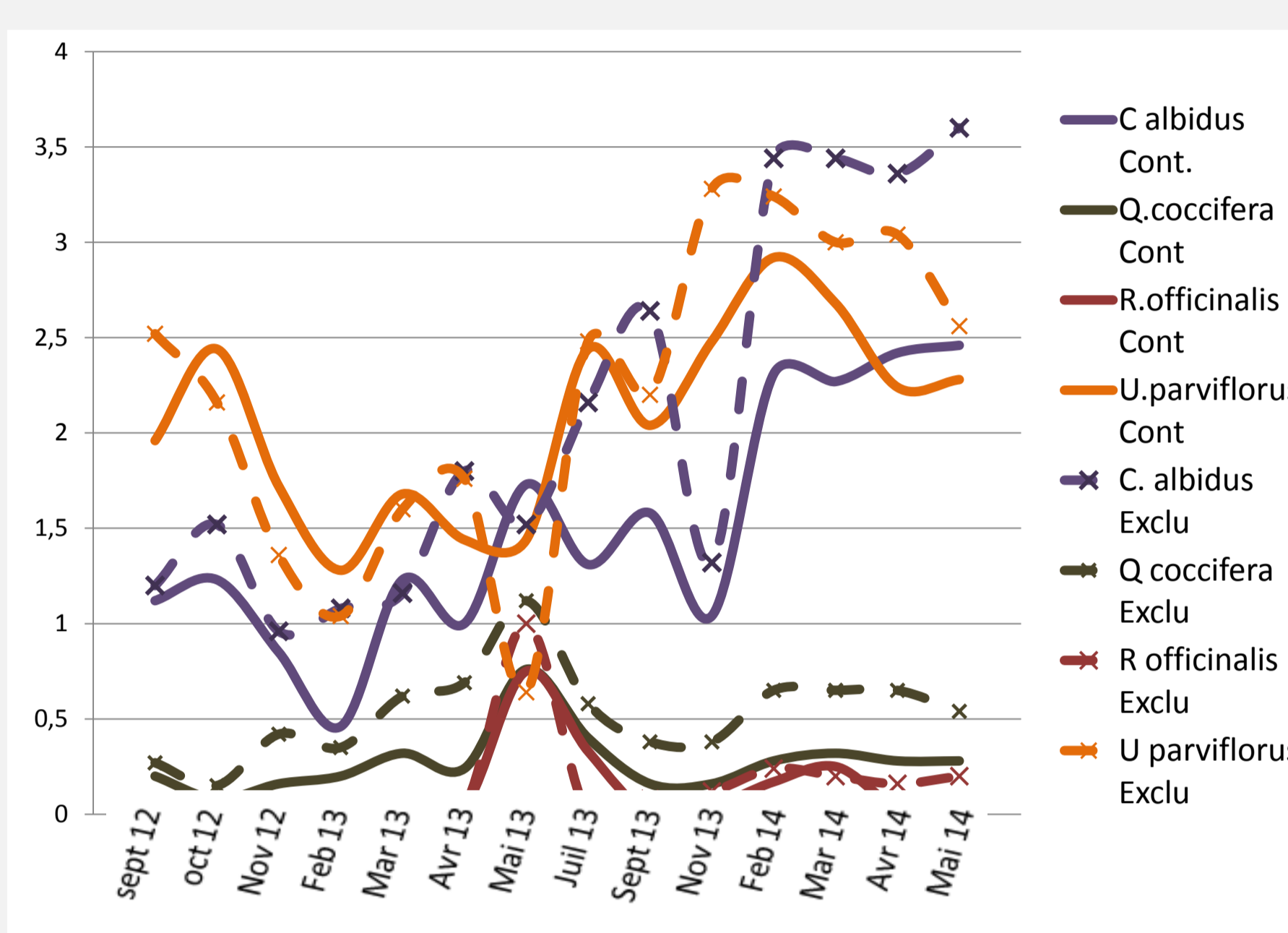
- Resistance to drought and recovery capacity
- Phenology
- Foliar traits (SLA, DMC C, N and P contents)

### Ecophysiology

- Water Use Efficiency
- Maximum quantum efficiency (Fv/Fm)

### Ecosystem functions: primary production, C and N cycles

## Some Results



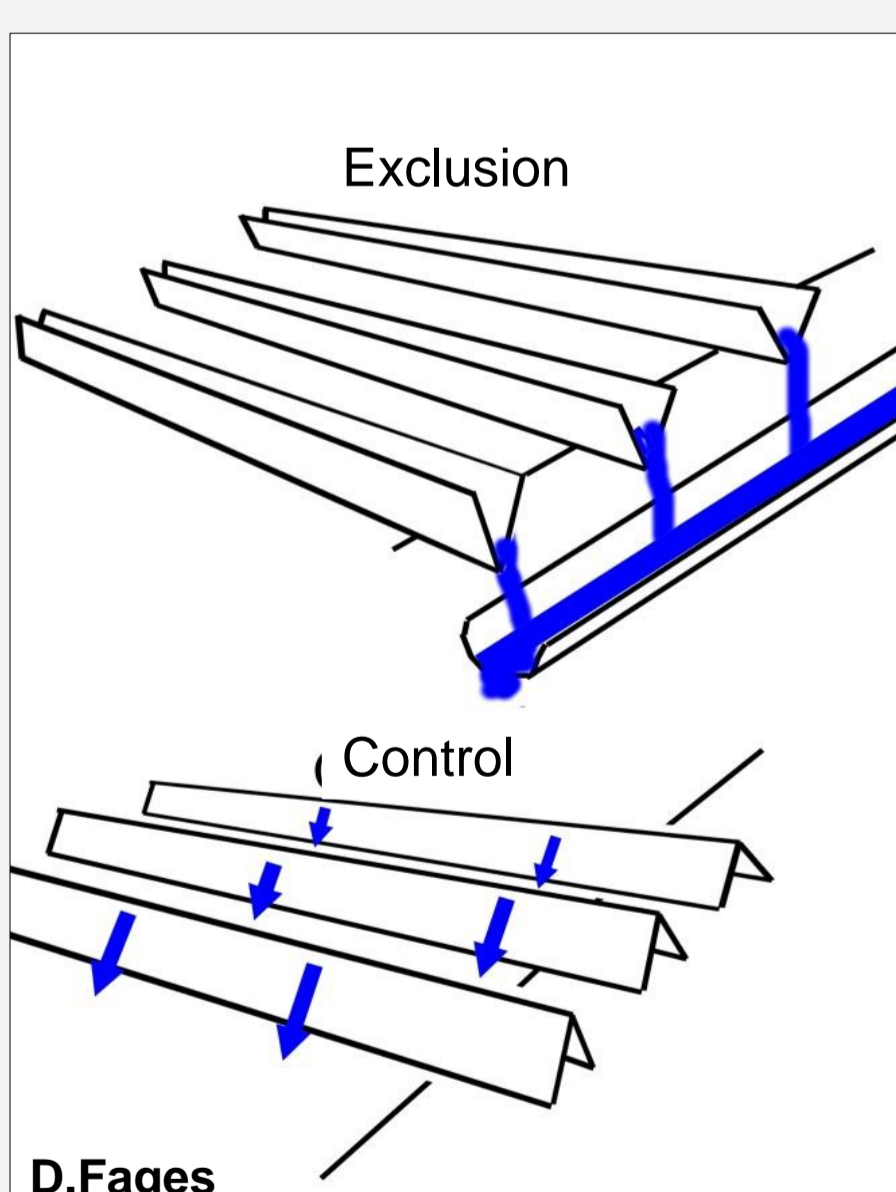
- The resistance to total drought of the aboveground biomass depends of the specie and the season
- *R. officinalis* seems more resistance to drought than the other dominant species.
- With the decrease precipitation *C. albidus* and *U. parviflorus* are the most vulnerable to total drought of the dominant species

Mean of shoots with aboveground biomass totally drought, by plot, of the 4 dominant ligneous species in CLIMED for each level of precipitation

## CLIMED Rain Exclusion Experiment



Mediterranean shrubland (2 ha), North of Marseille (280 m)



93 plots (4x4m, each):

- 46 with rain exclusion device in « Exclusion »
- 47 with rain exclusion device in « Control »

Over,

« natural » mixtures of 1, 2, 3 or 4 of the ligneous dominant species:



