

FUNCTIONAL DIVERSITY AND MOWING REGIME OF FLOWER STRIPS AS TOOLS TO SUPPORT POLLINATORS AND TO SUPPRESS WEEDS

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Co-promotor: Frédéric Francis

Public PhD Defense
Ulg - Gembloux Agro-Bio Tech

1. INTRODUCTION

Agricultural intensification

- Habitat loss
- Larger fields
- Trees/hedgerows disappeared
- Fertilizer and pesticide input

➔Biodiversity crisis

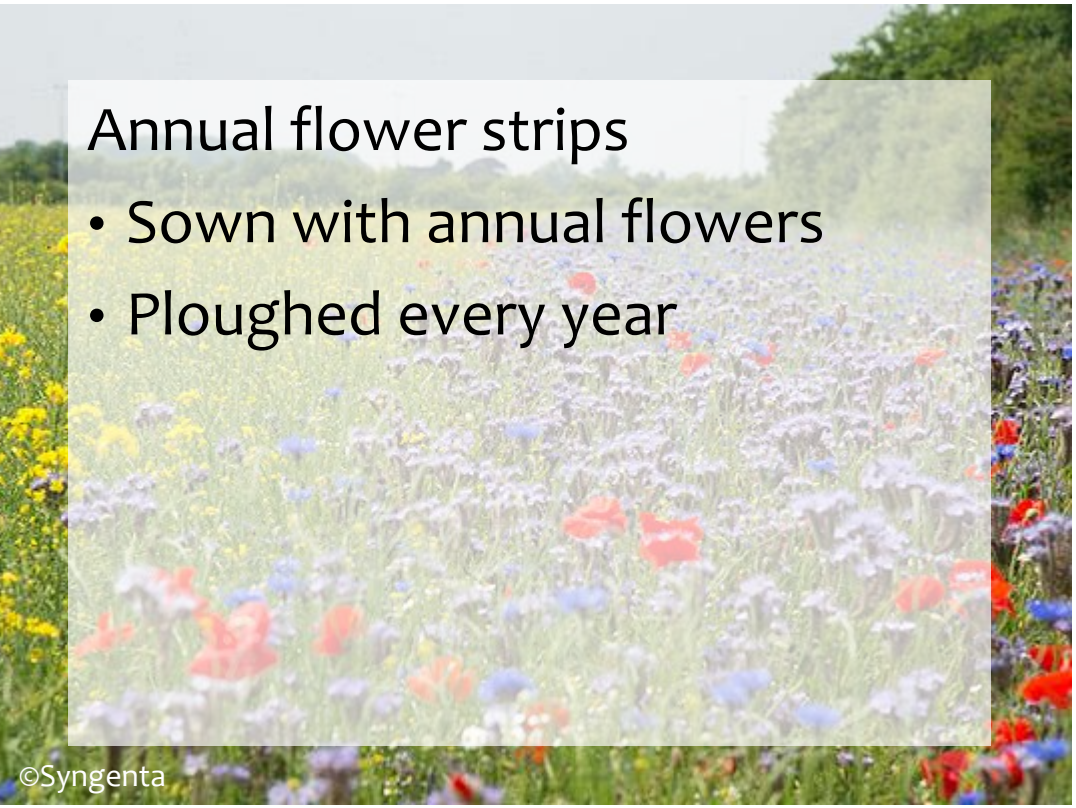
Agricultural intensification

➔Ecological intensification

- Maximize yield
- Minimize impact environment and biodiversity
- Use ecosystem services

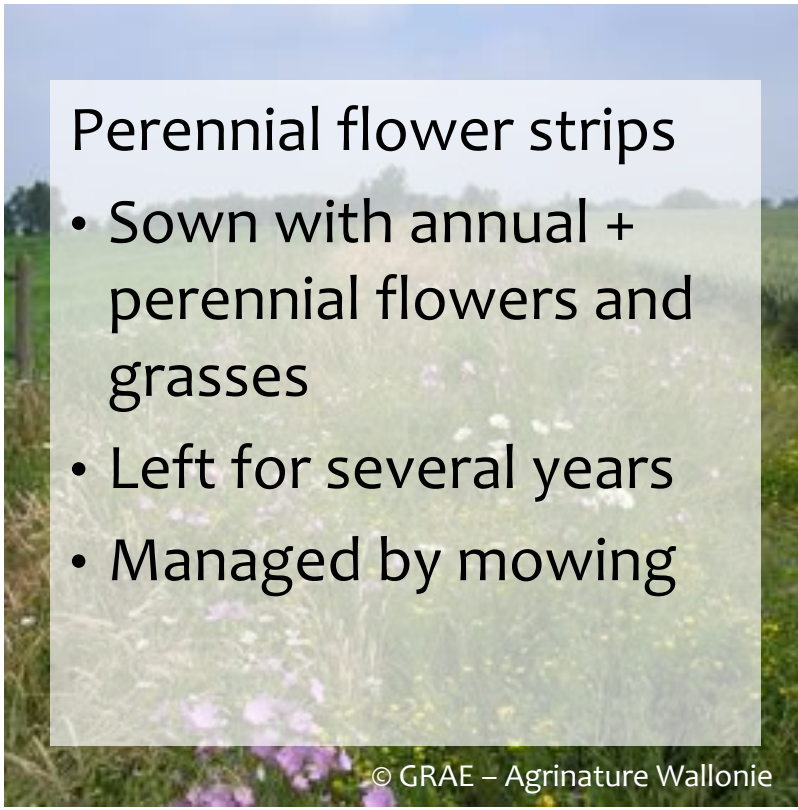
Flower strips

Flower strips



Annual flower strips

- Sown with annual flowers
- Ploughed every year



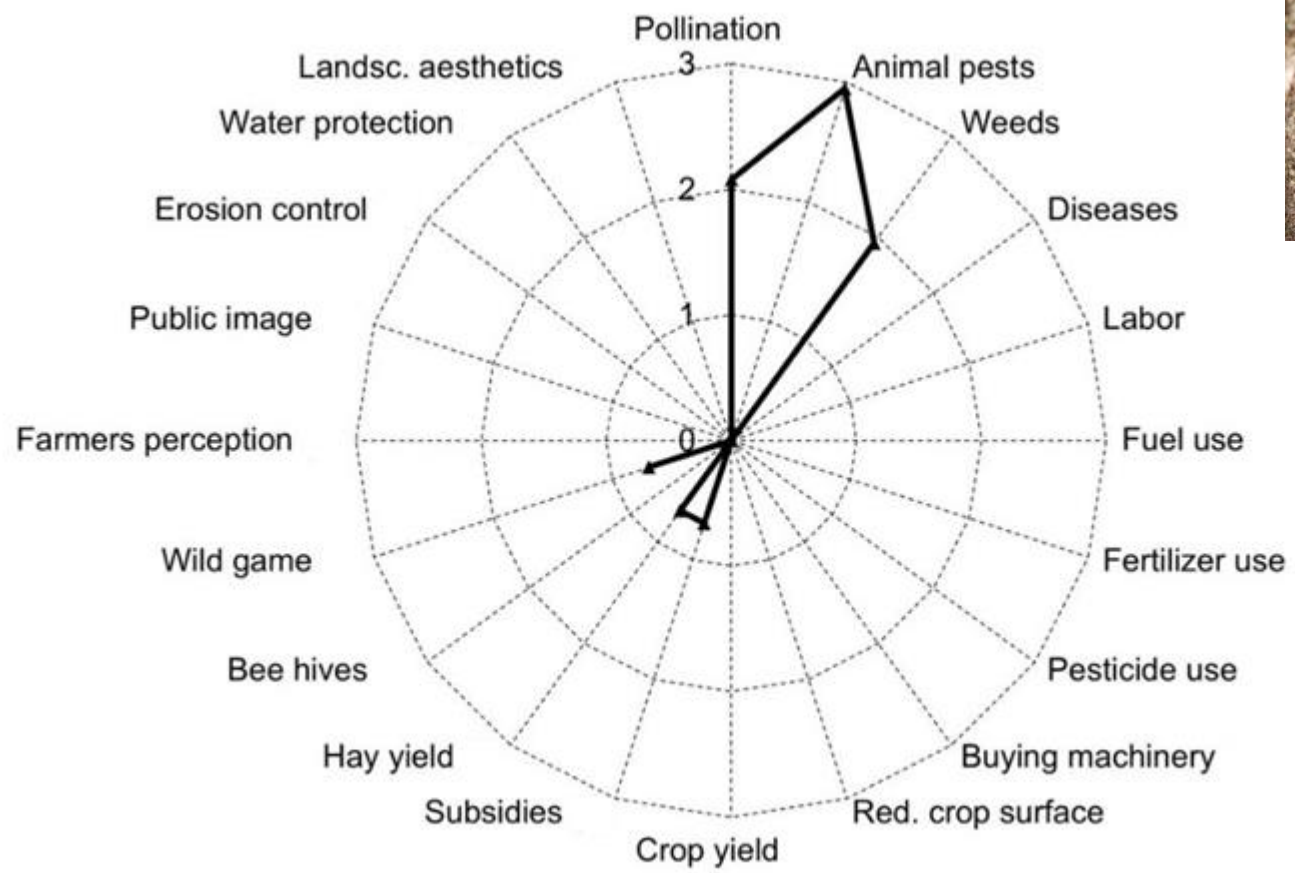
Perennial flower strips

- Sown with annual + perennial flowers and grasses
- Left for several years
- Managed by mowing


Hay meadows
© Wikimedia Commons

Services and disservices

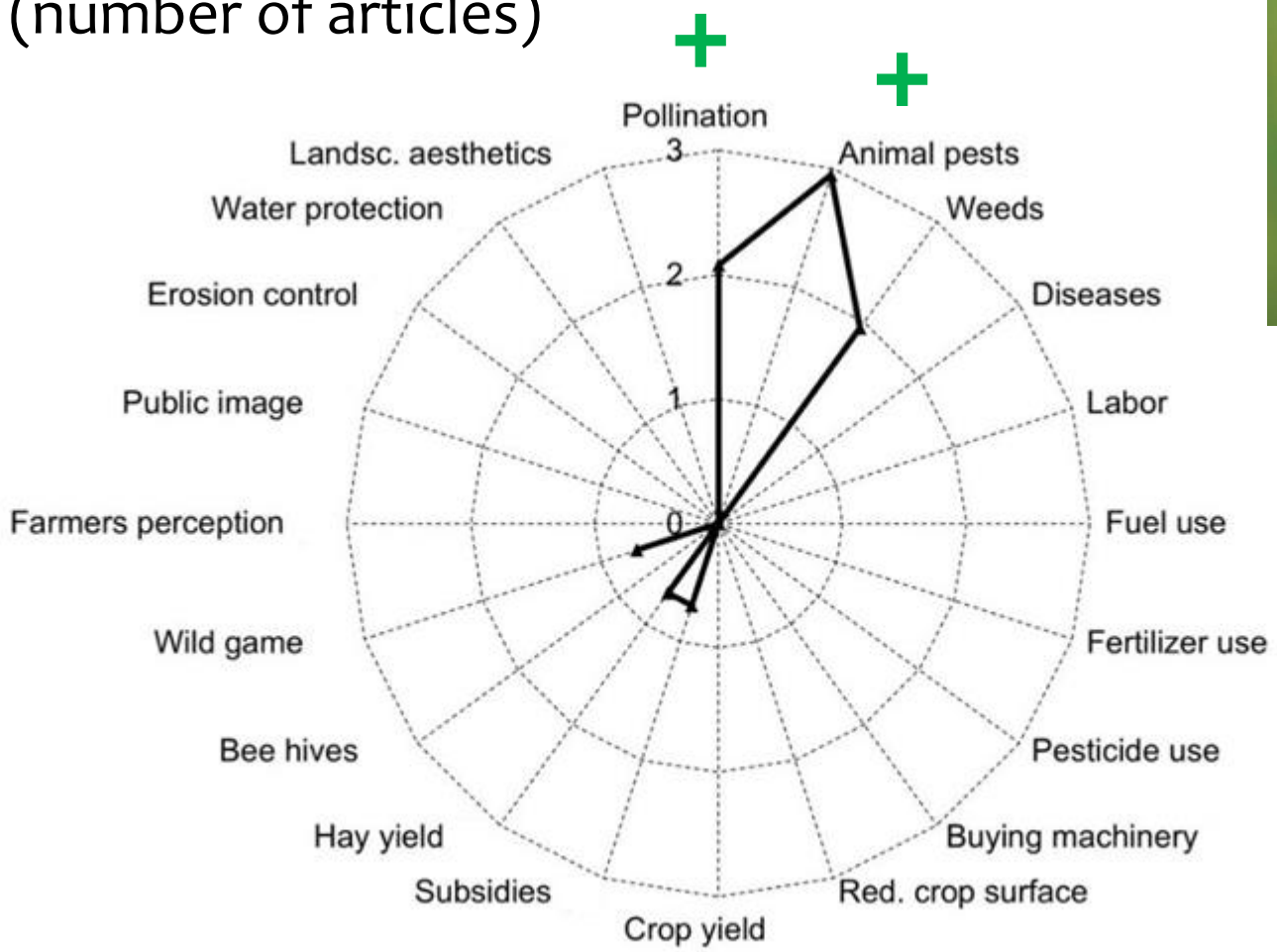
Log (number of articles) +



Uyttenbroeck et al., Biotechnol. Agron. Soc. Environ. (2016)

