Functional diversity and potential of weeds as forage and floral resources: the case of Mediterranean vineyards and olive groves

SEMINAIRE CBGP

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anses

CBGP
Centre de Biologie pour la Gestion des Populations

Who am I ?

- Léa Genty – postdoc at ANSES with Guillaume Fried and Christine Meynard → « *Plants and Coleopteran diversity in agricultural field margins* », 2024-2025

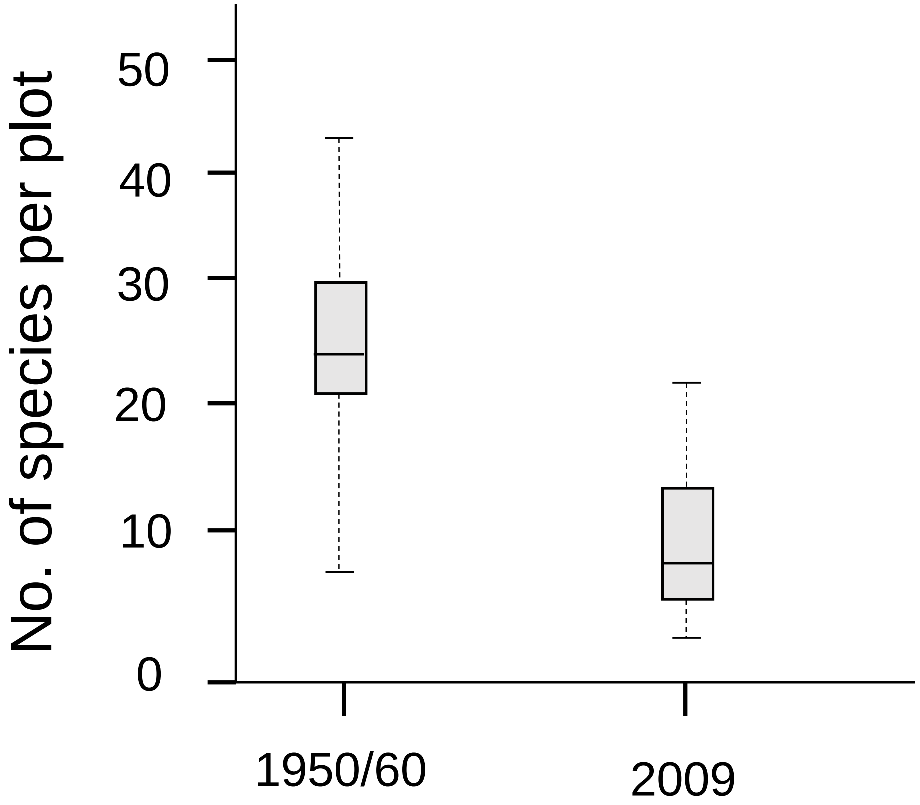
- Phd Cirad 2020-2023 at UMR Absys with Aurélie Metay, Elena Kazakou and Karim Barkaoui on ecosystem services of weeds

Introduction

Plant biodiversity decline in agricultural environments

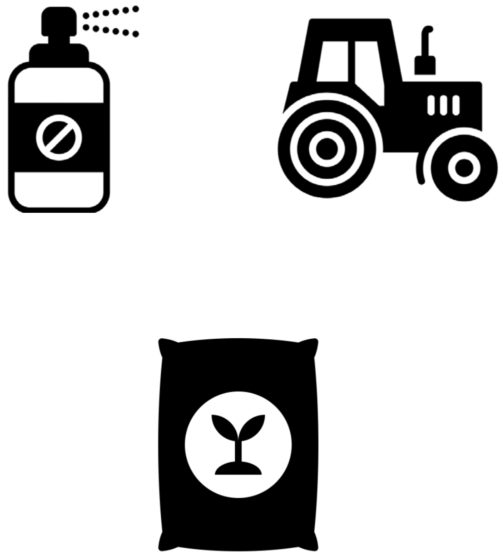
Since the 2nd half of XXth century

Reduction in the richness and abundance of plants in agricultural environments



Adapté de Meyer et al., 2013

Direct links with intensification due to the 2nd agricultural revolution



Emmerson et al., 2016 ; Fried et al., 2009 ; José-Maria et al., 2010 ; Richner et al., 2015

Plant biodiversity in cultivated environments: weeds

Weeds: plant species that occur spontaneously in agricultural plots

1200 species in France

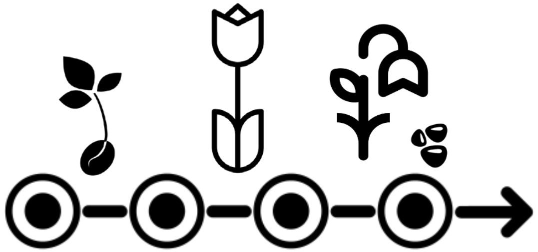
Adapted to a strong filter: agricultural practices

Jauzein, 2001

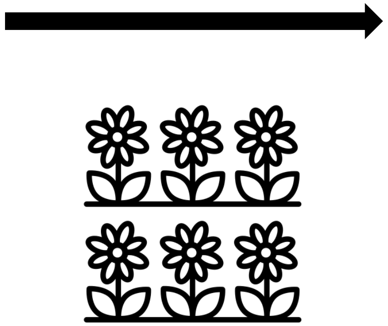
Weed biodiversity: adaption to disturbance and cultivated environments

Dominant common features:

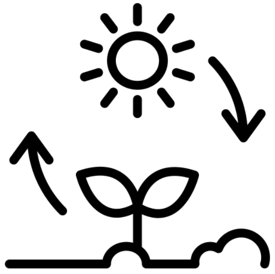
Annual life cycle



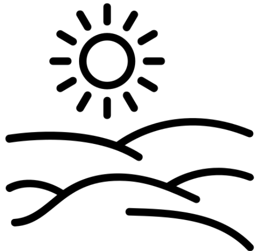
Early and long flowering



Fast resources acquisition



Rich, sunny and dry environments



Bourgeois et al., 2019

These characteristics vary according to the agroecosystem:

Gaba et al., 2017 ; Hall et al., 2020 ; Fried et al., 2022

Perennial crops: high potential for weed biodiversity

$^{1}/_{3}$ to $^{2}/_{3}$ of the plot

Chemical weeding in vineyard inter-row

ANSES, 2020

Mowing and plant cover

Bopp, 2023

Rare or threatened species

Bruggiser et al., 2010 ; Cohen et al., 2015

Weeds deliver ecosystem services in perennial crops

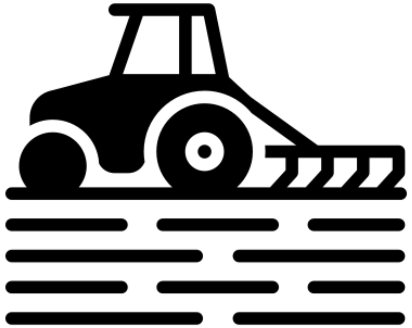
Ecosystem service: "the contribution of ecosystems to human well-being".

Haines-Young & Potschin, 2010

Supporting

Limit soil erosion

Increase bearing capacity of the soil

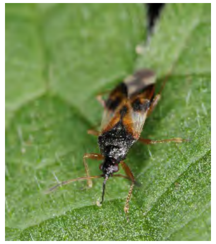


Regulation

Favor pests natural enemies or pollinators

Bethylidae

Proctotrupidae



Anthocoridae

Few studies on weeds potential to provide **supply services**

Carpio et al., 2019 ; Daane et al., 2018 ; Garcia et al., 2018 ; Garcia-Ruiz et al., 2010 ; Gomez et al., 2011 ; Kratschmer et al., 2019 ; Winter et al., 2018

Few studies on the provision of food resources by weeds

- Sheep grazing in vineyards, orchards or olive groves increases

- Socio-economic benefits
- Beneficial effects on soil
- Ecological benefits

Forage quality of weeds in perennial crops was not yet assessed

Niles et al., 2018 ; Ryschawy et al., 2021 ; Schoof et al., 2021

Few studies on the provision of food resources by weeds

- Flower strips: perenial agroecosystem species

Sonchus arvensis, Papaver rhoeas, Calendula arvensis, Malva sylvestris…

- Some common weed perenial agroecosystem species favored by bees

Picris hieracioides

Cirsium vulgare

Taraxacum sp

Echium vulgare

Floral resources in perennial crops was not yet assessed

Balfour & Ratnieks, 2022 ; Kowalska et al., 2022 ; Kuppler et al., 2023

Research question

What is the potential of **weeds** in Mediterranean vineyards and olive groves as **forage and floral resources** and how is it related to **weed communities functional structure**?

The functional approach to assess ecosystem services

Functional trait: "any morphological, physiological or phenological characteristic that can be measured at the individual level".

Violle et al., 2007

Taxonomic approach	**Functional approach**
Species	Height
Medicago minima	7 cm
Diplotaxis erucoides	12 cm

From species to community via the community weighted mean (CWM)

Garnier et al., 2004

Trait-function-service framework in agricultural environments

Abiotic filters

Response trait

Plant communities Traits

Effect traits

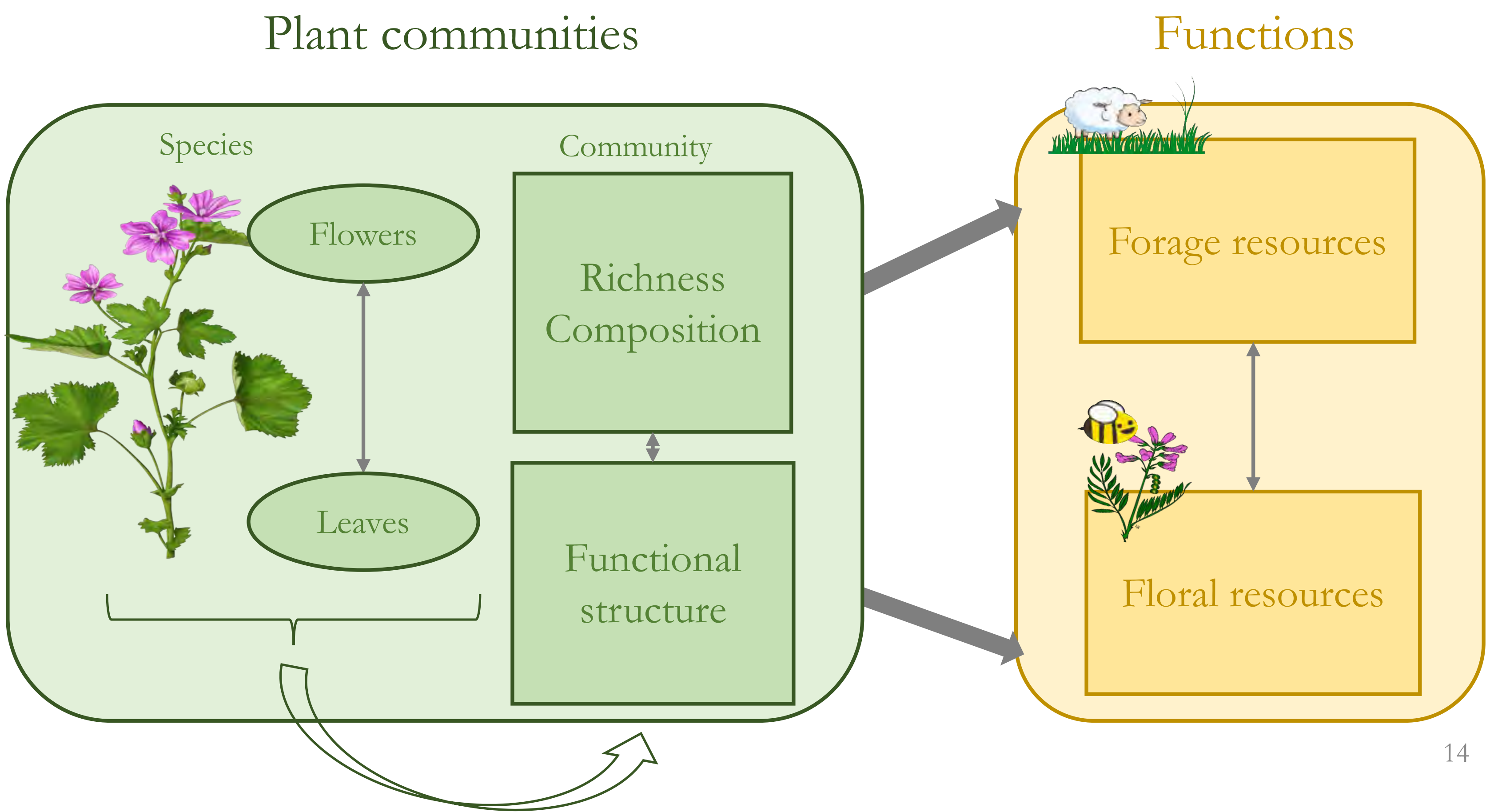
Function

Fertilization ⇢ + Height ⇢ + Insect detection

Damour et al., 2018 ; Fornoff et al., 2017 ; Gaba et al., 2017 ; Lavorel et al., 2013 ; Petit et al., 2021

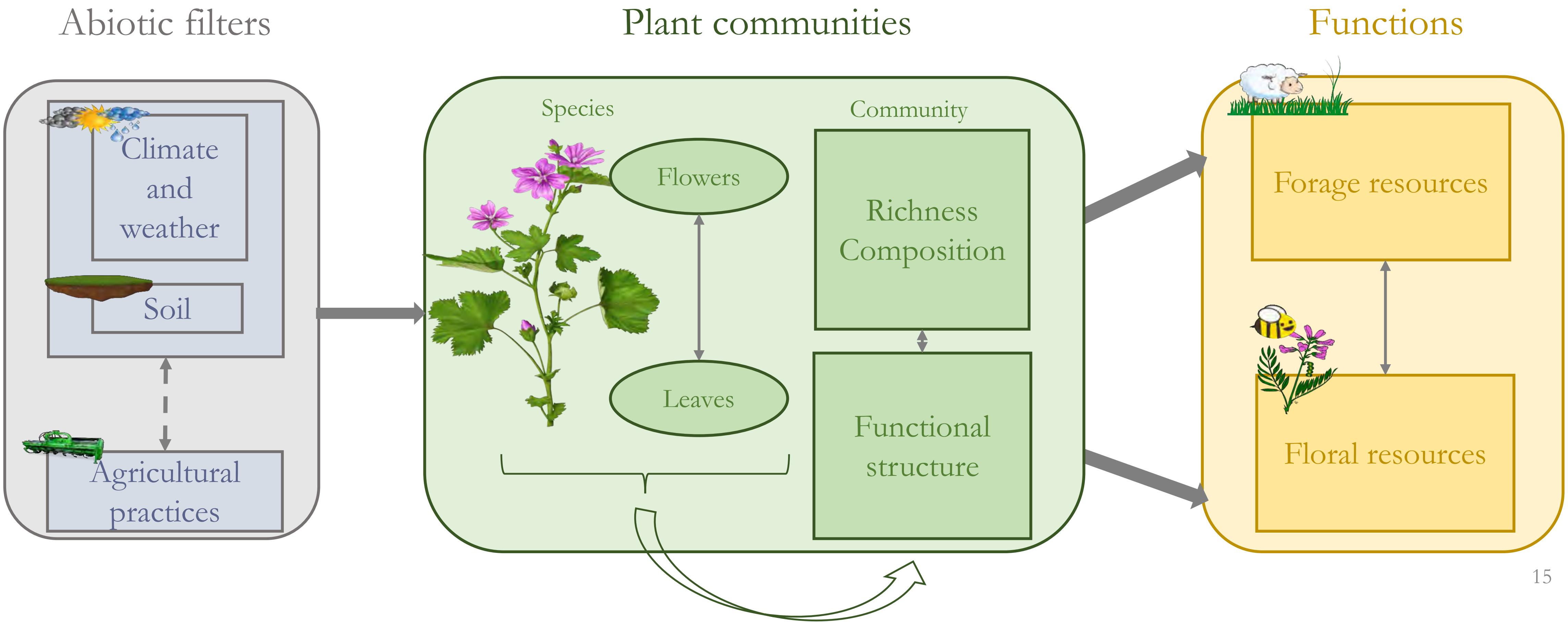
Hypotheses

- Resource potential is determined by the functional structure of weed communities



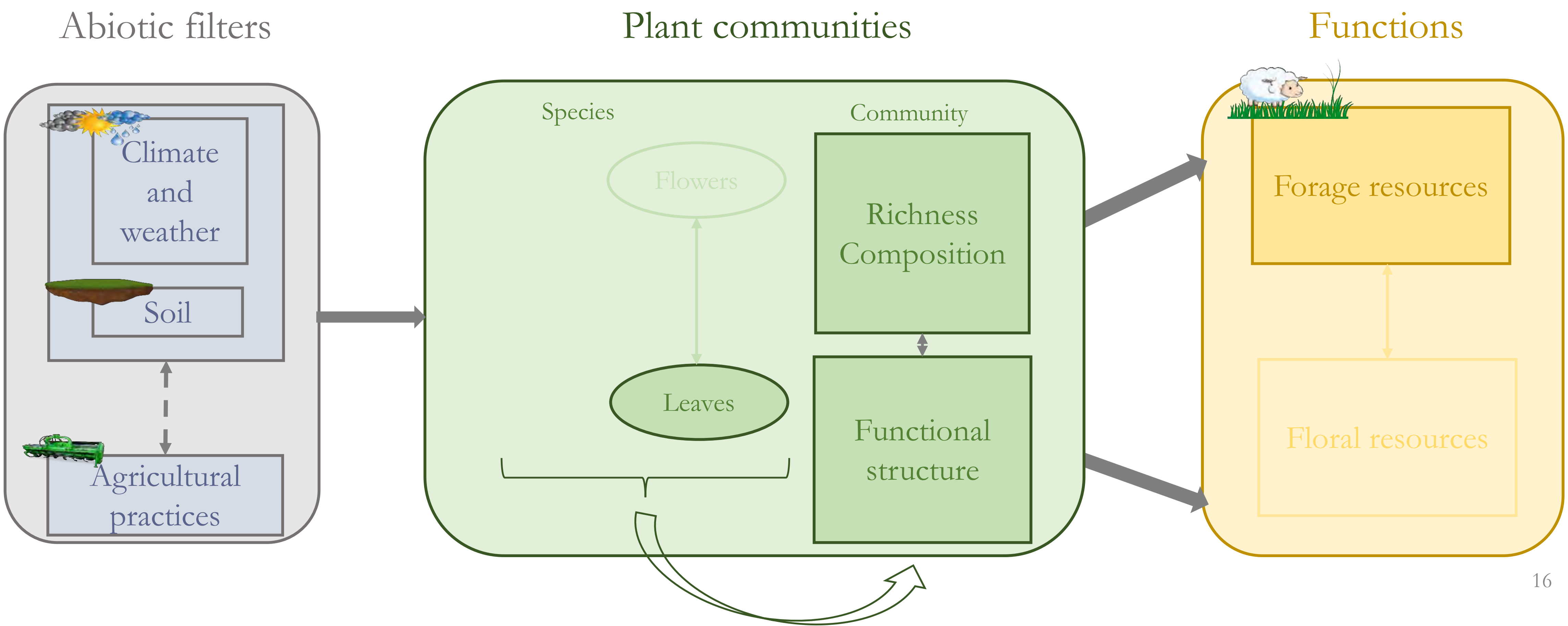
Hypotheses

- Resource potential is determined by the functional structure of weed communities
- Abiotic filters have an impact on forage and floral potential through their direct effect on the functional structure of weed communities.



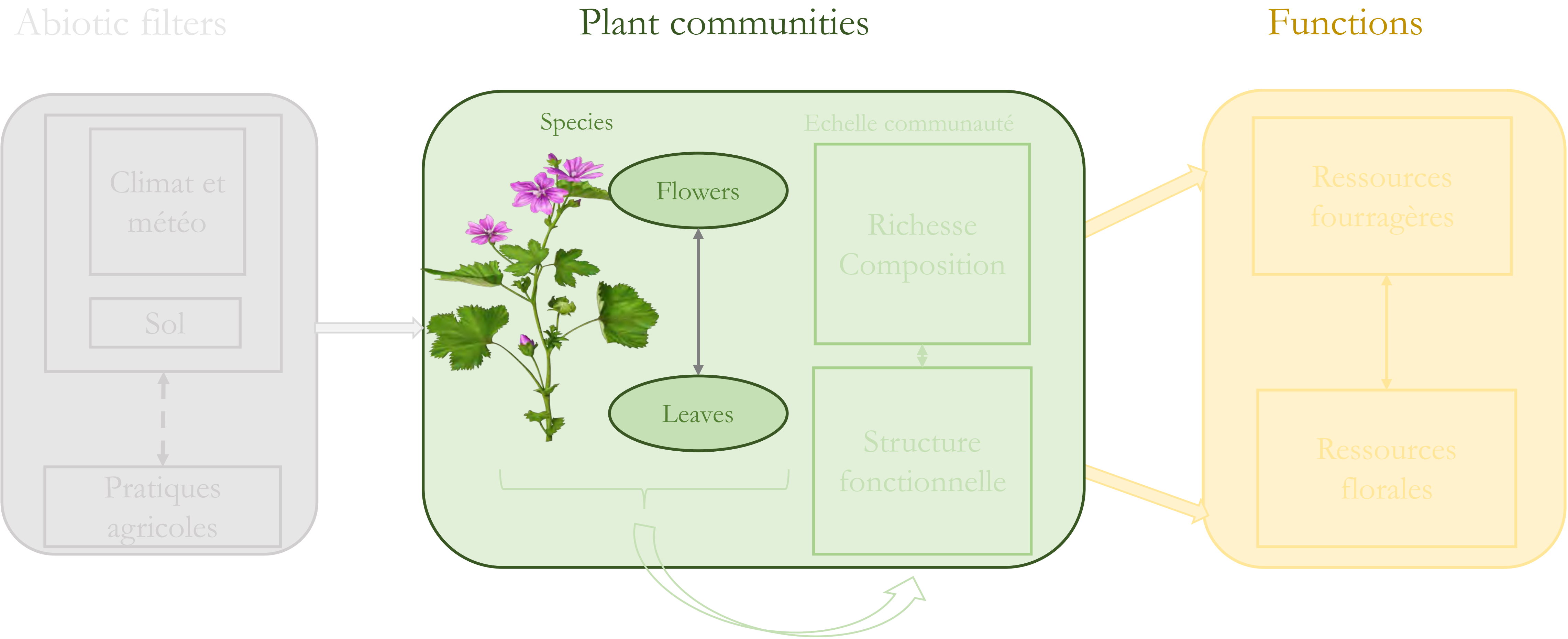
Outline

I. Weeds as forage resources



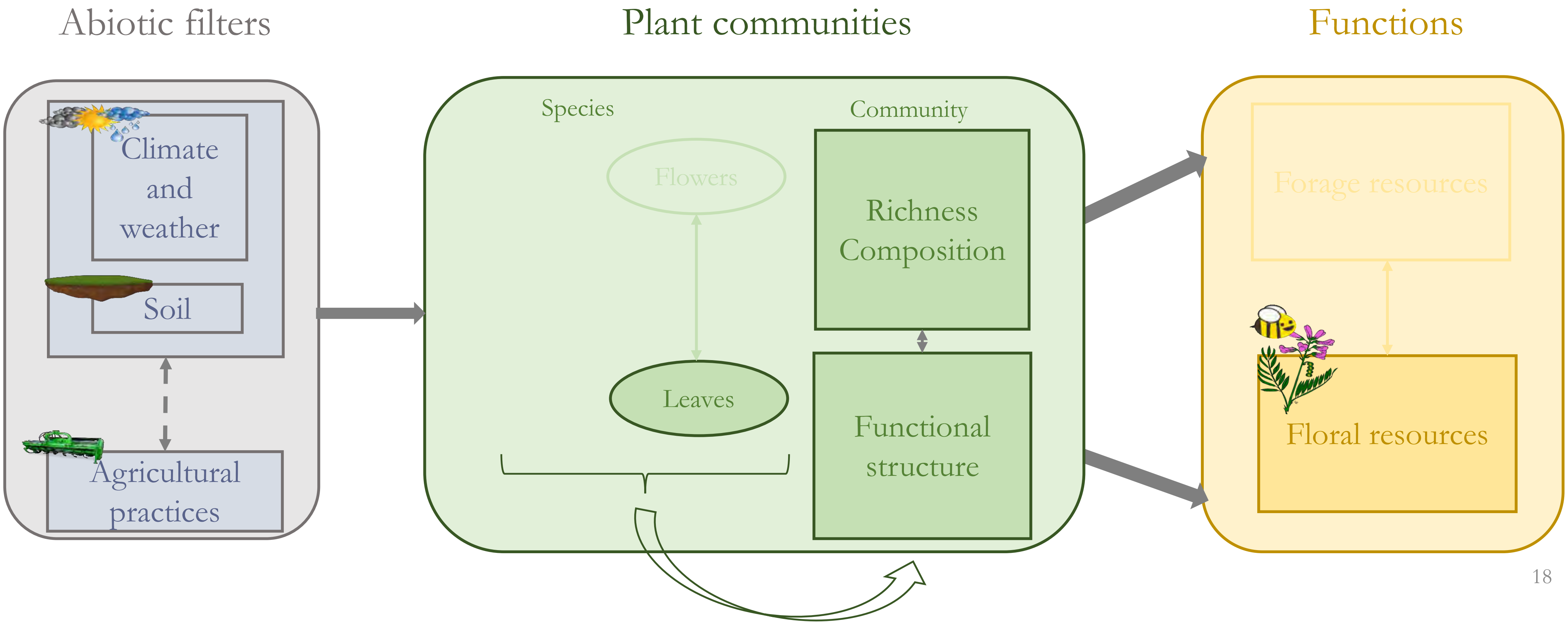
Outline

II. Functional characterization of weed flowers



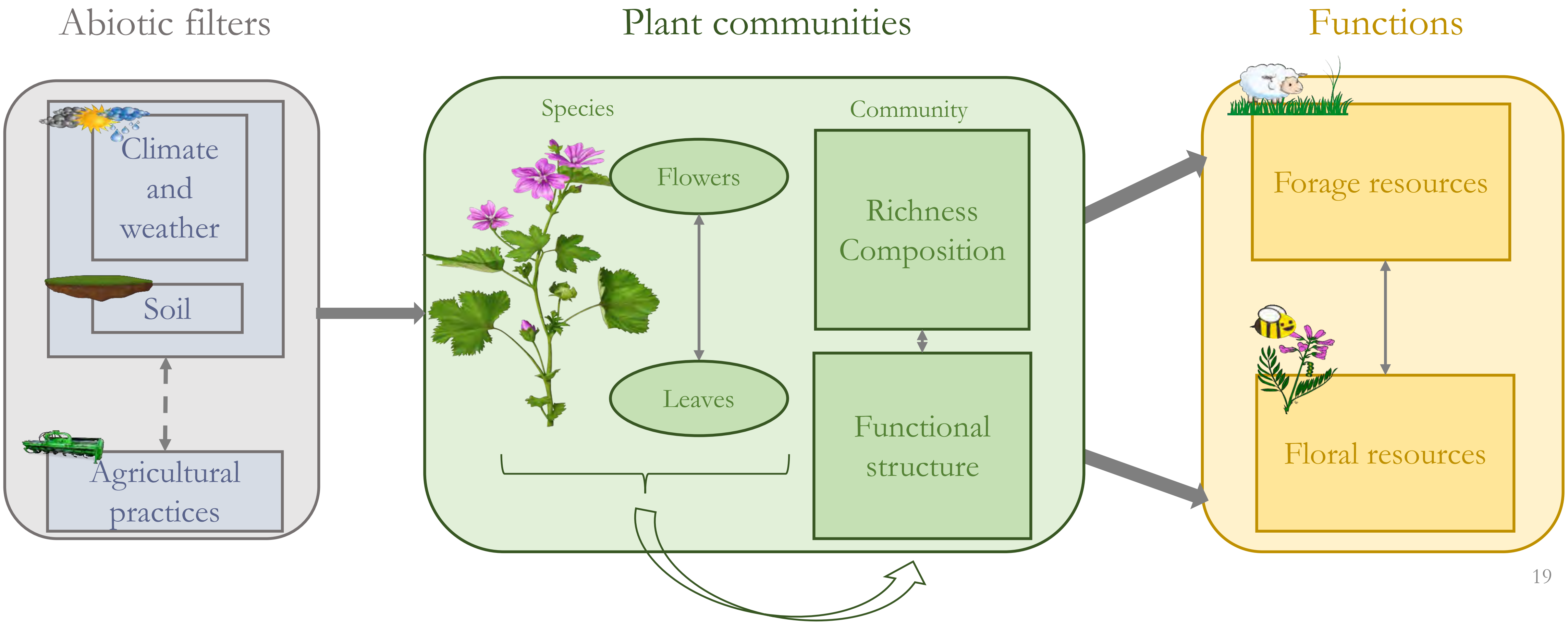
Outline

III. Weeds as floral resources



Outline

- I. Weeds as forage resources
- II. Functional characterization of weed flowers
- III. Weeds as floral resources



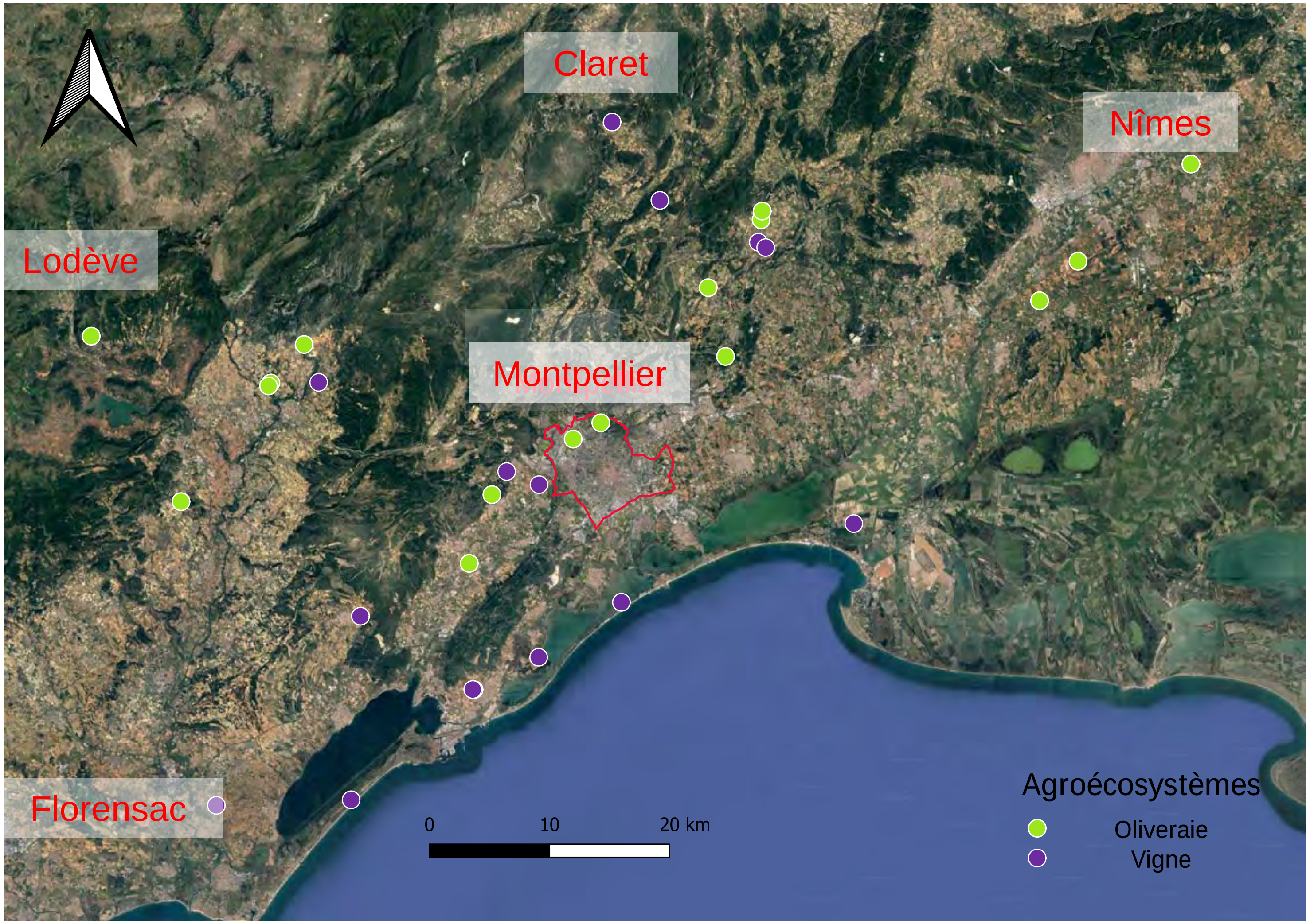
Material and methods

The thesis plot network

→ 16 vineyards

→ 16 olive groves

32 agricultural plots



- No use of herbicides in the inter-row area
- Plots in production

Mowing	11 plots : tillage 5 plots : ½ mowing
1,9 t/ha	56 hL/ha
0,1 à 7 t/ha	*20 à 115 hL/ha*

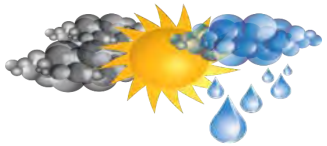
Abiotic variables collected during the thesis

2-year survey of farmers' weed management practices

Number of mowing and tillage

Fertilization

Irrigation



Climatic data

Long-term climate trends: average temperatures and precipitation since 1980

Temperature and precipitation in sampling year

Soil variables

Soil organic matter content

Texture

Total soil nitrogen content

pH

Cation exchange capacity

Weed sampling

50 cm

50 cm

2021 sampling: « forage »

5 quadrats per plot

Spring - Fall

Identification and abundance of ***all species*** *in the community*

n = 320

2022 sampling: « flowers »

5 quadrats per plots

7 dates : september, october, january, march, april, may, june

Identification and abundance of all ***species at the flowering stage*** *in the community*

n = 560

Weed trait measurement

Leaf traits

In situ, in each agroecosystem

Floral traits

Under controlled conditions

Species making up at least 80% of each community

$$CWM_{trait} = \sum_i p_i \times trait_i$$

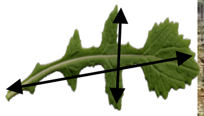
Garnier et al., 2004

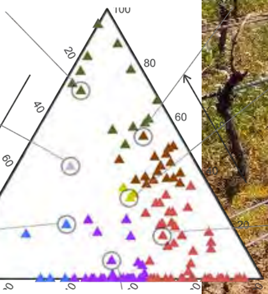
→ For each sampled community * each trait

Summary of data collected in my thesis

Abiotic variables

Functional traits





2021 sampling « forage »

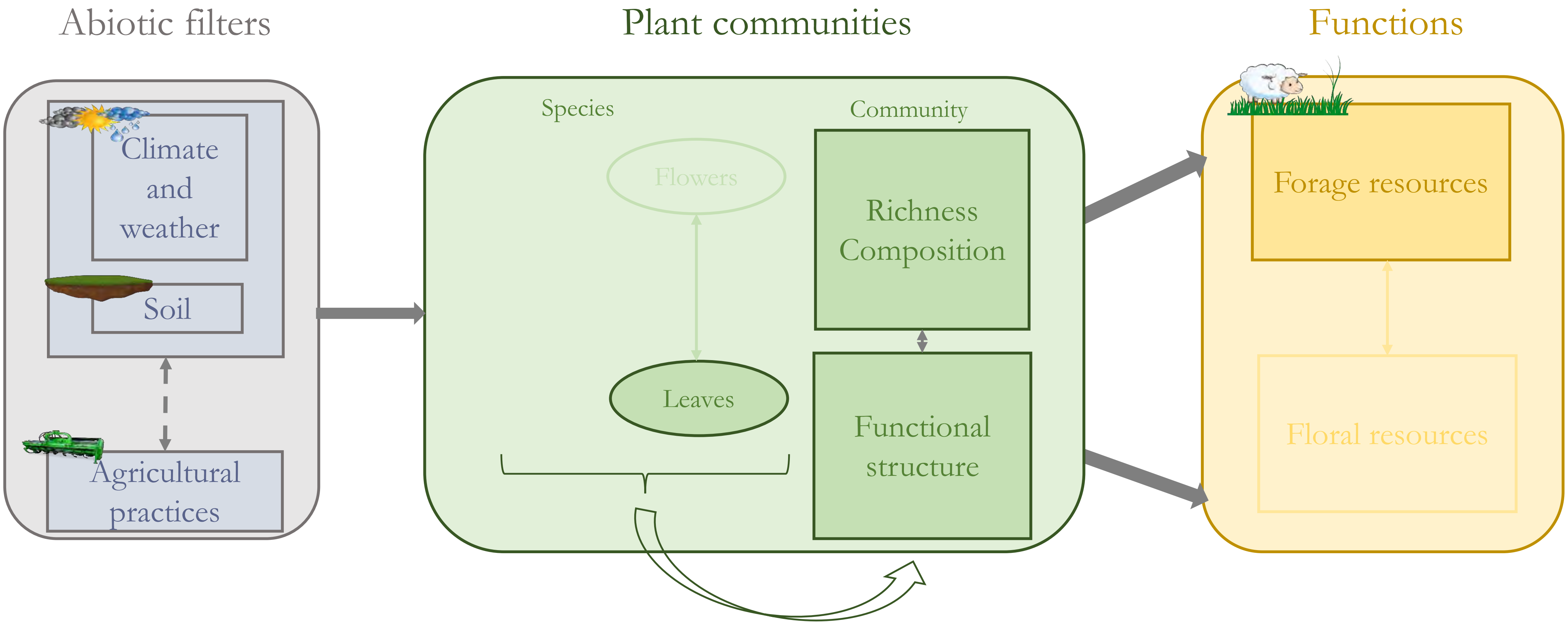
2022 sampling « flowers »

CWM of functional traits

I. Weeds as forage resources

Weeds as forage resources

- What is the potential of weed communities in Mediterranean vineyards and olive groves as a forage resource, and how do **agricultural practices** and pedoclimate modify forage quality and associated traits?