*Cistus albidus*



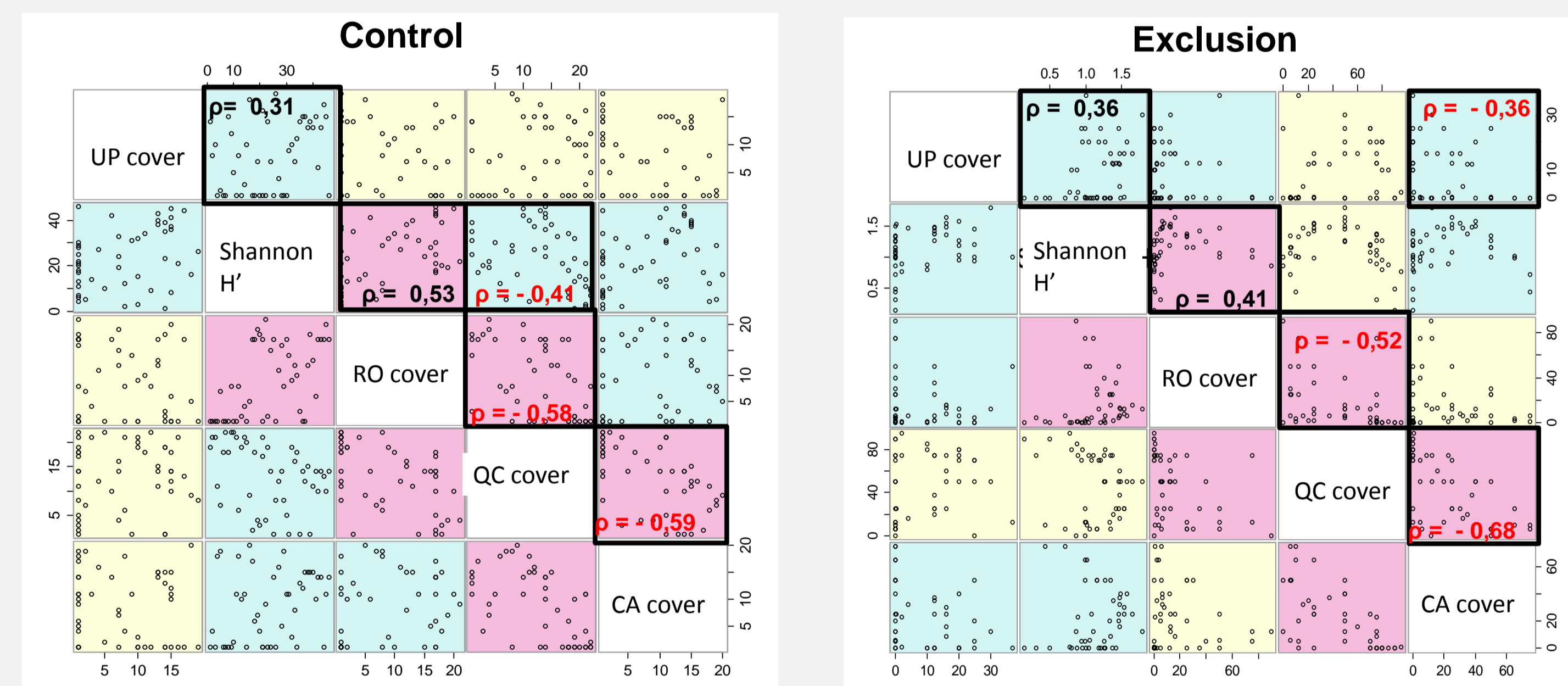
*Rosmarinus officinalis*



*Quercus coccifera*



*Ulex parviflorus*



Correlation matrices of the cover of the 4 dominant species and diversity by plot, ordered and colored by the Spearman correlation (Rho « ρ ») magnitude: ■ ρ > ■ ρ > ■ ρ. CA = *C. albidus*, QC = *Q. coccifera*, RO = *R. officinalis*, UP = *U. parviflorus*  significant correlations (p-value < 0.05)

- The **positively correlation between diversity (H') and U. parviflorus** cover is almost the same no matter the precipitation level
- The magnitude of the **negative correlation between the covers of Q. Coccifera and C. albidus** becomes **stronger under rain exclusion**
- The **negative correlation between the covers of C. albidus and R. officinalis** becomes significant under rain exclusion.

## Discussion

- Under the precipitation decrease (-40%) projected for the south of France by the end of the century, the diversity and structure of the mediterranean shrubland vegetation could be modified.
- Under higher drought conditions the cover of *C. albidus* and *U. parviflorus* could **sharply** decrease
- The vulnerability of *U. parviflorus*, a legume, to the decrease of precipitation could have an effect on nitrogen cycle
- The tendency to total drought of *U. parviflorus* with the precipitation decrease, could affect the total diversity of the community as it's positively correlated to it.
- The interspecific relationships in the mediterranean shrubland community seems to be modified with the decrease of water availability. In particular the negative relationships between dominant species could be stronger under a more drought environment.

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# Increased drought of the mediterranean climate and biotic interactions: functional consequences on plant communities in a shrubland ecosystem