Services and disservices

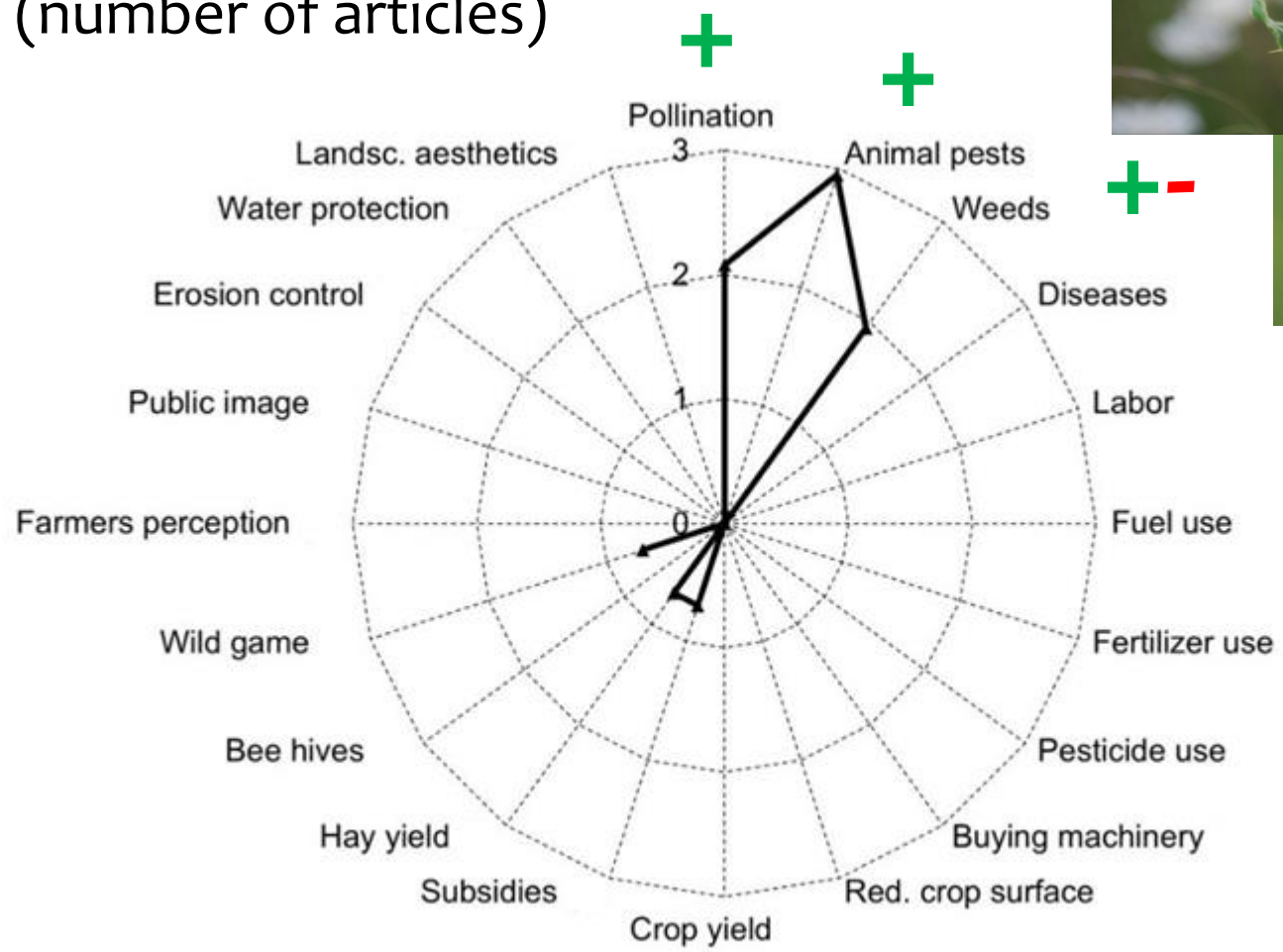
Log (number of articles)



Uyttenbroeck et al., Biotechnol. Agron. Soc. Environ. (2016)

Services and disservices

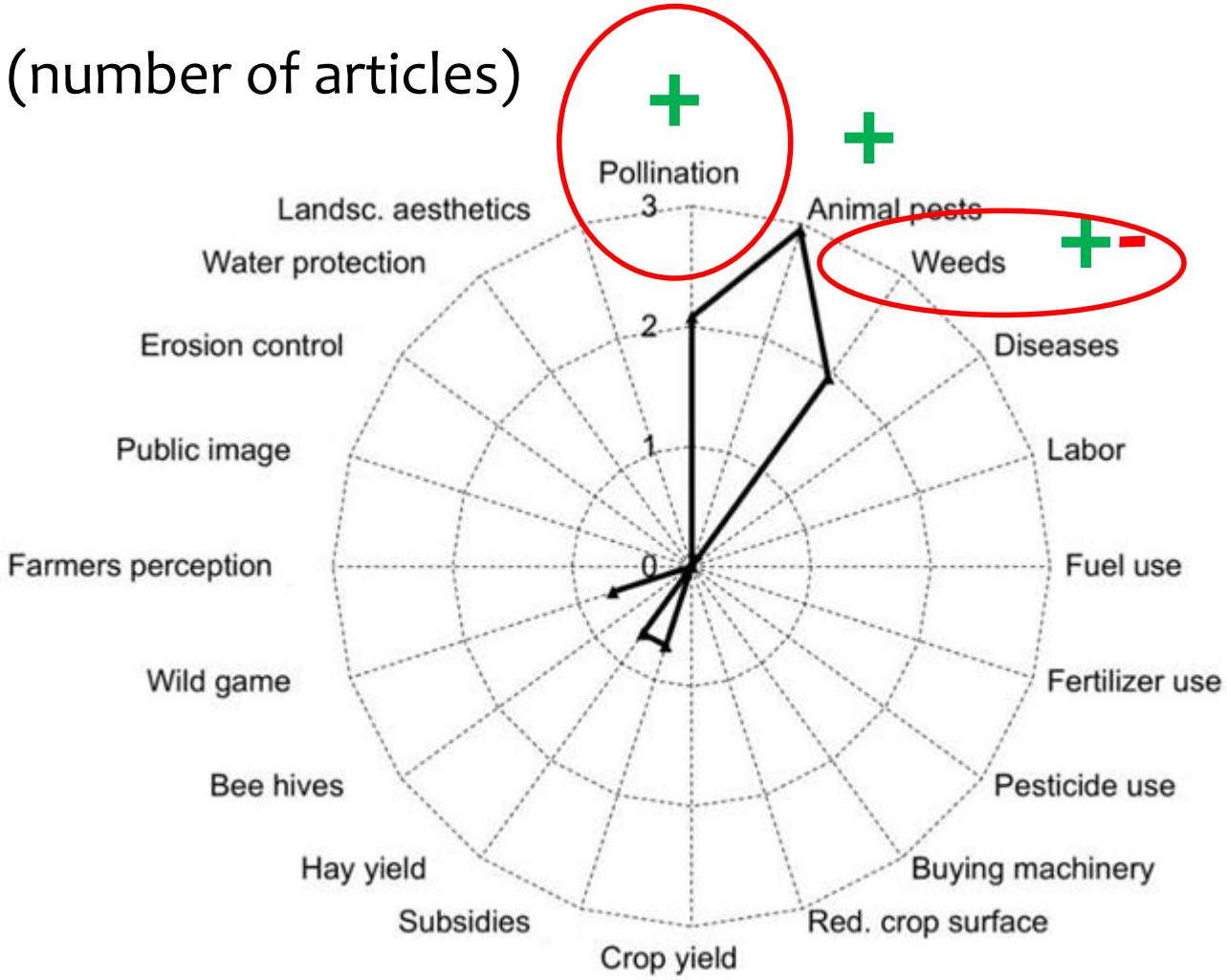
Log (number of articles)



Uyttenbroeck et al., Biotechnol. Agron. Soc. Environ. (2016)

Services and disservices

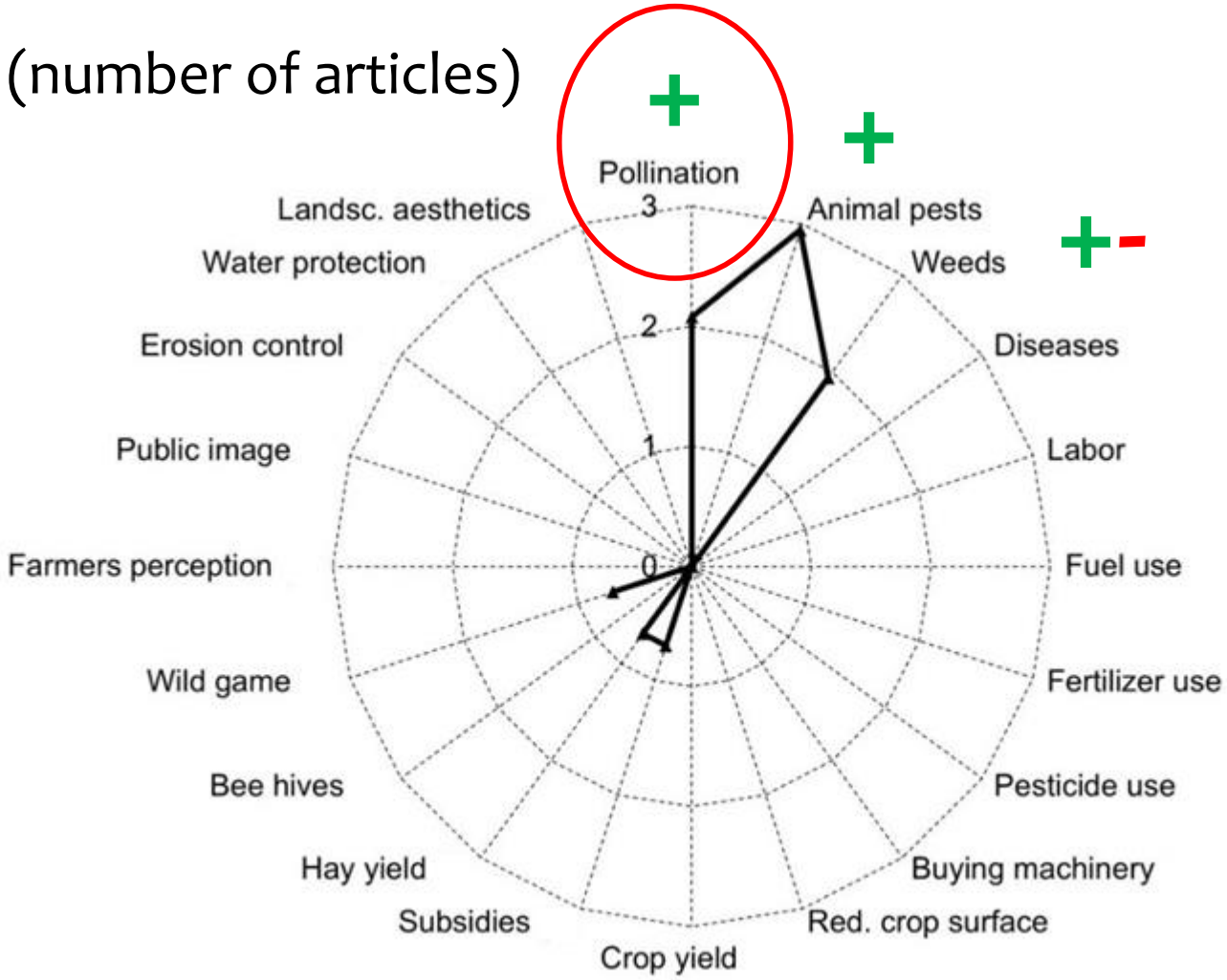
Log (number of articles)