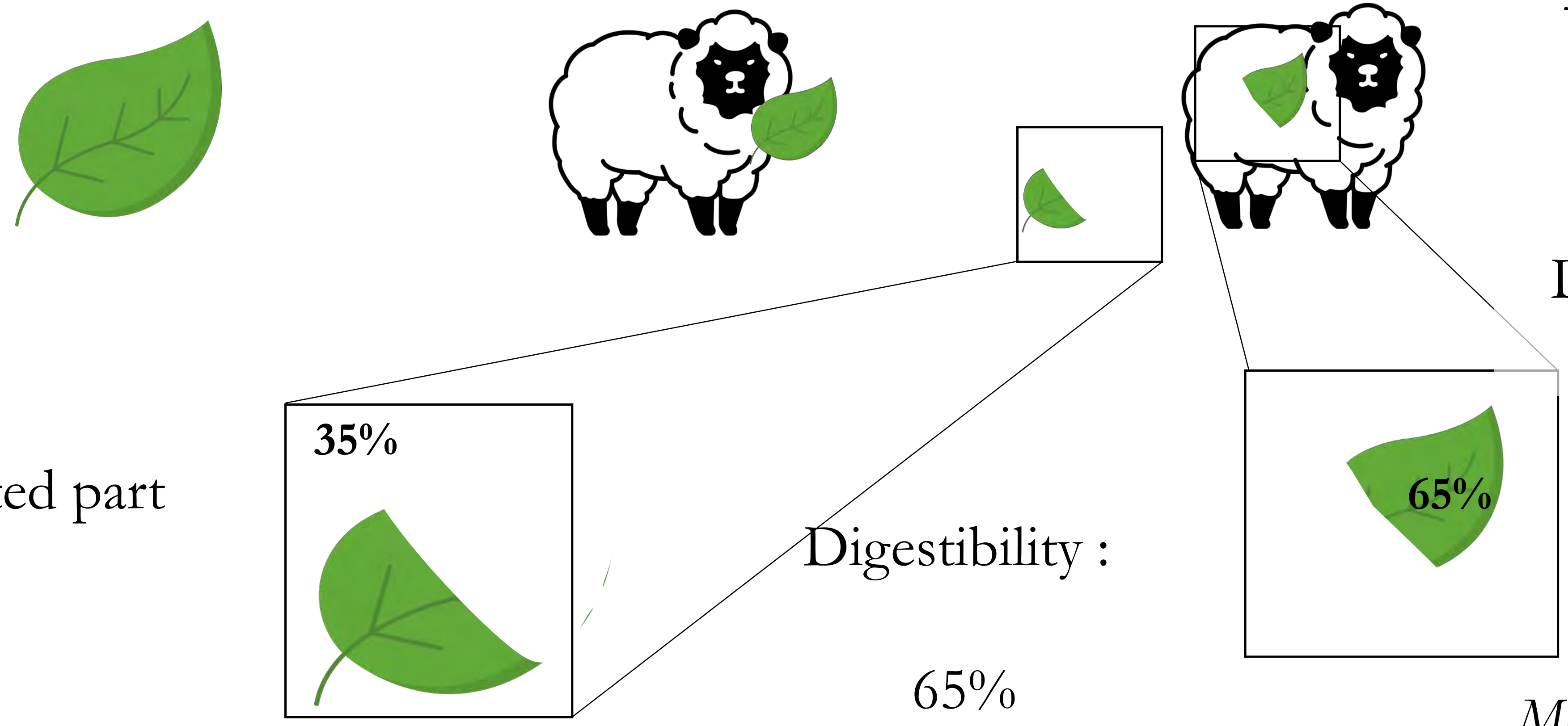


Digestibility: an indicator of forage quality

Here, digestibility is predicted using **near infrared spectrometry**

D. Bastianelli
L. Bonnal
E. Baby

n = 88 sp et 302 communities

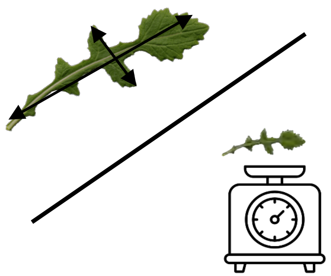


Meyer, 2023

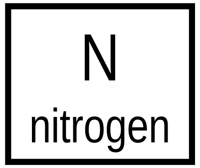
In situ measurement of weed leaf traits related to forage resources

+ / **–**

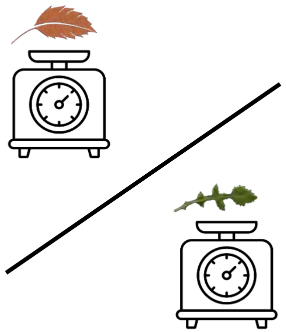
Specific leaf area 'SLA'



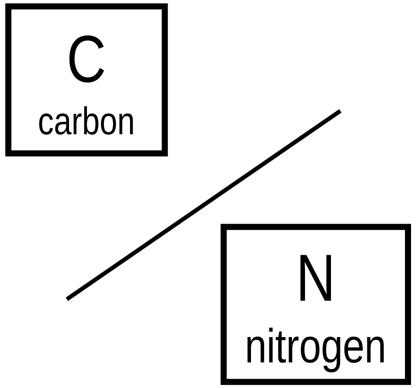
Leaf nitrogen content 'LNC'



Leaf dry matter content 'LDMC'



C/N leaf ratio

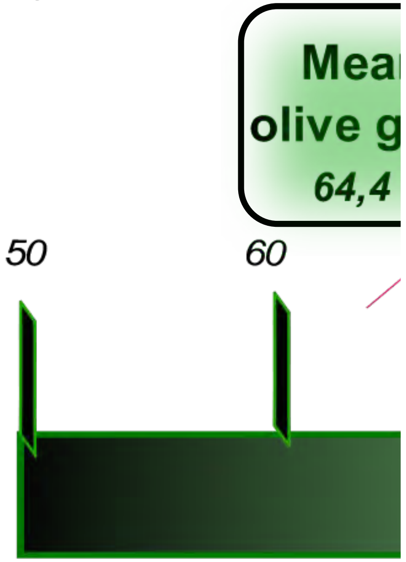


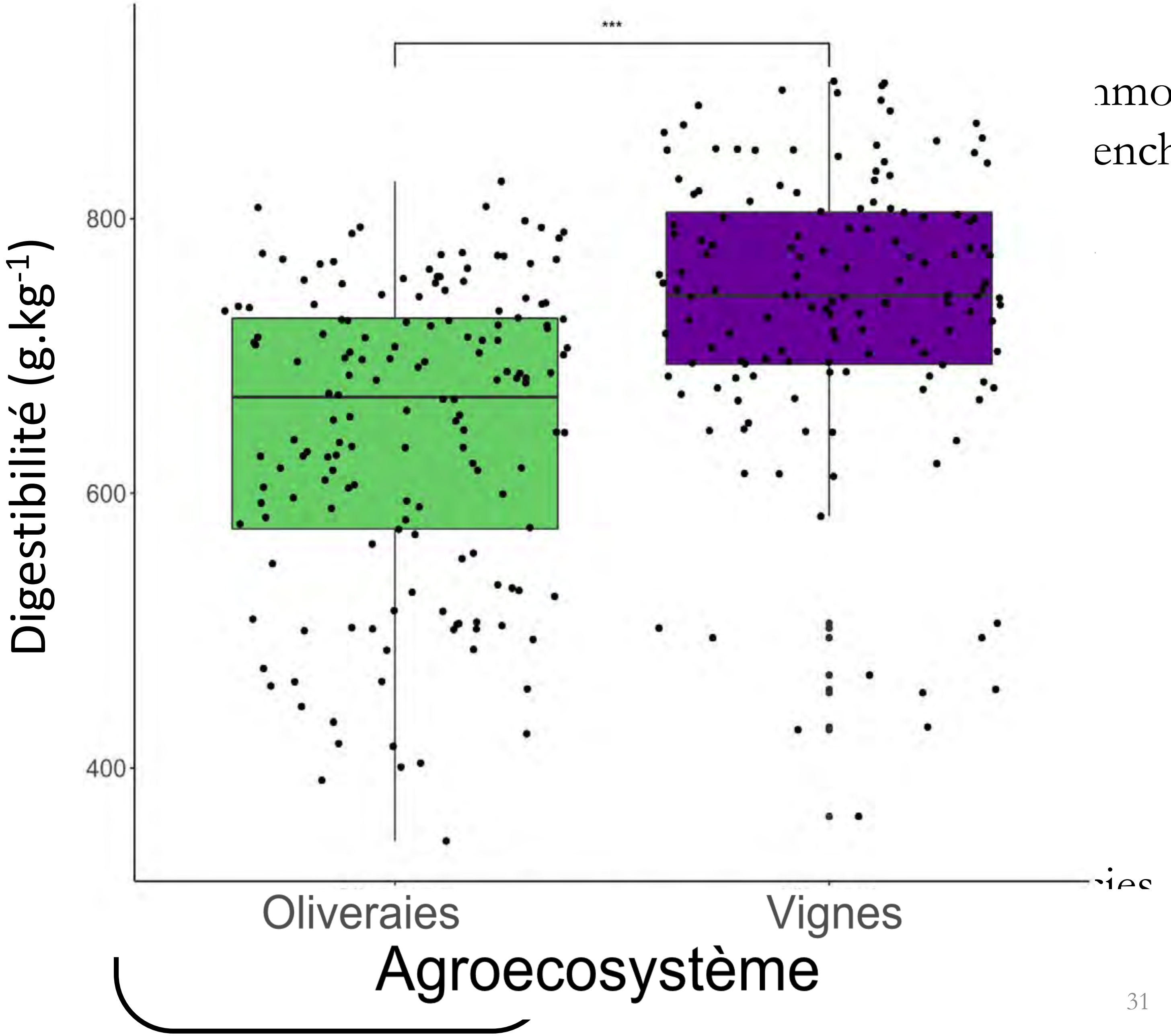
n = 105

Gardarin et al., 2014 ; Bumb et al., 2016 ; Kazakou et al., 2022 ; Khaled et al., 2006

Digestibility of weed communities

Mean of each agroecosystem at the community level





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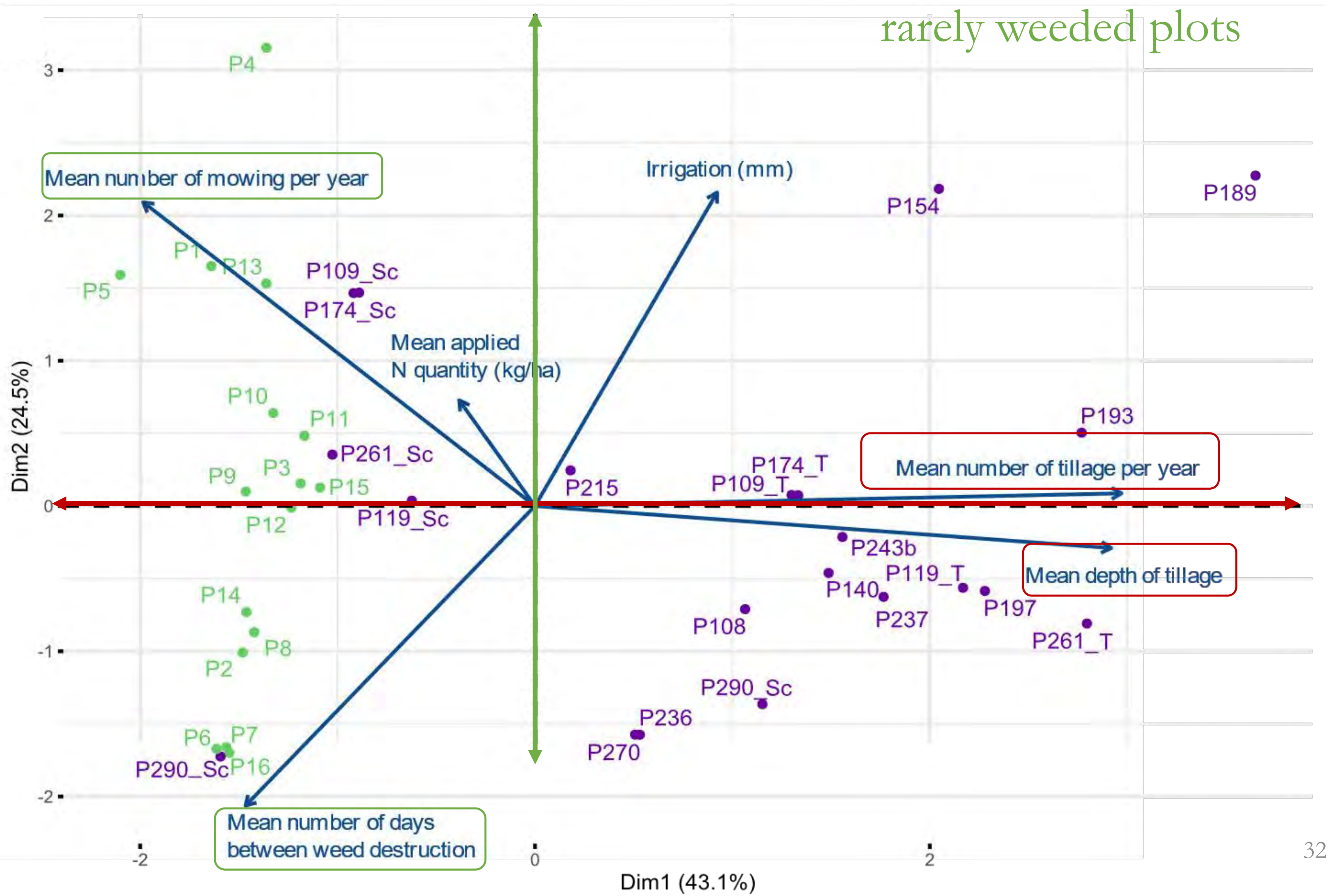
Are these differences due to agricultural practices?

Characterization of agricultural practices

- Principal composant analysis on agricultural practices

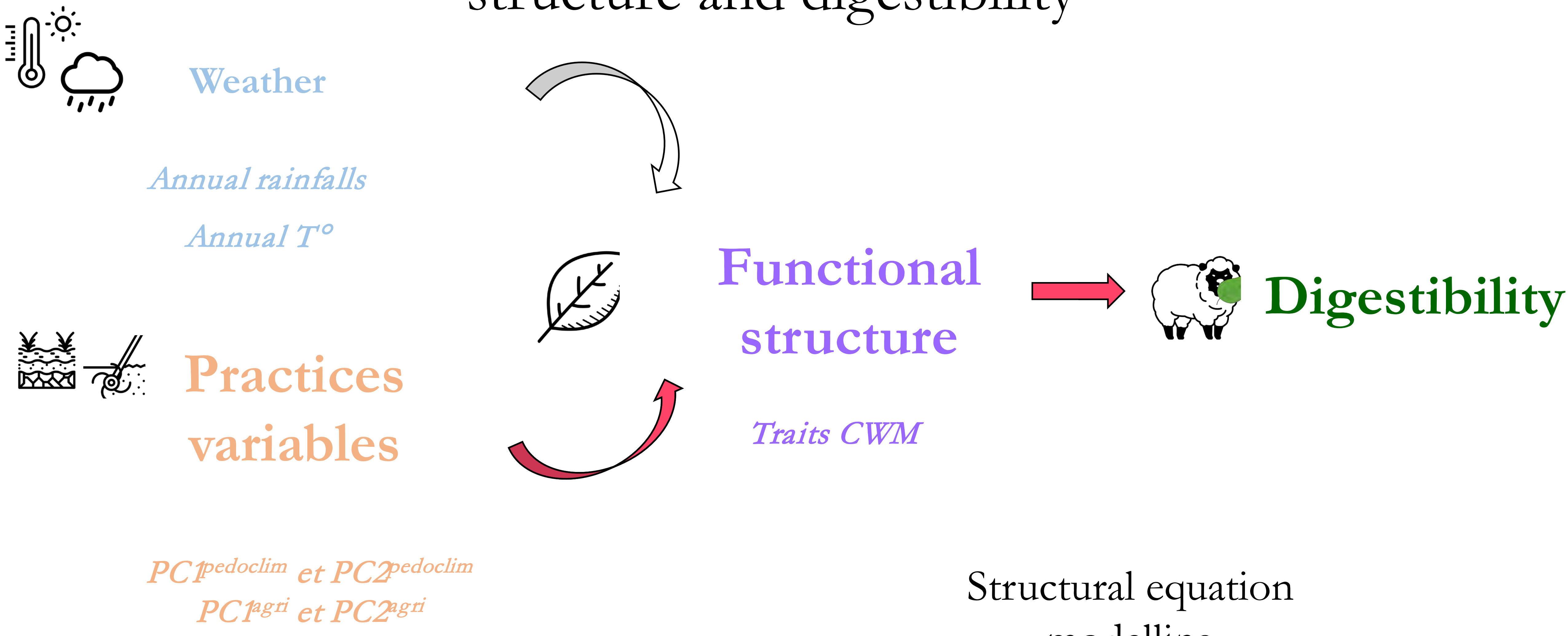
PC1^{agri} : tilled *vs* not-tilled plots

PC2^{agri} : regularly *vs* rarely weeded plots



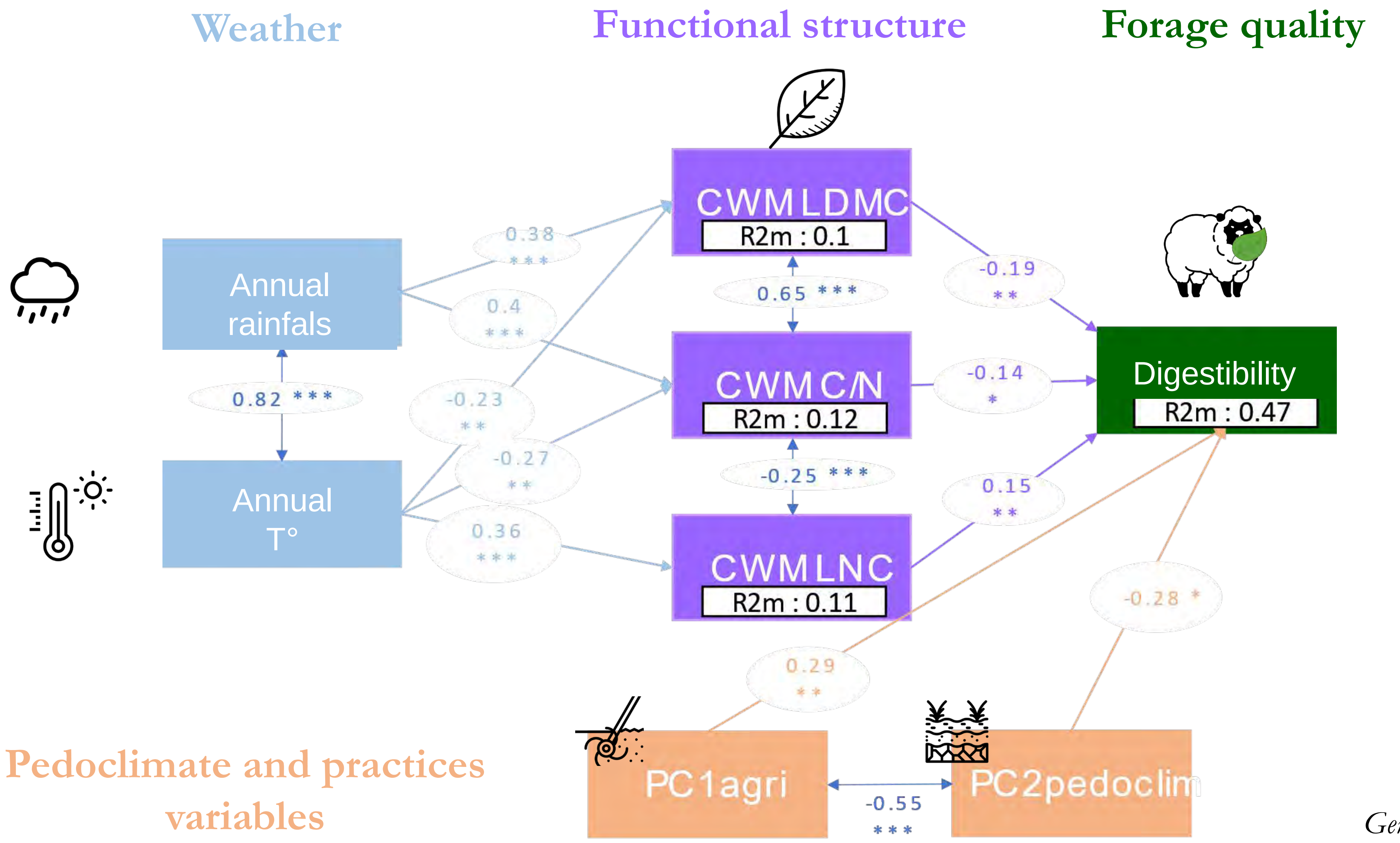
Genty et al., 2023a

Relationships between abiotic variables, functional structure and digestibility



Structural equation modelling

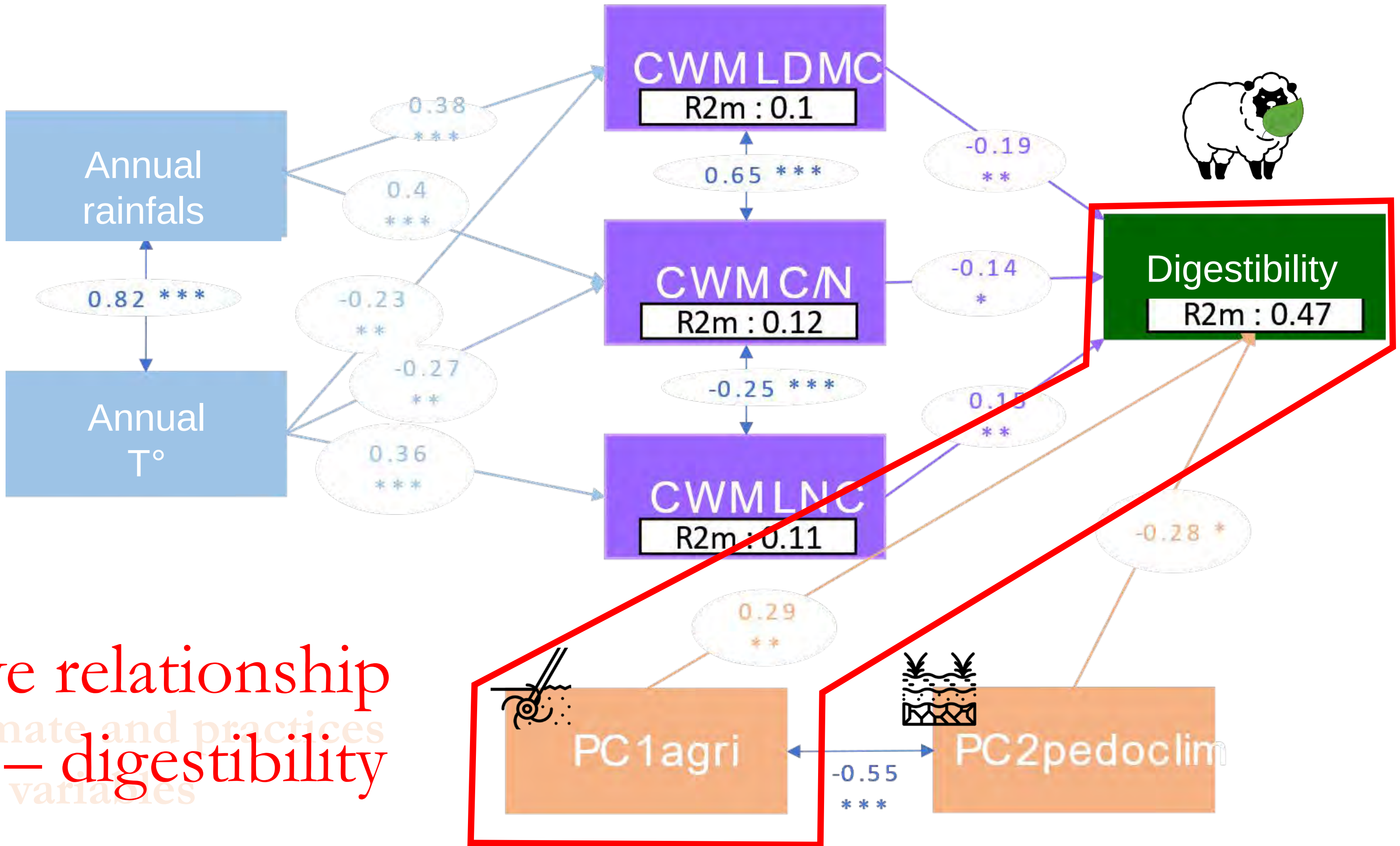
Relationships between abiotic variables, functional structure and digestibility