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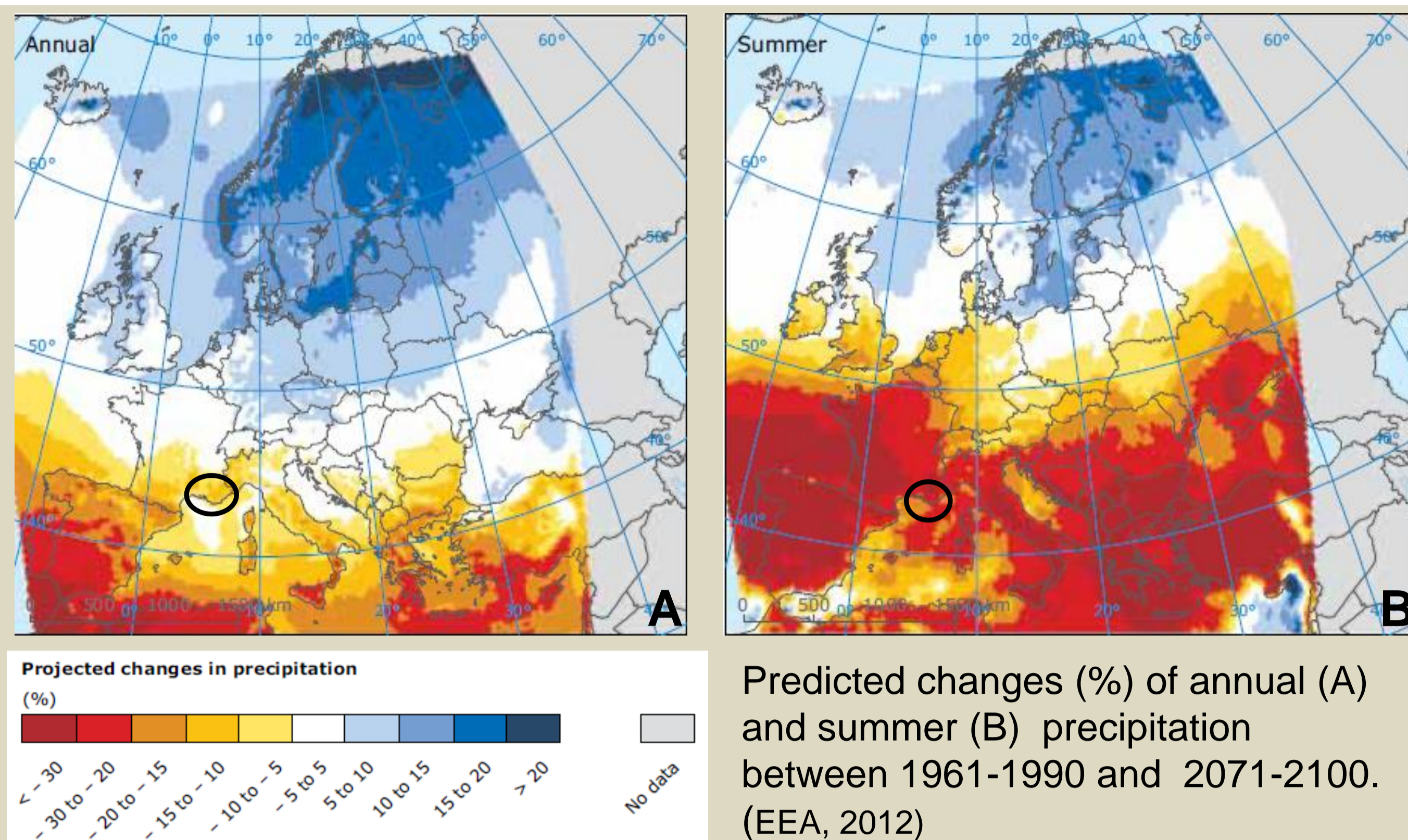
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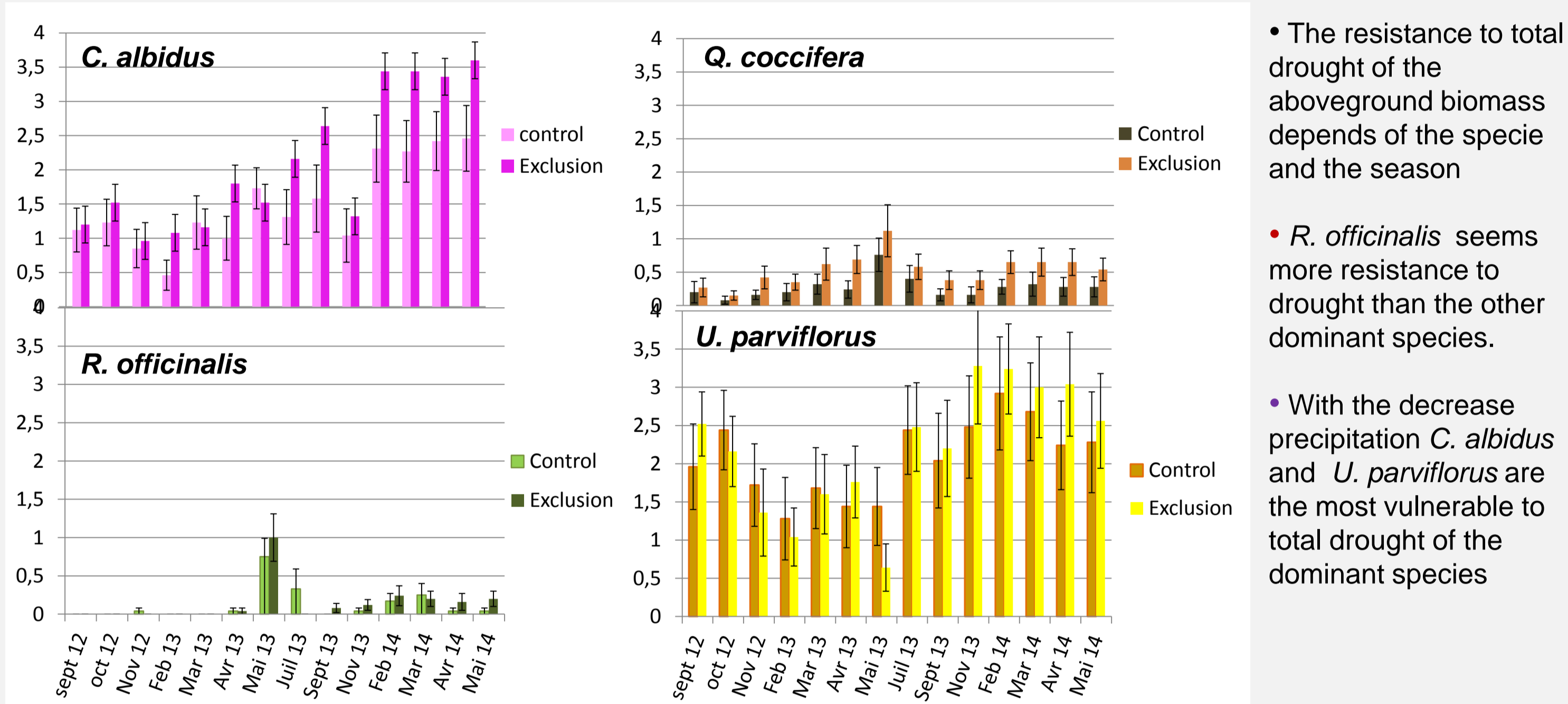
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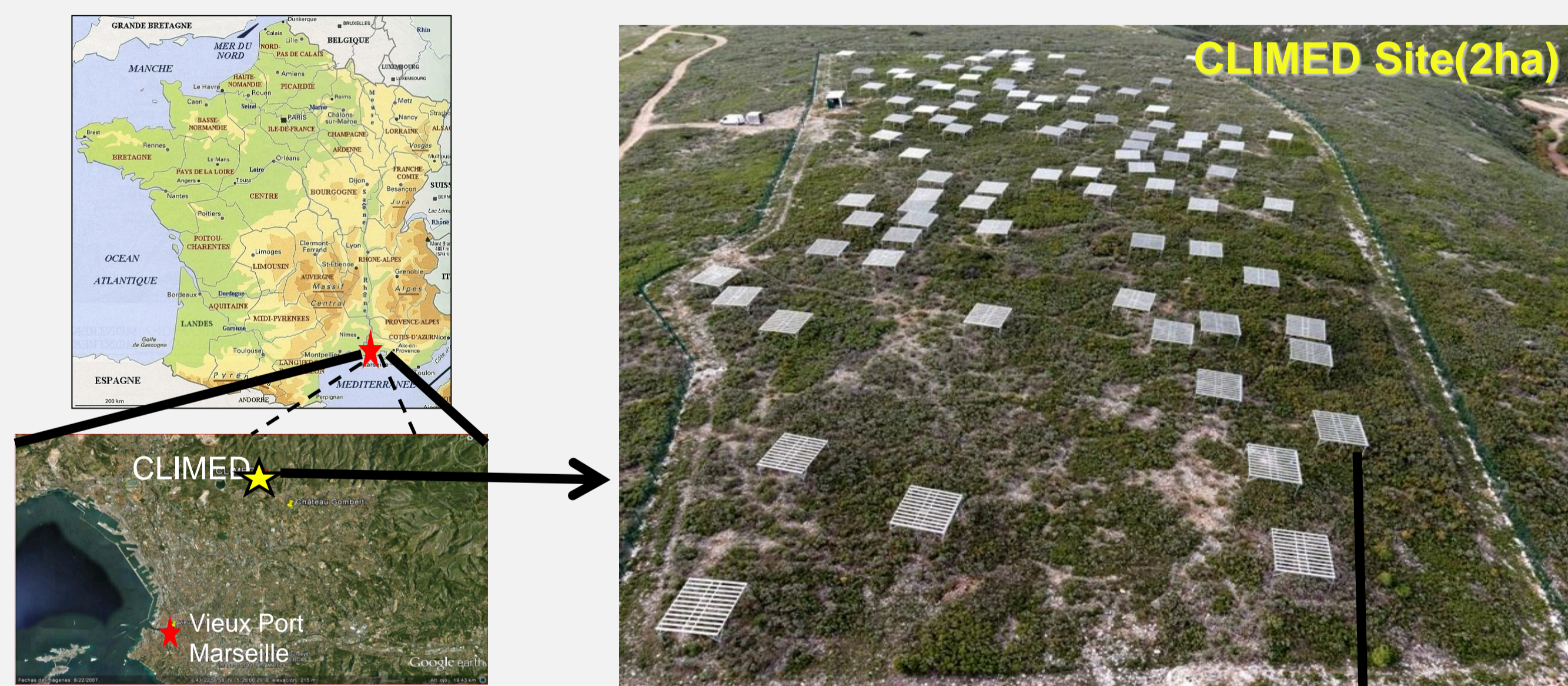
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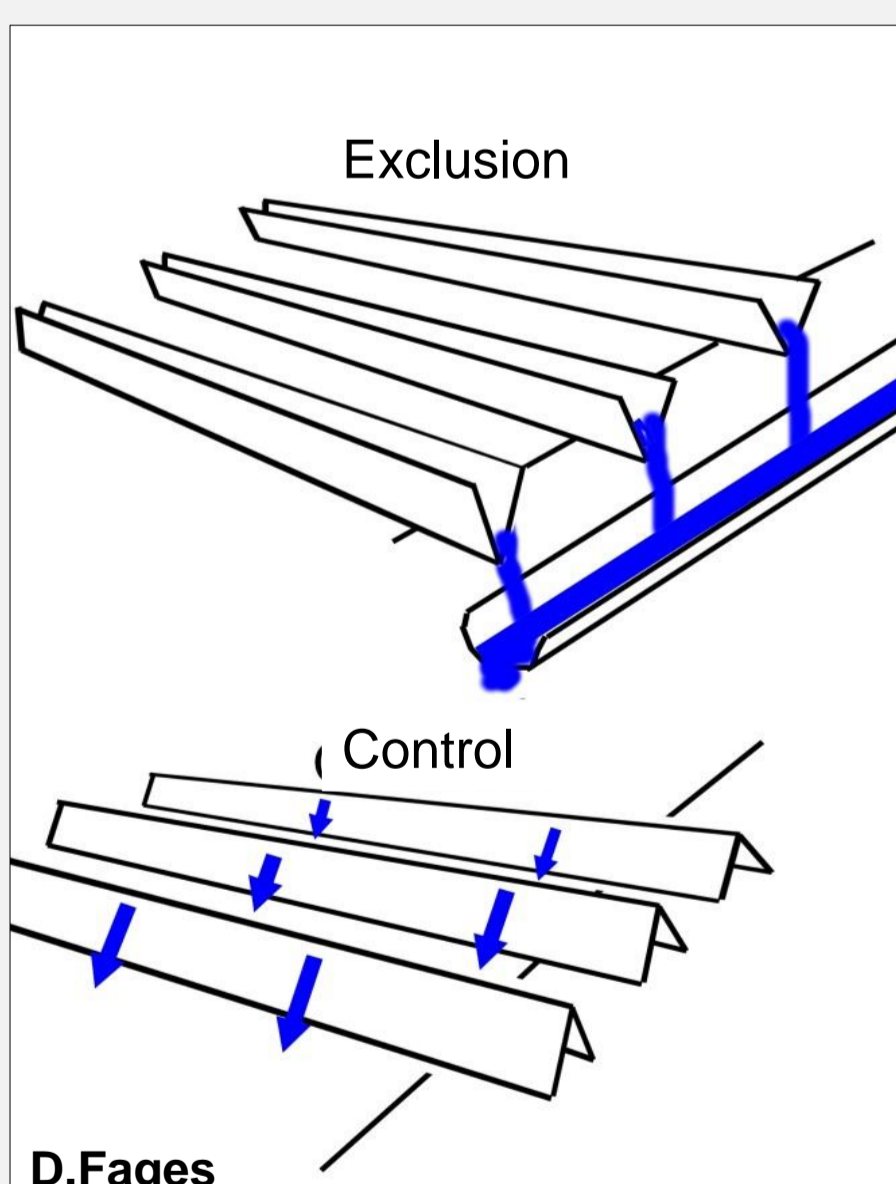