Uyttenbroeck et al., Biotechnol. Agron. Soc. Environ. (2016)

Pollination

Log (number of articles)



Uyttenbroeck et al., Biotechnol. Agron. Soc. Environ. (2016)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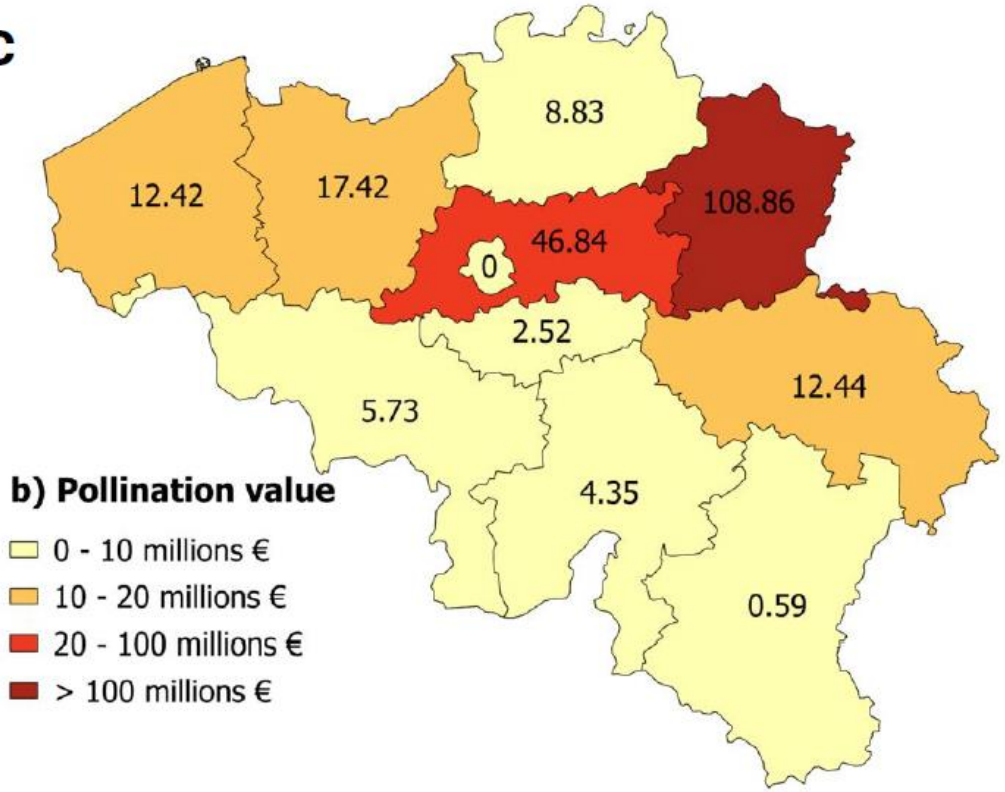
Pollinators importance

- 60-80% of wild plants
- 70% of crops
- 35% of world crop production

Jacquemin et al., One Ecosystem (2017)

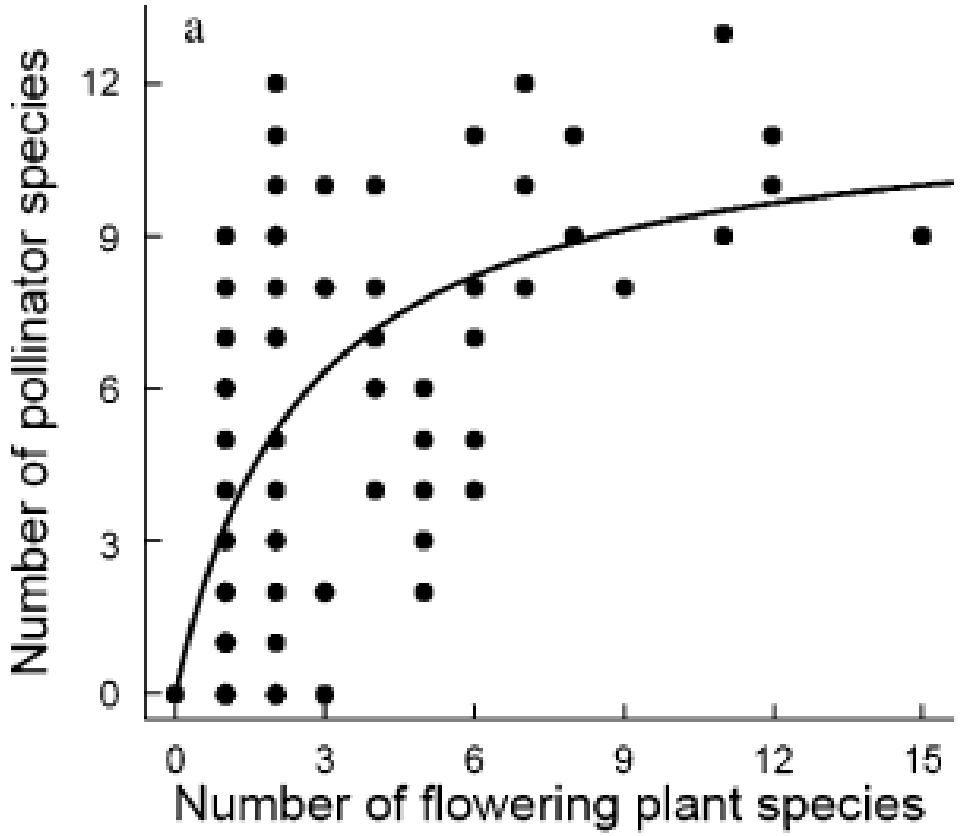
Pollinators importance

- 60-80% of wild plants
- 70% of crops
- 35% of wc



Jacquemin et al., One Ecosystem (2017)

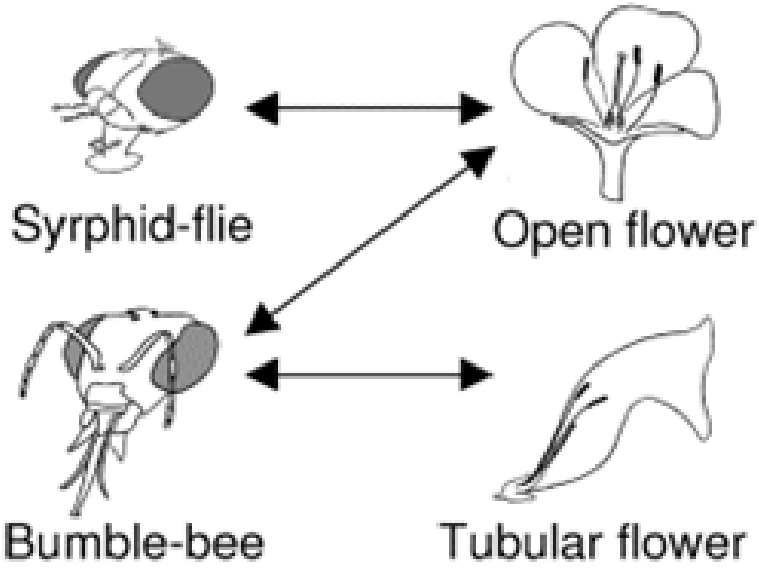
Supporting pollinators in flower strips?



Ebeling et al., Oikos (2008)

Functional diversity

Functional traits



Fontaine et al., PLoS. Biol. (2006)

Functional diversity

Low

High

646 Review TRENDS in Ecology & Evolution Vol.16 No.11 November 2001

Vive la différence: plant functional diversity matters to ecosystem processes

Sandra Díaz and Marcelo Cabido

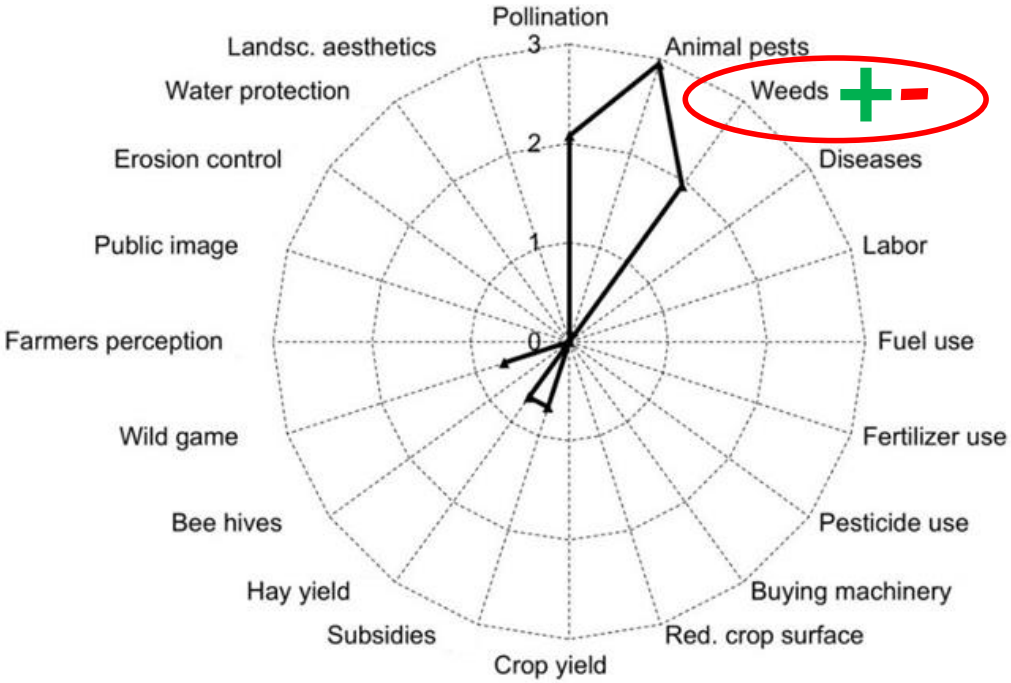
The links between plant diversity and ecosystem functioning remain highly controversial. There is a growing consensus, however, that functional diversity, or the value and range of species traits, rather than species numbers *per se*, strongly determines ecosystem functioning. Despite its importance, and the fact that species diversity is often an inadequate surrogate, functional diversity has been studied in relatively few cases. Approaches based on species richness on the one hand, and on functional traits and types on the other, have been extremely productive in recent years, but attempts to connect their findings have been rare. Crossfertilization between these two approaches is a promising way of gaining mechanistic insight into the links between plant diversity and ecosystem processes and contributing to practical management for the conservation of diversity and ecosystem services.

ecosystem processes and the ECOSYSTEM SERVICES (see Glossary) that humans derive from them[1]. The issue of whether plant diversity influences ecosystem processes has received increasing attention in the past five years, as a consequence of the publication of several groundbreaking theoretical developments and experiments[2–13].