Genty et al., 2023a

Links abiotic variables and digestibility

Weather | Functional structure | Forage quality

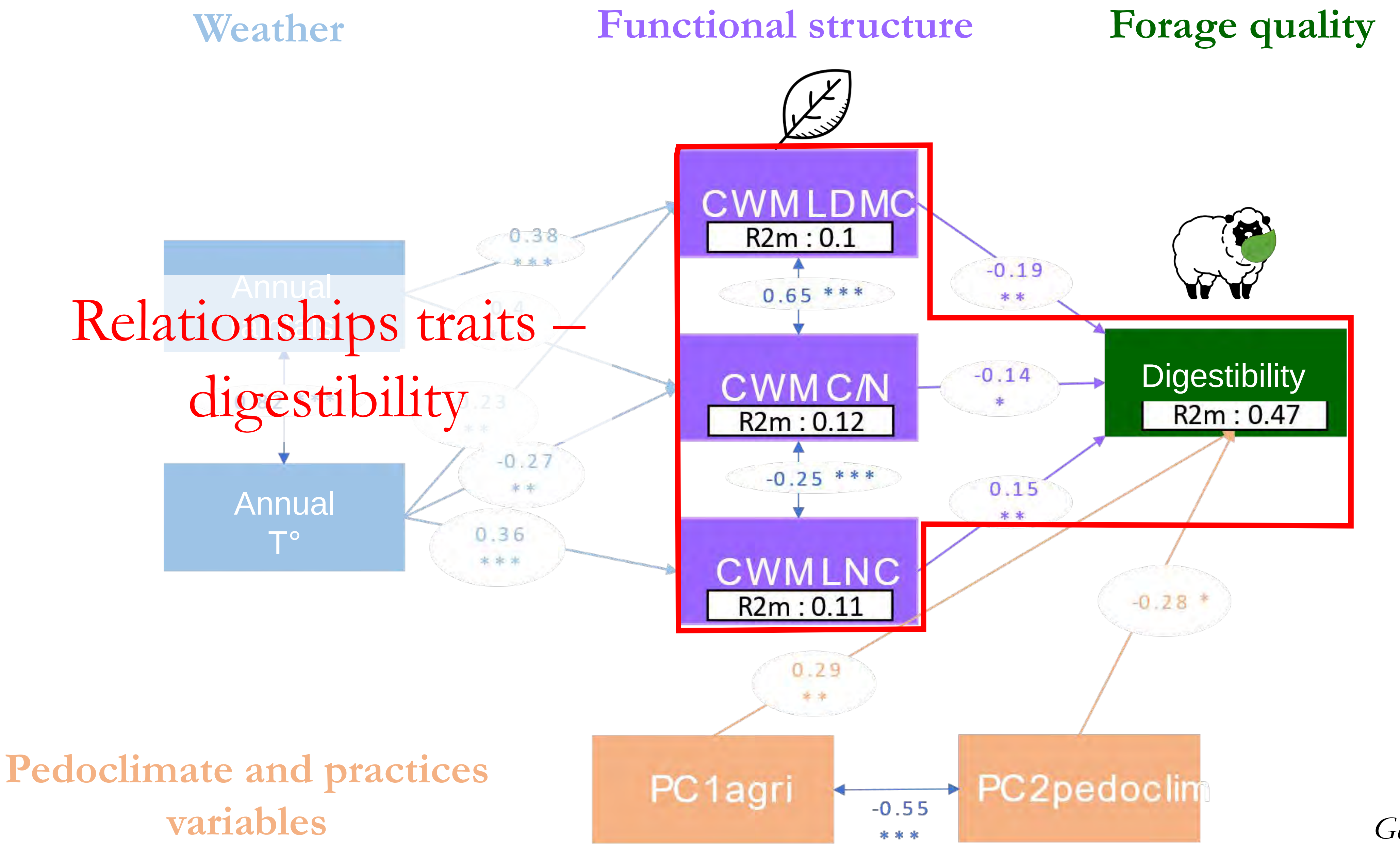


Positive relationship tillage – digestibility

Pedoclimate and practices variables

Genty et al., 2023a

Links functional structure - digestibility

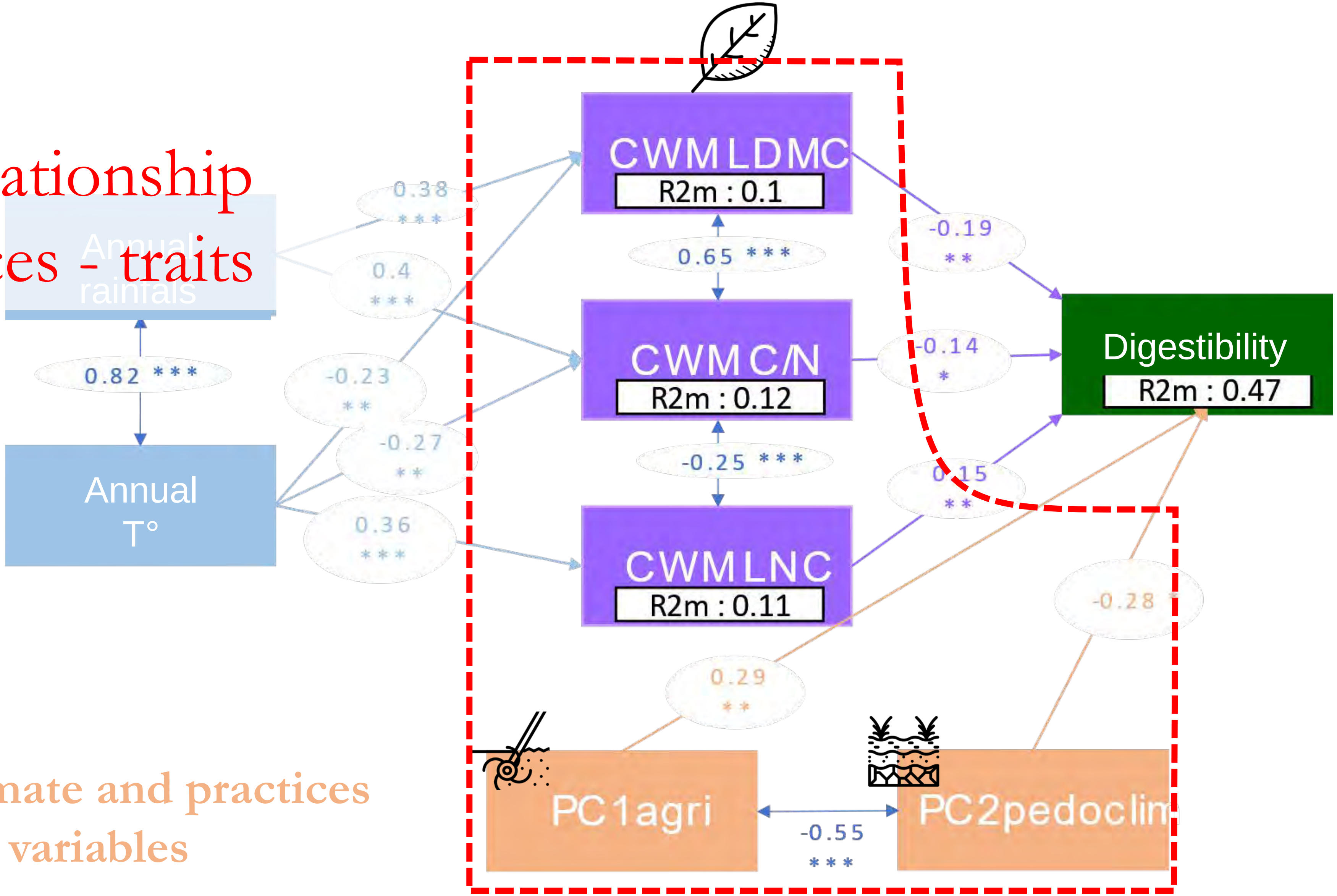


Relationships traits – digestibility

Genty et al., 2023a

No link pedoclimate-practices and functional structure

Weather | Functional structure | Forage quality



No relationship practices - traits

Pedoclimate and practices variables

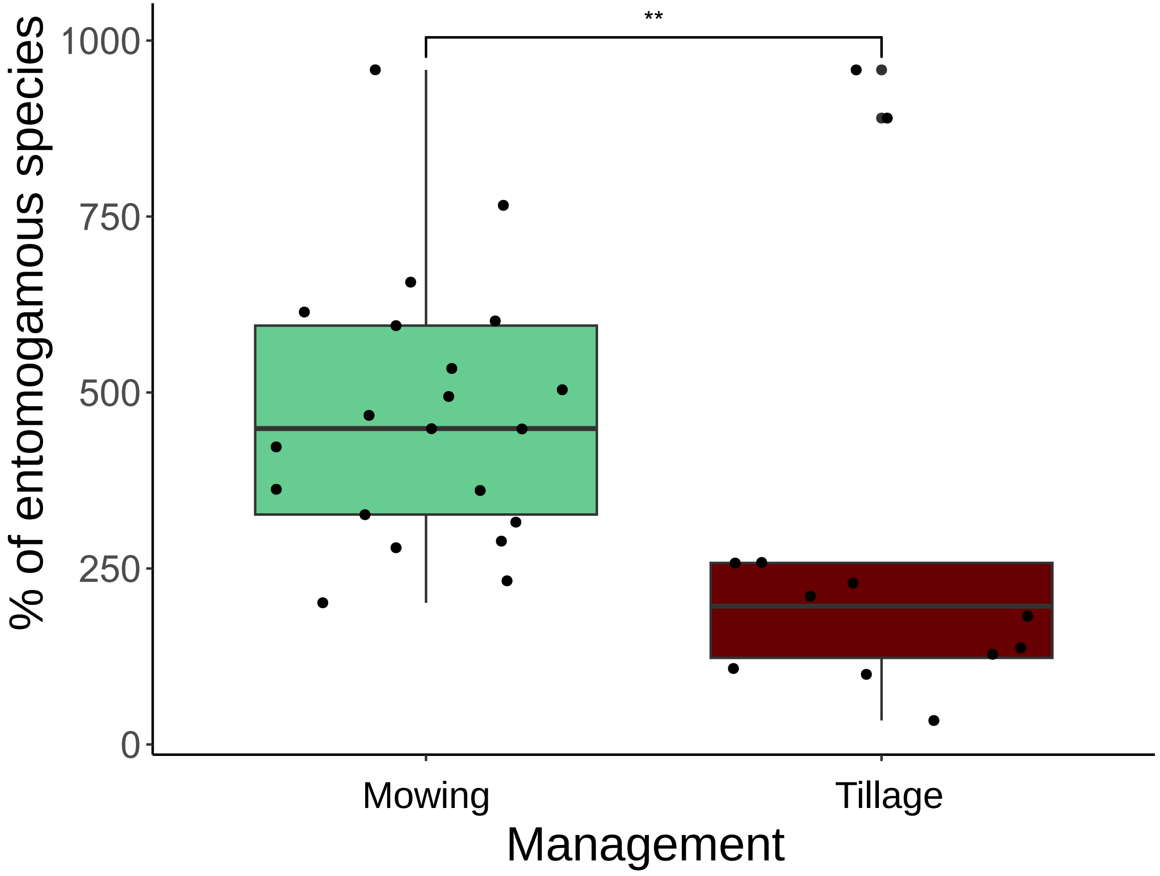
Genty et al., 2023a

Summary of part I

- Weeds → qualitative forage resources
- Forage quality higher in 
- Tillage ↗ forage quality because of disturbance
- Traits determine forage quality

Discussion: the effects of practices on digestibility

- Tillage promotes digestibility but not other services or biodiversity



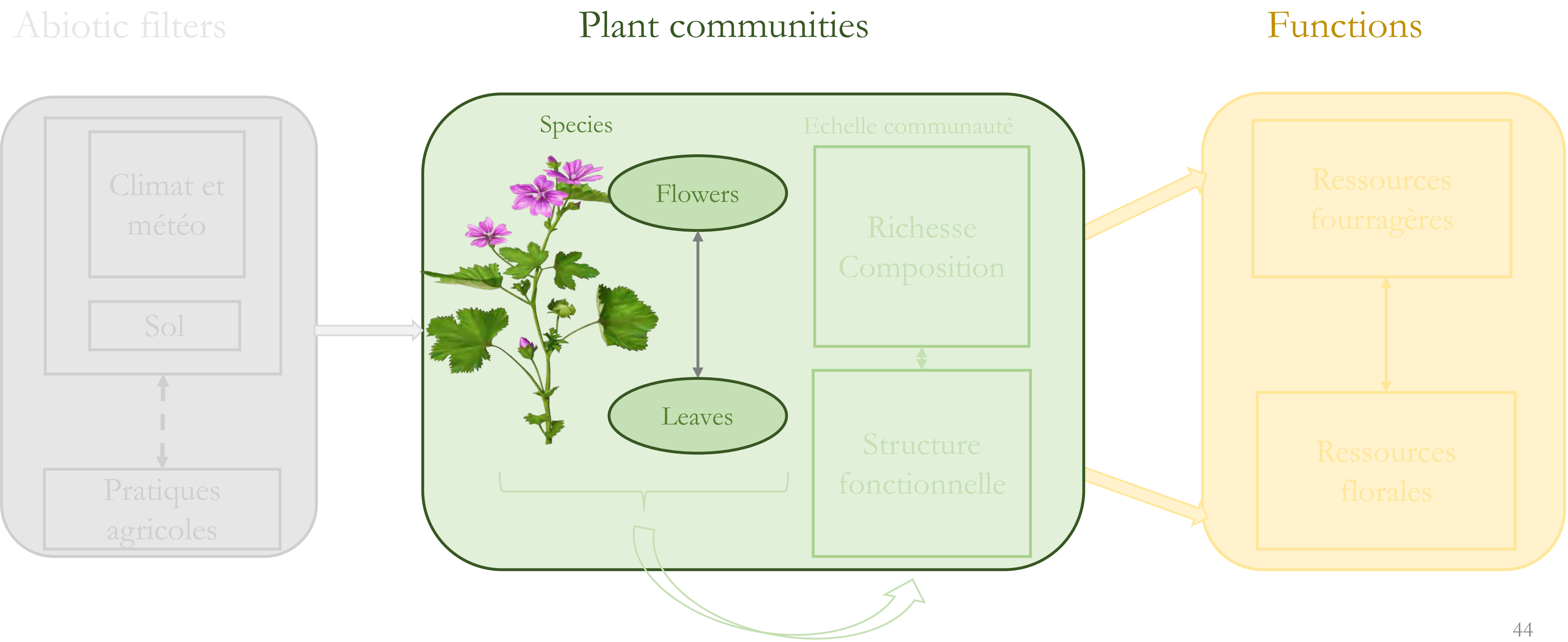
- Confirmation of known disturbance/digestibility relationships in grasslands but in a different range of disturbances

Carpio et al., 2019 ; Cohen et al., 2015 ; Gardarin et al., 2014 ; Kratschmer et al., 2018 ; Meyer et al., 2013

II. Functional characterization of weed flowers

Functional characterization of weed flowers

- What are the characteristics of vineyards and olive groves weed flowers?
- Do weed ecological strategies incorporate floral traits?



Floral traits linked to insect visits

- Floral morphology

Area, height, flower numbers

- Rewards

Nectar, pollen

- Availability

Flowering onset and duration

Fornoff et al., 2017 ; Hegland & Totland, 2005 ; Lazaro et al., 2013 ; Rowe et al., 2020 ; Tuell et al., 2008 ; Uyttenbroeck et al., 2017

Measurement of weed floral traits under controlled conditions

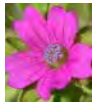
19 of the most abundant species in bloom in spring 2021

Arenaria serpyllifolia 

Carduus pycnocephalus 

Cerastium glomeratum 

Diplotaxis erucoides 

Geranium dissectum 

Geranium rotundifolium 

Malva sylvestris 

Medicago arabica 

Medicago minima 

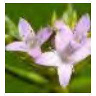
Picris hieracioides 

Plantago lanceolata 

Ranunculus bulbosus 

Poterium sanguisorba 

Senecio vulgaris 

Sherardia arvensis 

Torilis arvensis 

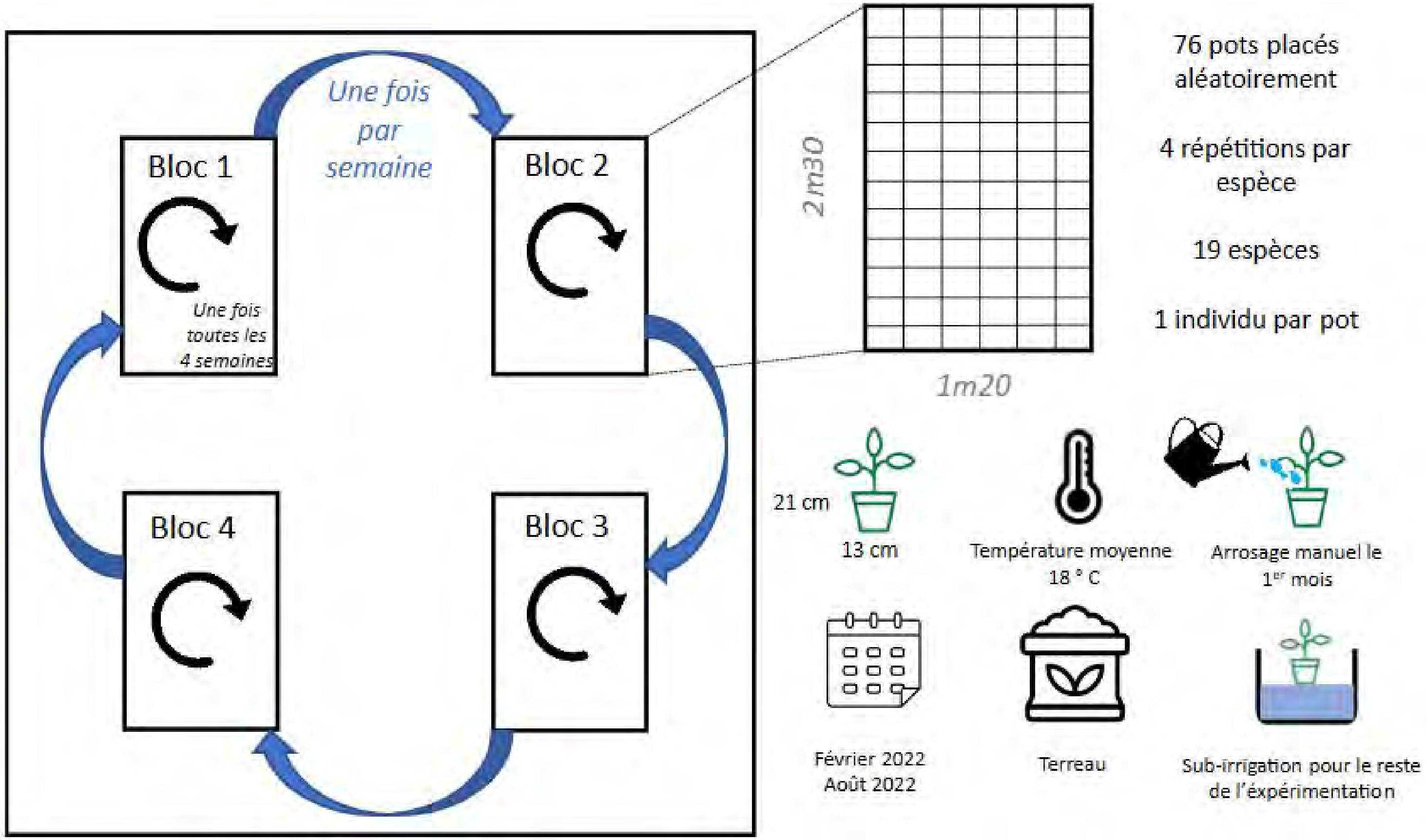
Torilis nodosa 

Trifolium campestre 

Veronica persica 

Measurement of weed floral traits under controlled conditions

16 repetitions per species
304 plants



Measurement of weed floral traits under controlled conditions

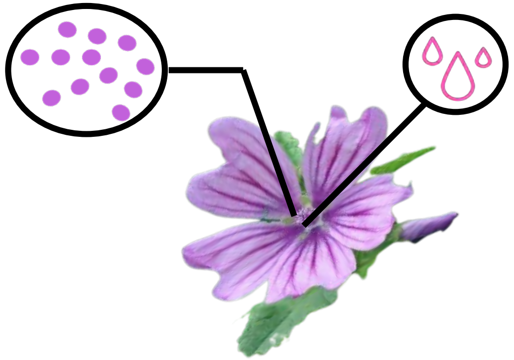
Morphological traits


Floral height


Floral area

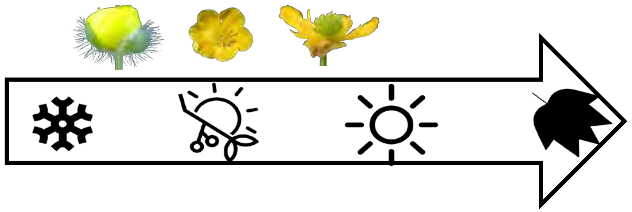

Number of flowers per individual

Resources traits

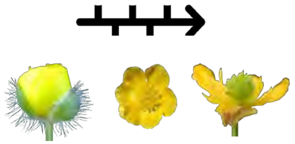

Pollen volume and nutrient content

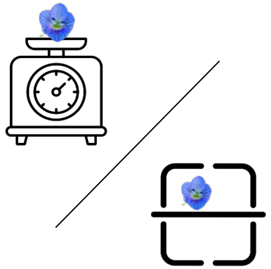
Nectar sugar content

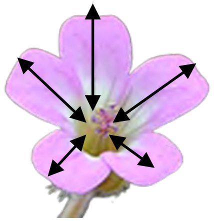
Phenological traits


Flowering onset and duration

Traits related to manufacturing and maintenance costs

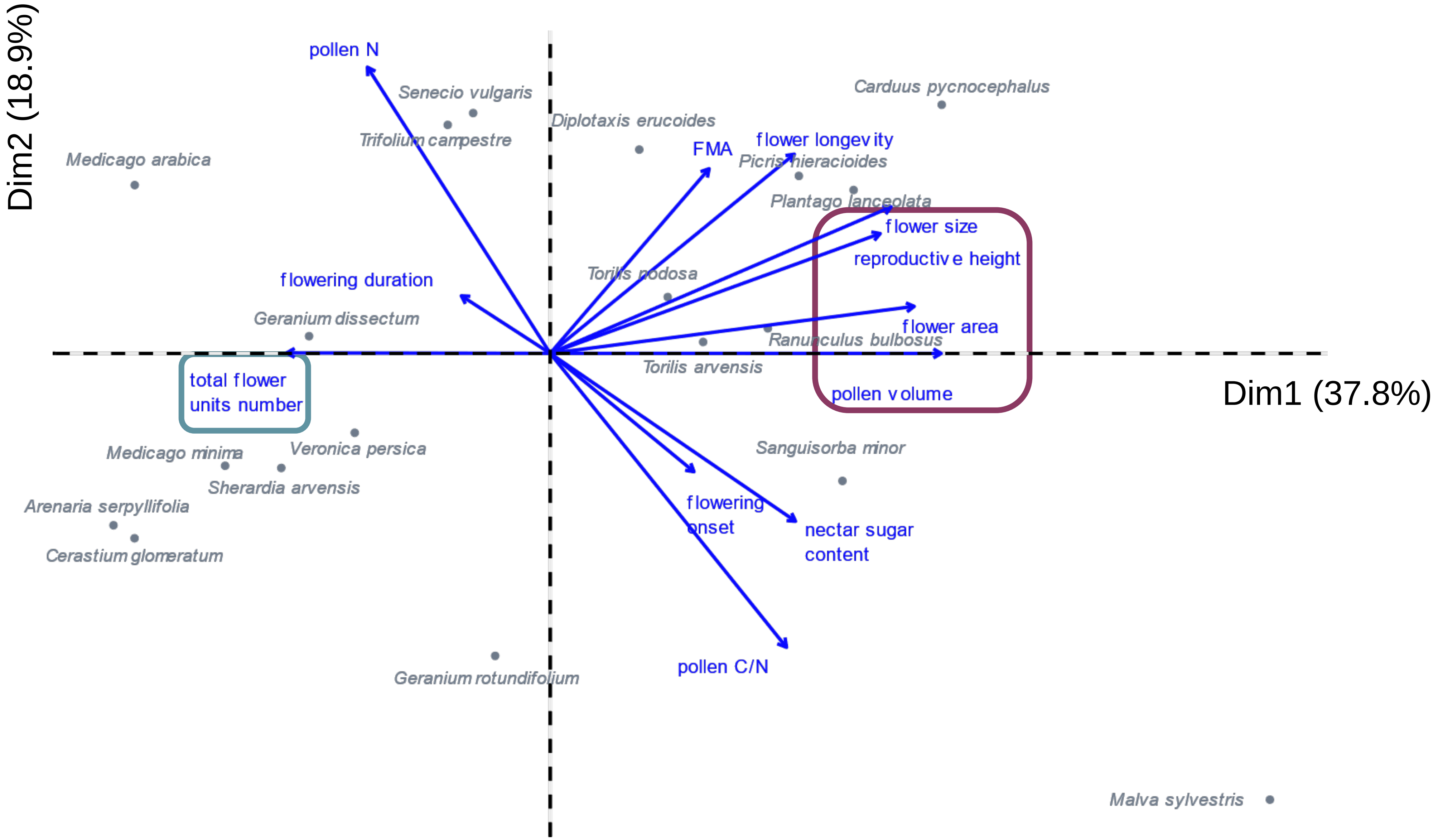

Flower lifespan


Floral mass area


Flower size

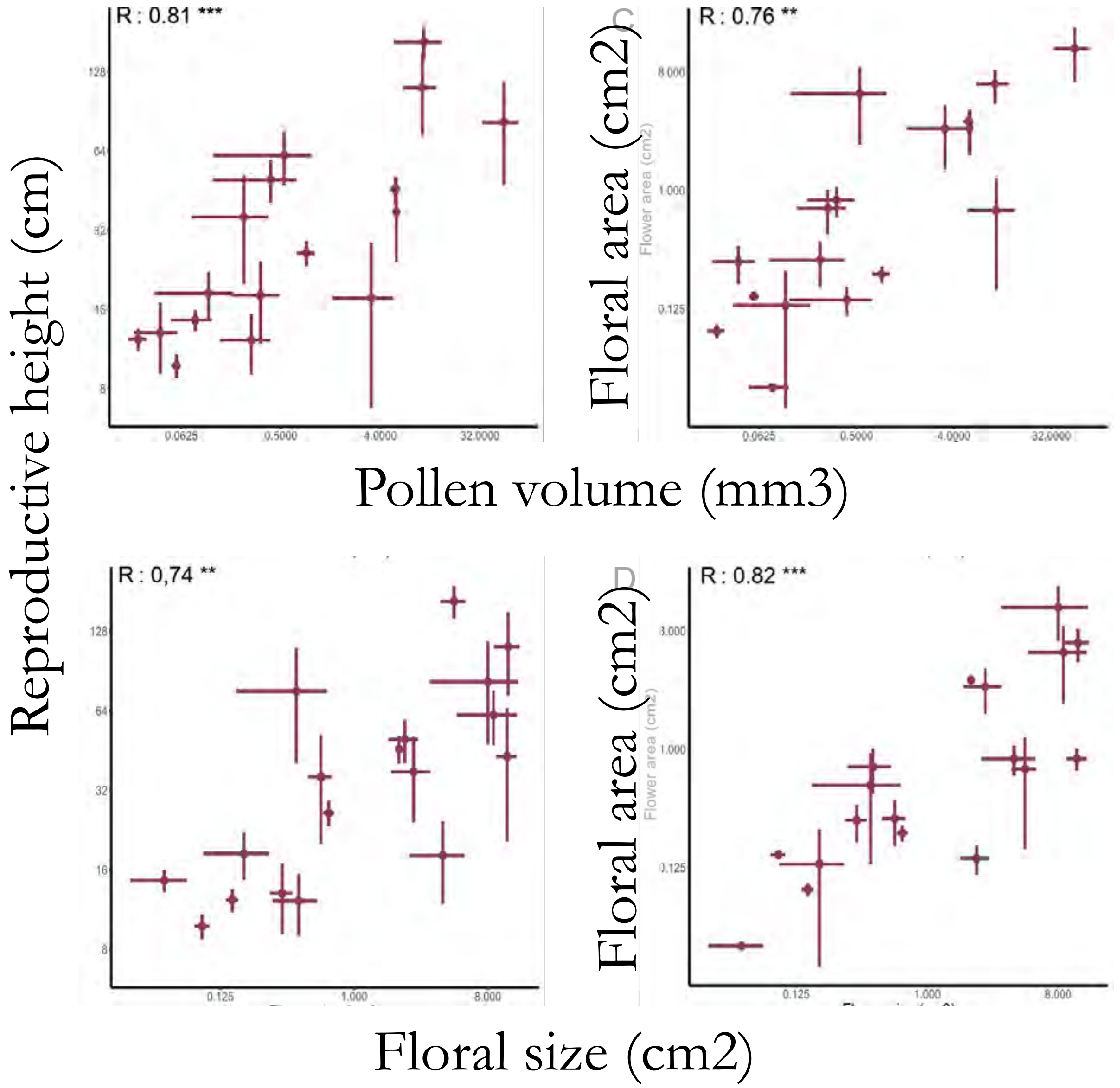
Roddy et al., 2021

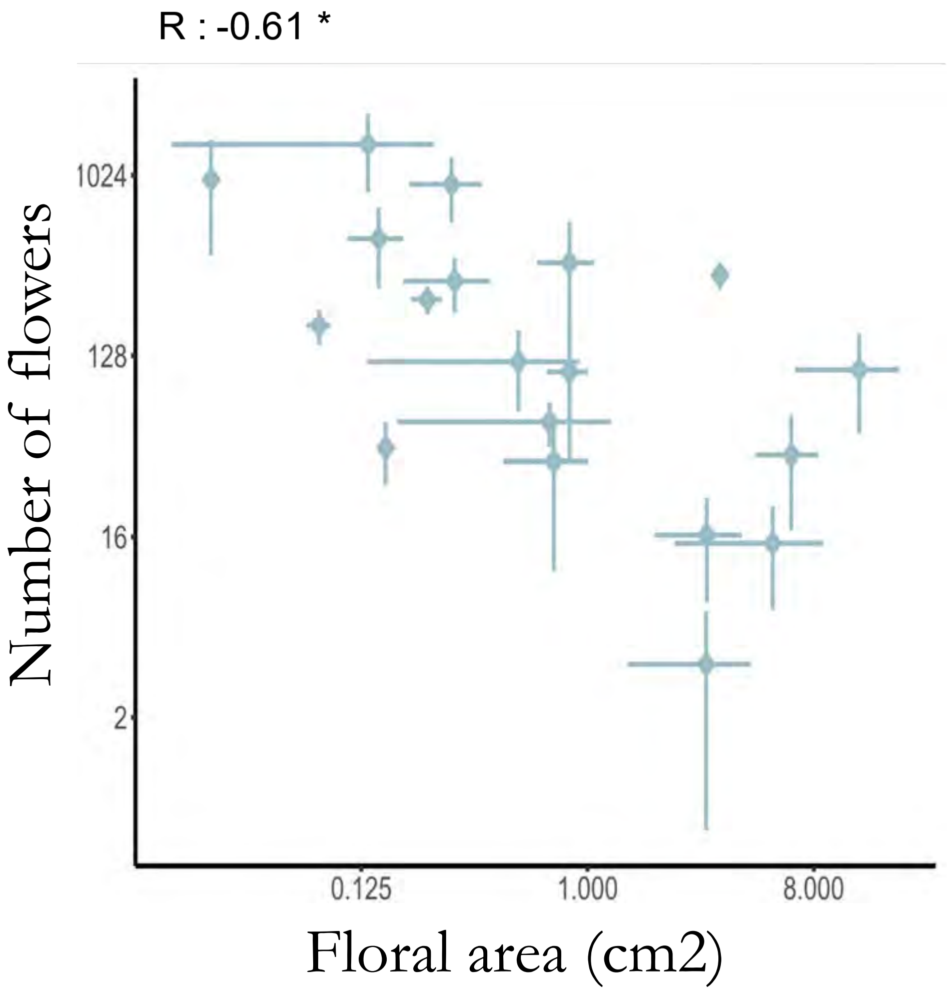
Weed floral phenotype: flower quality *vs.* quantity



Genty et al., 2023b

Weed floral phenotype: flower quality *vs.* quantity

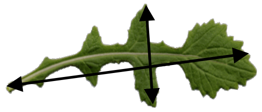




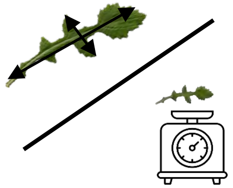
Genty et al., 2023b

CSR strategies

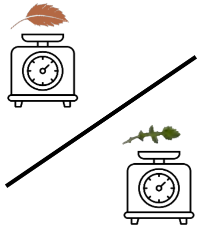
Leaf area



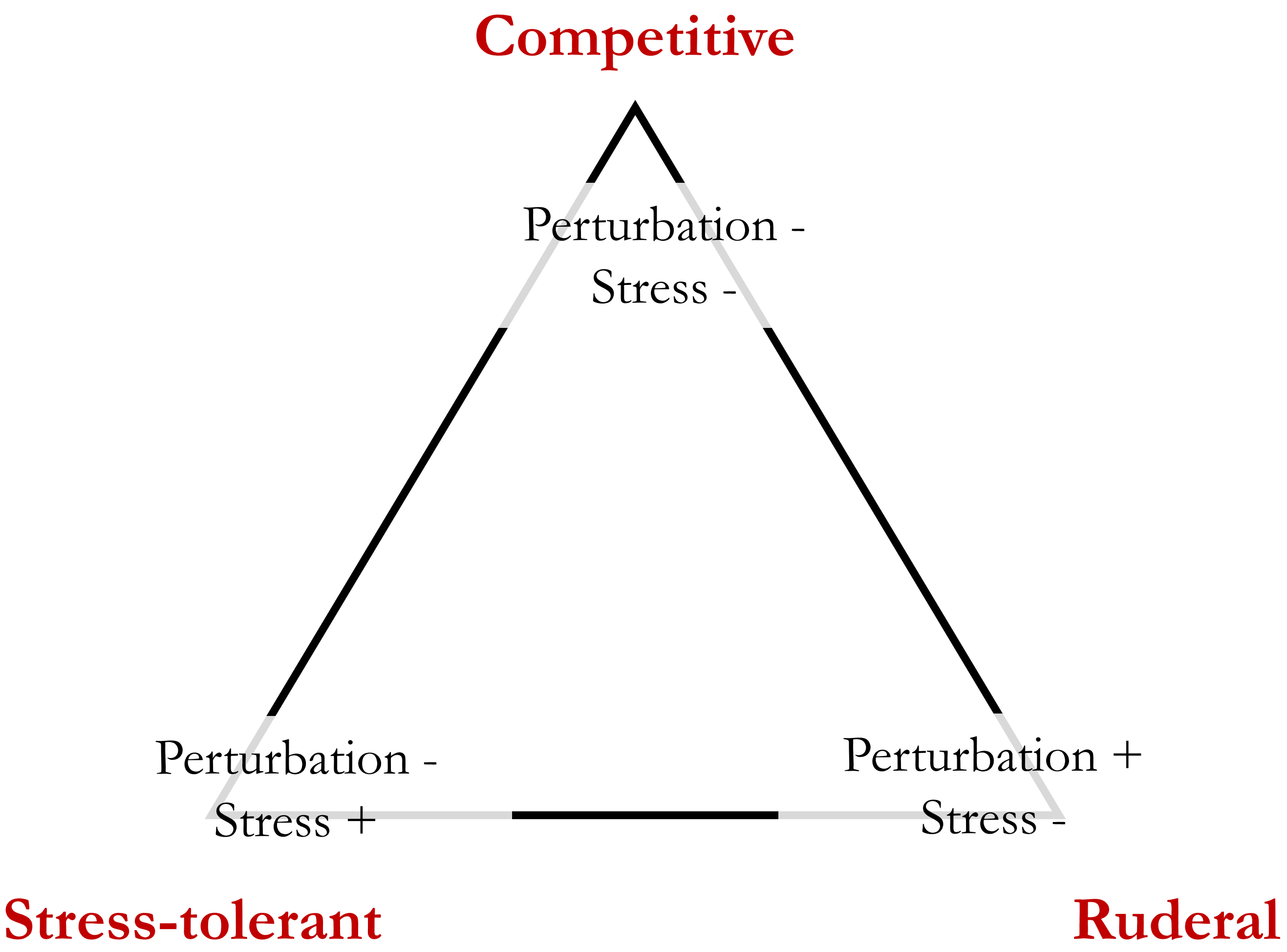
SLA



LDMC

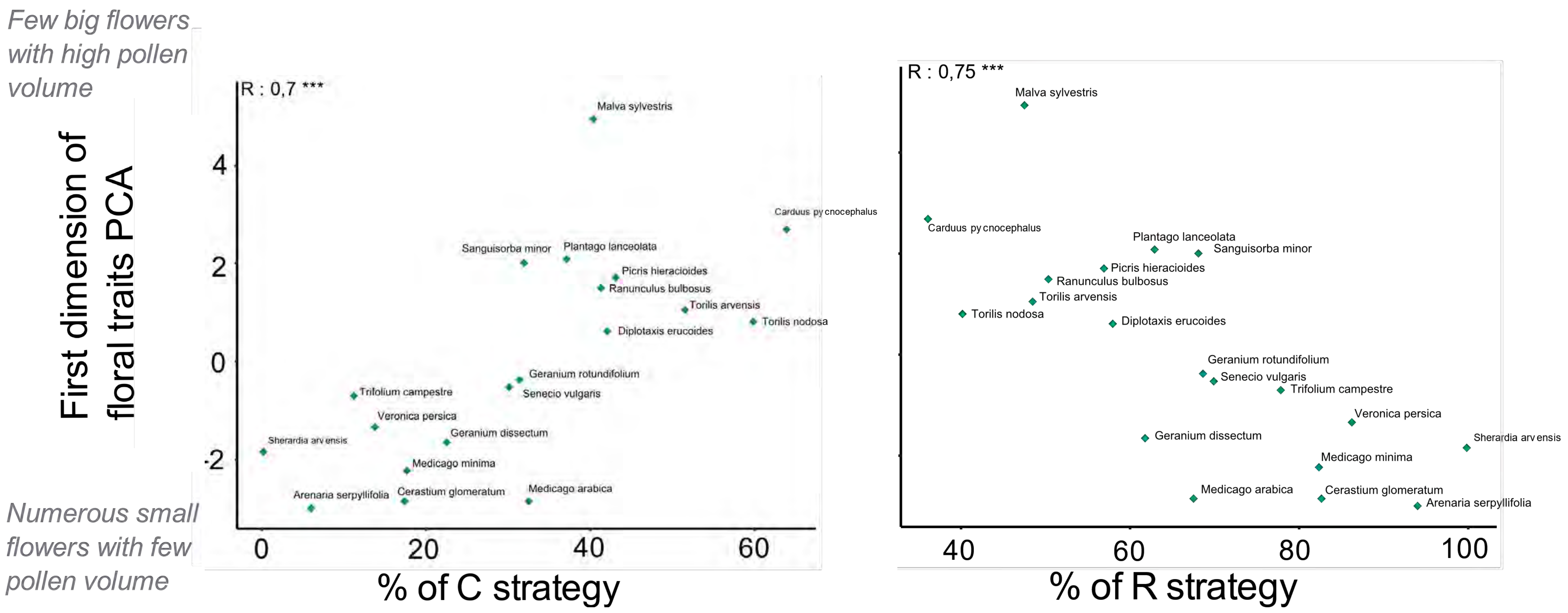


n = 19



Pierce et al., 2017 ; Grime et al., 1974

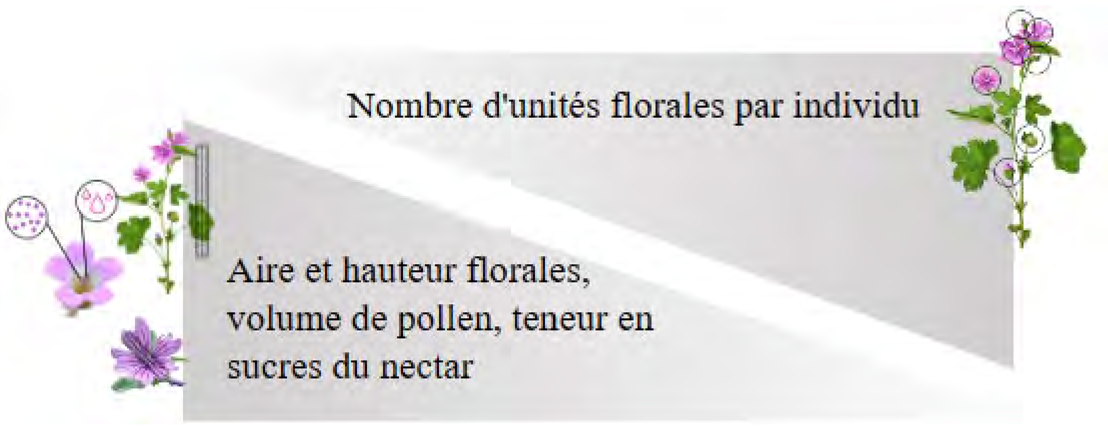
Floral and leaf traits covary in weeds: integrated ecological strategies