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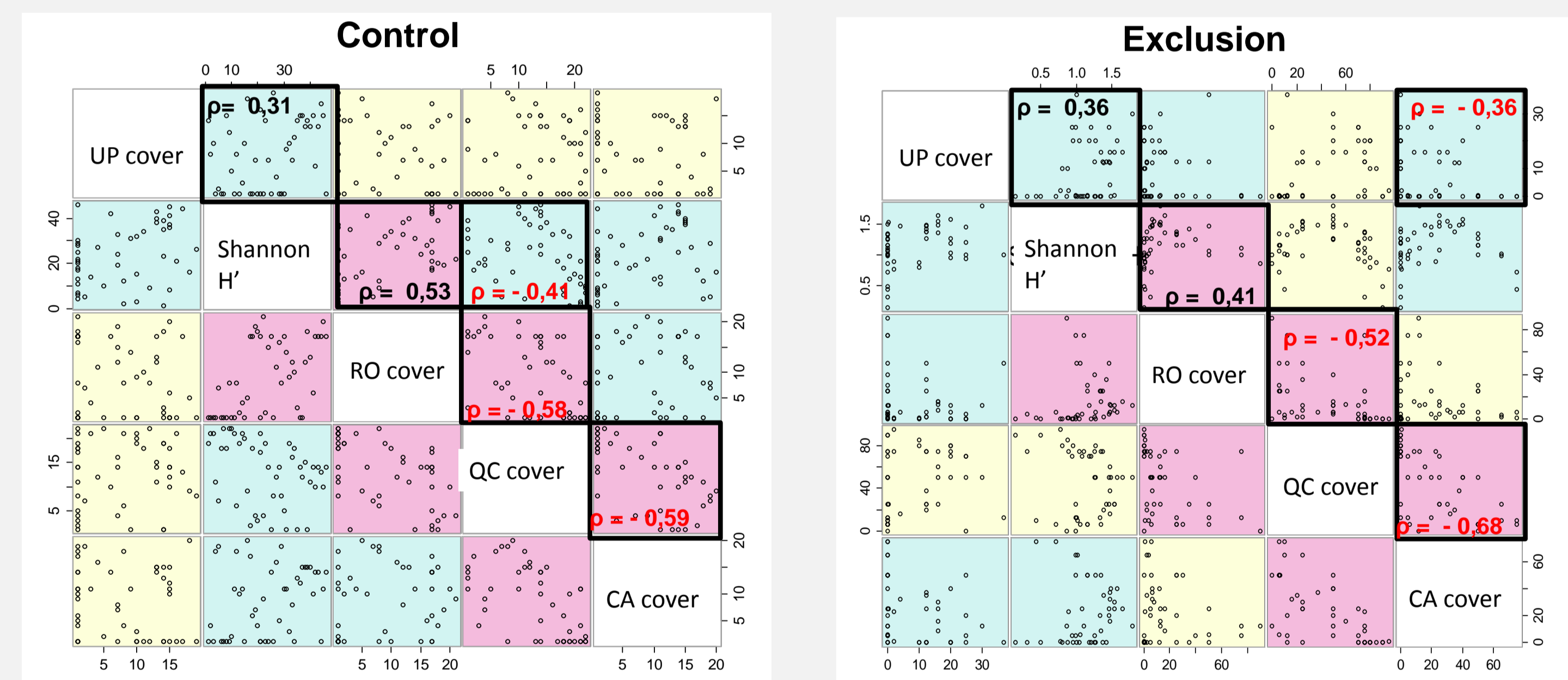
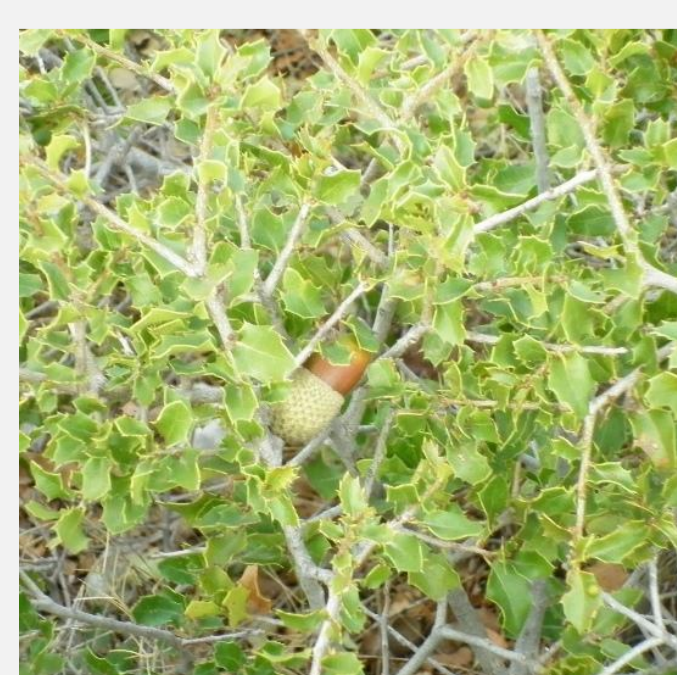


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Correlation matrices of the cover of the 4 dominant species and diversity by plot, ordered and colored by the Spearman correlation (Rho «  $\rho$  ») magnitude:  $\rho > 0.5$  (red),  $0.3 < \rho < 0.5$  (orange),  $0.1 < \rho < 0.3$  (yellow),  $\rho < 0.1$  (green).  $\square$  significant correlations (p-value < 0.05)

CA = *C. albidus*, QC = *Q. coccifera*, RO = *R. officinalis*, UP = *U. parviflorus*