There is now general agreement that diversity (a synonym of biodiversity and biological diversity) includes both number and composition of the genotypes, species, functional types and landscape units in a given system. However, diversity is often equated to SPECIES RICHNESS, and other components of

Weeds

- Sowing seed mixture: competition?
- Mowing regime



General objective

Focus on: perennial flower strips

pollination and weeds

General objective:

Test methods of flower strips creation and management to maximize pollinator support and minimize weed infestation

Research questions

- Functional traits suggested to play key role

=> increasing functional diversity as a tool to improve flower strips for pollinator support

- ***Q1: Can we create plant functional diversity in flower strips?***

Research questions

- Functional traits suggested to play key role

=> increasing functional diversity as a tool to improve flower strips for pollinator support

- ***Q1: Can we create plant functional diversity in flower strips?***
- ***Q2: Is plant functional diversity the key to promote pollinators in flower strips?***

Research questions

- Weeds influenced by:
  - Sowing seed mixture => competition
  - Timing and frequency of mowing
- ***Q3: Can adapting mowing regime and forb competition be used as tools to reduce weed infestation in perennial flower strips?***

Research questions

- Reference habitat for flower strips?
  - Perennial flower strips: mowing, meadow species

  => Hay meadows?
- ***Q4: Are perennial flower strips a surrogate for hay meadows?***

2. CAN WE CREATE PLANT FUNCTIONAL DIVERSITY IN FLOWER STRIPS?

Published in Agriculture and Agricultural Science Procedia (2015), 6:95-101

R. Uyttenbroeck, S. Hatt, J. Piqueray, A. Paul, B. Bodson, F. Francis & A. Monty

Q1: Can we create plant functional diversity in flower strips?

Species
Achillea millefolium
Anthriscus sylvestris
Crepis biennis
Galium verum
Geranium pyrenaicum
Heracleum sphondylium
Hypericum perforatum
Hypochaeris radicata
Knautia arvensis
Leontodon hispidus
Leucanthemum vulgare
Lotus corniculatus
Lythrum salicaria
Malva moshata
Medicago lupulina
Origanum vulgare
Prunella vulgaris
Ranunculus acris
Silene latifolia
Trifolium pratense

- 20 species used in perennial flower strips in Wallonia

How to measure functional diversity?

Species	Flower color
Achillea millefolium	white
Anthriscus sylvestris	white
Crepis biennis	yellow
Galium verum	yellow
Geranium pyrenaicum	Violet/ purple
Heracleum sphondylium	white
Hypericum perforatum	yellow
Hypochaeris radicata	yellow
Knautia arvensis	Violet/ purple
Leontodon hispidus	yellow
Leucanthemum vulgare	white
Lotus corniculatus	yellow
Lythrum salicaria	Violet/ purple
Malva moshata	Violet/ purple
Medicago lupulina	yellow
Origanum vulgare	Violet/ purple
Prunella vulgaris	Violet/ purple
Ranunculus acris	yellow
Silene latifolia	white
Trifolium pratense	Violet/ purple

Creating functional diversity

Species	Flower color	Flowering duration	UV pattern
Achillea millefolium	white	6	no
Anthriscus sylvestris	white	2	no
Crepis biennis	yellow	3	yes
Galium verum	yellow	5	no
Geranium pyrenaicum	Violet/ purple	5	yes
Heracleum sphondylium	white	3	no
Hypericum perforatum	yellow	3	yes
Hypochaeris radicata	yellow	4	yes
Knautia arvensis	Violet/ purple	4	no
Leontodon hispidus	yellow	5	yes
Leucanthemum vulgare	white	4	no
Lotus corniculatus	yellow	5	no
Lythrum salicaria	Violet/ purple	4	yes
Malva moshata	Violet/ purple	3	yes
Medicago lupulina	yellow	7	no
Origanum vulgare	Violet/ purple	3	no
Prunella vulgaris	Violet/ purple	3	yes
Ranunculus acris	yellow	5	yes
Silene latifolia	white	6	yes
Trifolium pratense	Violet/ purple	6	no

...

Several traits?