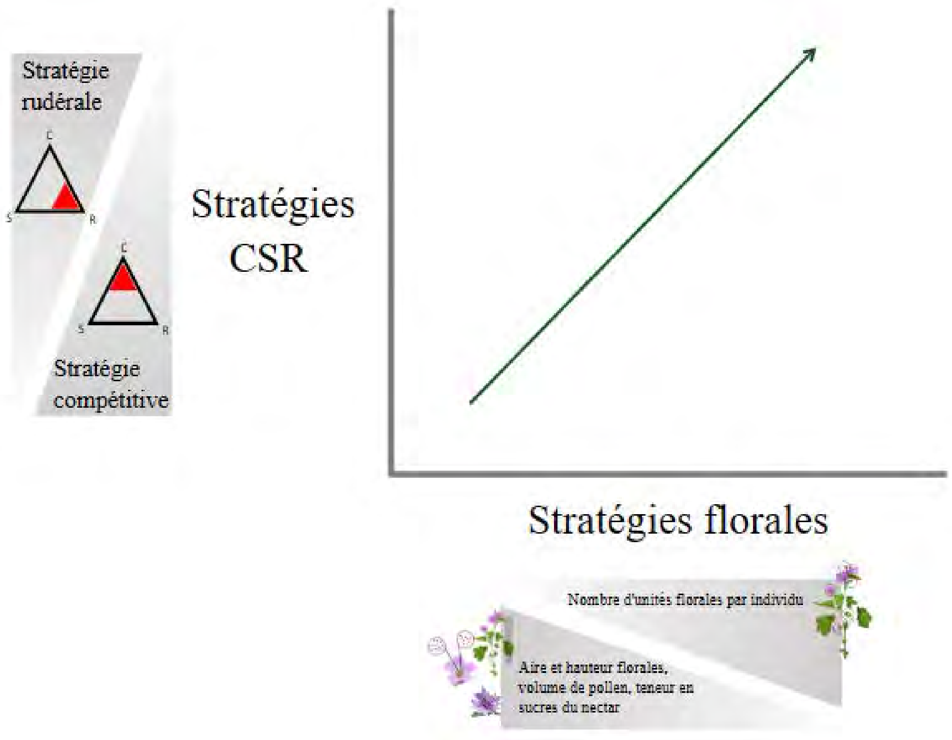
Genty et al., 2023b

Summary of part II

- Two floral strategies identified



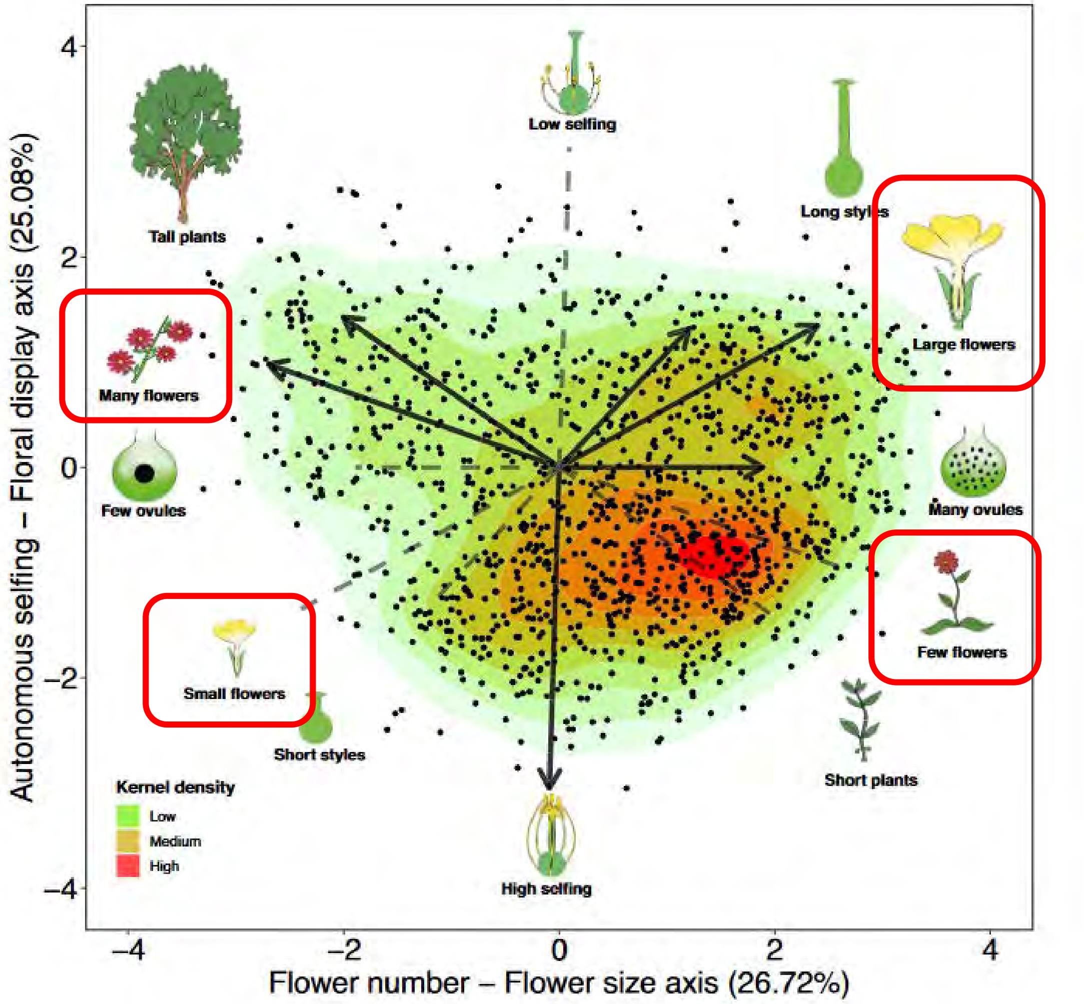
- Linked to CSR strategies



Discussion

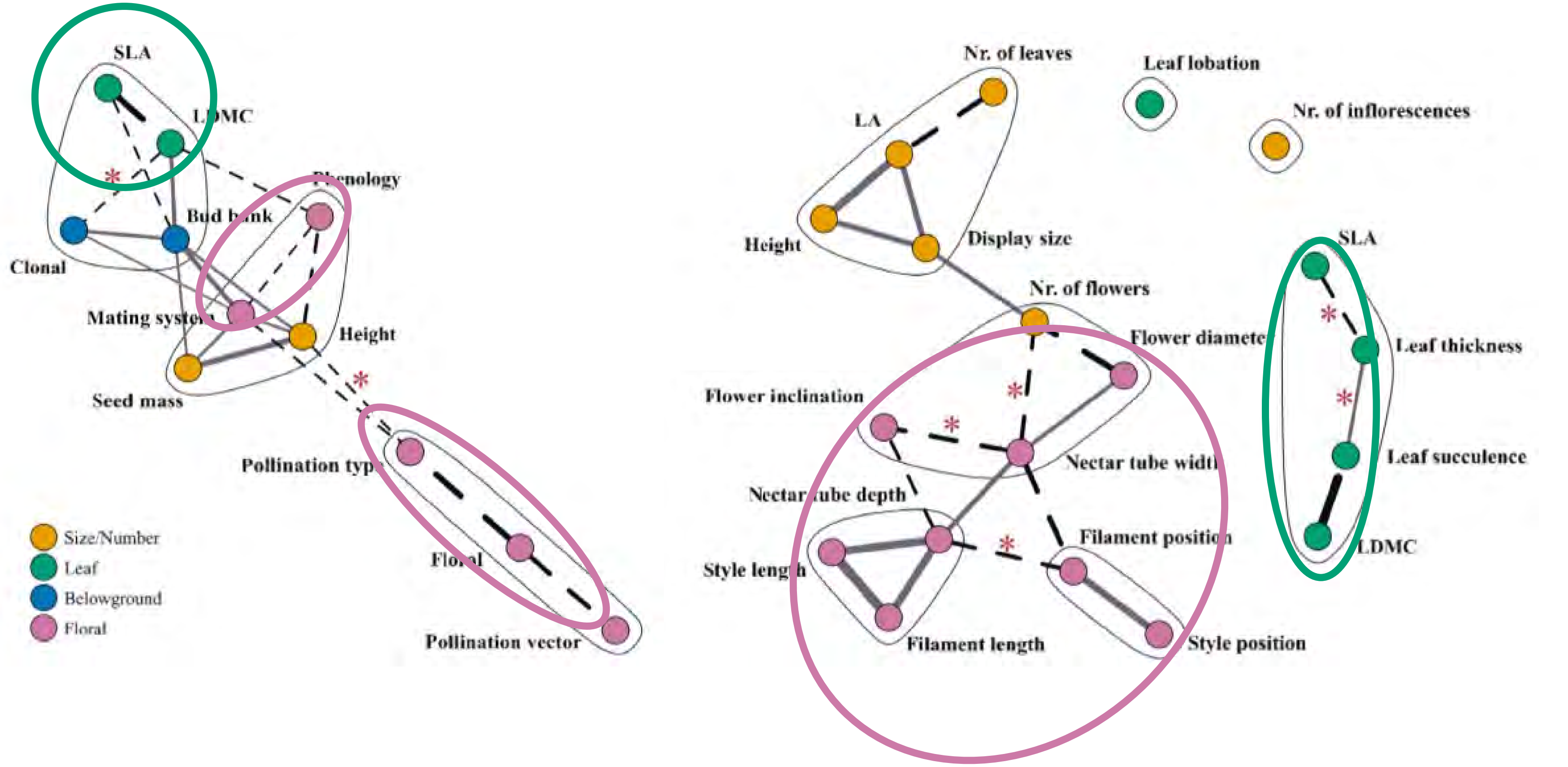
- The floral strategies described are in line with recent larger-scale results

B-Lanuza et al., 2023



Discussion

- Relationships between floral and leaf traits, not in line with recent results



Vojtko et al., 2022

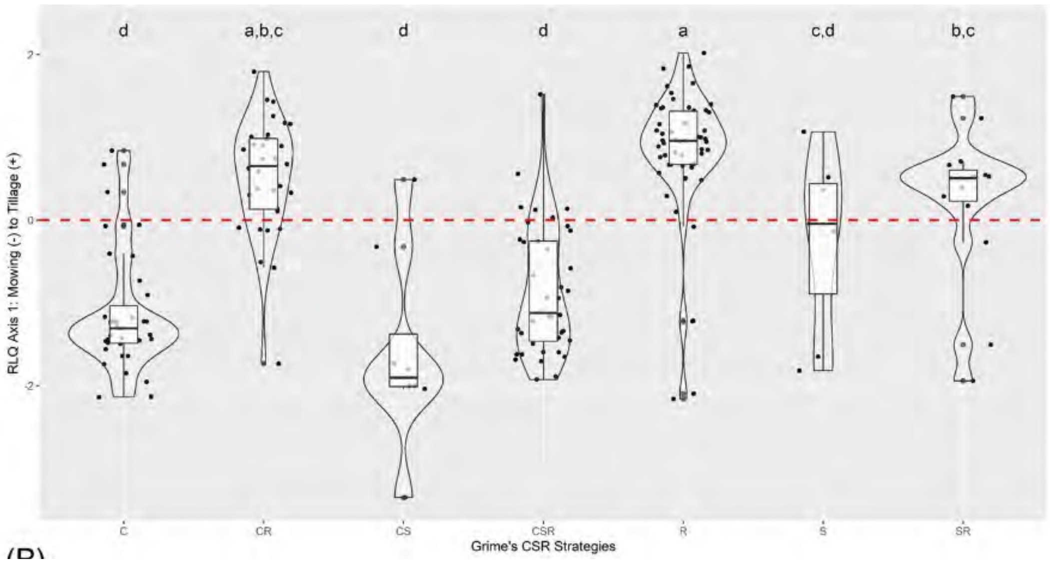
Discussion

Which results *in situ* ?

Floral and CSR strategies covary

CSR strategies respond to agricultural practices

Do the floral traits of weed communities respond to agricultural practices?

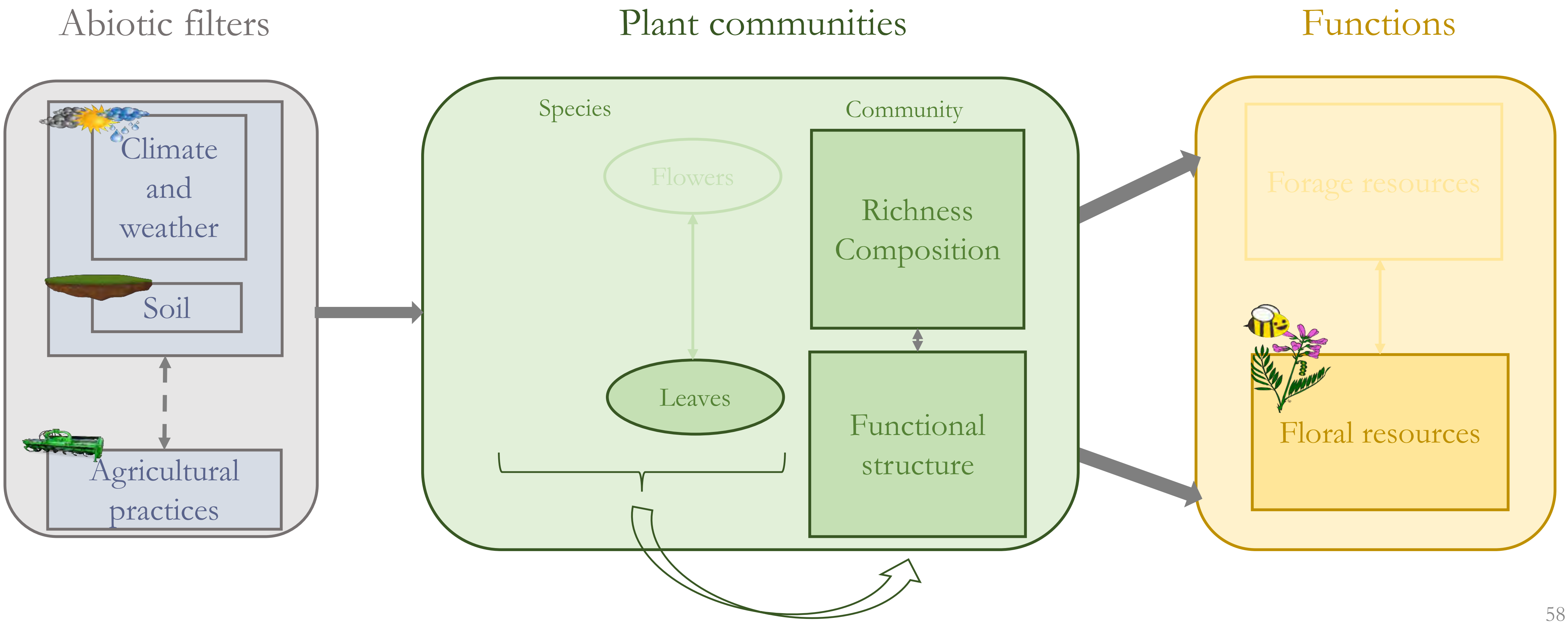


Fried et al., 2022 ; Vojtko et al., 2020

III. Weeds as floral resources

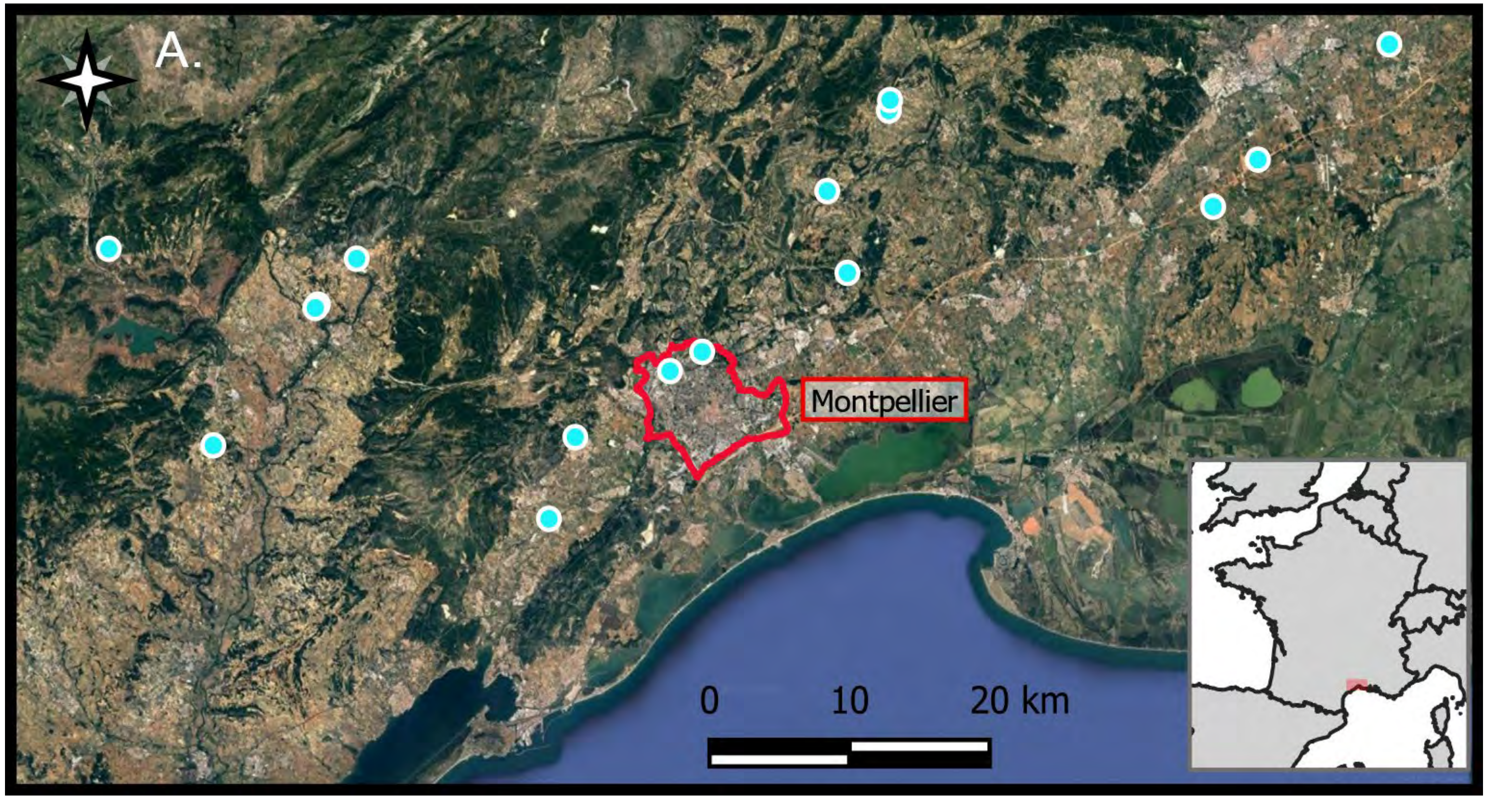
Weeds as floral resources

- What is the potential of Mediterranean vineyards and olive groves weed communities as floral resources, and how do agricultural practices and pedoclimate modify the floral resources and associated traits?

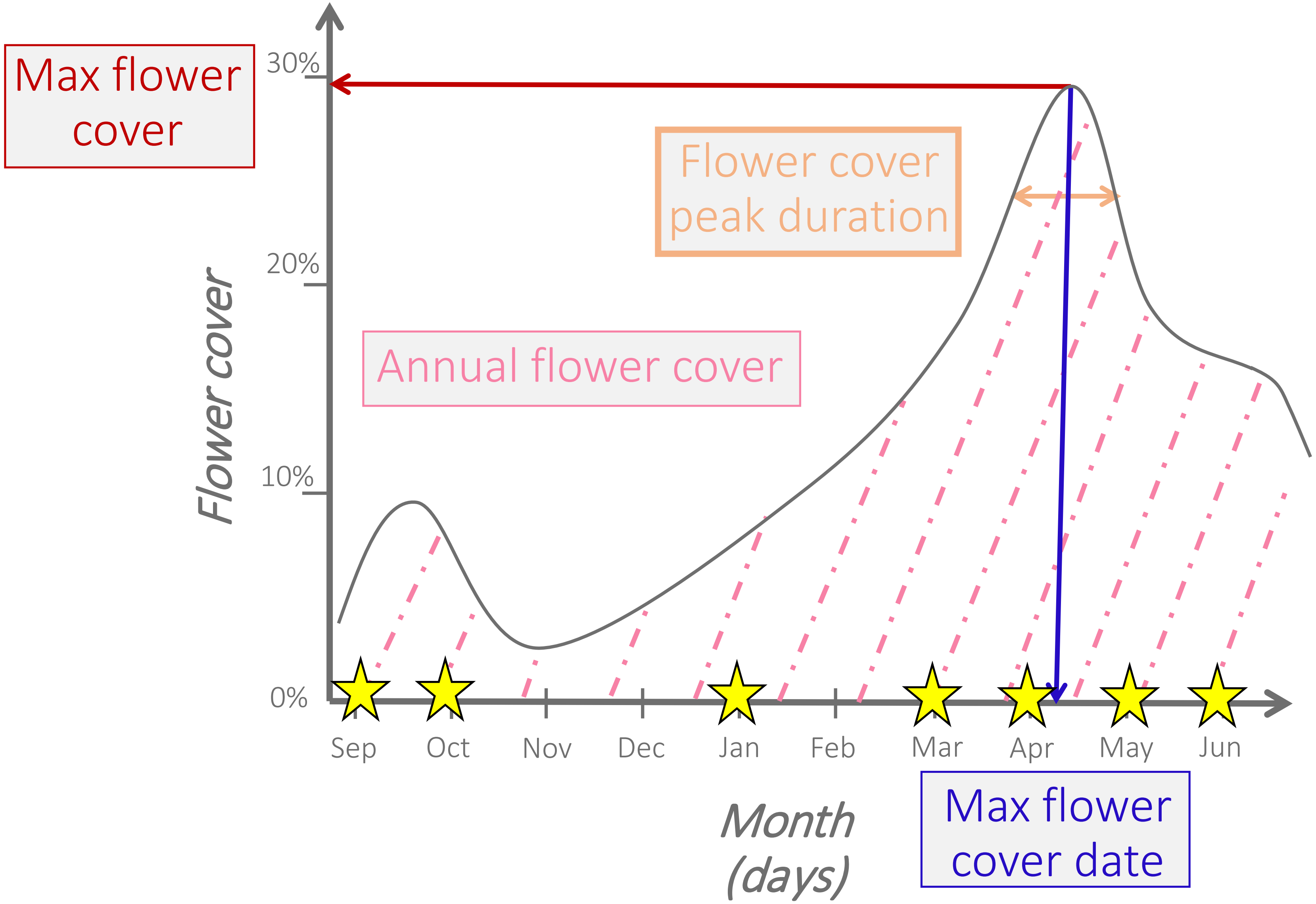


Olive grove network to assess floral resources

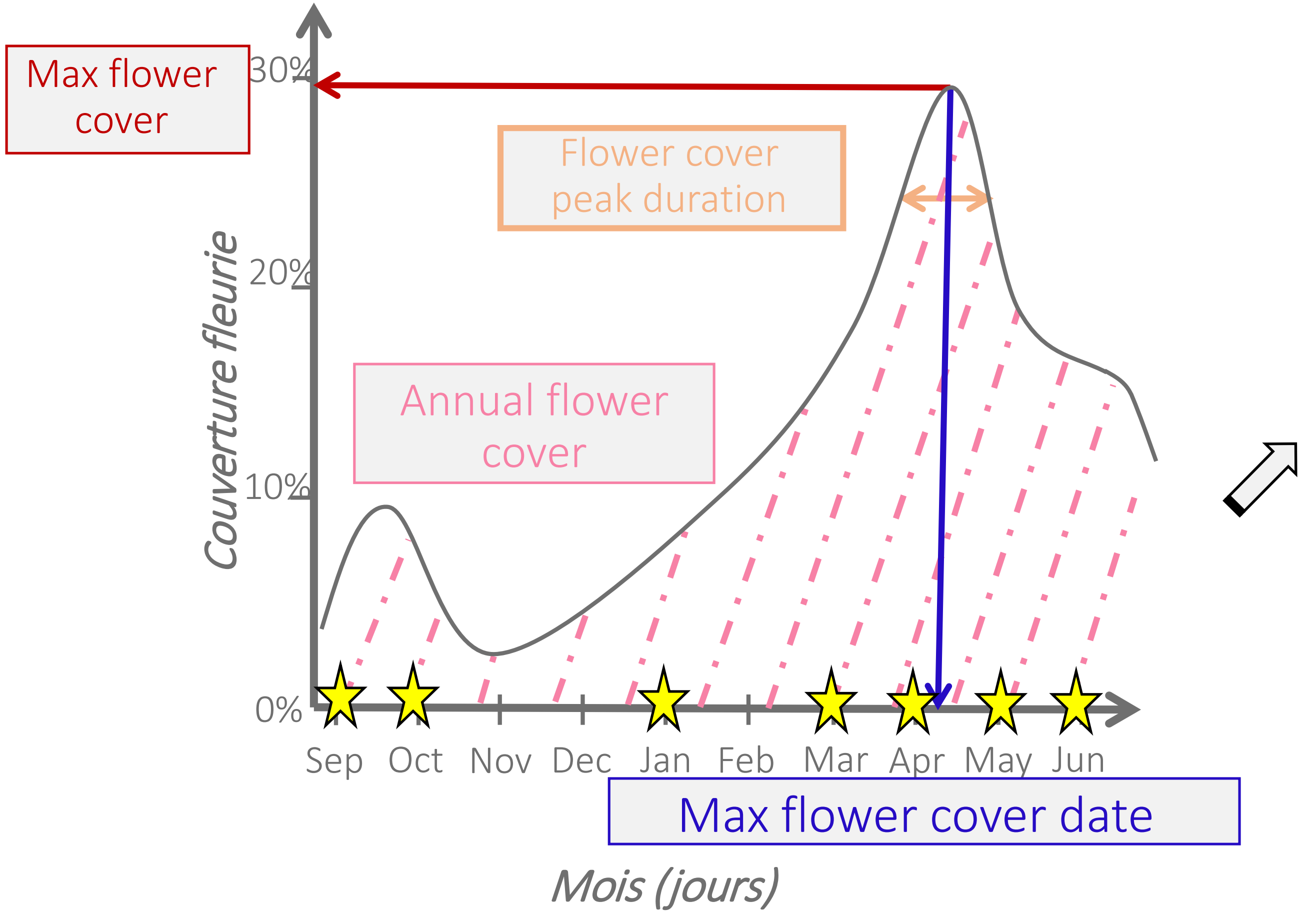
- Gradient 0 to 6 mowings per year
- Floral cover measured at 7 dates