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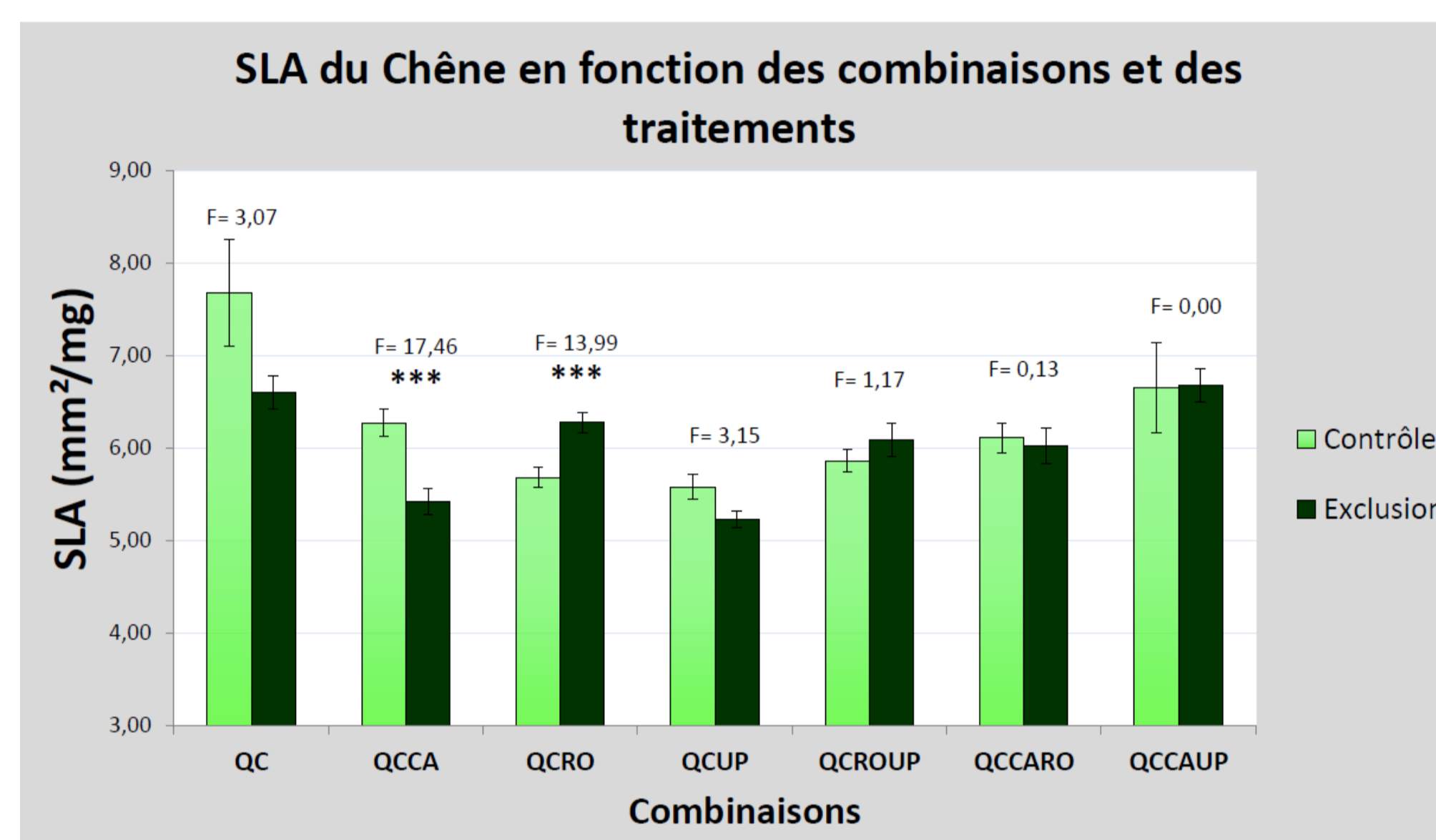
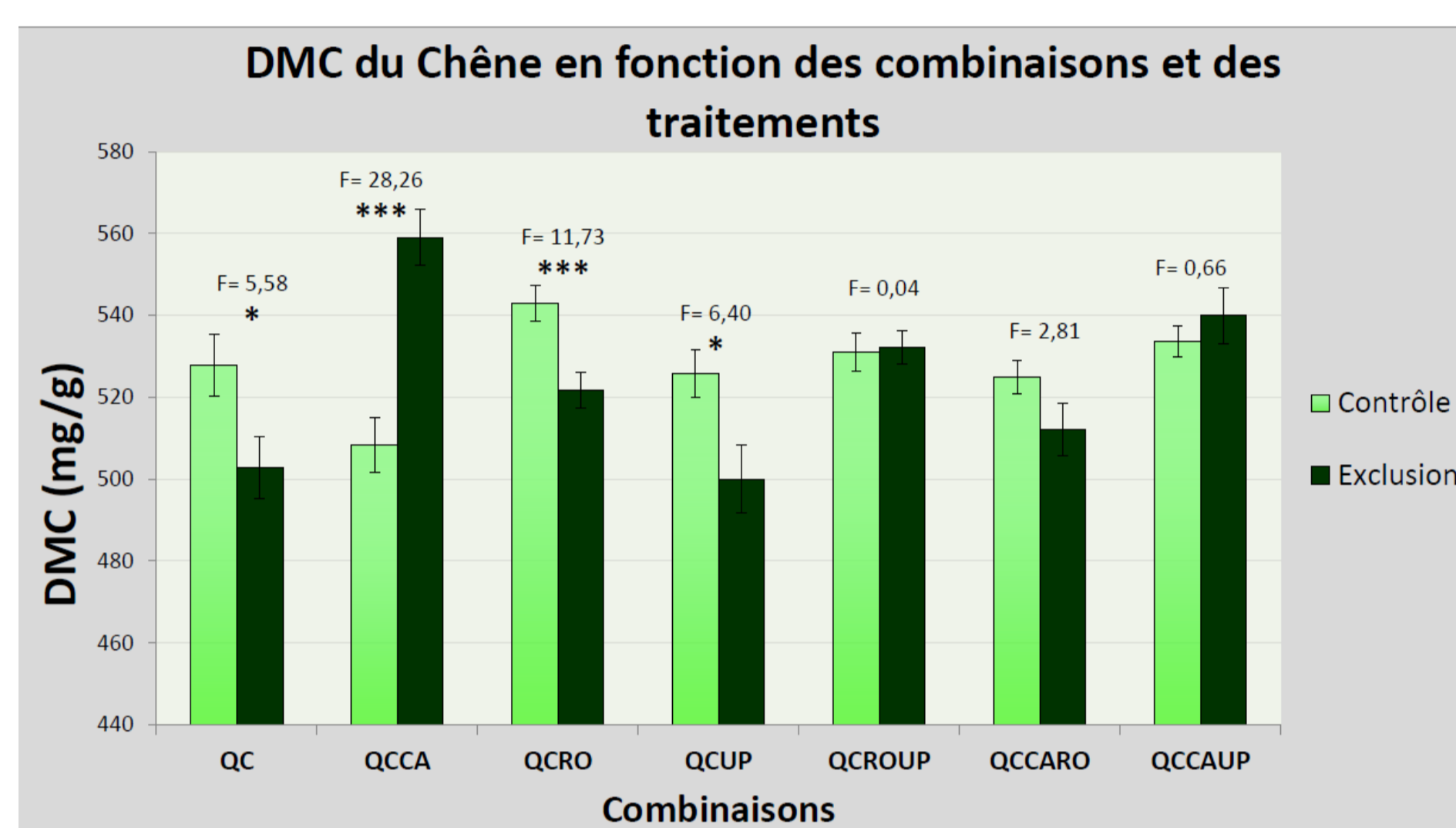
```
anovaSecs<-aov(secs~Tmt*SP*Mois,
data=secs)
> summary(anovaSecs)
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Tmt	1	37	36.9	10.629	0.00113	**
SP	3	2085	694.9	200.083	< 2e-16	***
Mois	13	317	24.4	7.016	1.47e-13	***
Tmt:SP	3	31	10.5	3.010	0.02908	*
Tmt:Mois	13	27	2.1	0.602	0.85413	
SP:Mois	39	445	11.4	3.285	4.26e-11	***
Tmt:SP:Mois	39	49	1.2	0.360	0.99992	
Residuals	2702	9384	3.5			

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Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

En relation avec le suivie de la nécromasse. Anova factoriel avec es données de tous les mois ( mois as a factor)

## results QC traits?



What's next:

Bras, isotopes analysis, correaltion with other ecosystems trophic levels



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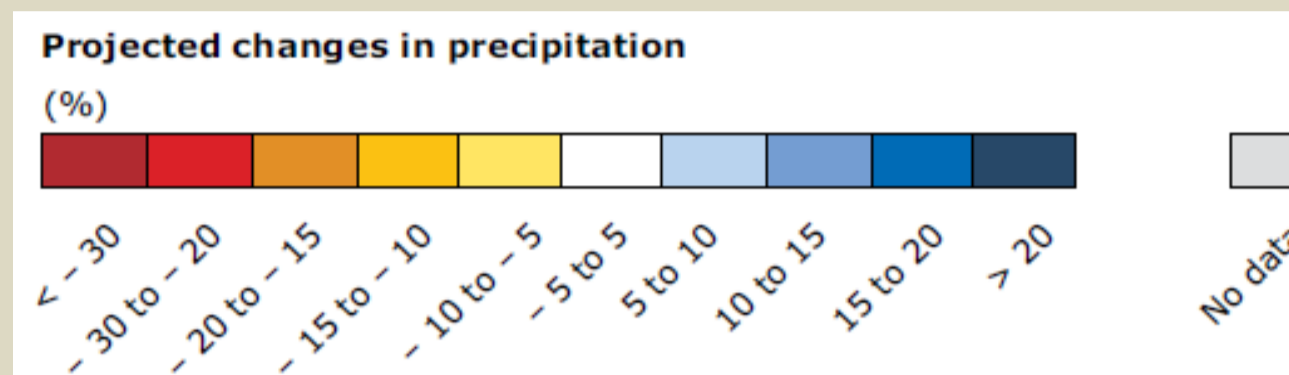
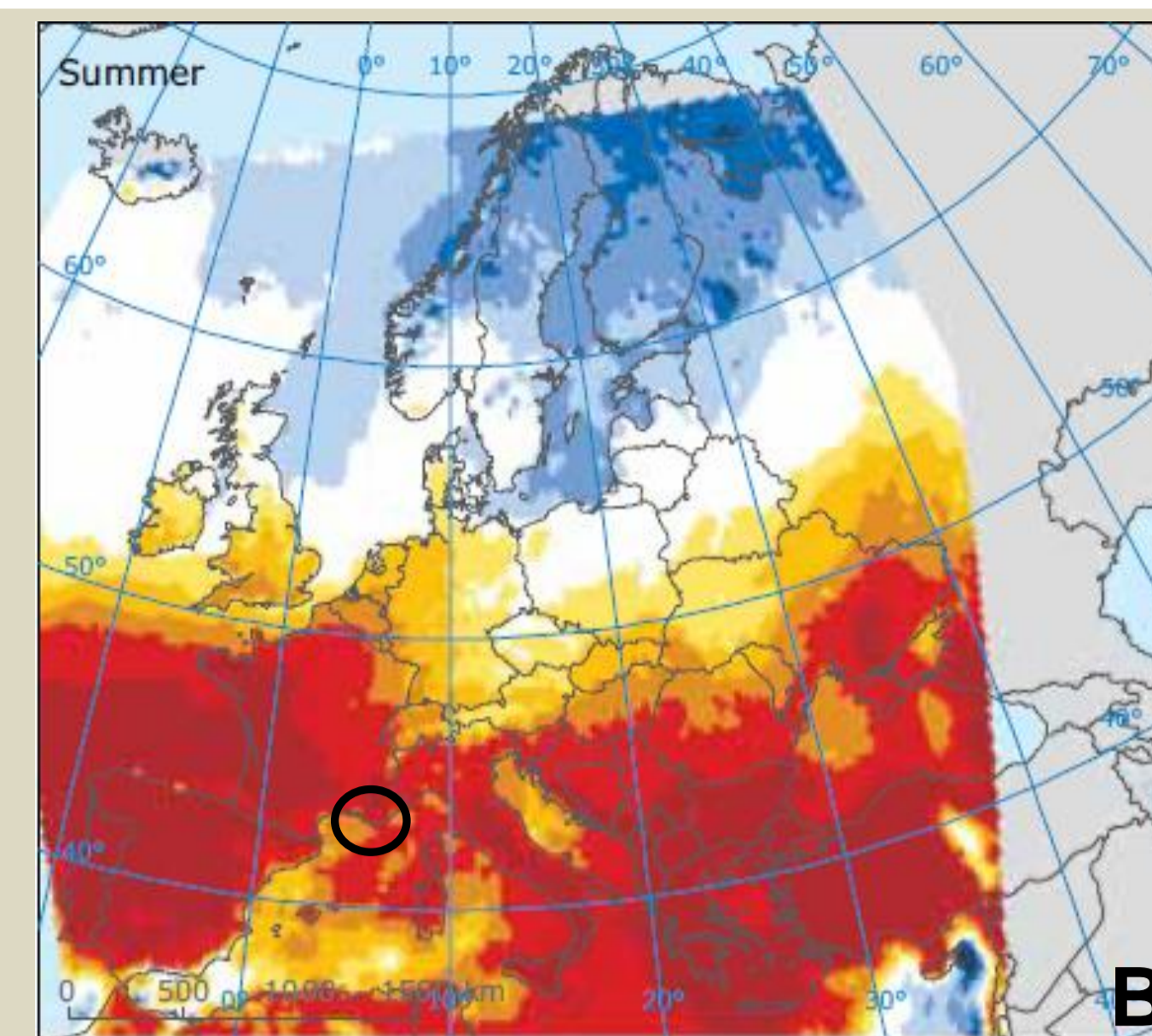
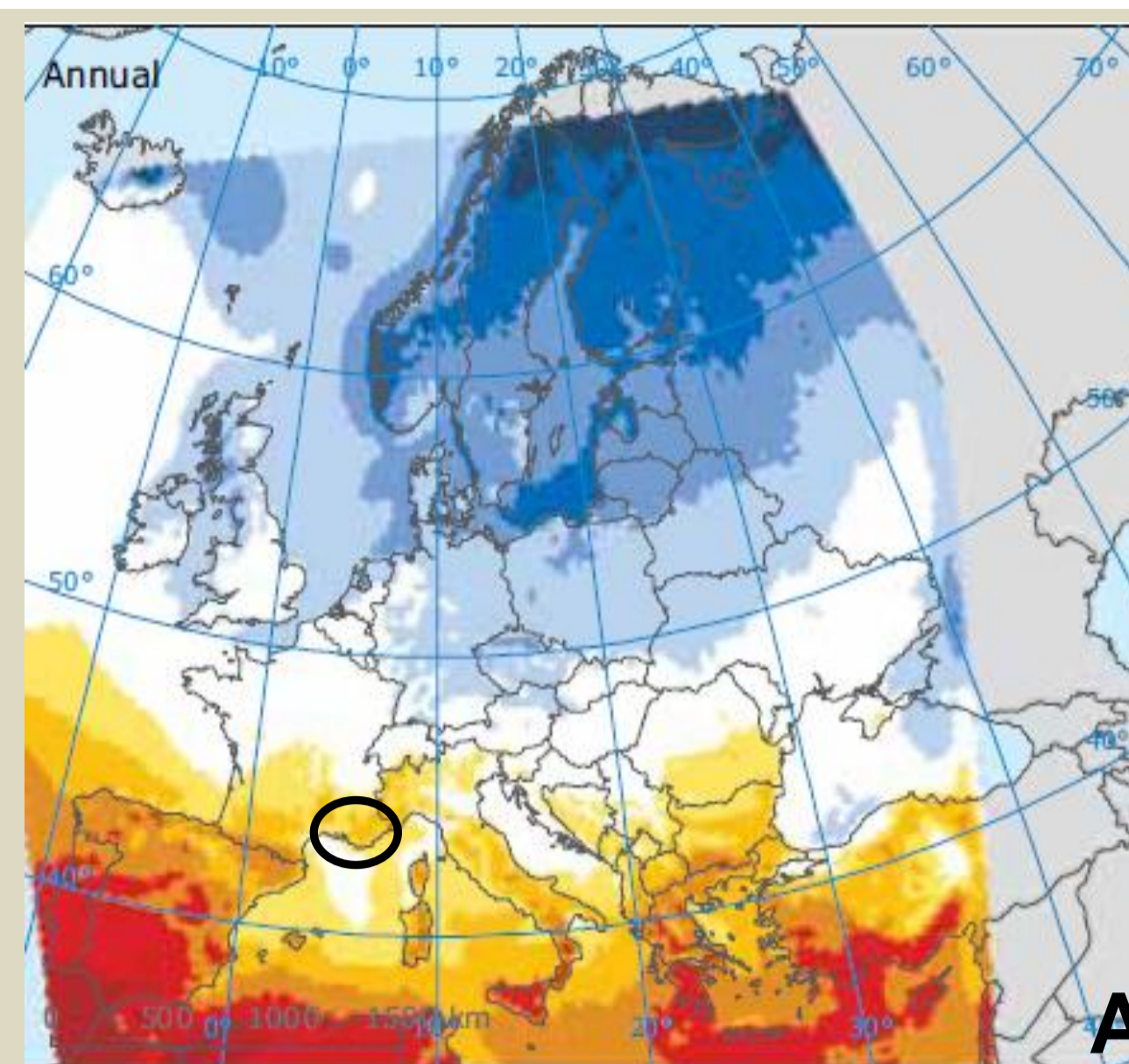
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## Introduction

Le bassin méditerranéen est considéré comme une région particulièrement vulnérable face au changement climatique, avec **une diminution jusqu'à 40% des précipitations estivales** et une augmentation des températures