=>Rao's quadratic entropy index

All possible mixtures of 7 species: 77520

Functional diversity gradient

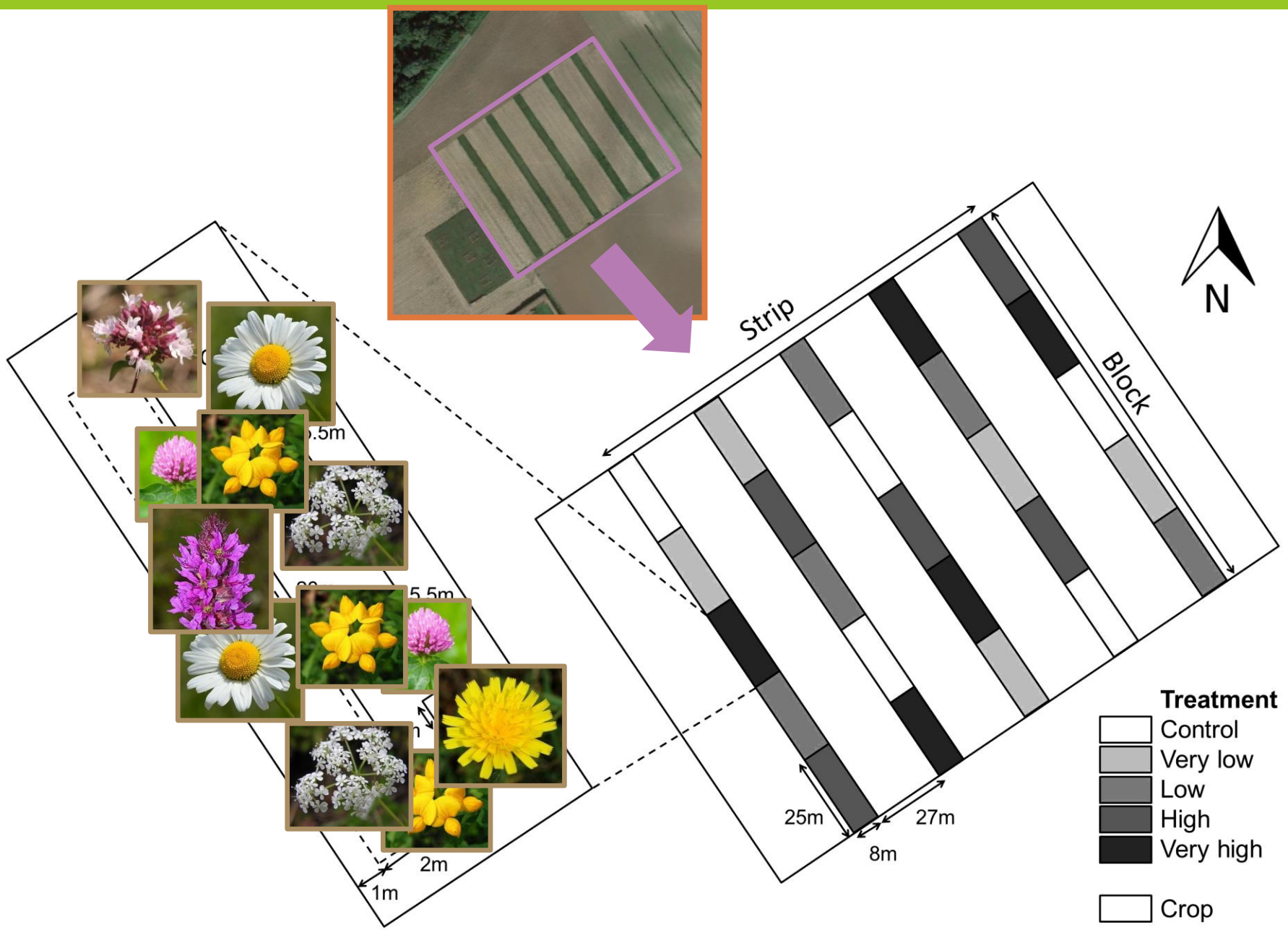
- Very low FD

- Low FD
- High FD
- Very high FD

AgricultureIsLife experimental farm

AgricultureIsLife experimental farm

Creating functional diversity

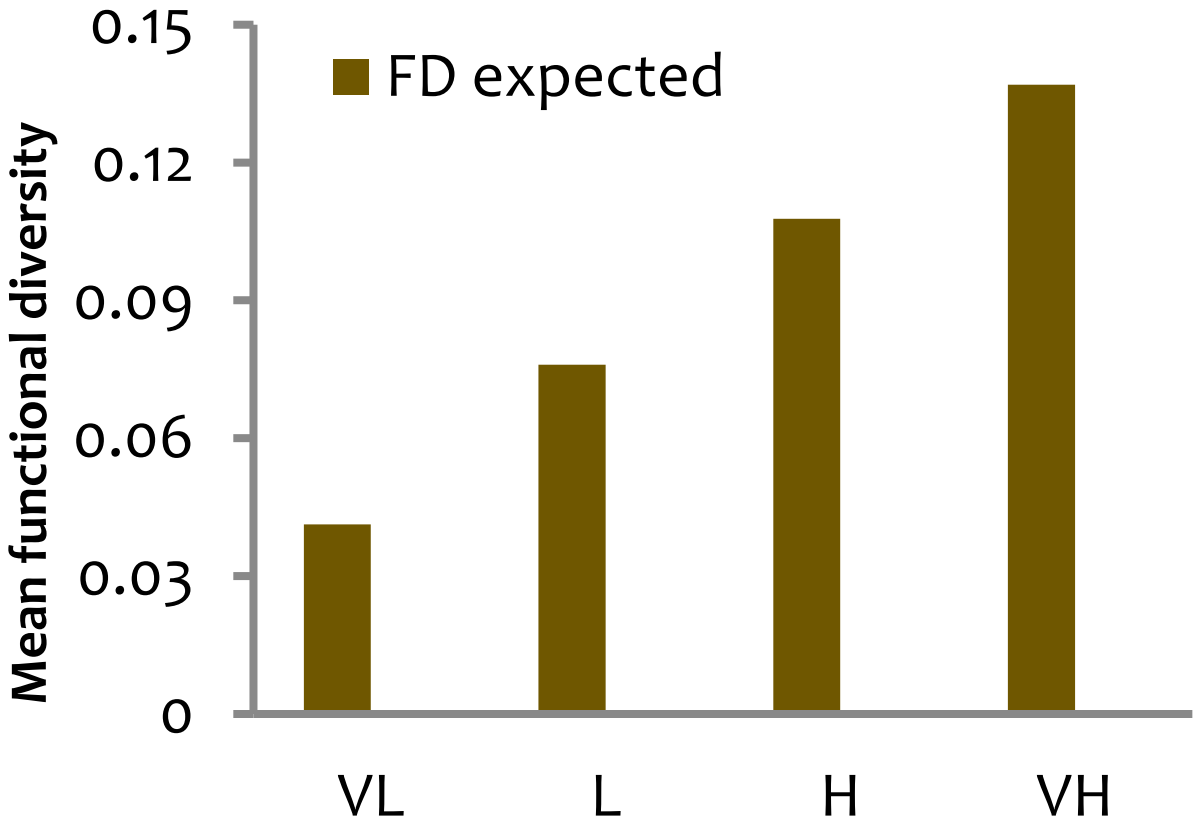


Vegetation monitoring

- Horizontal cover in quadrats

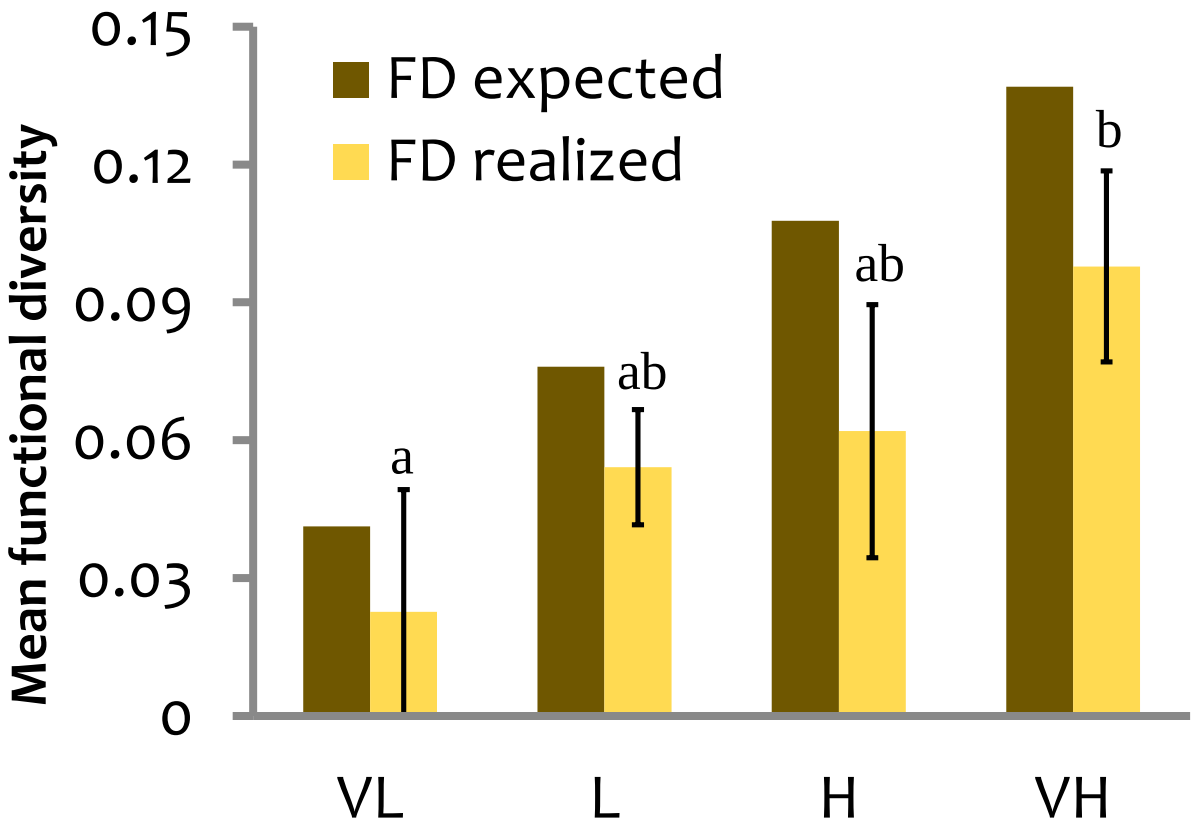
Results

What was sown:



Results

What is established in the field?



P=0.007 (Kruskal-Wallis rank sum test)

Realized functional diversity influenced by:

- Species that did not germinate

Realized functional diversity influenced by:

- Species that did not germinate
- Spontaneous species

Realized functional diversity influenced by:

- Species that did not germinate
- Spontaneous species
- Species more or less abundant

Key message

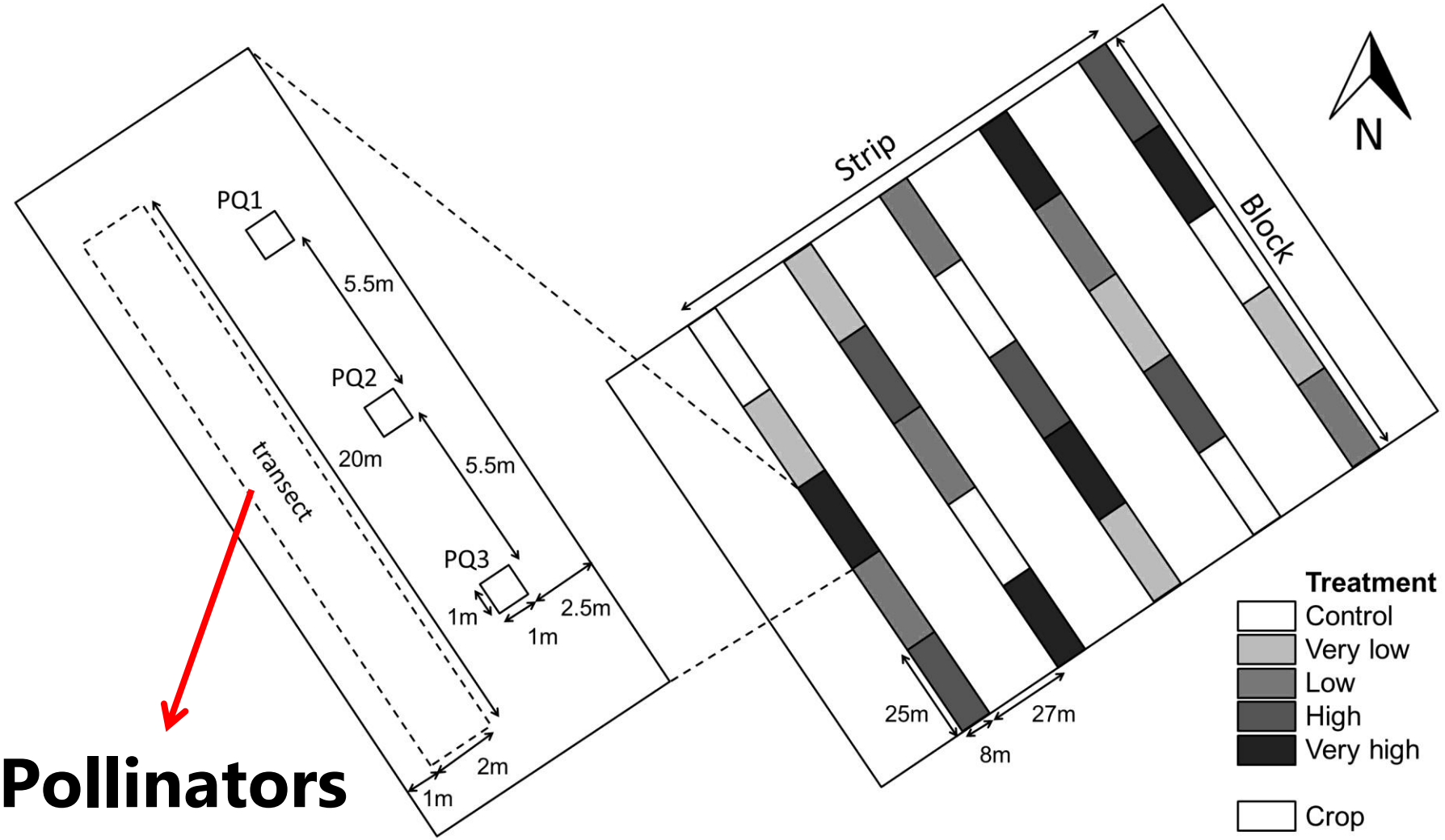
- Possible to manipulate FD when sowing flower strips

3. IS PLANT FUNCTIONAL DIVERSITY THE KEY TO PROMOTE POLLINATORS IN FLOWER STRIPS?

Published article in Agriculture, Ecosystems and Environment (2017), 249: 144-155

R. Uyttenbroeck, J. Piqueray, S. Hatt, G. Mahy & A. Monty

Q2: Is plant functional diversity the key to promote pollinators in flower strips?

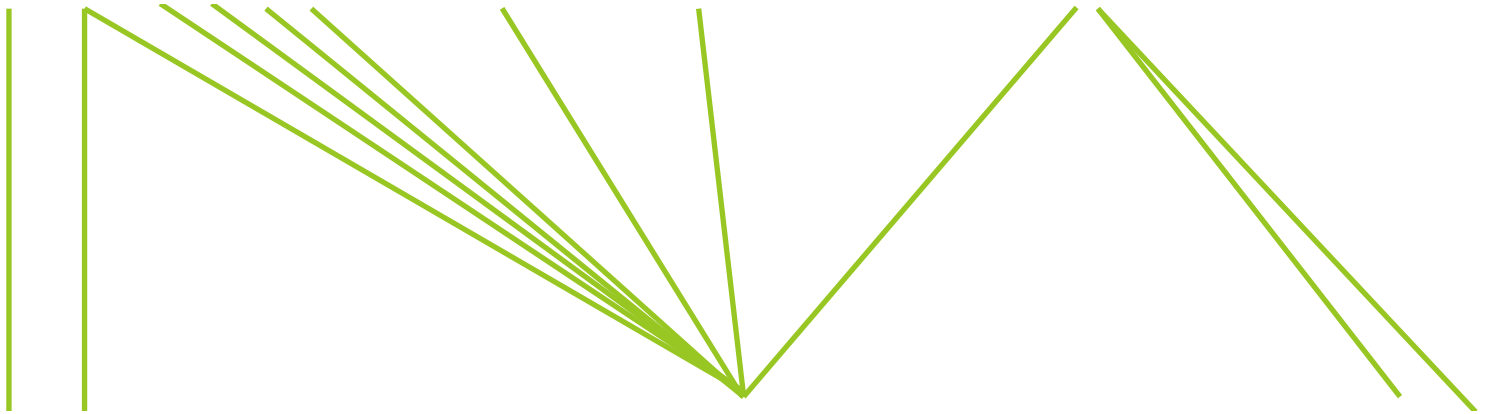


Pollinators

Functional diversity for pollinators




Pollinators



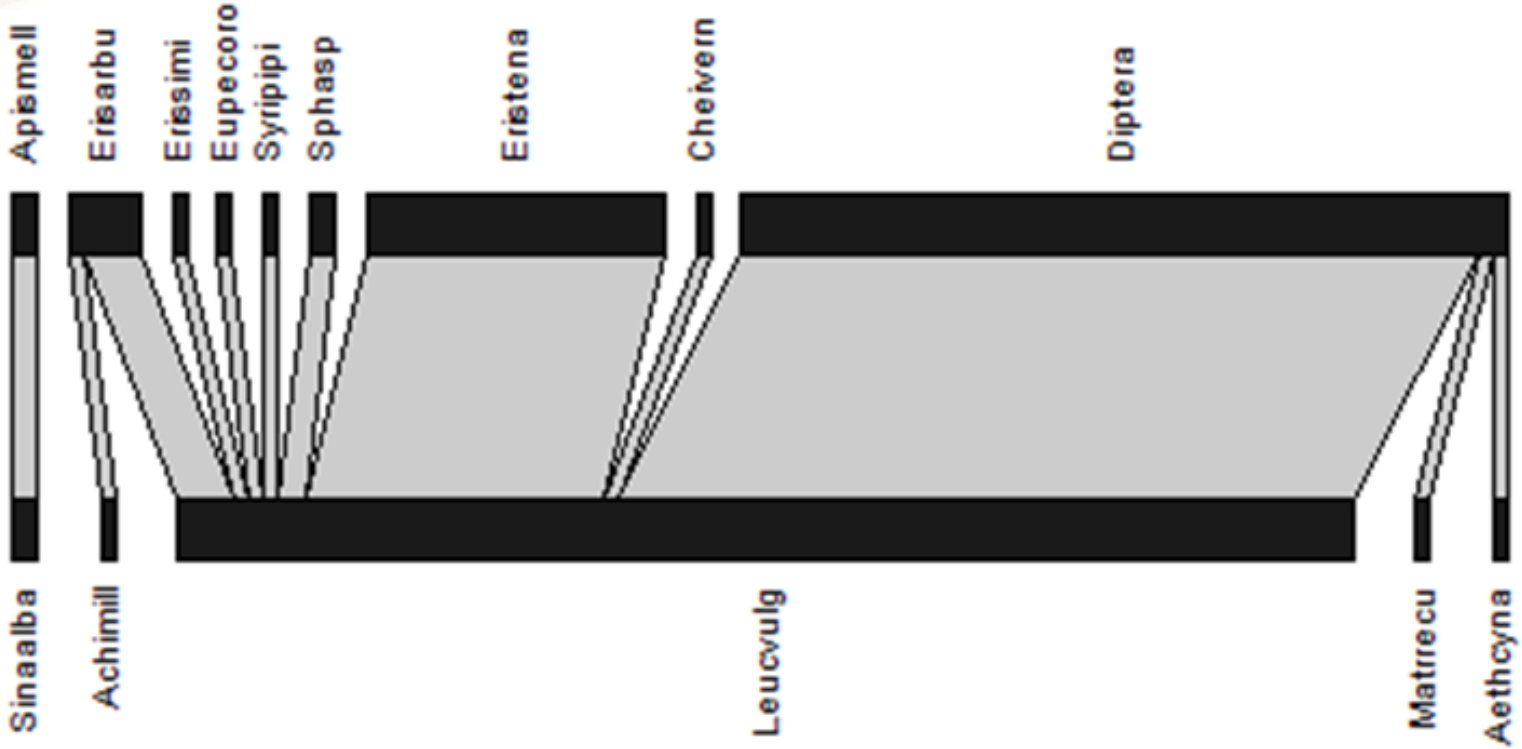
Plants




Functional diversity for pollinators




Pollinators



Plants




Identification

Which pollinators


Eristalis tenax


Dipera sp.