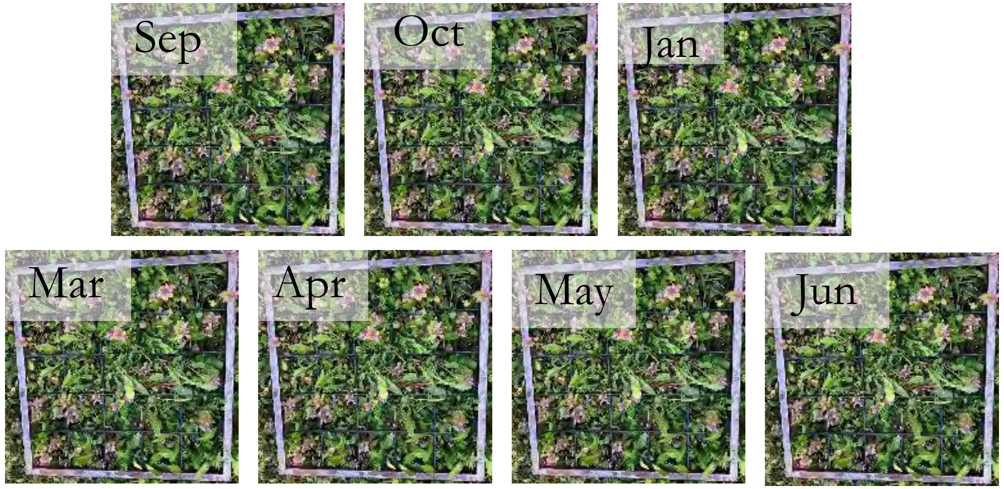


Floral resources indicators

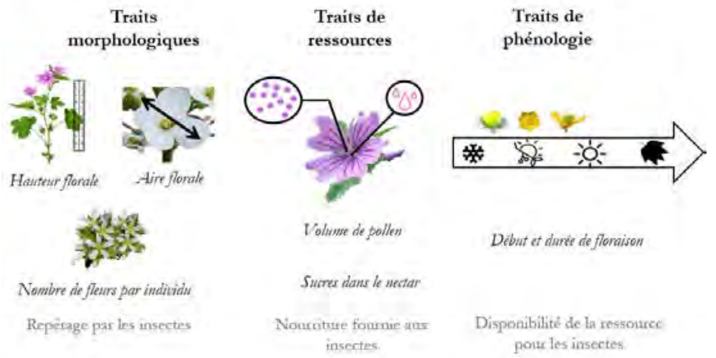


Floral resources indicators





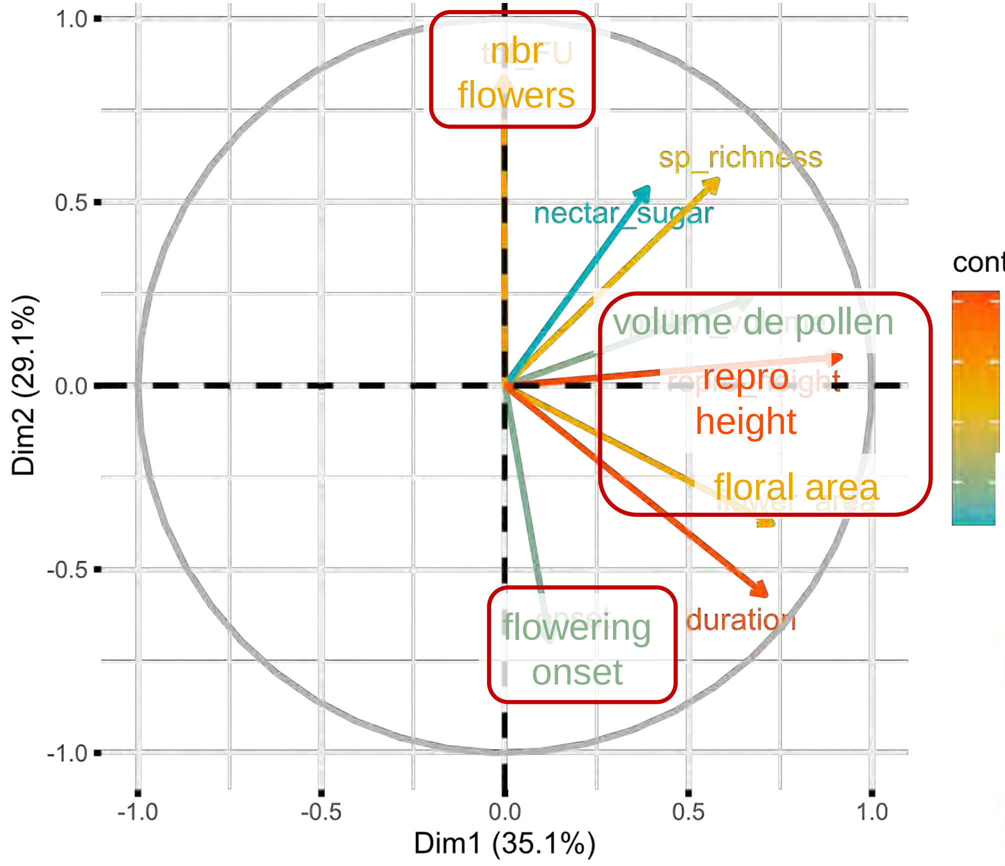
CWM of each trait at the year scale

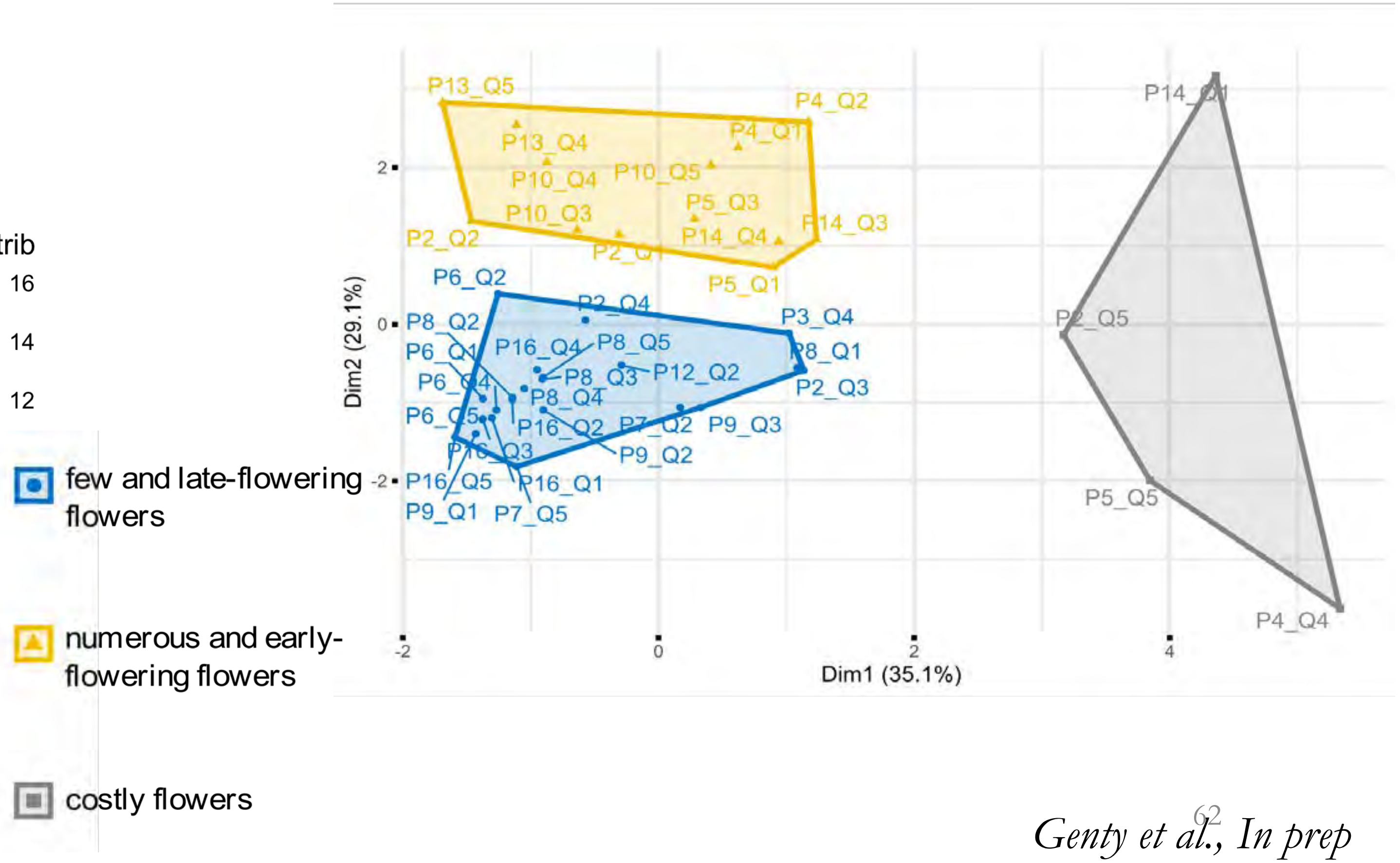


Links between the functional structure of floral communities and floral resources

Principal component analysis on CWMs of floral traits and floral species richness

- Hierarchical ascending classification to classify communities

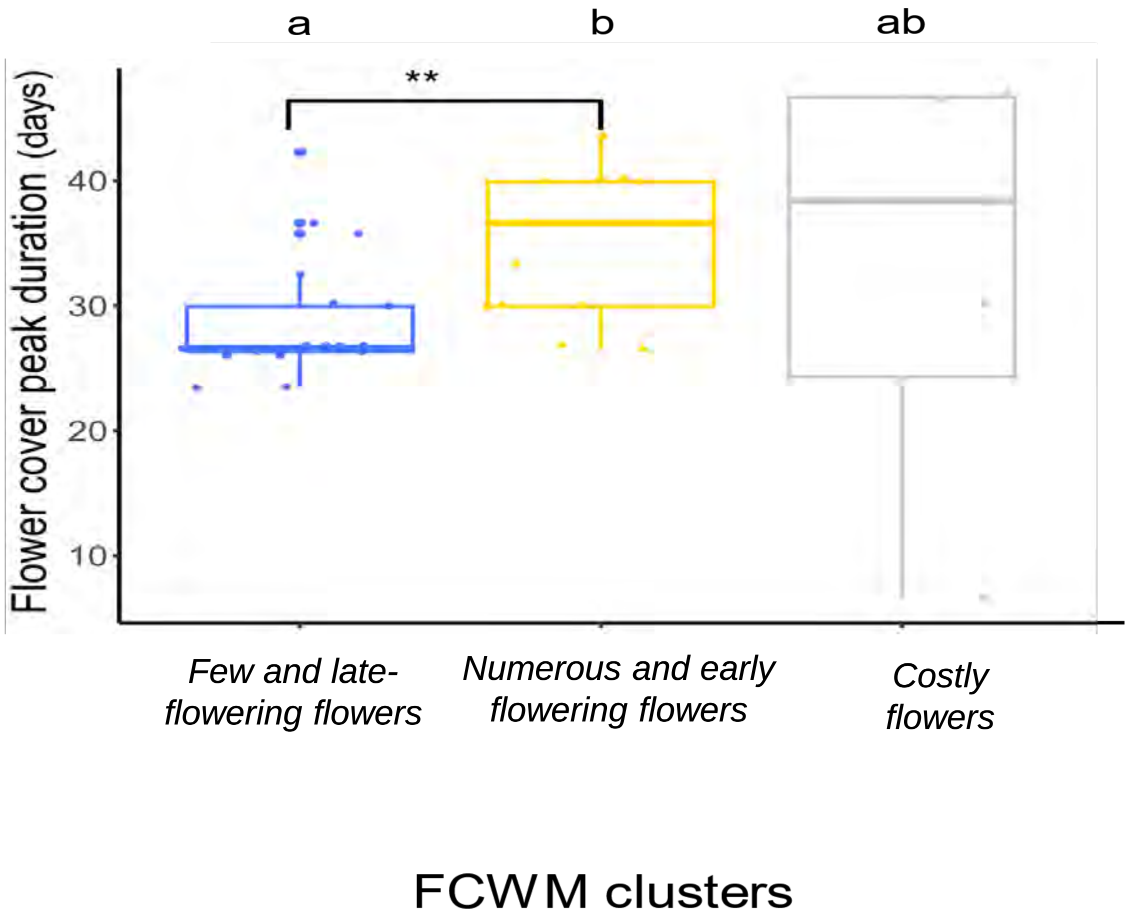




Genty et al., In prep

Links between floral traits and floral resources

- Flower cover peak duration varies between groups

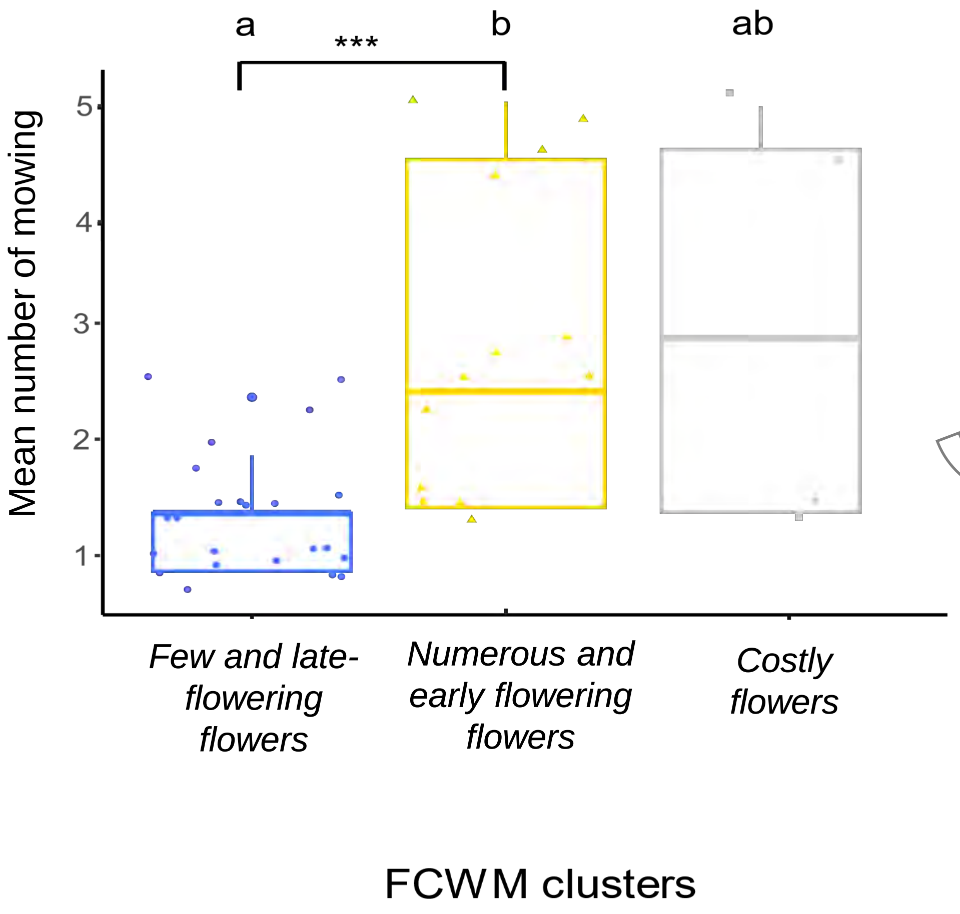


Communities composed of species flowering earlier and with more flowers per individual have a longer flowering peak.

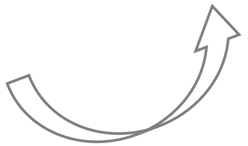
Is it linked to agricultural practices ?

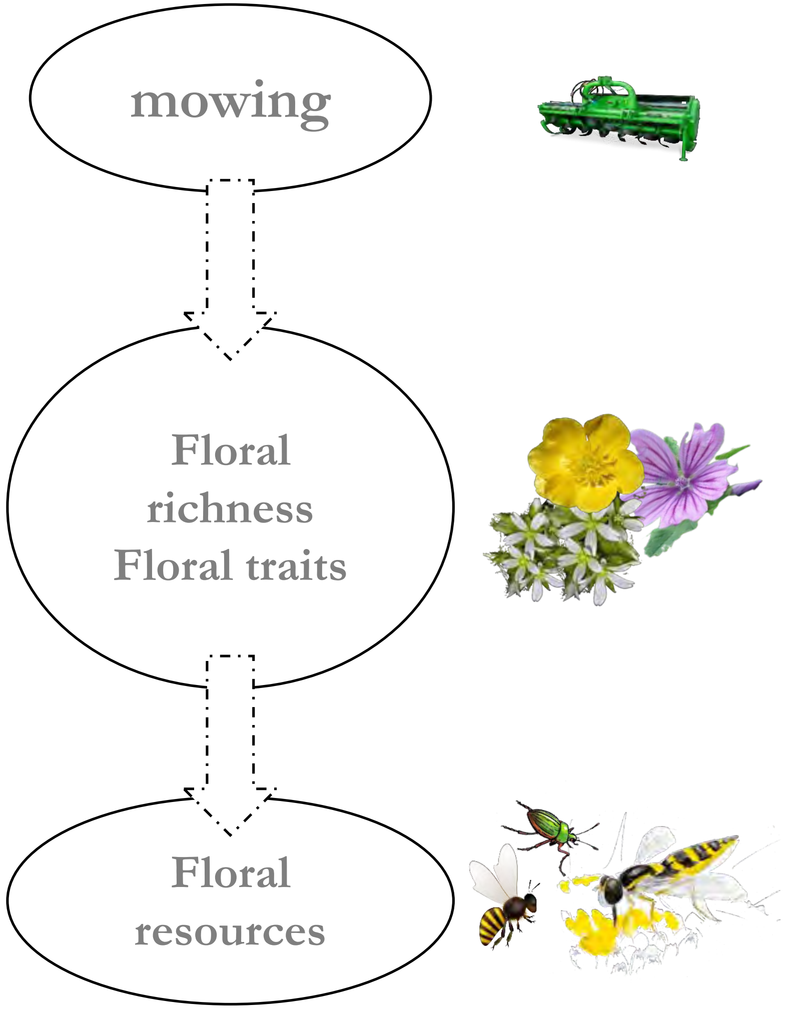
Links between floral traits, resources and agricultural practices

- Mean number of mowing varies between groups



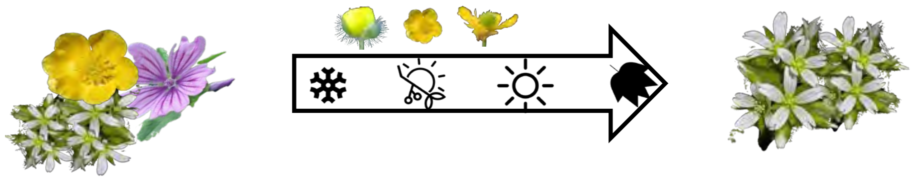
Communities composed of species flowering earlier and with more flowers per individual are more regularly mown

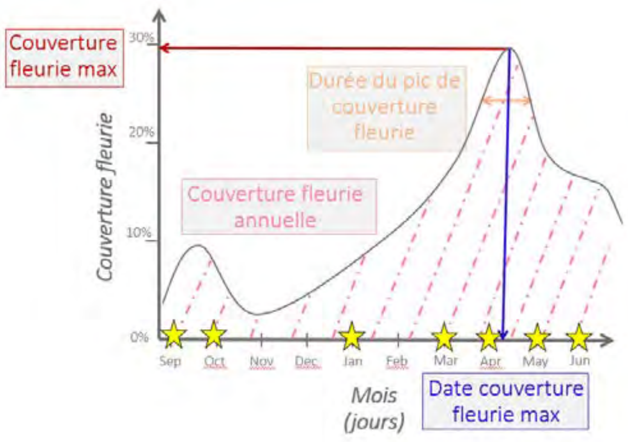




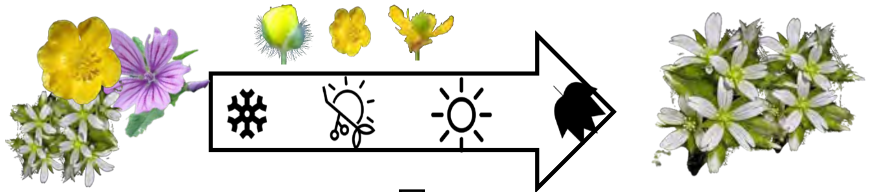
Summary of part III

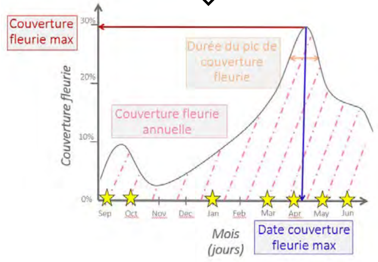
- Floral richness and traits determine floral resources





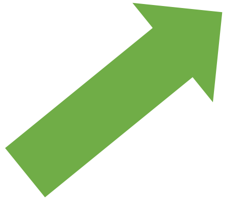
- Which are impacted by practices, indirectly determining floral resources





Discussion

- Mowing already known for promoting services in vineyards and olive groves



Biodiversity

Soil water storage

Microbial activity

Decomposition

Soil erosion

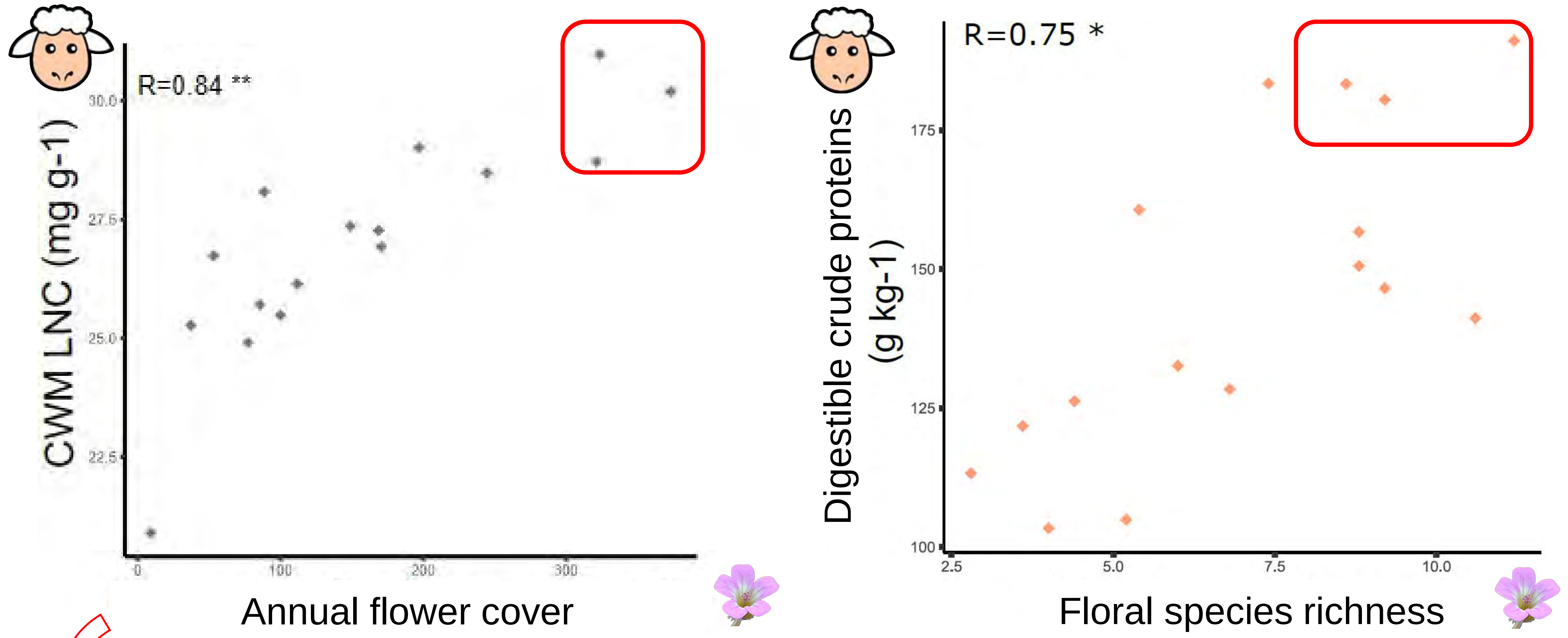
Also favorable to **floral resources**

Carpio et al., 2019 ; Bopp, 2023 ; Kavvadias & Koubouris, 2019 ; Winter et al., 2018

General discussion

Two irreconcilable resources?

Communities *theoretically* capable of providing both resources



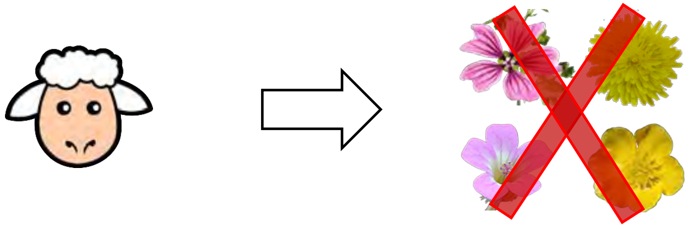
Common features

- High richness and soil cover
- Dicotyledonous dominance

Two complex resources to reconcile?

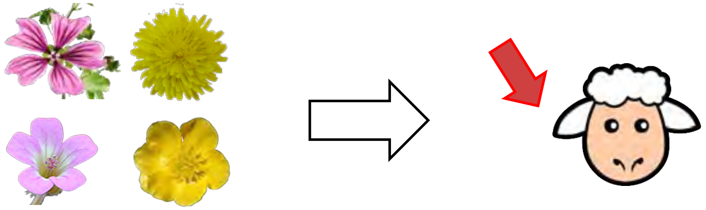
A complex temporality to manage...

Delayed flowering, consumption of floral parts



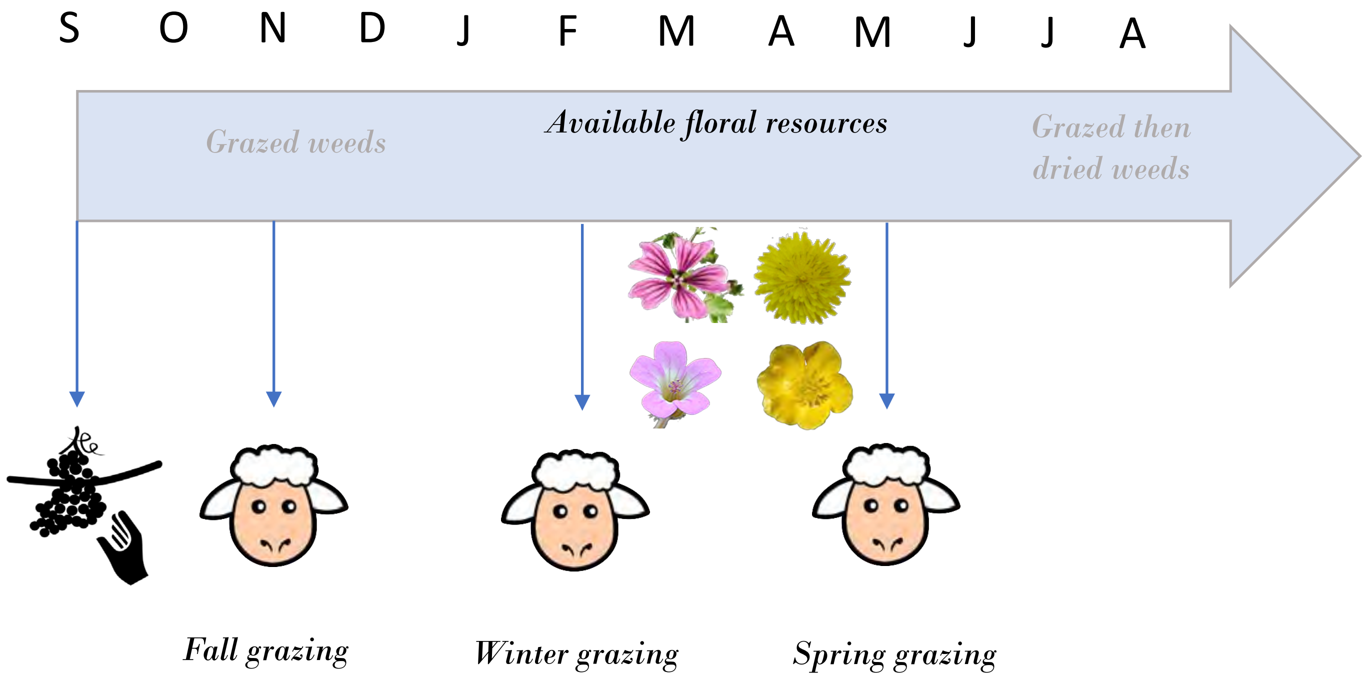
Garcia & Eubanks, 2018

Digestibility decrease



Bumb et al., 2018

Conciliation options?

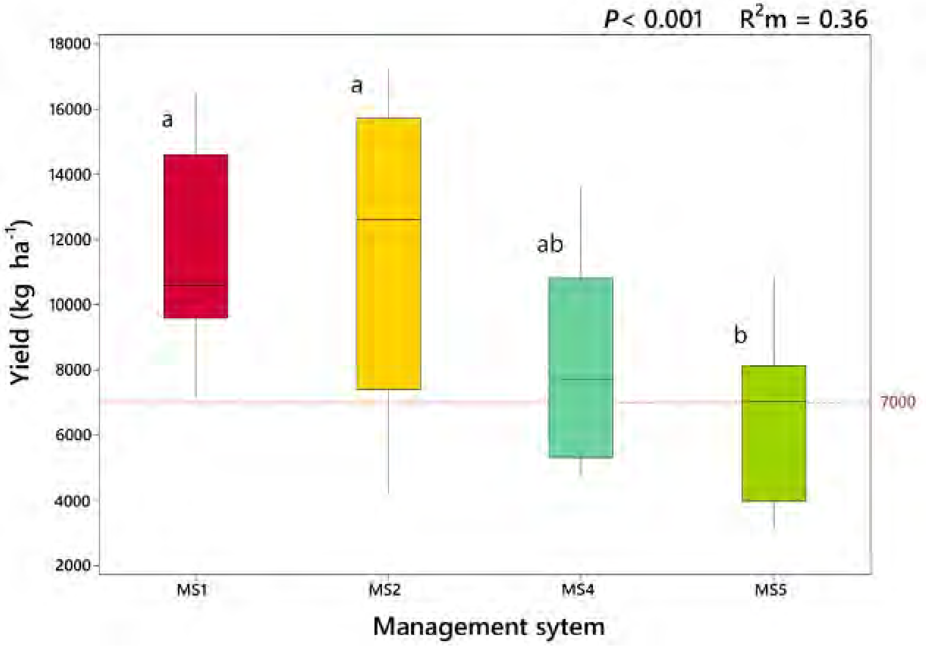


- Adapt to the resources
- Rangeland grazing in agreement with a shepherd

Is agricultural production compatible with the supply of floral and forage resources?

- Proven competition impacting harvest and quality

Guerra et al., 2022 ; Griesser et al., 2022



- But it's a documented practice!

38% *17%*

? but majoritary

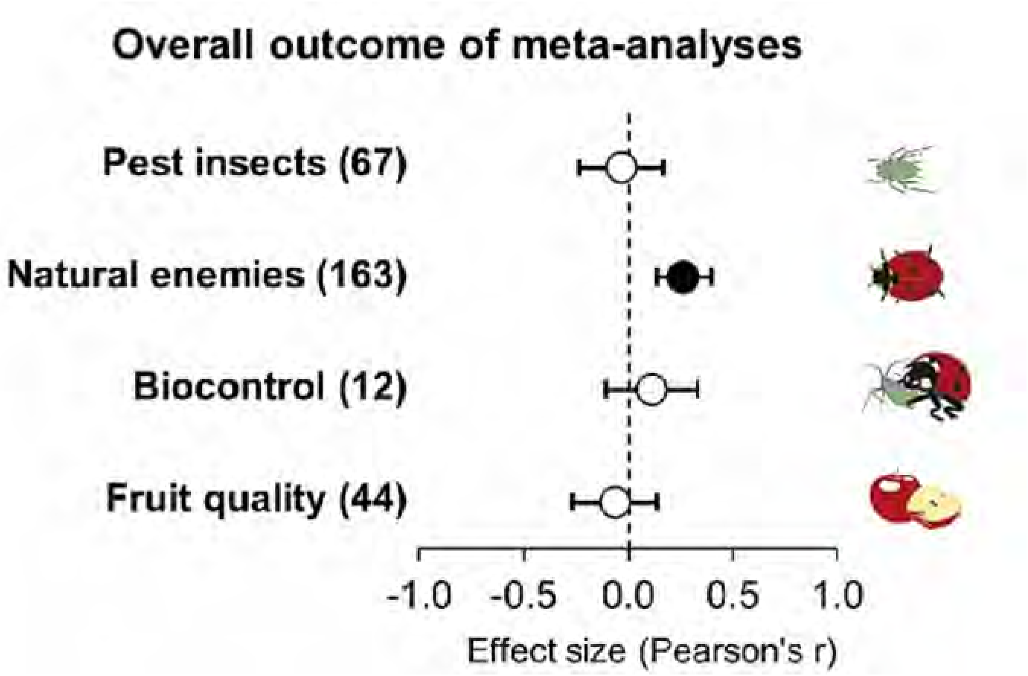
88% of orchards

Agreste, 2019

These impacts vary according to the weather, management and weed community composition! *(Adeux et al., 2019 ; Daane et al., 2018 ; Morugán-Coronado et al., 2020 ; Petit et al., 2021)*

Weeds: associated biodiversity that provides services

- More services than dis-services



- Intrinsic value of weed biodiversity :

-25% of weeds

Jauzein et al., 2021 ; Judt et al., 2023 ; Yvoz et al., 2021

Conclusion : contributions of the thesis

- Knowledge of weed strategies at the species and community levels, integrating floral traits

- Assessment of forage and floral resources in relation to practices

Perspectives

- Study the impact of grazing practices in perennial crops on both resources and services

- Study the upper trophic level: which insects and how do they interact with weeds?

Thank you !

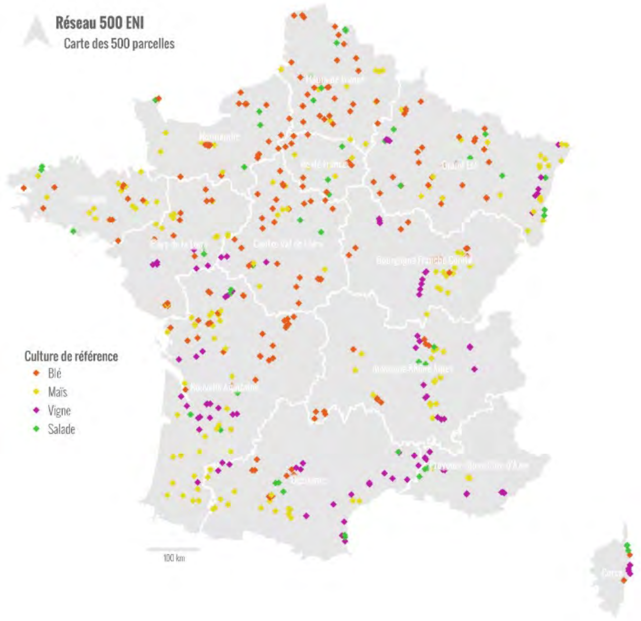
Any questions ?

My post-doc work

Research question :

How agricultural practices impact flora field margins as floral resources for insects ?

How agricultural practices directly and inderctly impact Coleopteran diversity in field margins?

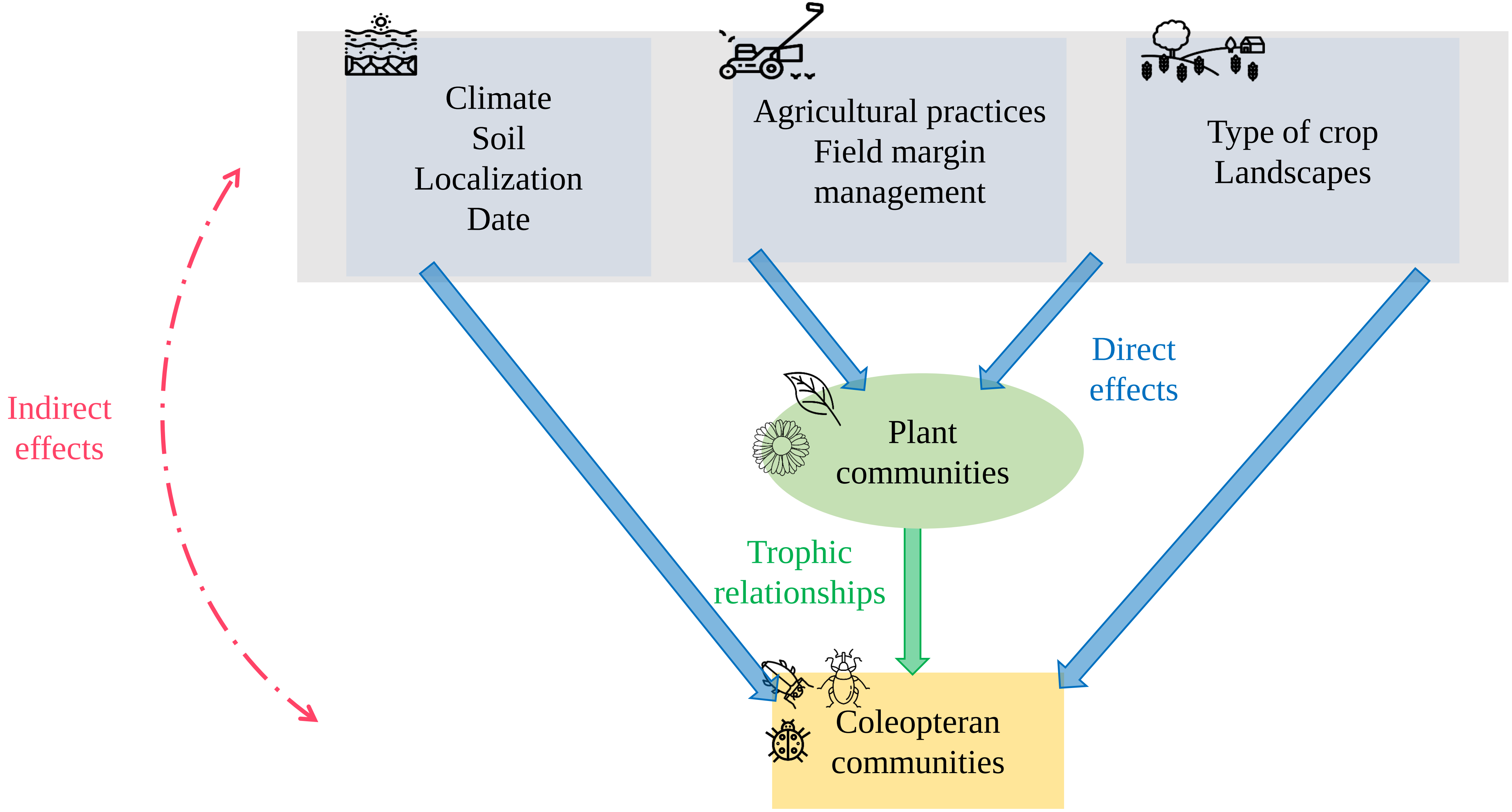


500 ENI - Biovigilance

- Since 2013
- All France
- 550 fields representing 4 major crops

High precision on both agricultural practices and plant and Coleopteran diversity

My post-doc work




MERCI !!!
+ Cécile Combes et les agriculteur.ice.s du réseau


MES
AMI.E.S !!!