de 2,5° C à 4° C en 2071-2100 par rapport à la période 1961-1990, selon les prévisions (EEA,2012). On s'attend donc à des changements importants de la biodiversité dans le courant du siècle (Lloret *et al.* 2009, Quézel et Médail, 2003).

Le projet **CLIMED** (*Climate change effects on Mediterranean biodiversity and consequences for ecosystem functioning*, ANR CEP 2009) a pour **objectif** d'évaluer l'effet de la sécheresse accrue sur la biodiversité de la garrigue (végétation, litière, sol et faune associée), le fonctionnement de l'écosystème et les services environnementaux



Changements (%) projetés des précipitations annuelles (A) et estivales (B) entre 1961-1990 et 2071-2100. Source: EEA, 2012

## Principales questions:

Sur la végétation, quel sera l'effet de la sécheresse accrue sur:

### Relations Interspécifiques

Diversité structurelle communautaire

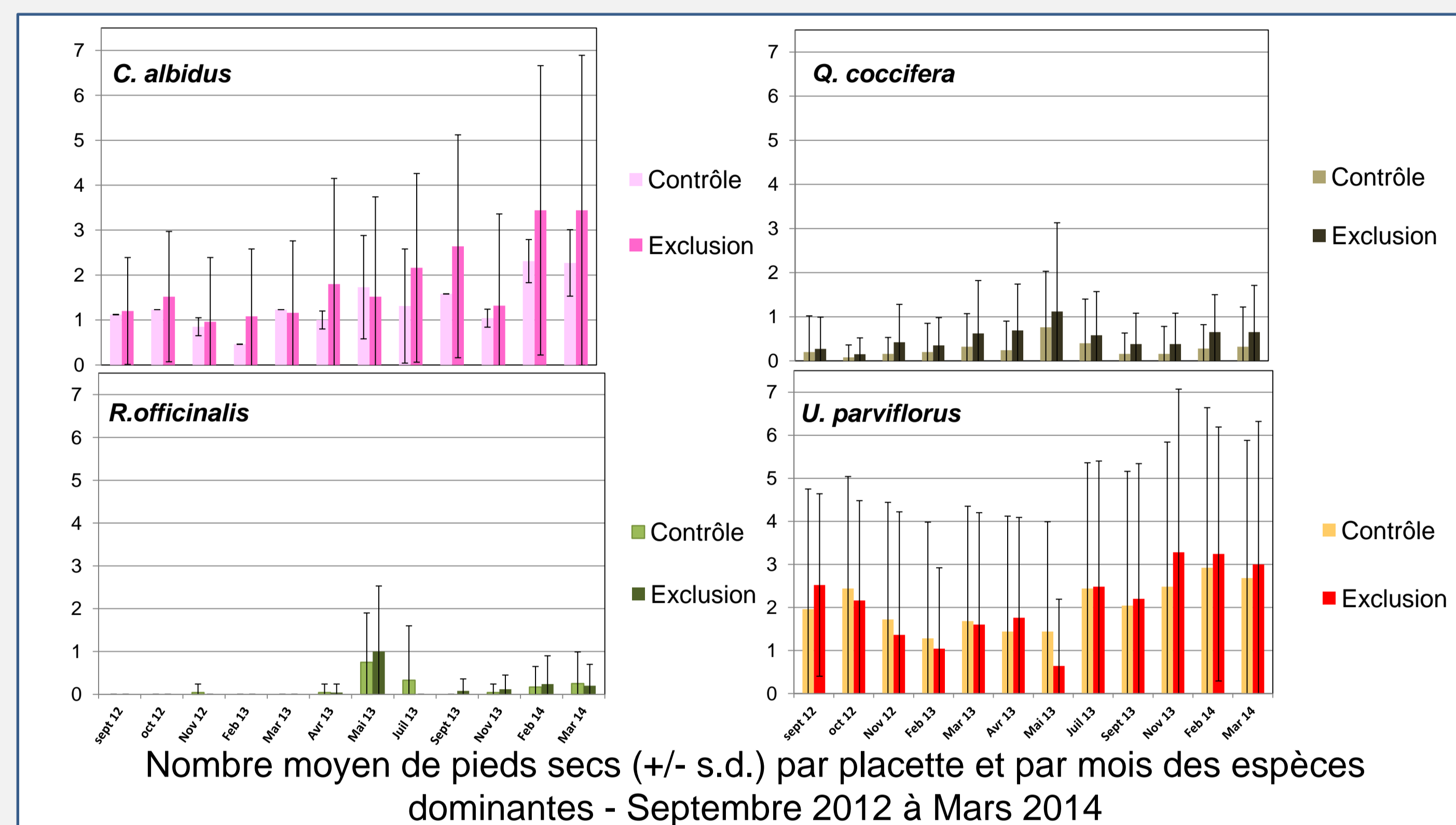
### Traits fonctionnels et fonctionnelle:

Phénologie  
Spore  
Résistance à l'assèchement  
Récupération  
Morphologiques  
Chimiques

### Écophysologie des espèces

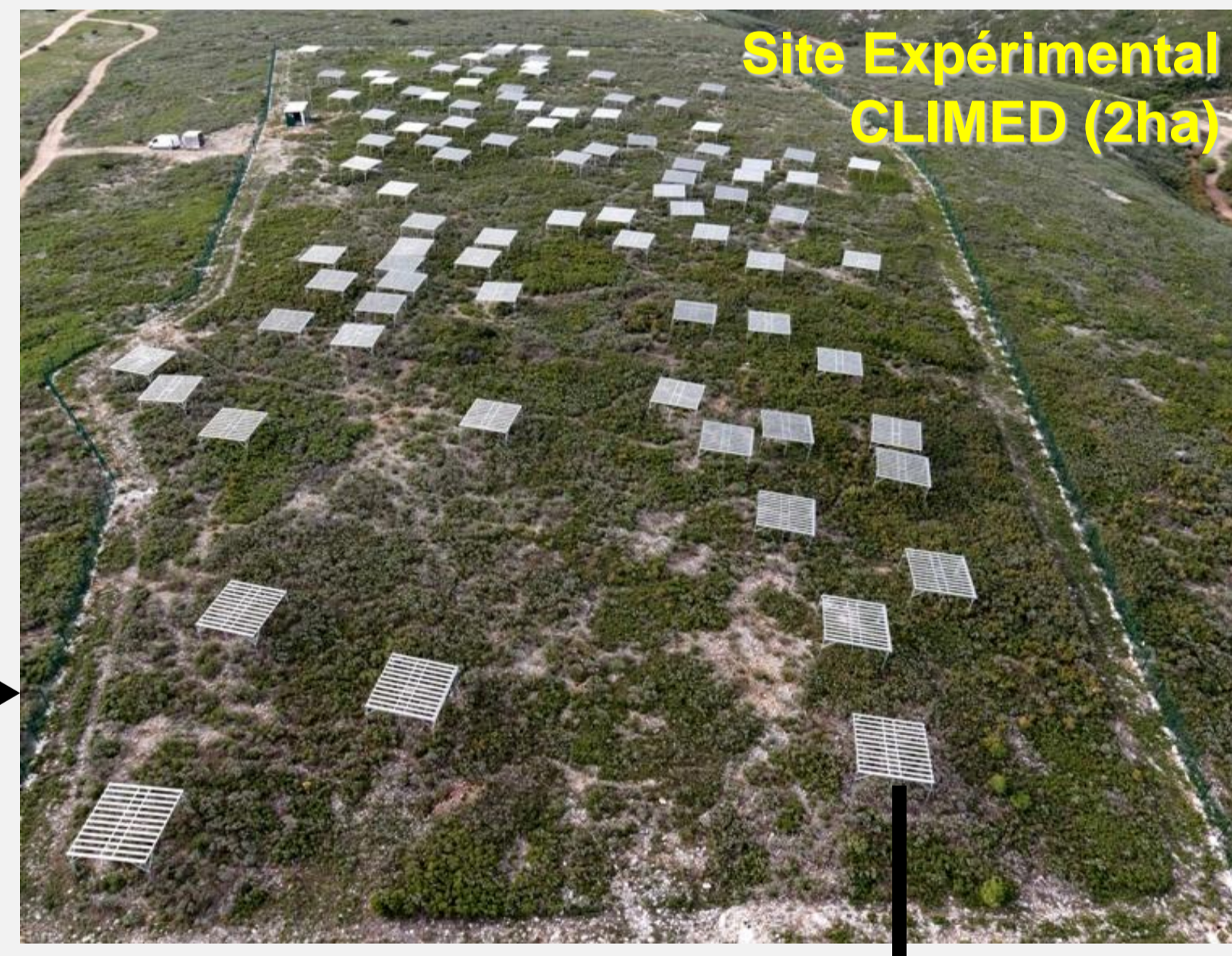
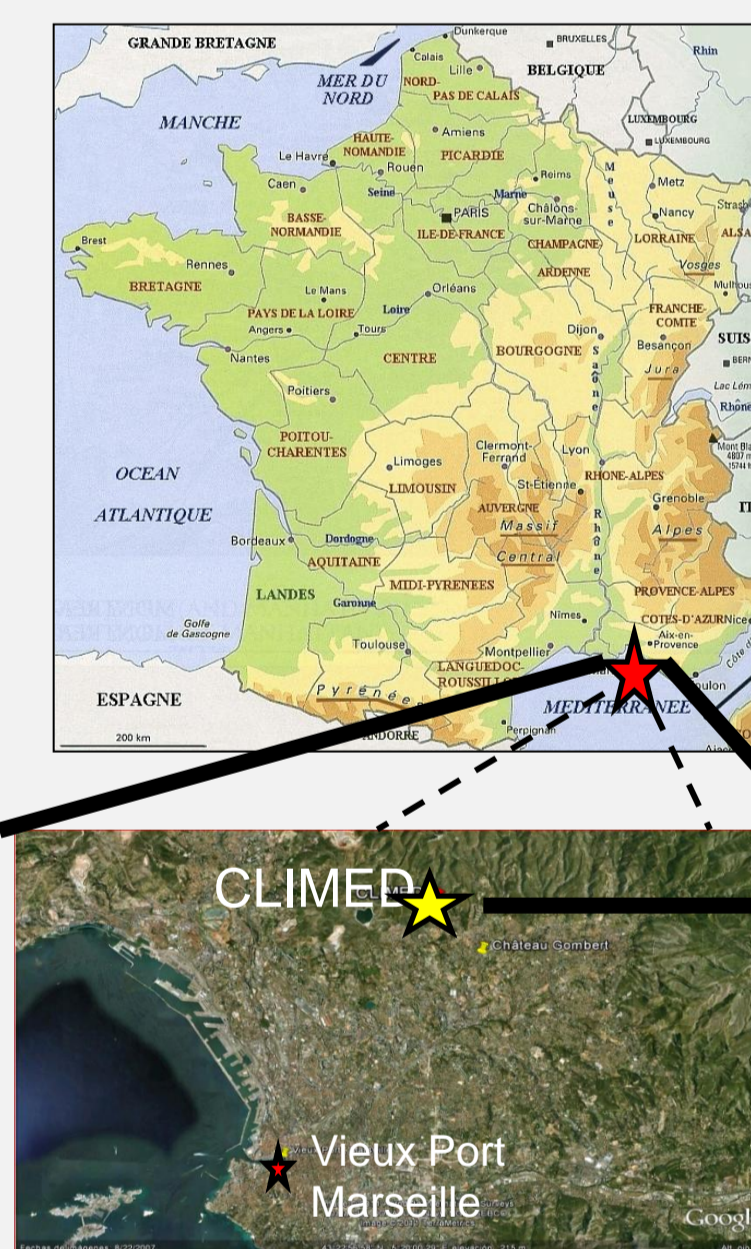
Fonctions de l'écosystème: Productivité Primaire, cycles du carbone et de l'azote

## Premiers résultats



Nombre moyen de pieds secs (+/- s.d.) par placette et par mois des espèces dominantes - Septembre 2012 à Mars 2014