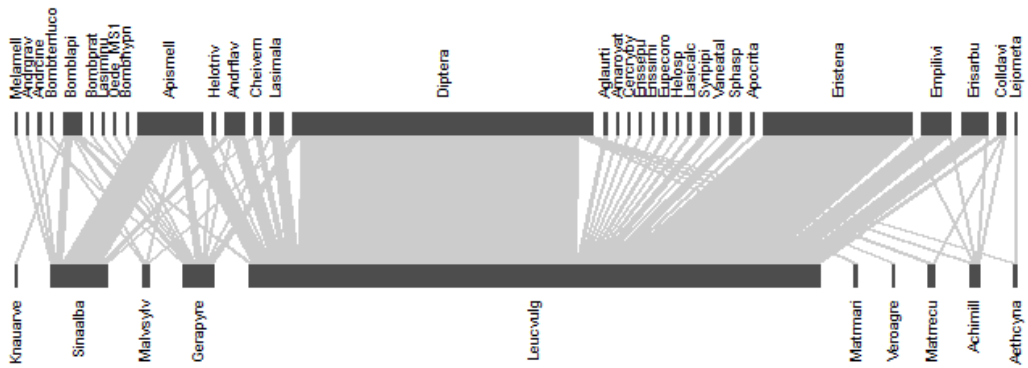

Apis mellifera


Andrena flavipes

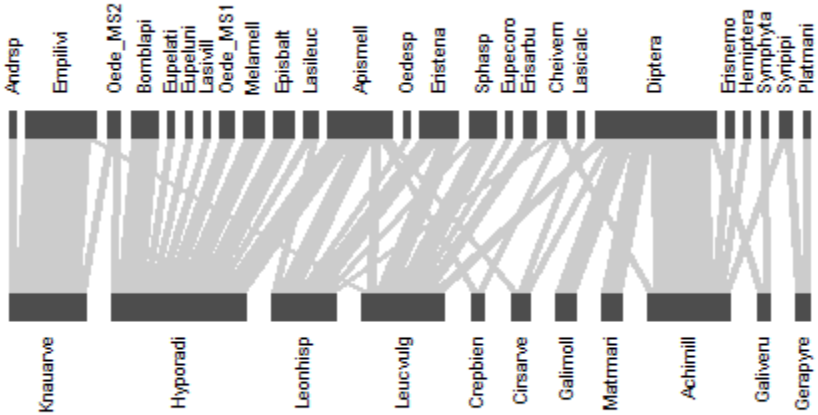
Pollinator group	Interactions	Number species
Syrphid flies	828	25
Other flies	678	-
Honeybees	288	1
Dagger flies	168	2
Bumblebees	129	5
Solitary bees	115	18
Oedemeridae	26	-
Butterflies	8	4
Digger wasp	5	4
Sawflies	4	-
Bugs	2	-
Moth	2	2
Other wasps	2	1
Ground beetles	1	1
Social wasps	1	1
Soldier flies	1	1