MA FAMILLE !!

MON INCROYABLE EQUIPE D'ENCADREMENT !!!!!!!!

ELENA

AURELIE

KARIM

Diversité fonctionnelle et potentiels des adventices comme ressources fourragères et florales : cas des vignobles et oliveraies méditerranéennes

Présentée par **Léa Genty**

23 novembre 2023

Sous la direction de

Aurélie Metay, Elena Kazakou et Karim Barkaoui

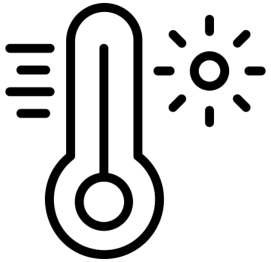
The PRIMA programme is supported under Horizon 2020 the European Union's Framework Programme for Research and Innovation.

Caractéristiques pédoclimatiques des parcelles du réseau

- Pluviométrie annuelle :

Moy : 660±129 mm
Min : 515 mm
Max : 952 mm

- Température moyenne annuelle :



Moy : 15.2±0.6 °C
Min : 13.7 °C
Max : 15.9 °C

Traits foliaires des espèces les plus abondantes en vignes

SLA ($m^2.kg^{-1}$) Moy : 27±10

LDMC ($mg.g^{-1}$) Moy : 188±27

n = 118 espèces

Sol nu : 53%

n = 105

Diplotaxis erucoides

4,45%

CR

SLA : **21** (*8* – *63*)

LDMC : **141** (*58* – *340*)

Helminthotheca echioides

3,29%

CR

SLA : **21** (*8* – *63*)

LDMC : **123** (*58* – *340*)

Veronica persica

3,05%

R

SLA : **36** (*8* – *63*)

LDMC : **174** (*58* – *340*)

Traits foliaires des espèces les plus abondantes en oliveraies

SLA ($m^2.kg^{-1}$) Moy : 27±10

LDMC ($mg.g^{-1}$) Moy : 188±27

n = 148 espèces

Sol nu : 34%

n = 105

Medicago minima

7,98%

SR

SLA : **24** (*8* – *63*)

LDMC : **262** (*58* – *340*)

Bromus spp

hordeaceus, madritensis, sterilis

7,4%

R

SLA : **33** (*8* – *63*)

LDMC : **181** (*58* – *340*)

Plantago lanceolata

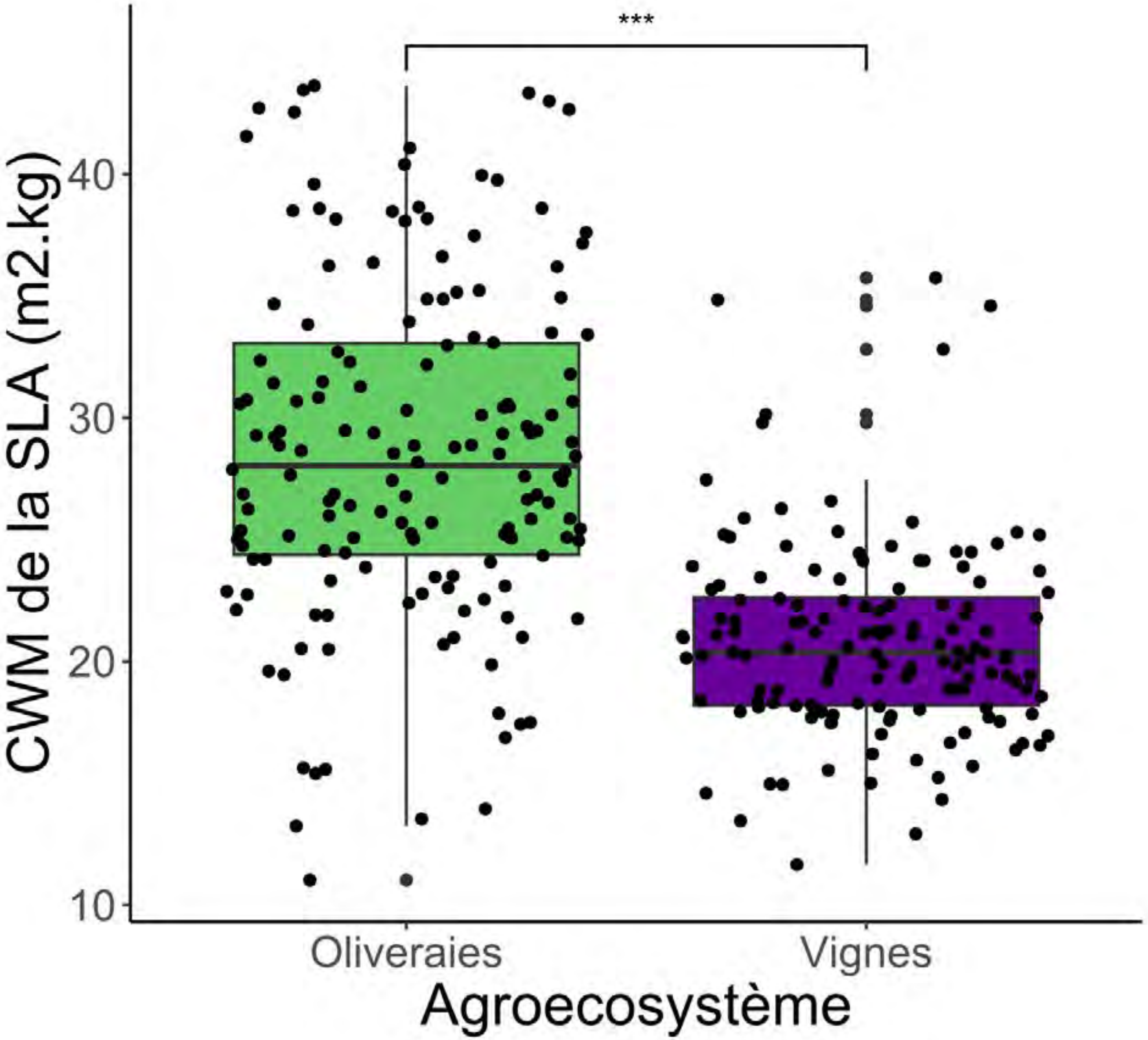
4,01%

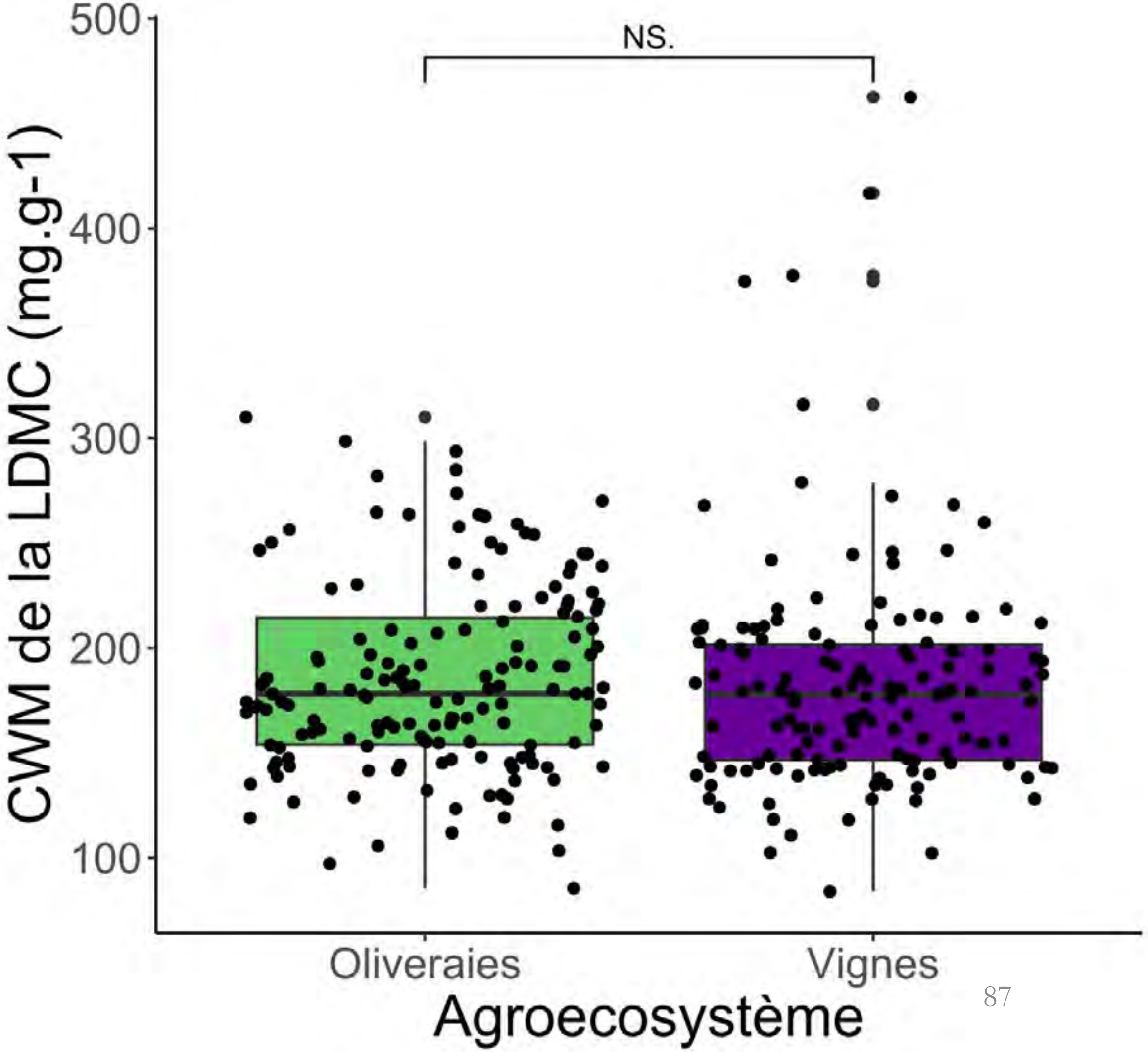
CR

SLA : **17** (*8* – *63*)

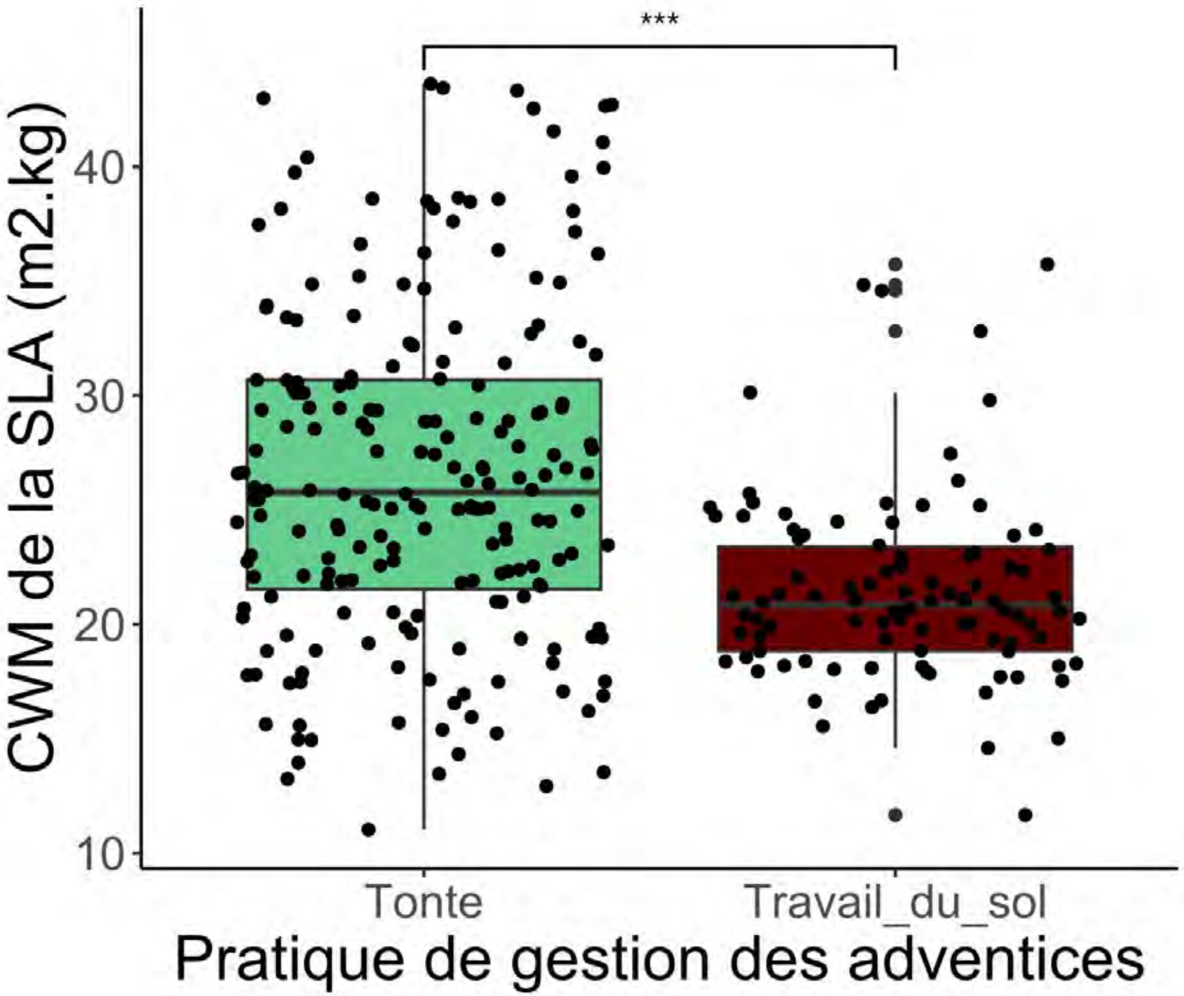
LDMC : **155** (*58* – *340*)

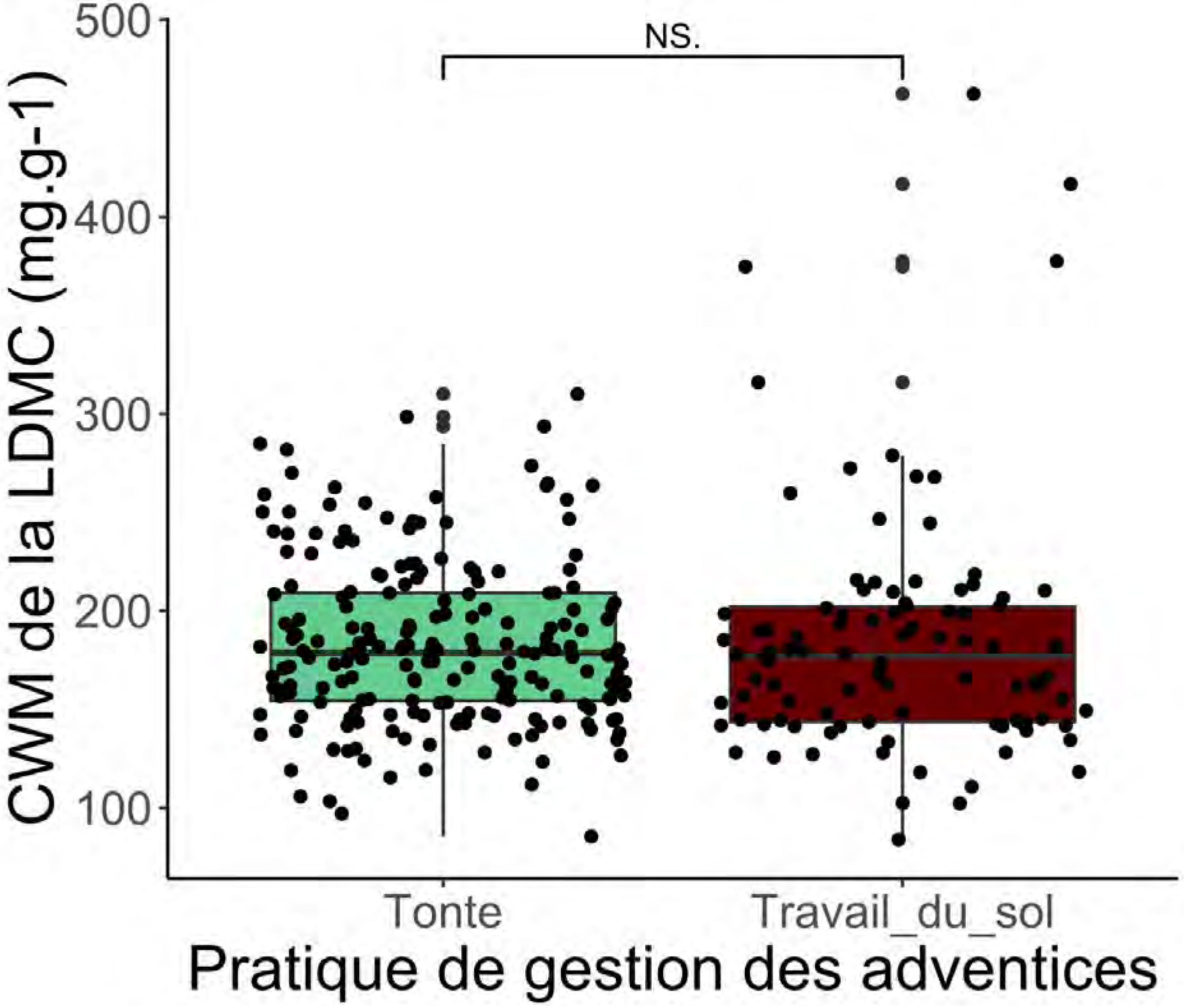
A l'échelle de la communauté : seule la SLA diffère entre les agroécosystèmes



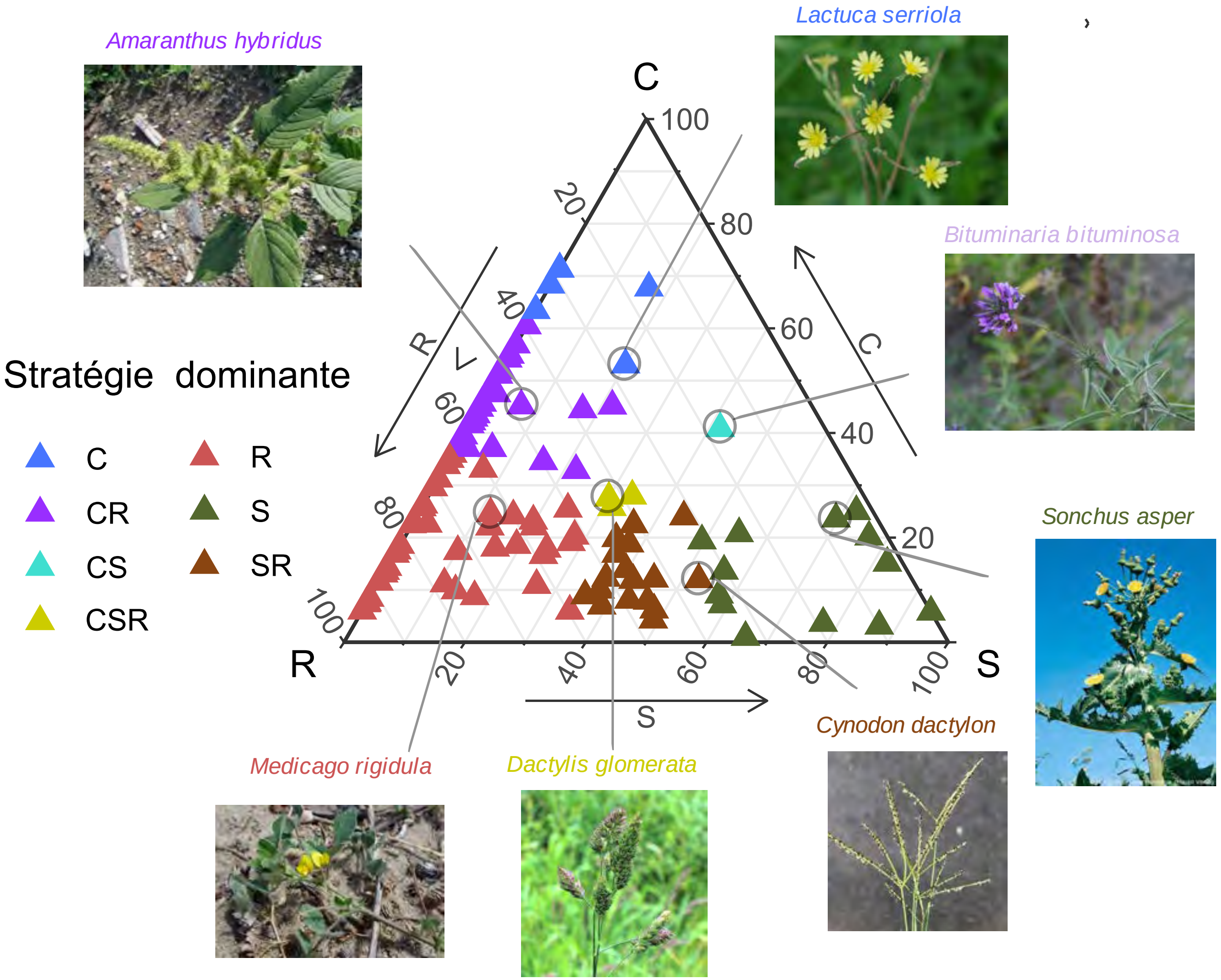


A l'échelle de la communauté : la SLA diffère entre méthode de gestion du sol





Stratégies CSR des adventices des vignes et oliveraies



C : 6 espèces
S : 11 espèces
R : 38 espèces

CR : 25 espèces
SR : 18 espèces
CS : 1 espèce

CSR : 2 espèces

n = 105

Traits floraux des espèces les plus abondantes en vignes

n = 118 espèces
Sol nu : 53%

n = 19

		Aire florale (cm^2) Moy : 1.8±3	**Teneur en sucres du nectar** (µg µl^{-1}) Moy : 100±362
	*Diplotaxis erucoides* 4,45%	**3,4** (échelle *0,03* – *12*)	**507** (échelle *0* – *1646*)
	*Helminthotheca echioides* 3,29%	*NS*	*NS*
	*Veronica persica* 3,05%	**0,7** (échelle *0,03* – *12*)	**1,66** (échelle *0* – *1646*)

Traits floraux des espèces les plus abondantes en oliveraies

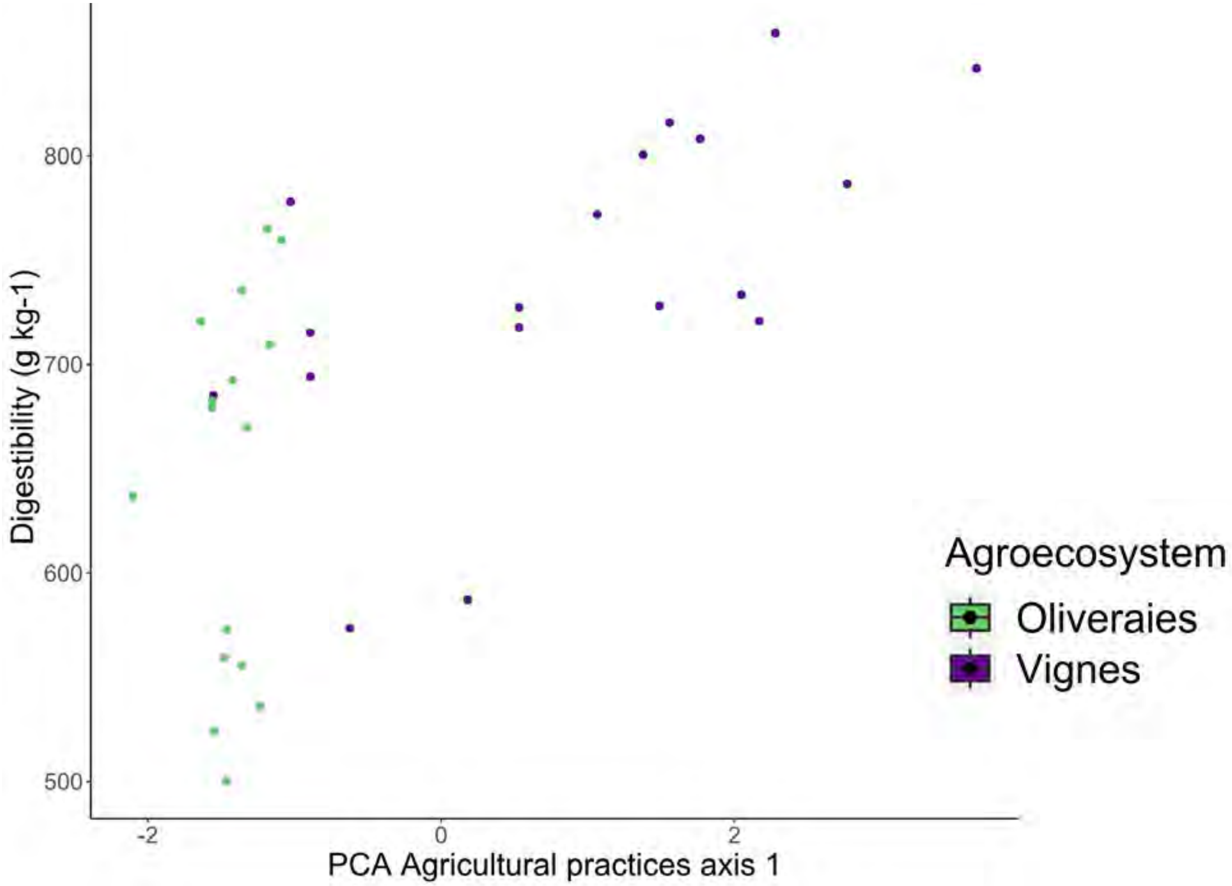
n = 148 espèces

Sol nu : 34%

n = 19

		Aire florale (cm²) Moy : 1.8±3	**Teneur en sucres du nectar** (µg µl⁻¹) Moy : 100±362
	*Medicago minima* 7,98%	**0,09** *0,03* – *12*	**0,36** *0* – *1646*
	*Bromus spp* *hordeaceus, madritensis, sterilis* 7,4%	*NS*	*NS*
	*Plantago lanceolata* 4,01%	**5,5** *0,03* – *12*	**0** *0* – *1646*

Liens directs entre intensité des pratiques et digestibilité



Tonte

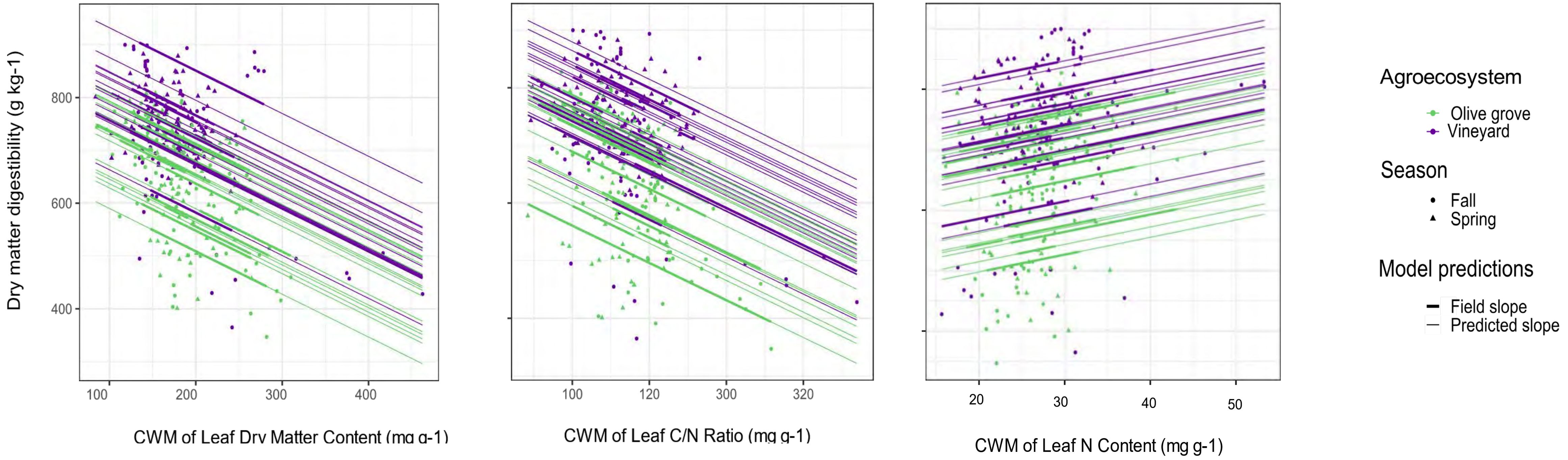
Intensité de la perturbation

Travail du sol

R : 0,64 ***

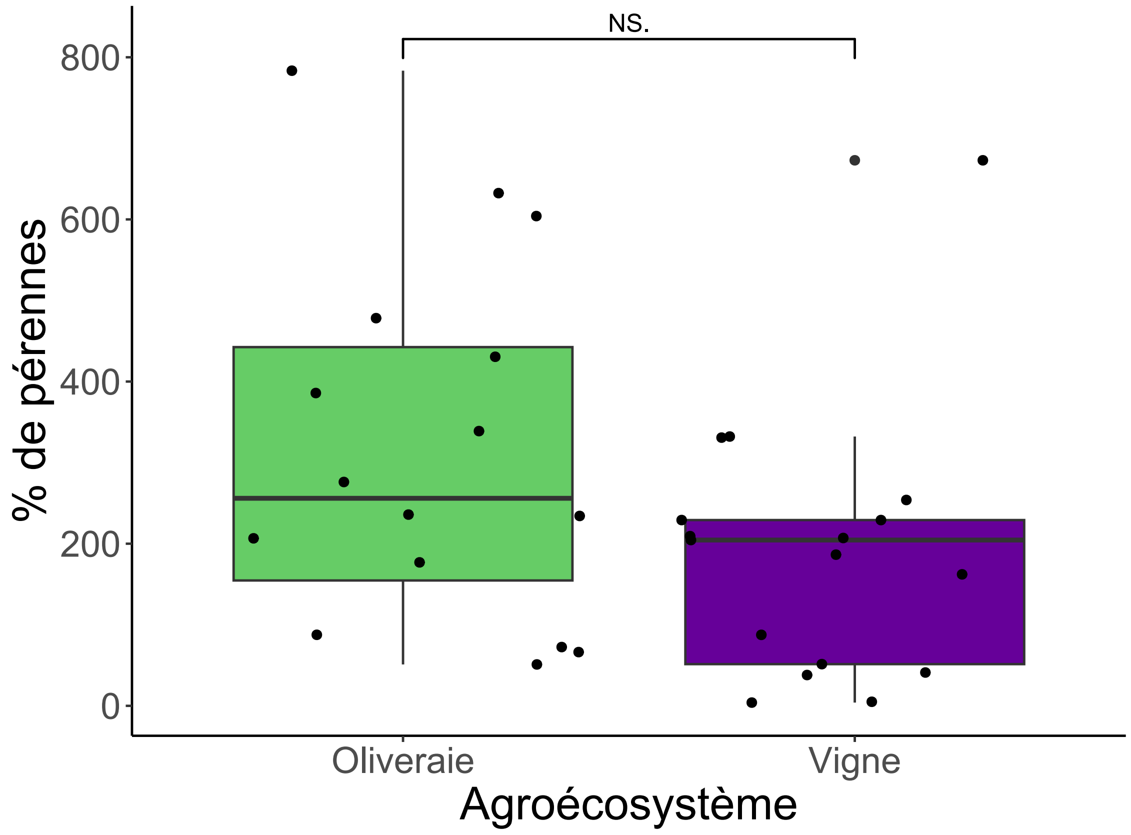
	Dry matter digestibility g kg^{-1}		
	Estimate (SE)	R^2m	p
$PC1_{agri}$	23 (±13.4)	0.35	0.011
$PC1_{pedoclim}$	-	-	ns
$PC2_{pedoclim}$	-21 (±8.1)	0.35	0.003
R_{growth}	-0.17 (±0.03)	0.35	< 0.001
MT_{growth}	-	-	ns