## Site d'étude



Garrigue localisée sur la Chaîne de l'Etoile (280 m) au Nord de Marseille

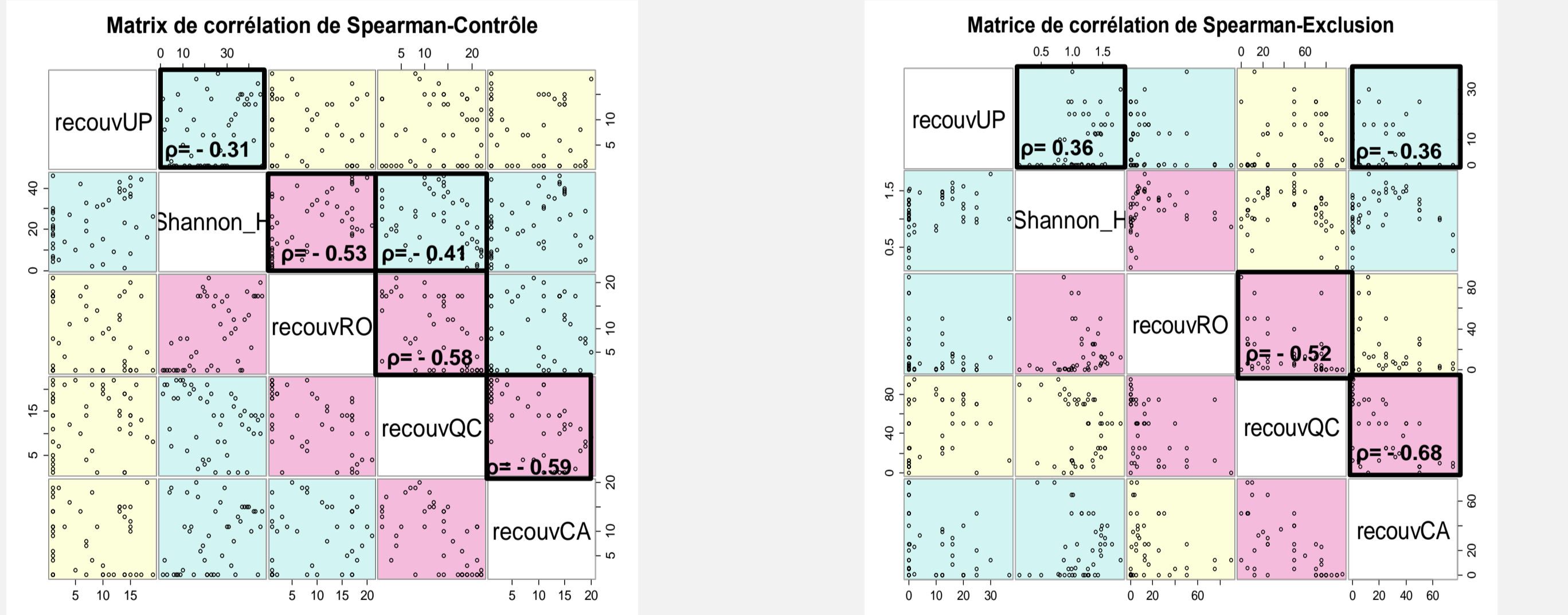


### Rain Exclusion devices

93 plots (2 x2 m each) :  
• 46 structures excluant environ 40% des précipitations  
• 47 structures en « Contrôle »



Lignous dominant species : *Cistus albidus*, *Quercus coccifera*, *Rosmarinus officinalis*, *Ulex Parviflorus*



NB: L'encadrement indique que la corrélation est significative ( $p < 0.05$ ). Les matrices sont ordonnées et colorées par la magnitude de la corrélation de Spearman (Rho) obtenues dans chaque cas: les corrélations jaunes sont relativement plus faibles que les vertes et celle-ci que les rouges

- La magnitude des corrélation entre les recouvrement d'une paire d'espèces ou le recouvrement d'une espèce et la diversité de Shannon-Weaver ( $H'$ ) varie dans certain cas avec le niveau de pluie
- Les recouvrements de *Q.coccifera* et *C. albidus* sont dans les deux cas **négativement corrélés** et la magnitude de cette corrélation est **plus élevée sous exclusion de pluie**.
- $H'$  est **négativement corrélée** au recouvrement du *Q. coccifera* quelque soient les conditions de précipitation.