Functional diversity for pollinators

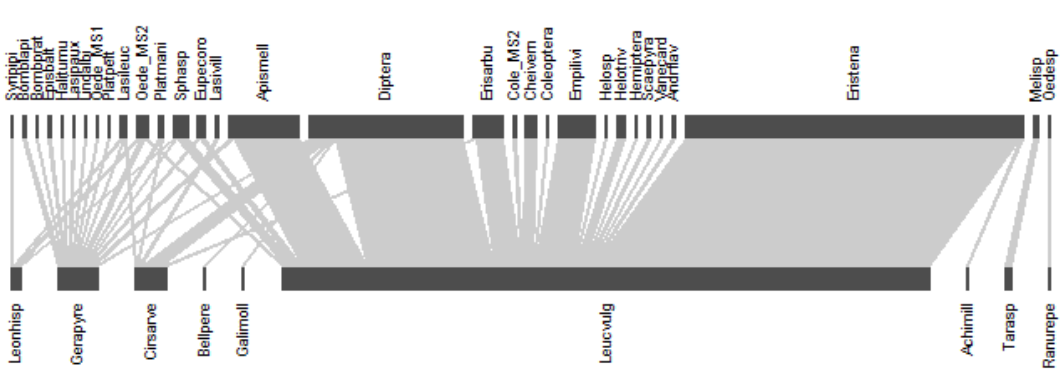
Very low



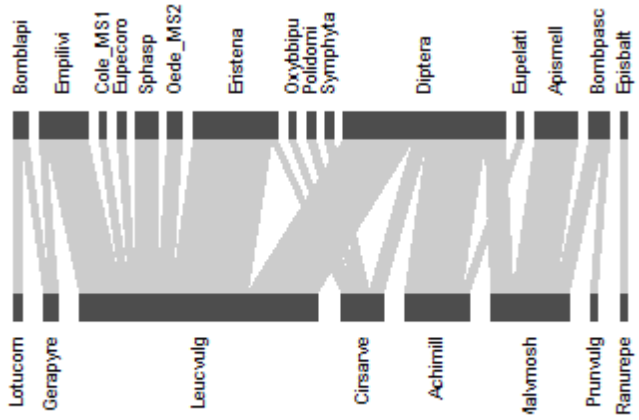
Low



High

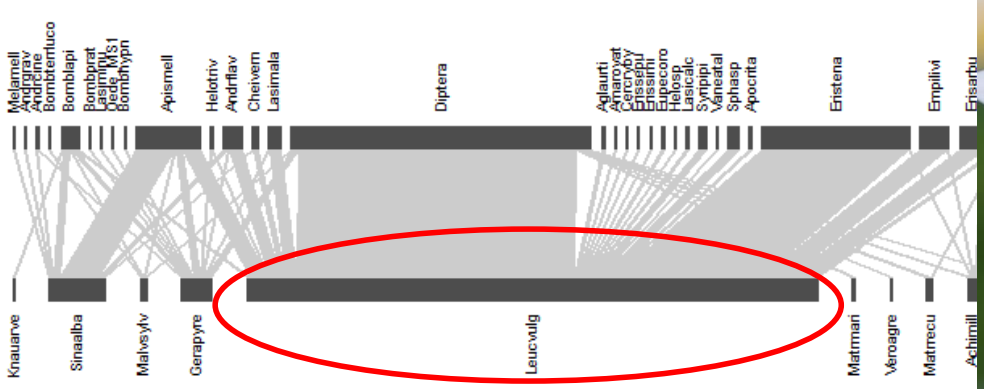


Very high

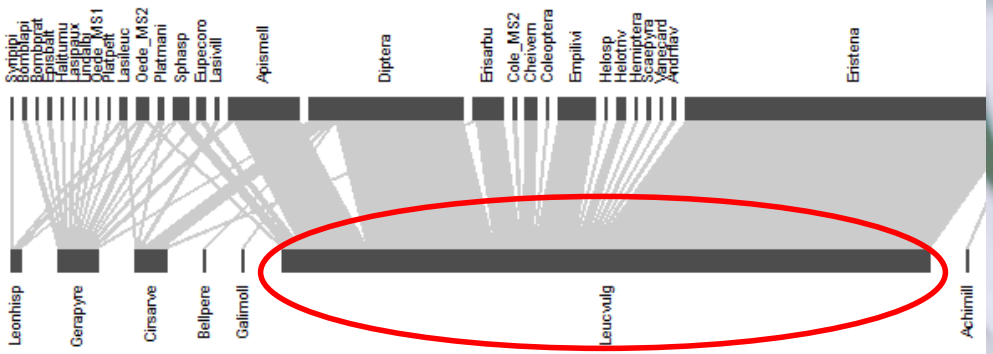


Functional diversity for pollinators

Very low

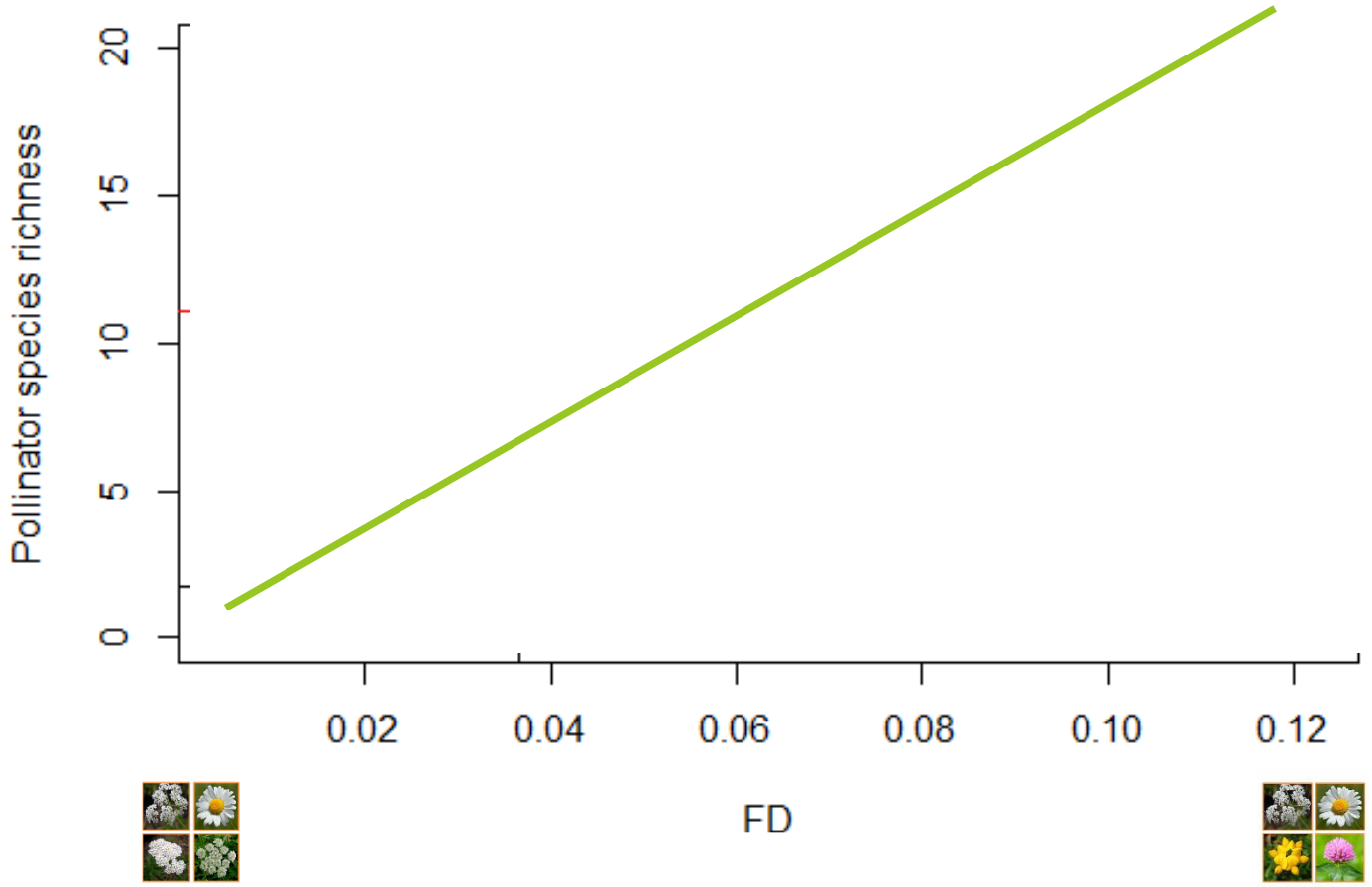


High



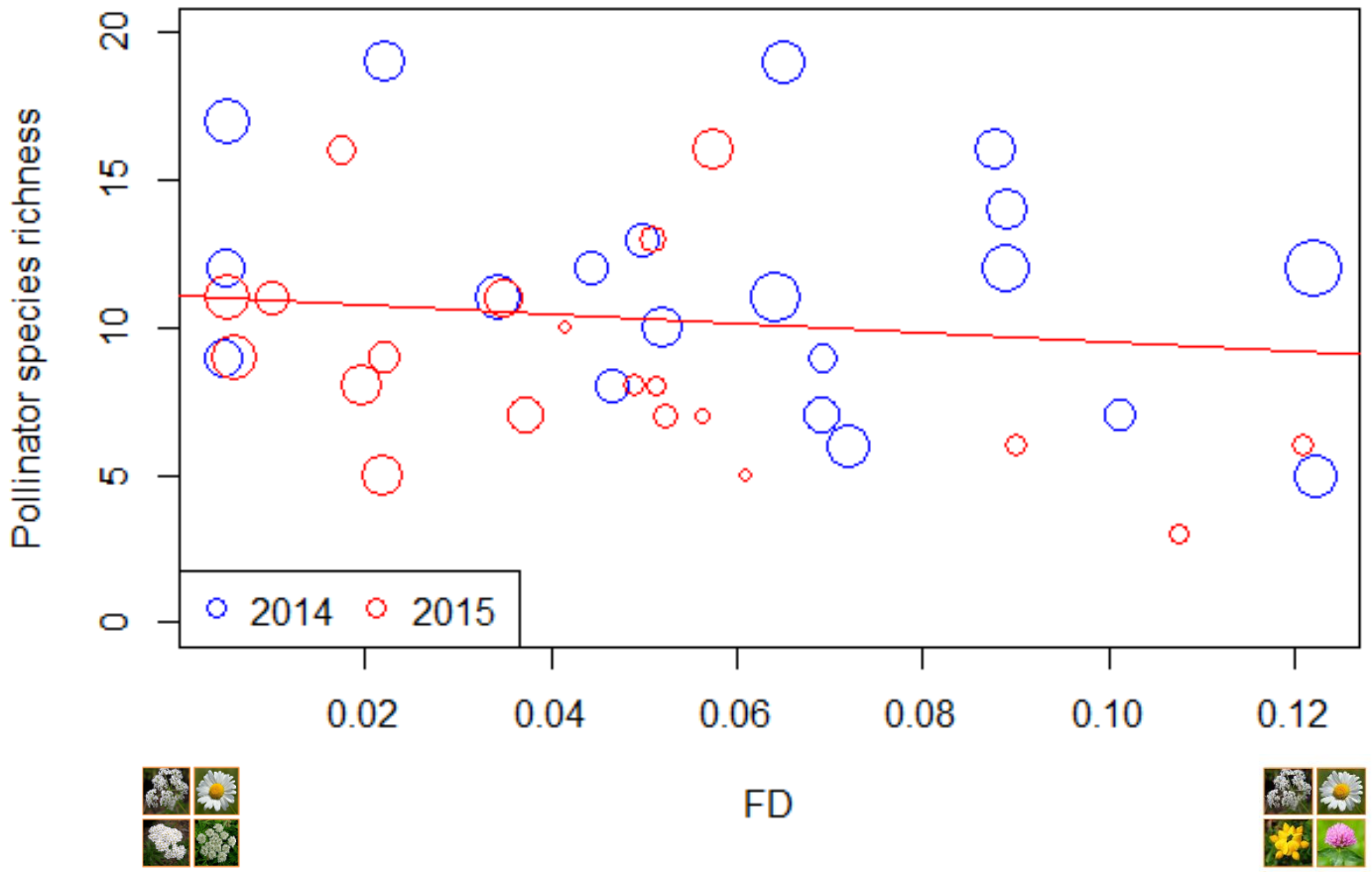
Pollinator species richness

Plant functional diversity↑ ➔ pollinator species richness↑?



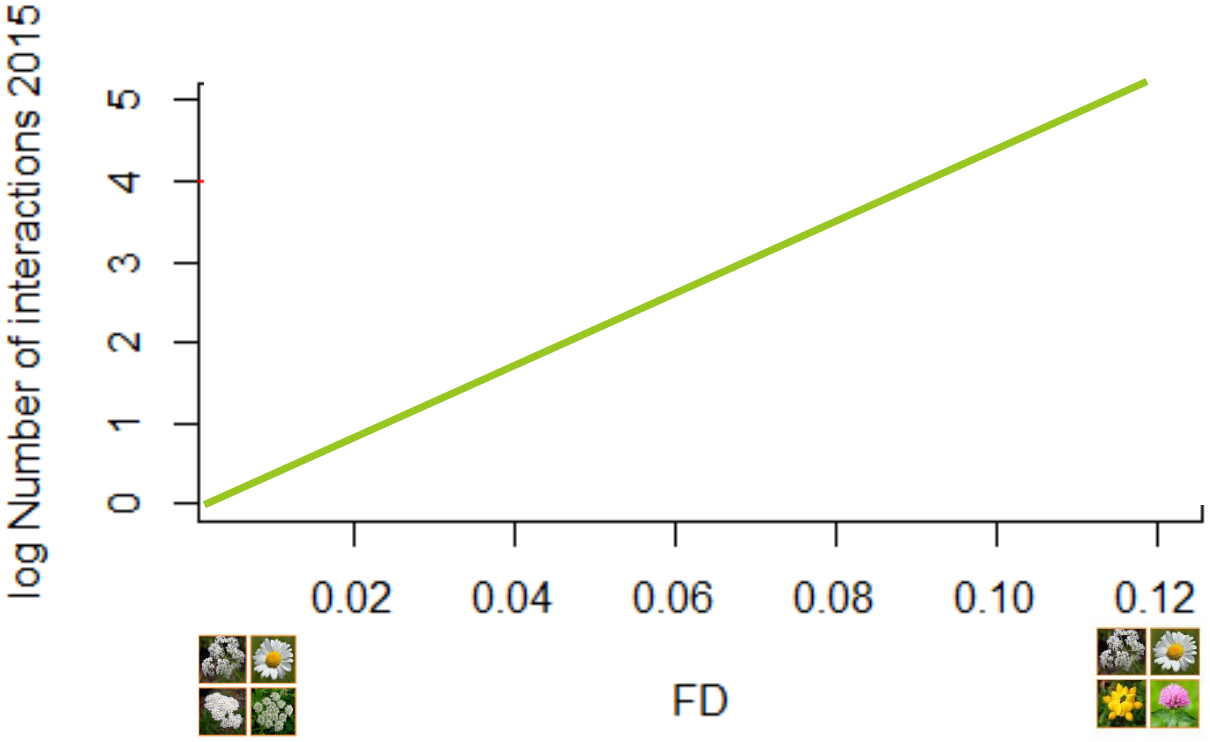
Pollinator species richness

Plant functional diversity↑ → pollinator species richness↑?



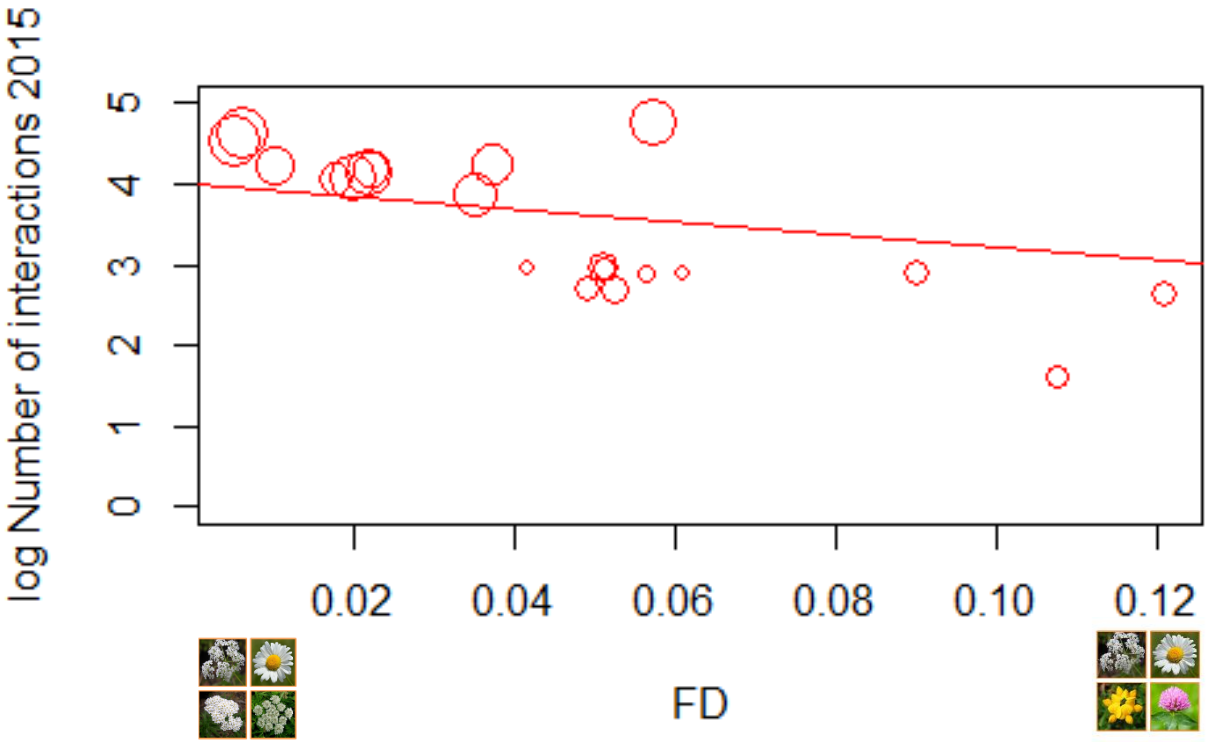
Number of interactions

Plant functional diversity↑ ➔ number of interactions↑?