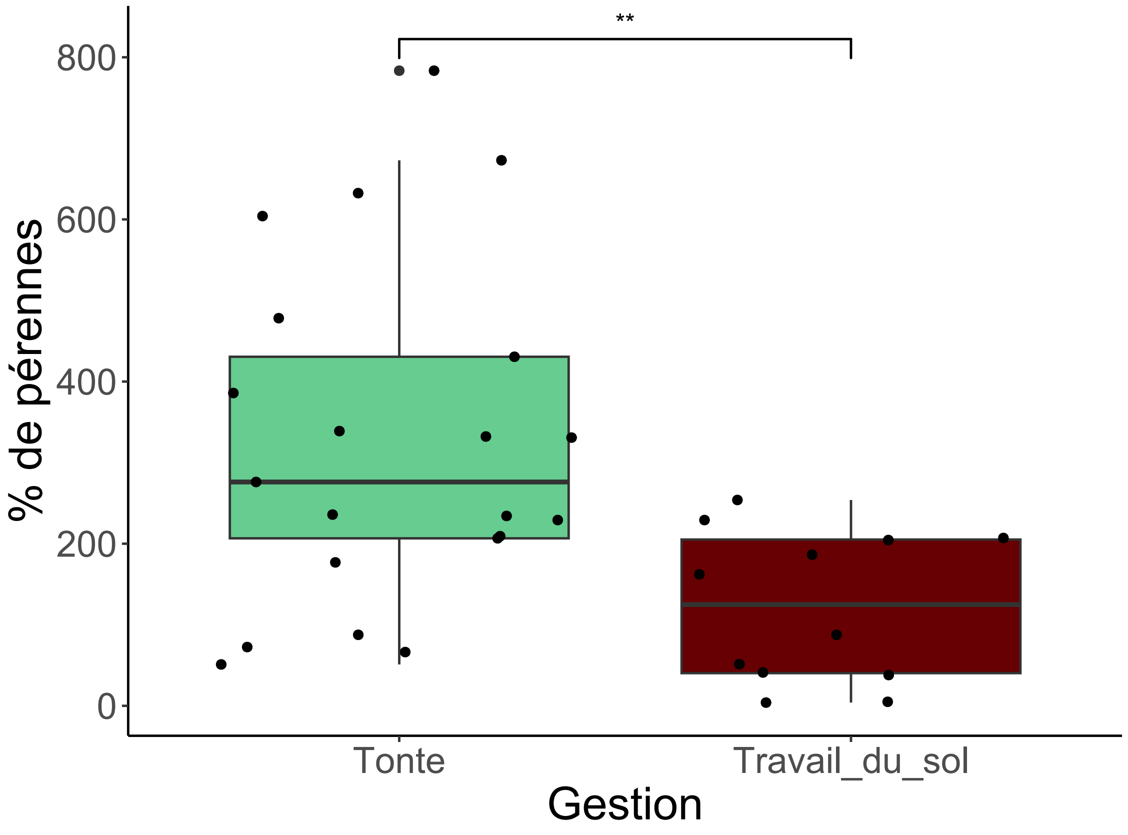
Liens directs entre traits foliaires et digestibilité



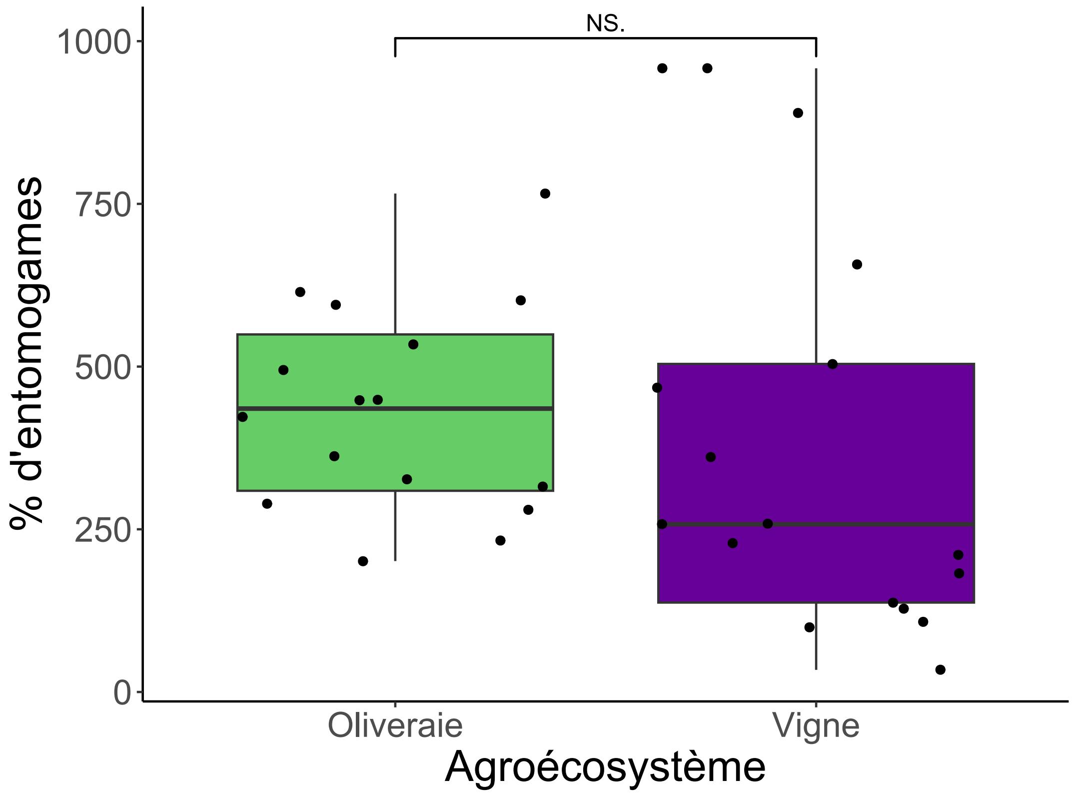
La LDMC, le ratio C/N et la LNC sont liés à la digestibilité

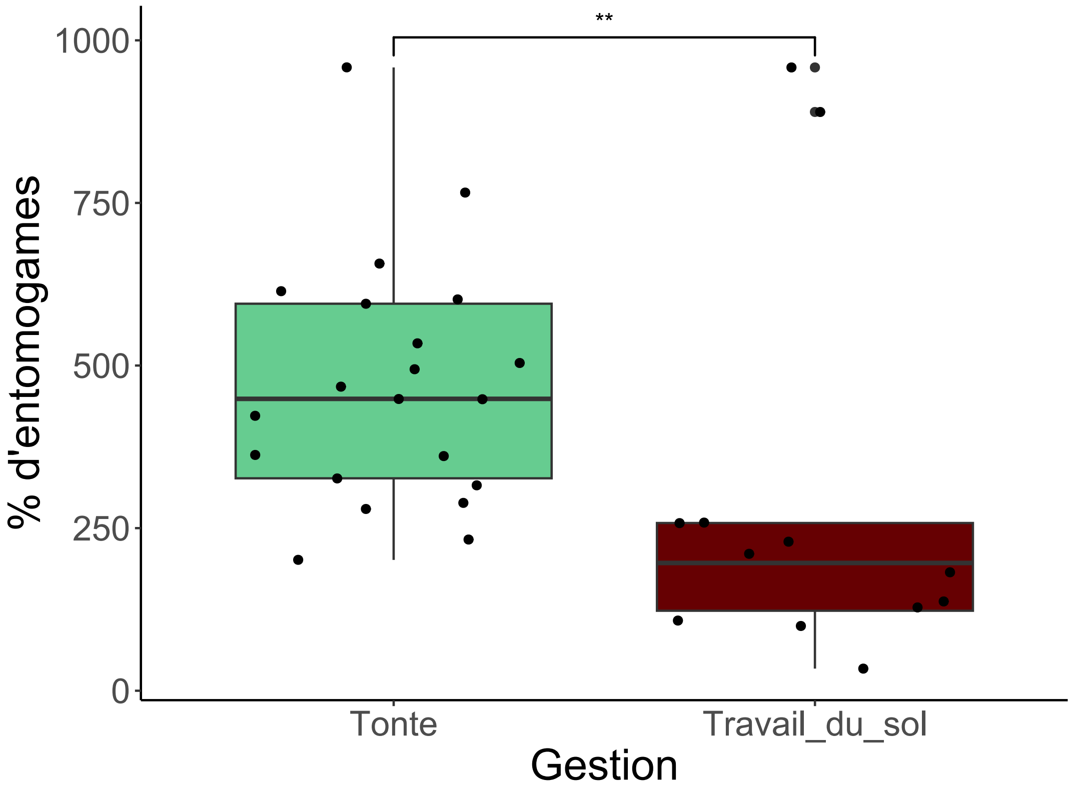
% de plantes pérennes selon l'agroécosystème *vs* le mode de gestion



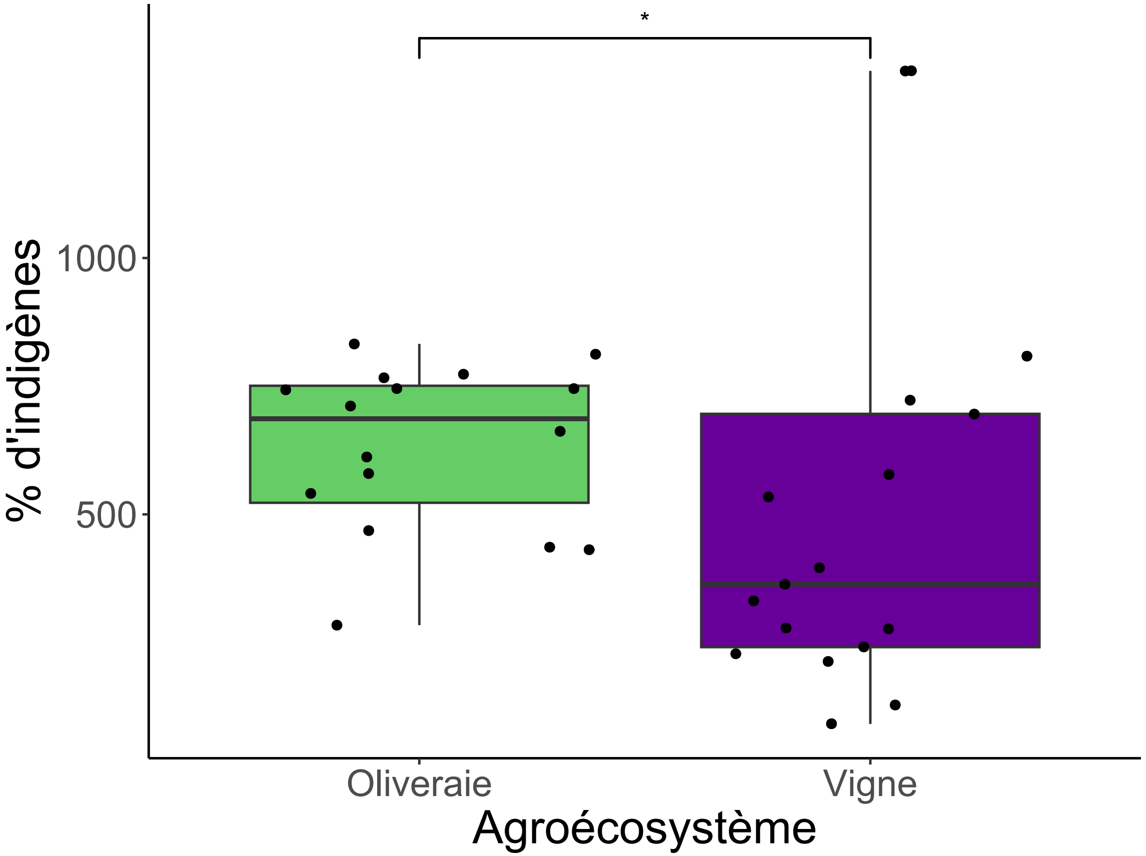


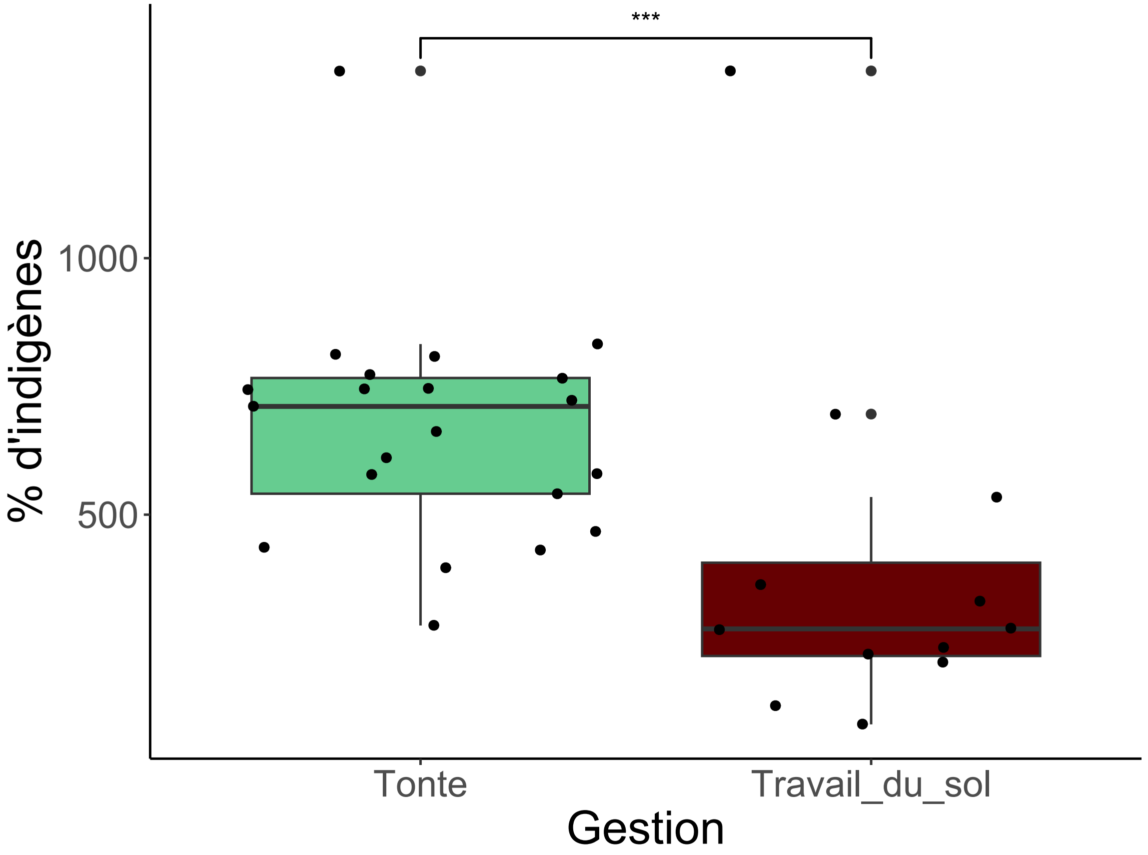
% de plantes entomogames selon l'agroécosystème *vs* le mode de gestion



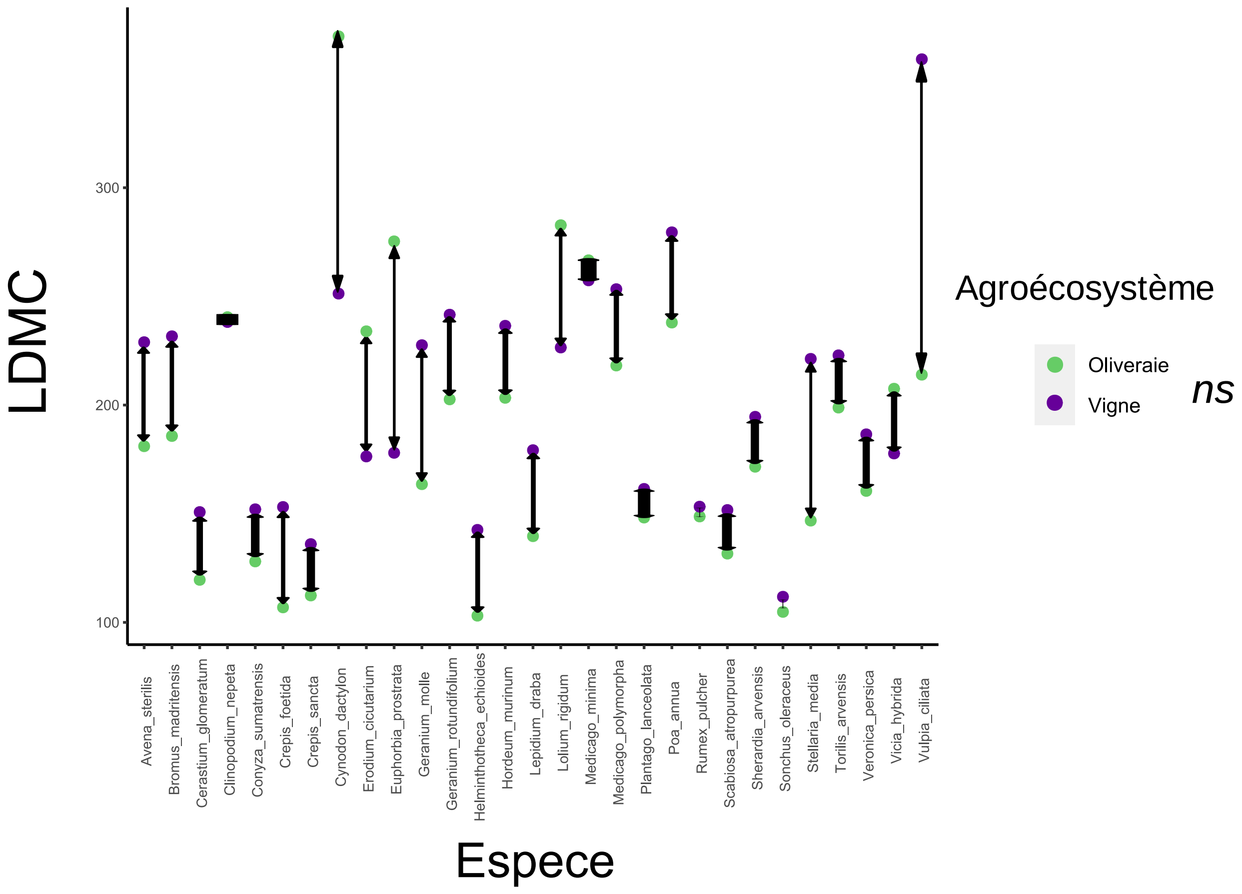


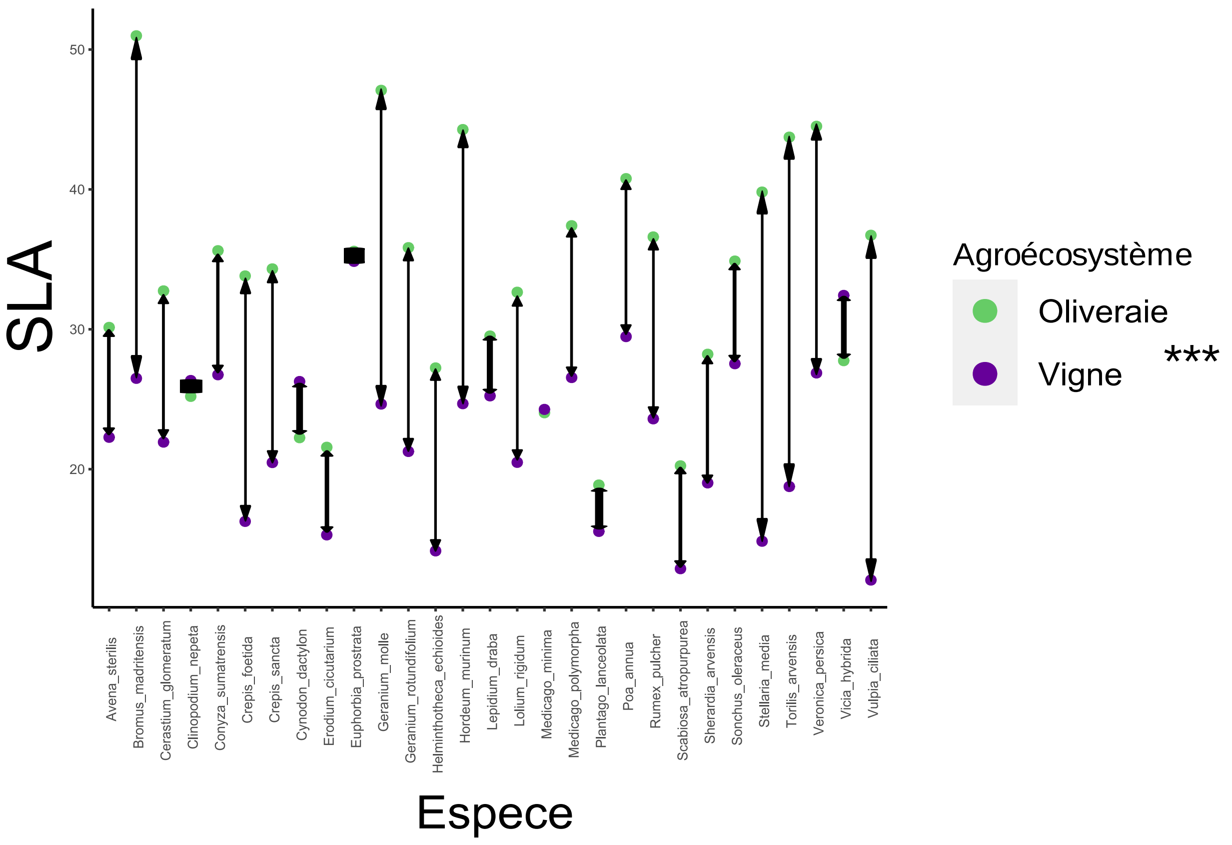
% de plantes indigènes selon l'agroécosystème *vs* le mode de gestion



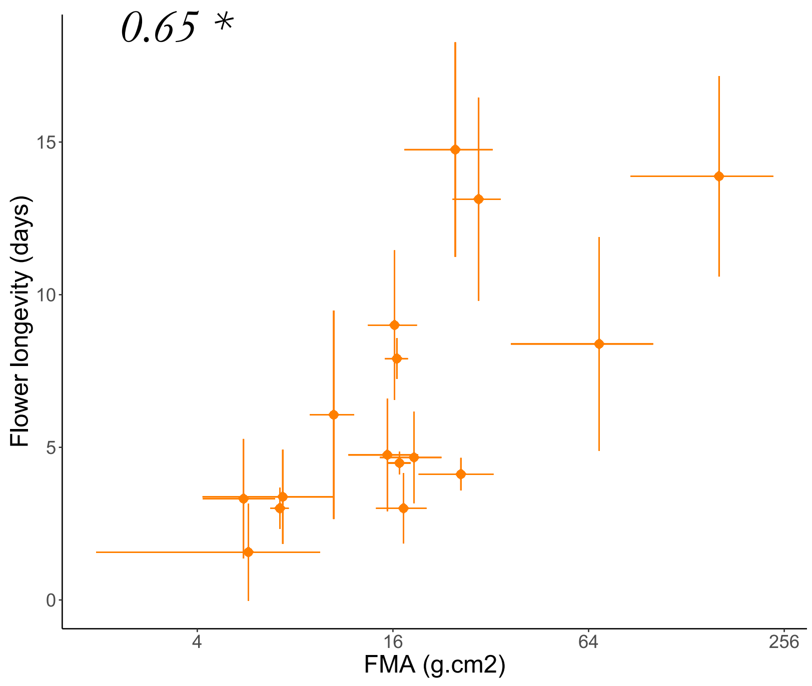


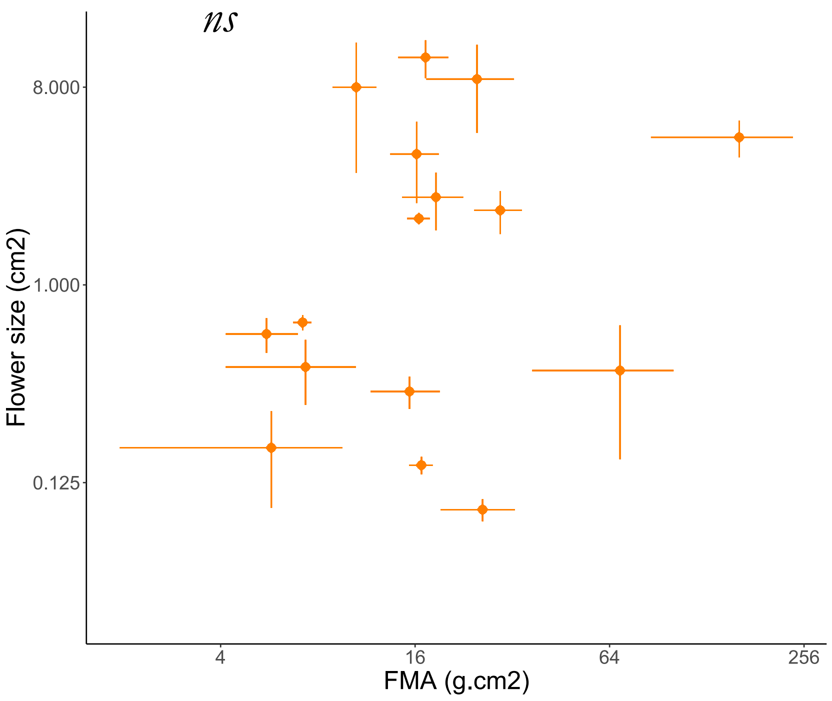
Variation intraspécifique de la SLA et de la LDMC entre agroécosystèmes

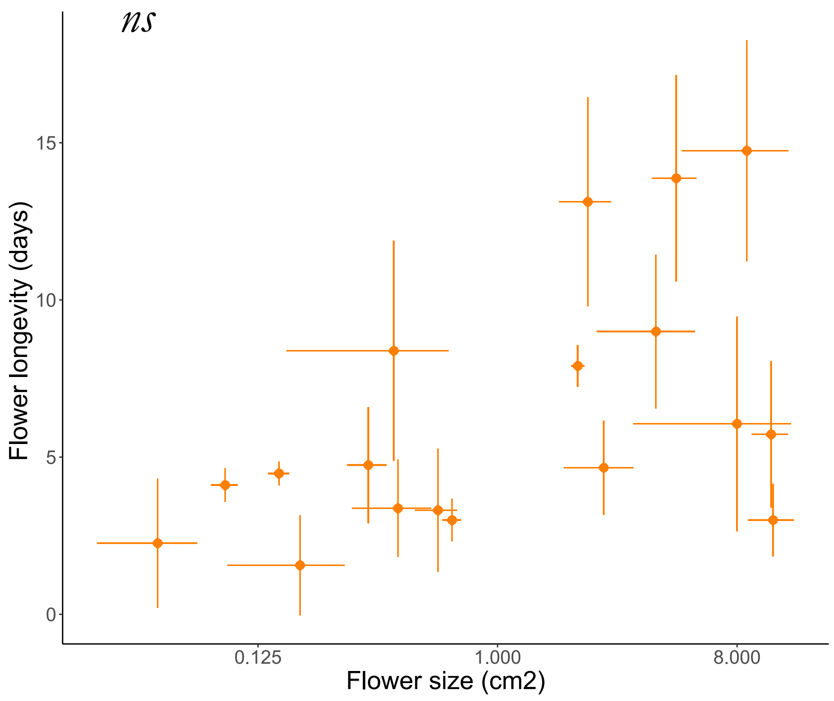




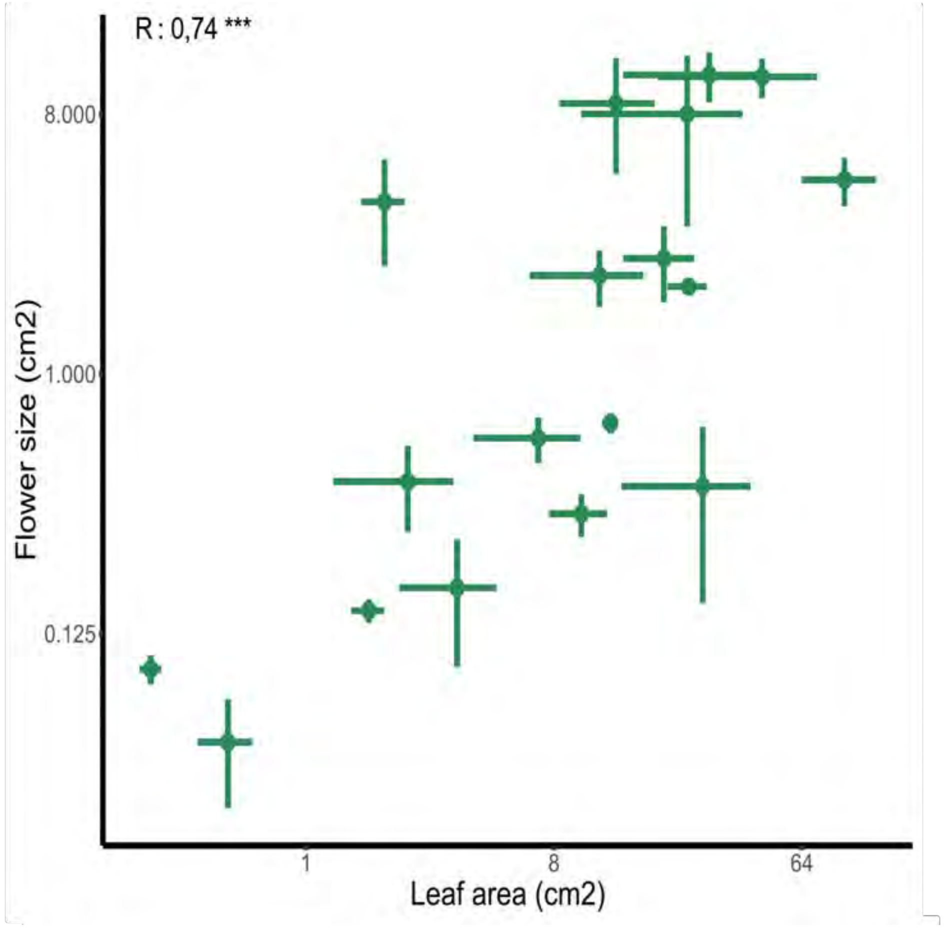
Relations entre longévité de la fleur, taille et FMA



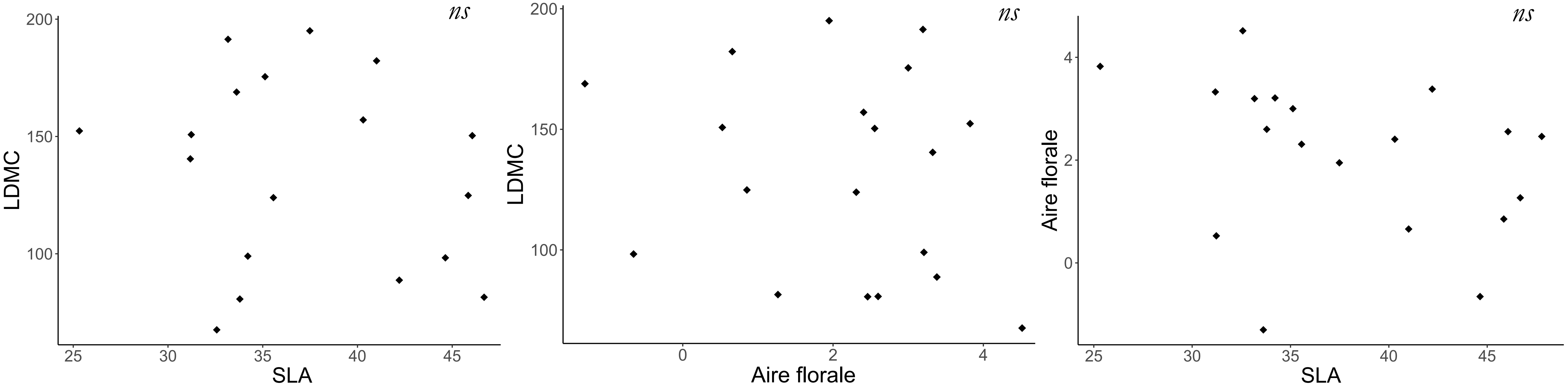




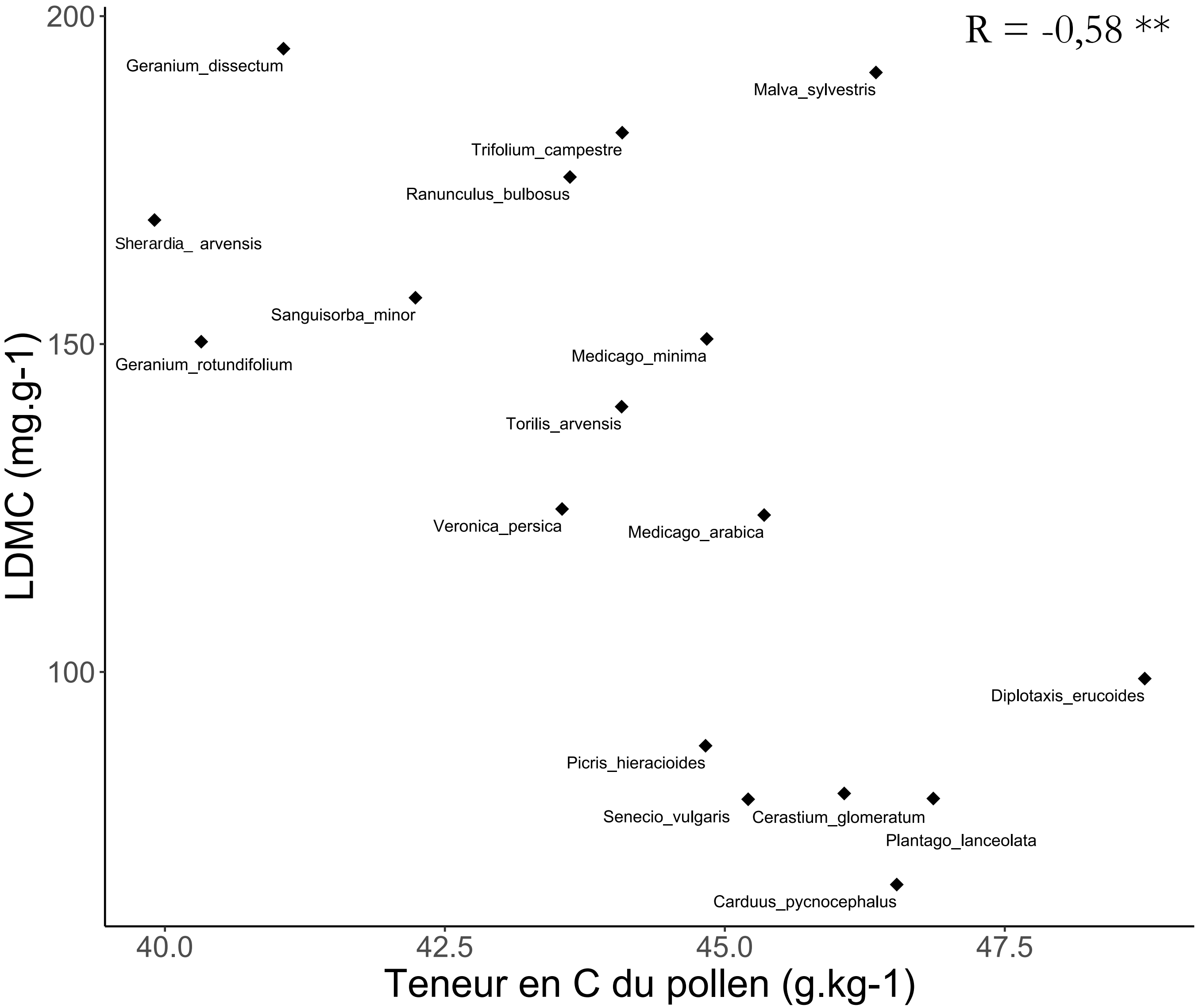
Relations taille fleur et surface foliaire