- $H'$  est **positivement corrélé** avec le recouvrement des autres espèces dominantes mais **sous forte sécheresse** cette relation est seulement significative **avec U. parviflorus**

## Discussion

- La mortalité de la partie aérienne dépend de l'espèce.
- La diminution des précipitations **paraît affecter plus fortement la biomasse de C. albidus et U. parviflorus**.
- La partie aérienne de *R. officinalis* paraît la **plus résistante** face à la diminution des précipitations et semble se récupérer après dessèchement total
- En général, *U. parviflorus* (légumineuse) paraît l'espèce dominante la **plus sensible à l'assèchement**. Ceci pourrait avoir des effet sur la fixation de  $N_2$ .
- **Sous exclusion de pluie, la diversité est positivement corrélée au recouvrement d' U. parviflorus**. Or sous ces conditions, la mortalité de cette espèce augmente. En conséquence, on pourrait donc s'attendre à **une diminution de la diversité**.
- Le recouvrement de *Q. coccifera* est **négativement corrélé à la diversité** de la végétation. Or, sous **sécheresse accrue sa partie aérienne est moins affectée que d'autres espèces dominantes** et semble **se récupérer après dessèchement total**. On pourrait alors s'attendre à un **déclin de la diversité** de la végétation de garrigue là où *Q. coccifera* est dominant.

## Références:

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