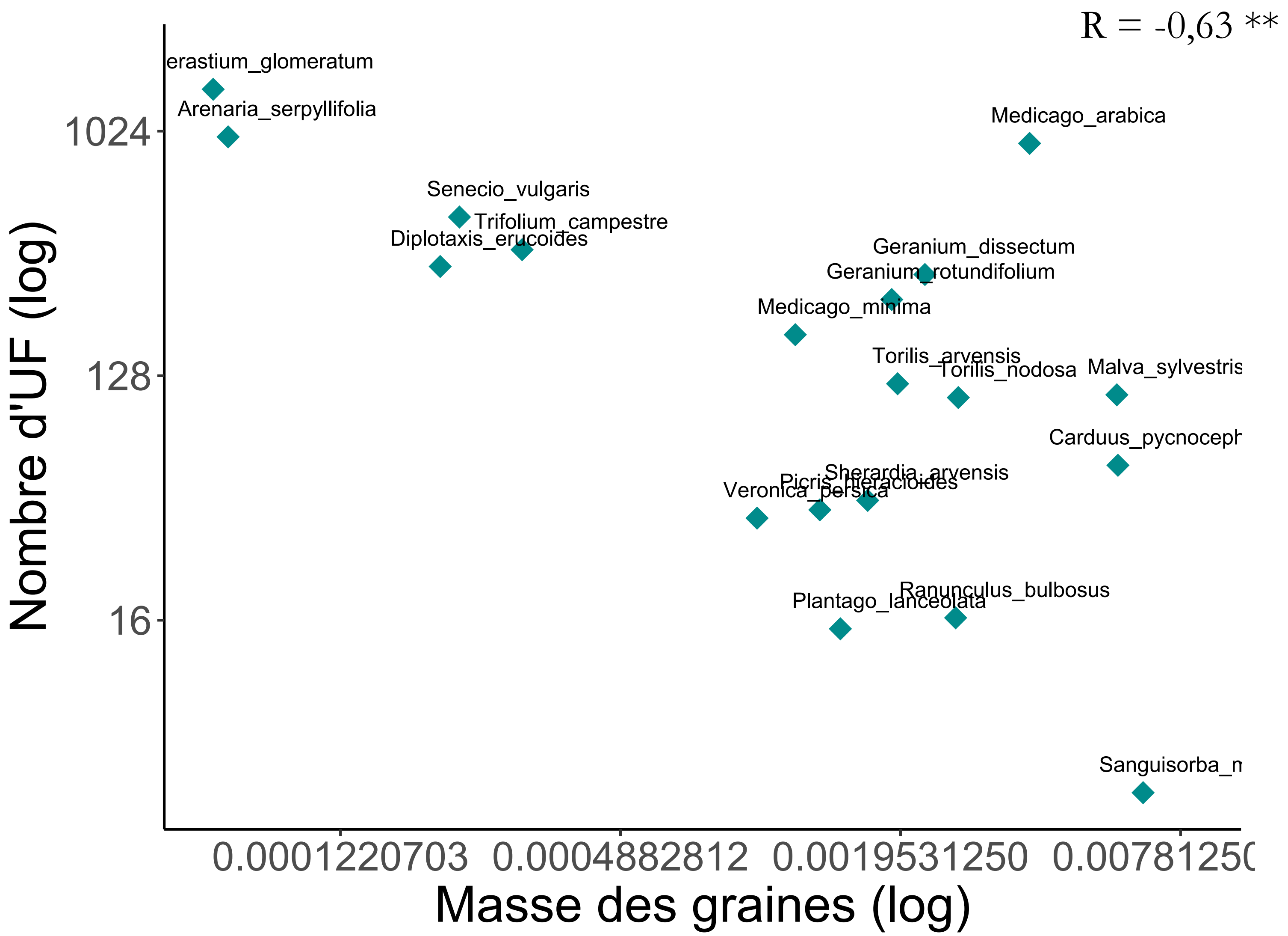
Relations SLA / LDMC / surface foliaire à l'échelle espèce (FLORES)



Relations entre la LDMC et le carbone du pollen : trade-off reproduction-structures végétatives ?



Relations entre le nombre de fleurs et la masse de graines : lien avec les stratégies r et K



Modèles mixtes effet variables abiotiques sur les indicateurs de ressource florale

Temporal scale	Response variable	Explanatory variable	Estimate	R2m	R2c
Month	Flower cover	last mowing	0.005*	0.01	0.37
Month	Floral richness	R_{sampl}	-0.005*	0.04	0.49
Year	Floral richness	pedoclim2 mowing	0.730* 1.021*	0.23	0.56
Year	Annual flower cover	ns	-	-	-
Year	Max flower cover	ns	-	-	-
Year	Max flower cover date	pedoclim2 N_dose	-3.754* 0.009-	0.13	0.2
Year	Flower cover peak duration	ns	-	-	-

Modèles mixtes effet CWM floraux sur les indicateurs de ressources florales

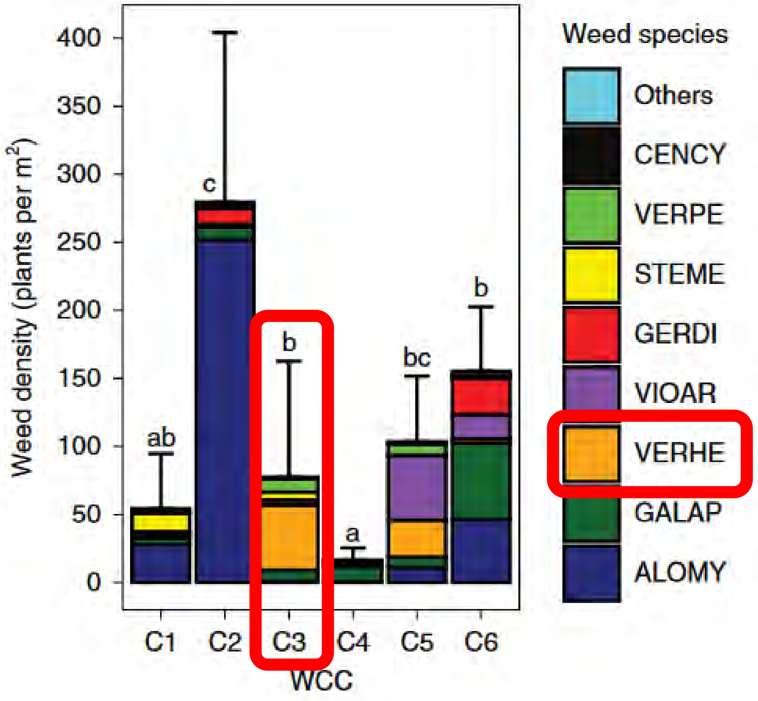
Functional indicator	Trait (response variable)	Explanatory variable	Estimate	R2m	R2c
FCWM	Area	mowing	0.306***	0.27	0.27
FCWM	Pollen	pedoclim2	0.106*	0.12	0.14
FCWM	Nectar	irrig	0.014**	0.32	0.64
FCWM	Height	mowing	3.117*	0.12	0.17
FCWM	FU number	N_dose	0.884***	0.6	0.6
		irrig	2.064**		
		T_min	91.06**		
FCWM	Duration	N_dose	-0.28**	0.27	0.27
		irrig	0.794*		
FCWM	Onset	N_dose	-0.648***	0.66	0.68
		irrig	1.483***		
		T_min	-49.7**		
		mowing	-44.29**		

Indicateurs de ressources florales

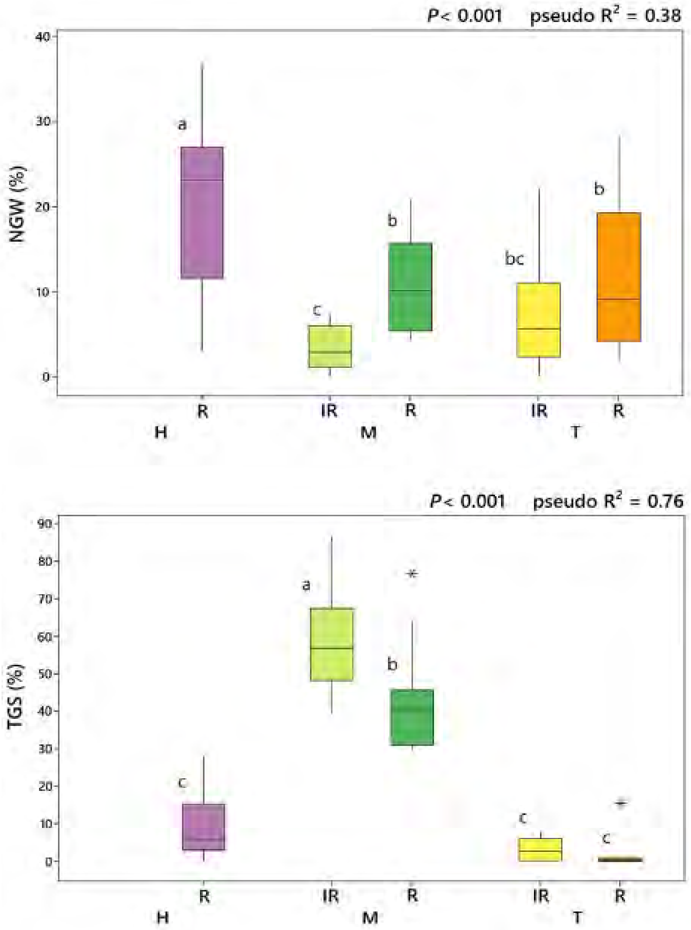
Indicator	Unit	Mean (sd)	Range	n
Floral richness	number of species	7 (±3)	1 - 13	80
Annual flower cover	unitless : integral of the curve of flower cover	157 (±145)	2.2 - 762	80
Max flower cover	% of flower cover	7.7 (±6.4)	0.1 - 33	80
Max flower cover date	date	16/04 (±50 days)	02/03 - 08/06	80
Flower cover peak duration	days	31 (±11)	3 - 57	71

Deux enherbements ne sont pas forcément similaires…

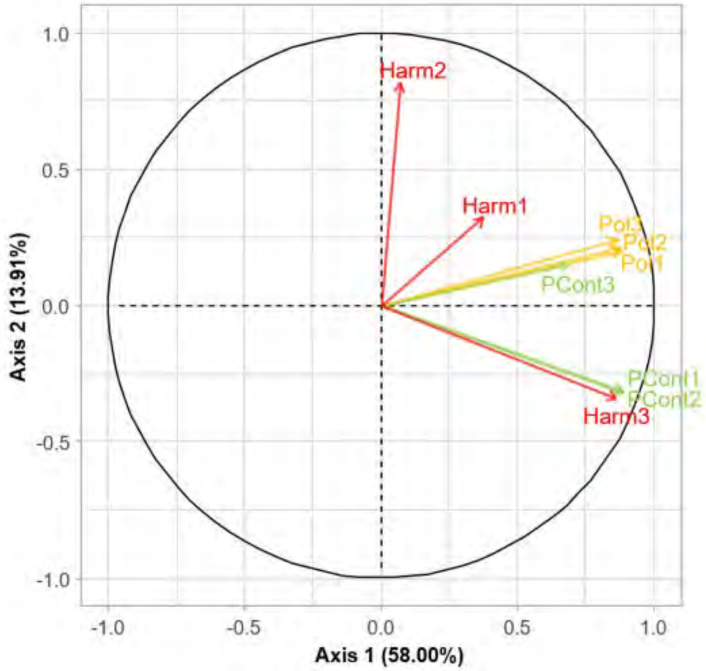
- Certaines communautés adventices, à richesse spécifique et densité égales, causent moins de pertes de rendements



- Les pratiques pour favoriser espèces favorables



- Synergie entre services et dysservices des adventices



Adeux et al., 2019 ; Guerra et al., 2022 ; Yovez et al., 2021

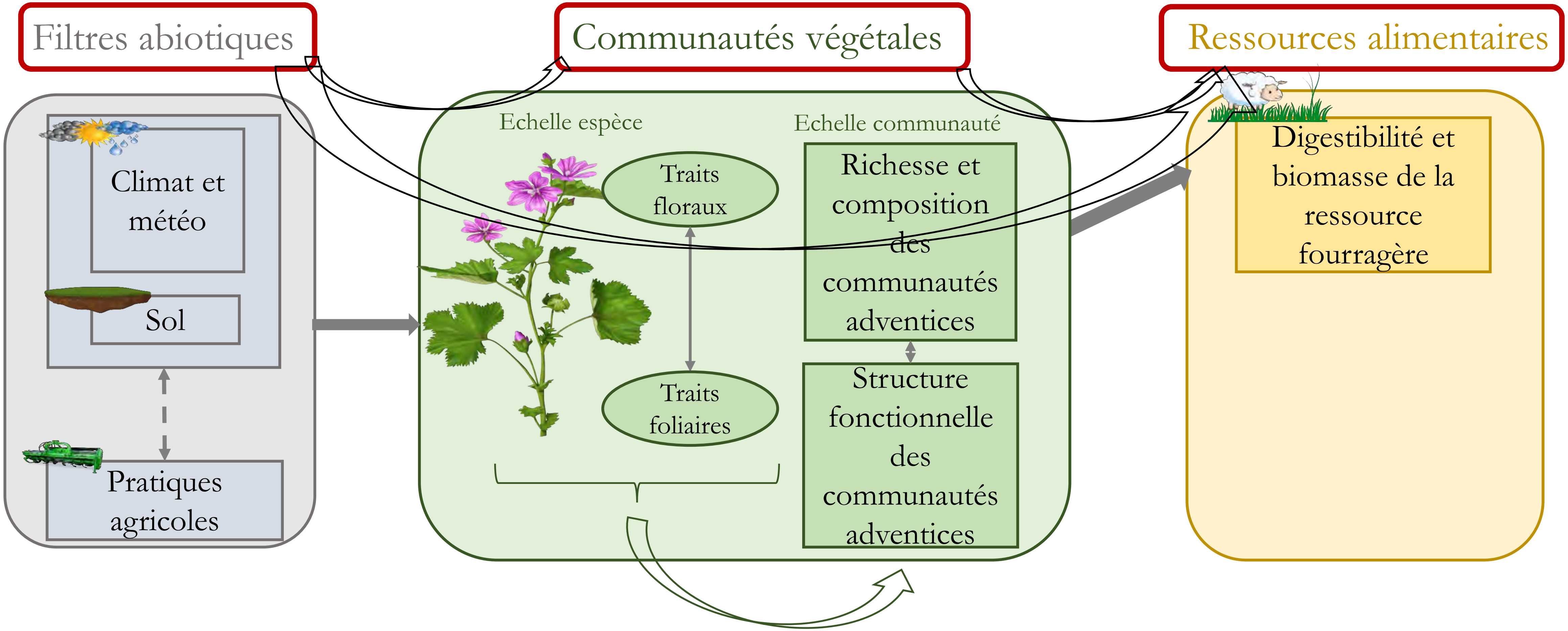
Retour sur le schéma de thèse

Pluviométrie et températures annuelle

Travail du sol

Fertilité du sol

I. Ressource fourragère

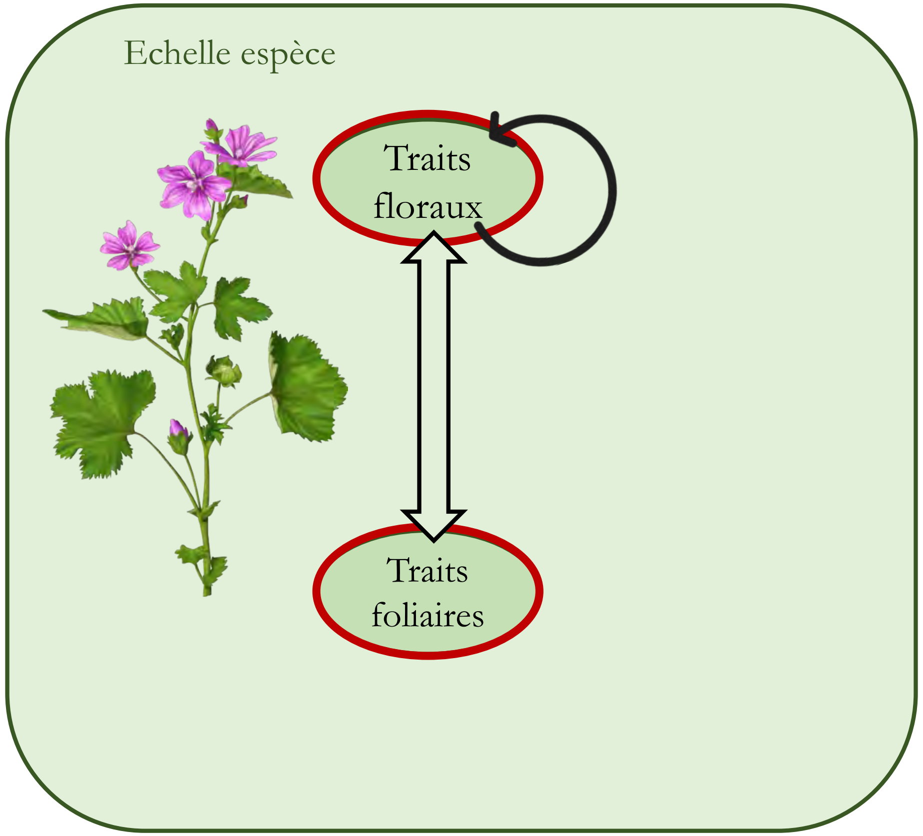


Retour sur le schéma de thèse

II. Fleurs adventices

Trade-off taille et nombre de fleurs

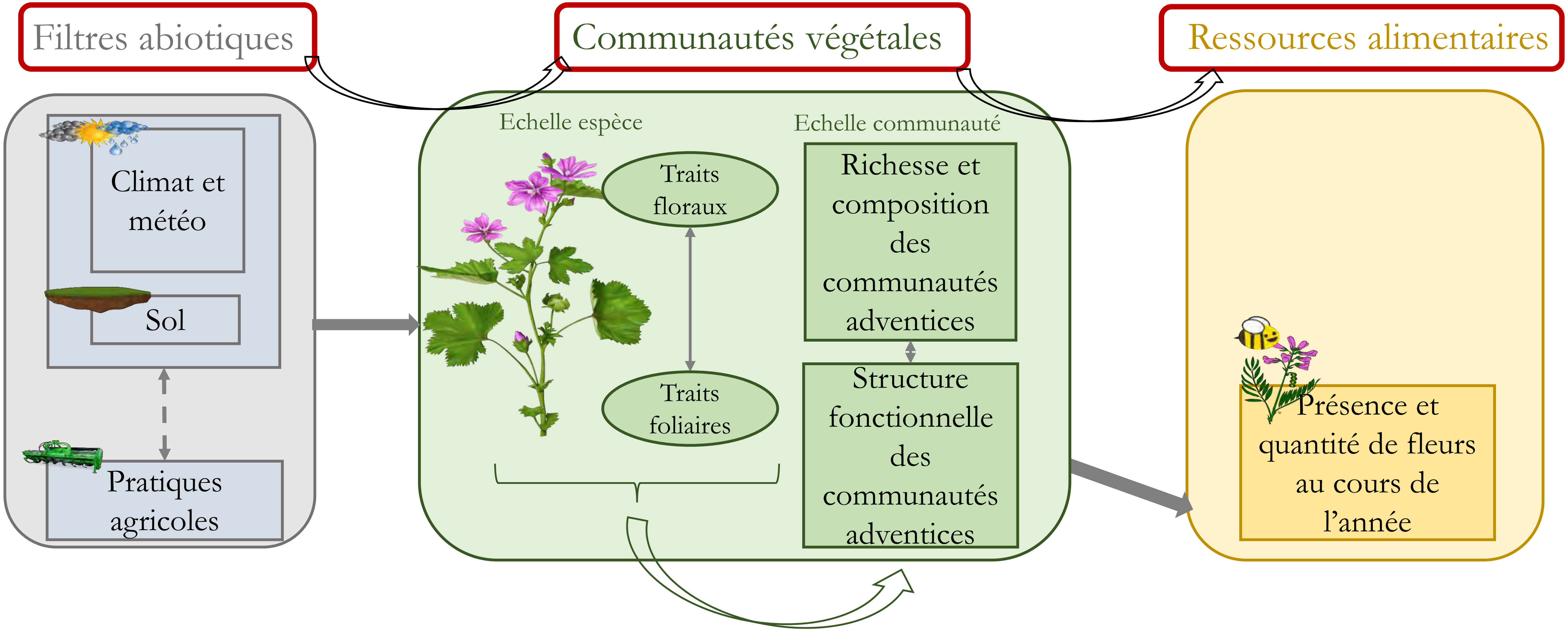
Relations traits floraux – stratégies CSR



Retour sur le schéma de thèse

Tonte, fertilisation, irrigation
Températures annuelles
Climat

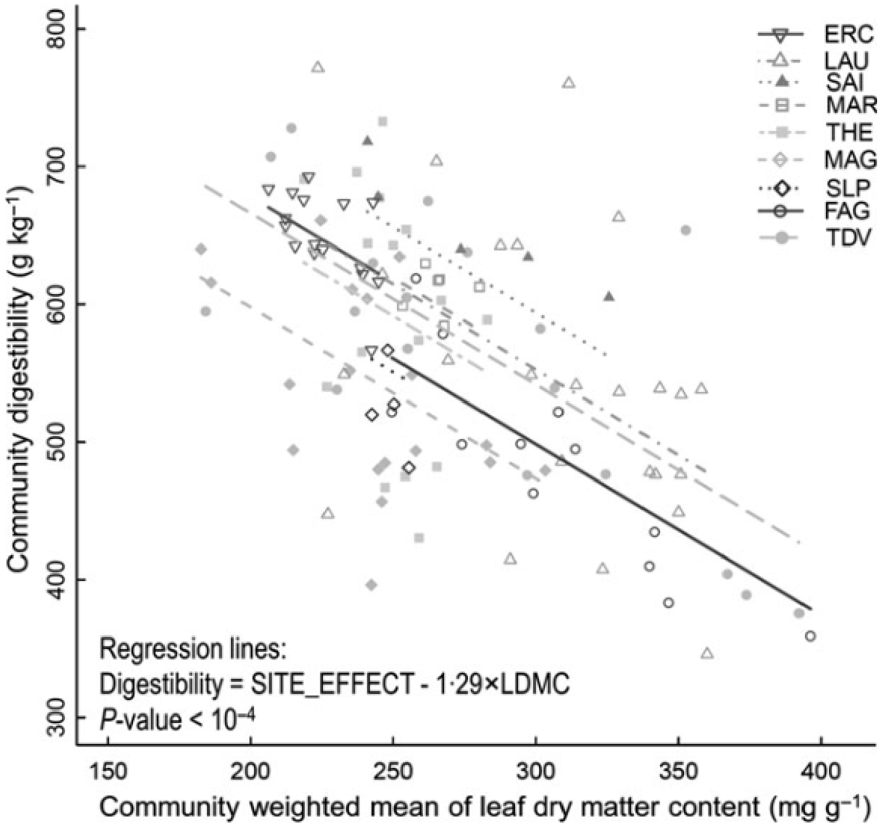
III. Ressource florale



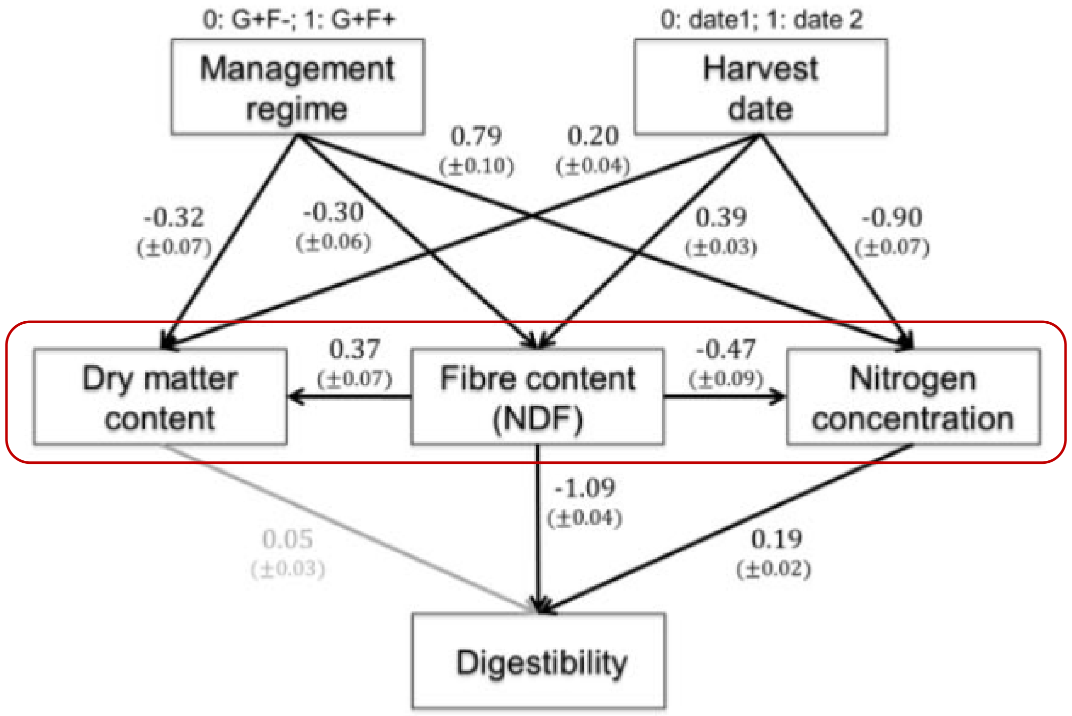
Les traits fonctionnels liés aux ressources

- **Traits foliaires liés à la qualité fourragère**

Teneur en matière sèche des feuilles (LDMC)



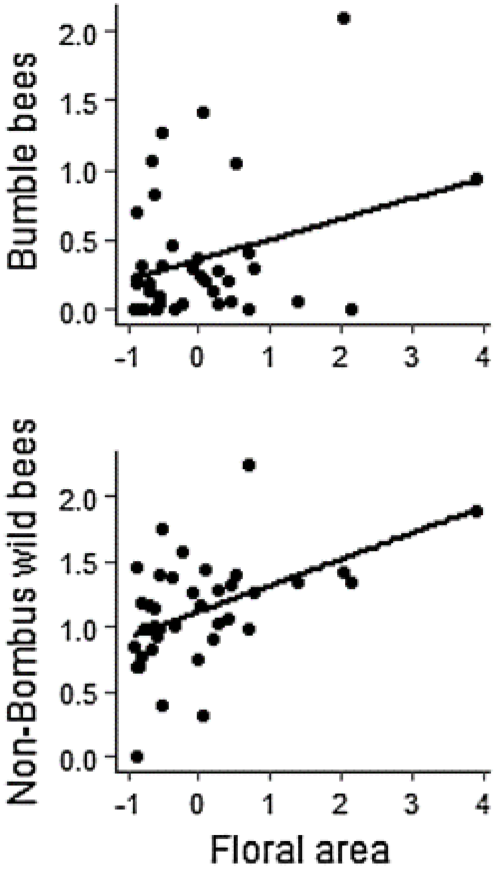
LDMC, teneur en fibres et en azote

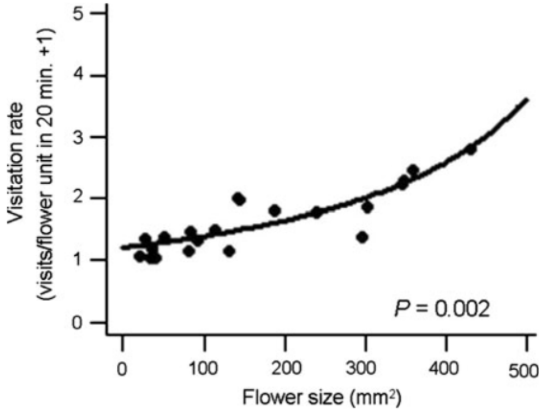


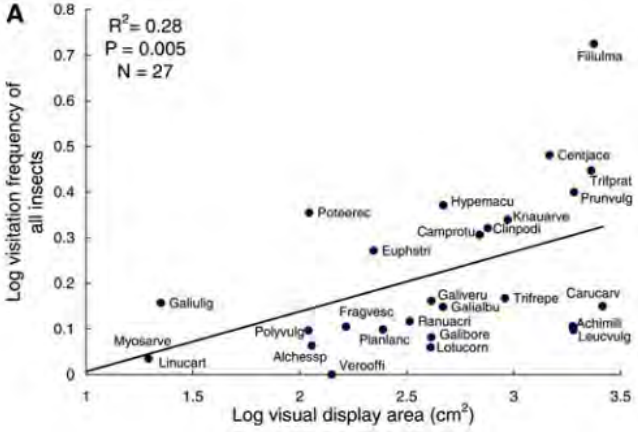
Gardarin et al., 2014 ; Bumb et al., 2016 ; Khaled et al., 2006

Les traits floraux liés à la visite des insectes

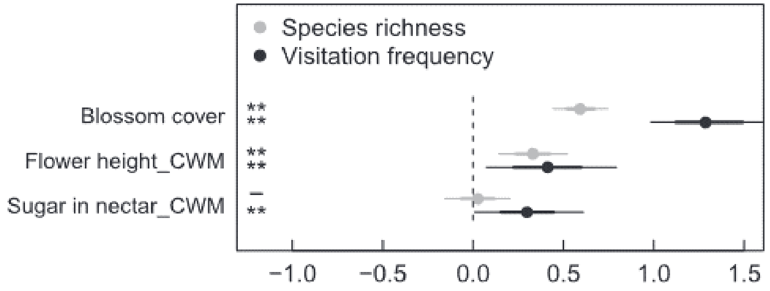
Surface florale



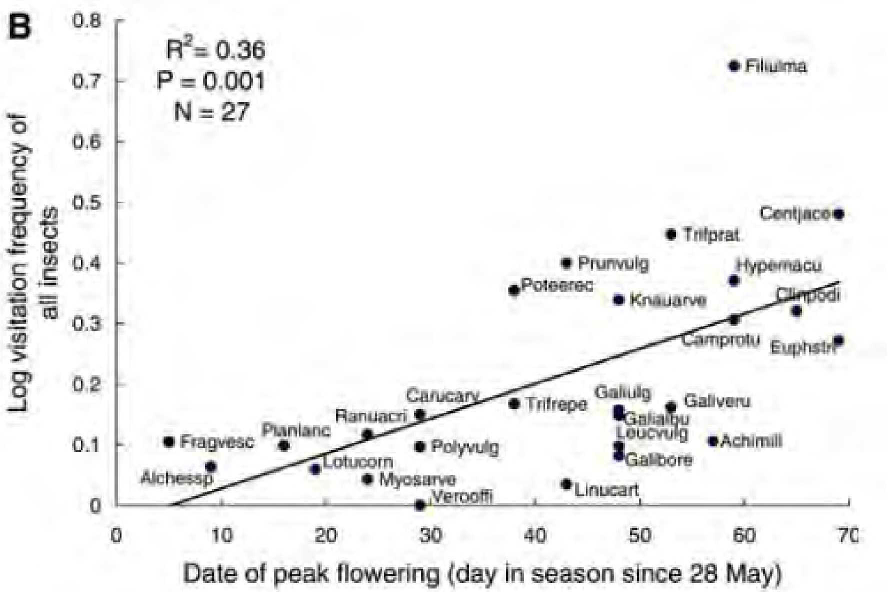




Couverture fleurie, hauteur et sucres dans le nectar



Phénologie



Fornoff et al., 2017 ; Hegland & Totland, 2005 ; Lazaro et al., 2013 ; Rowe et al., 2020 ; Tuell et al., 2008 ; Uyttenbroeck et al., 2017