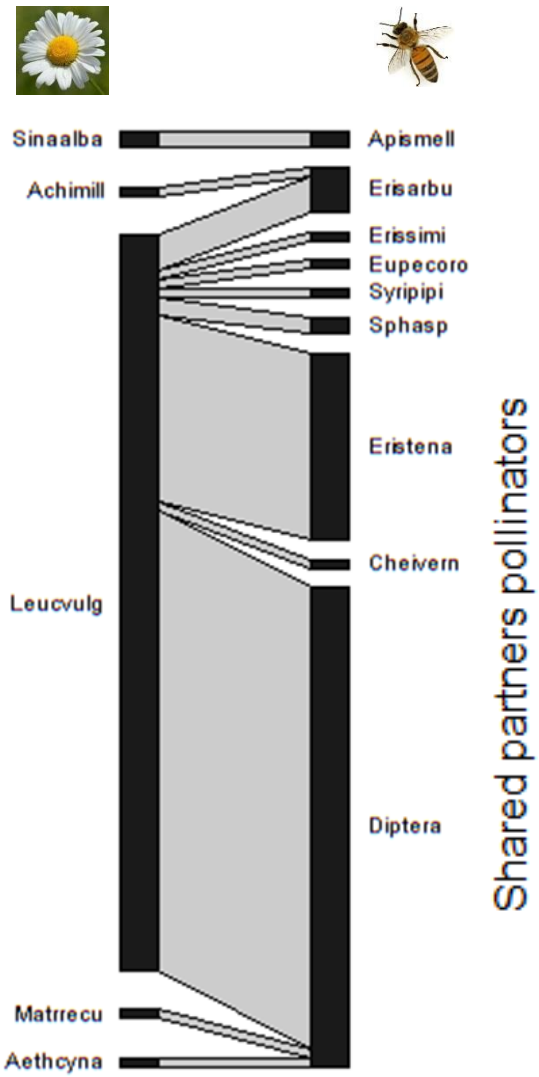


Number of interactions

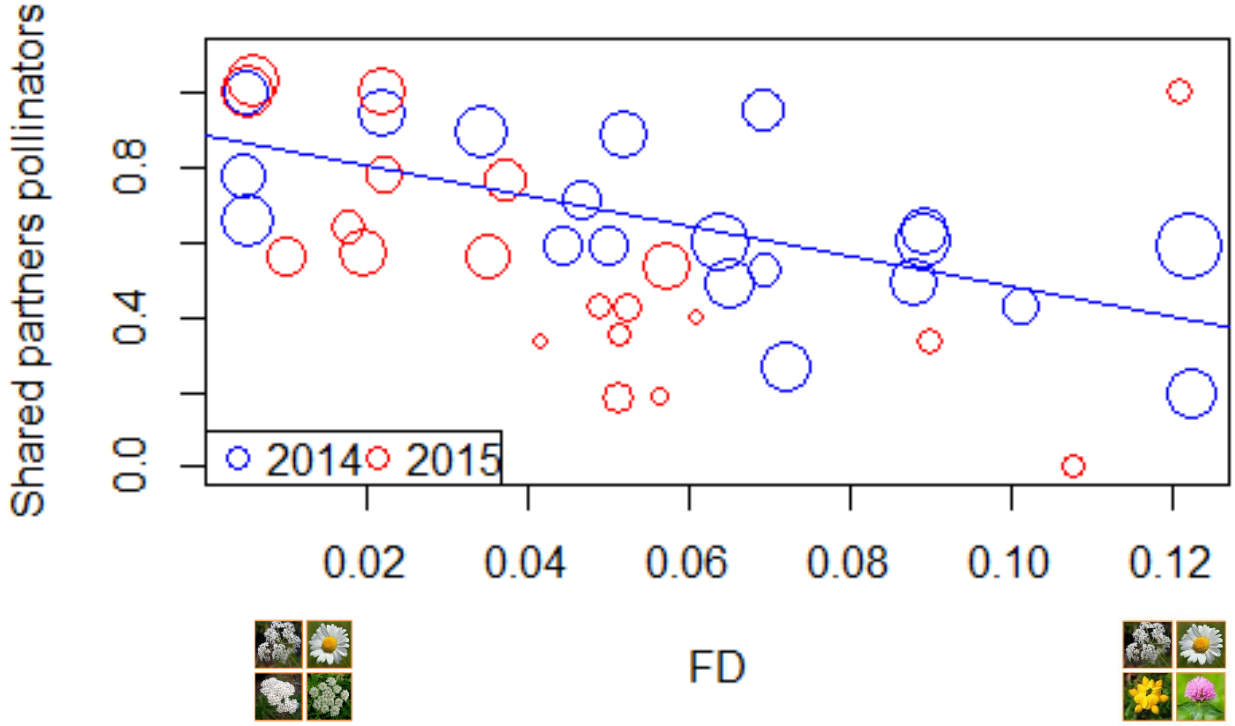
Plant functional diversity↑ → number of interactions↑?



Overlap in visited plant species



How many visited plant species (=feeding niche) do pollinators have un common?



Key messages

- Increasing FD is not the key
- ↑FD ➔ flower species functionally more different

  ➔ ↓ overlap pollinator feeding niches

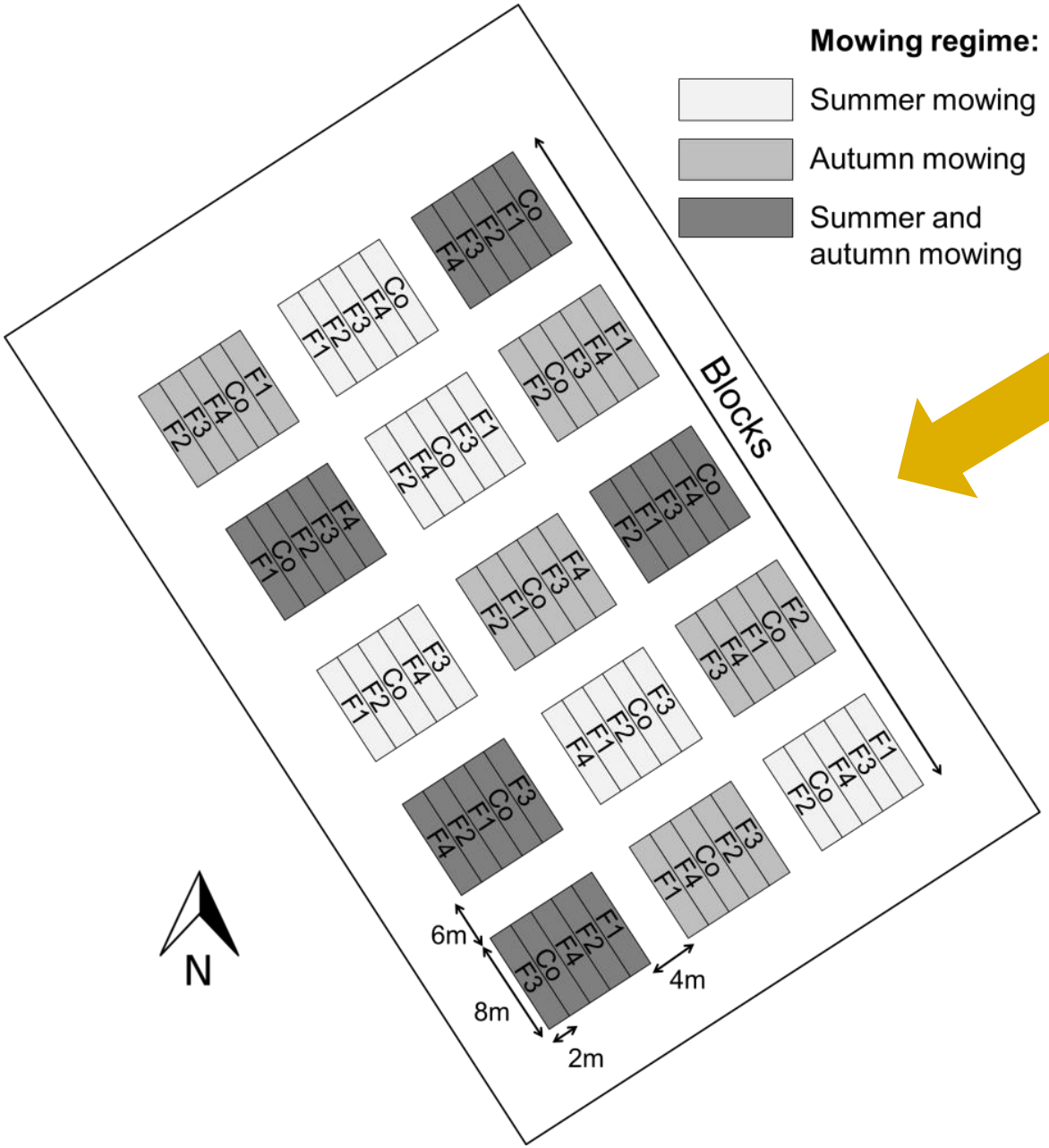
4. MOWING REGIME AND FORB COMPETITION AS TOOLS TO REDUCE WEEDS IN FLOWER STRIPS

Research paper in revision for Weed Research

R. Uyttenbroeck, J. Piqueray, S. Hatt, G. Mahy & A. Monty

Q3: Can adapting mowing regime and forb competition be used as tools to reduce weed infestation in perennial flower strips?

Weeds in flower strips



- Grass and forbs: F1,2,3,4
- Grass only: Co

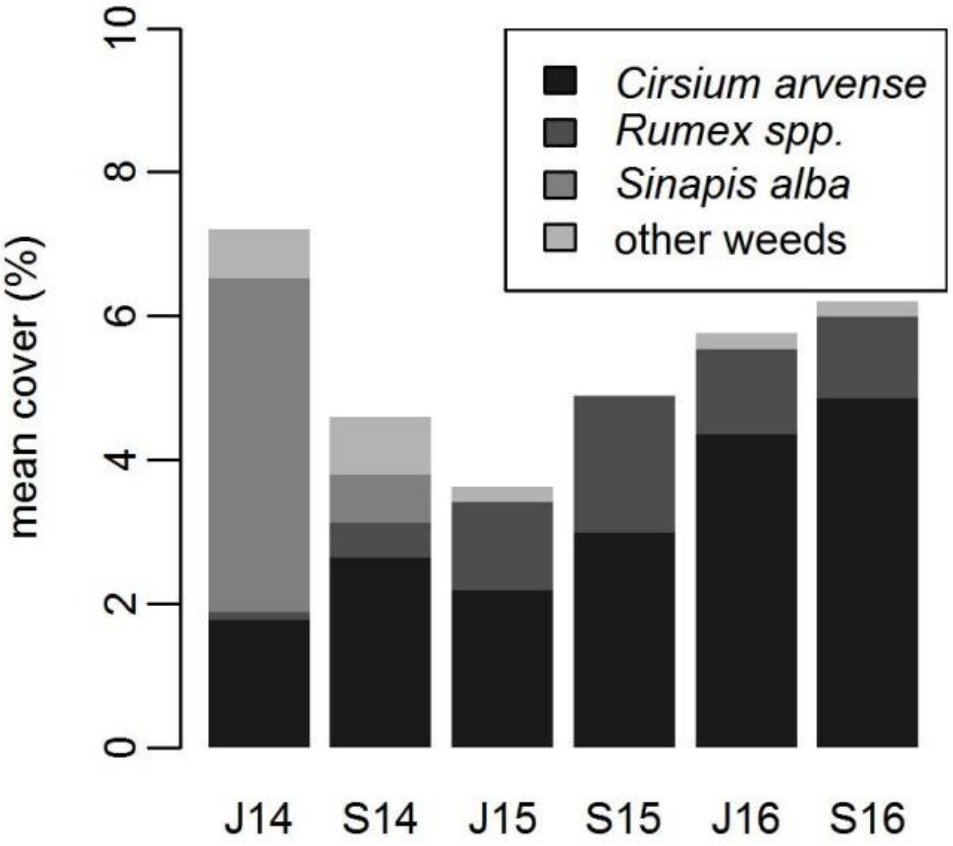
- Mowing timing and frequency:

  Summer, autumn, summer and autumn

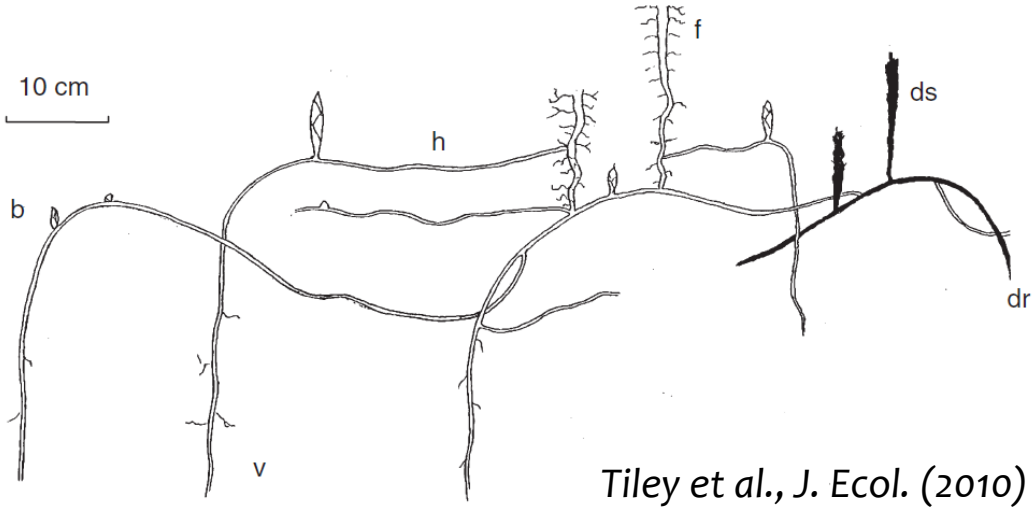
Vegetation monitoring

- Horizontal cover in a 1x1m quadrat
- 2014-2015-2016

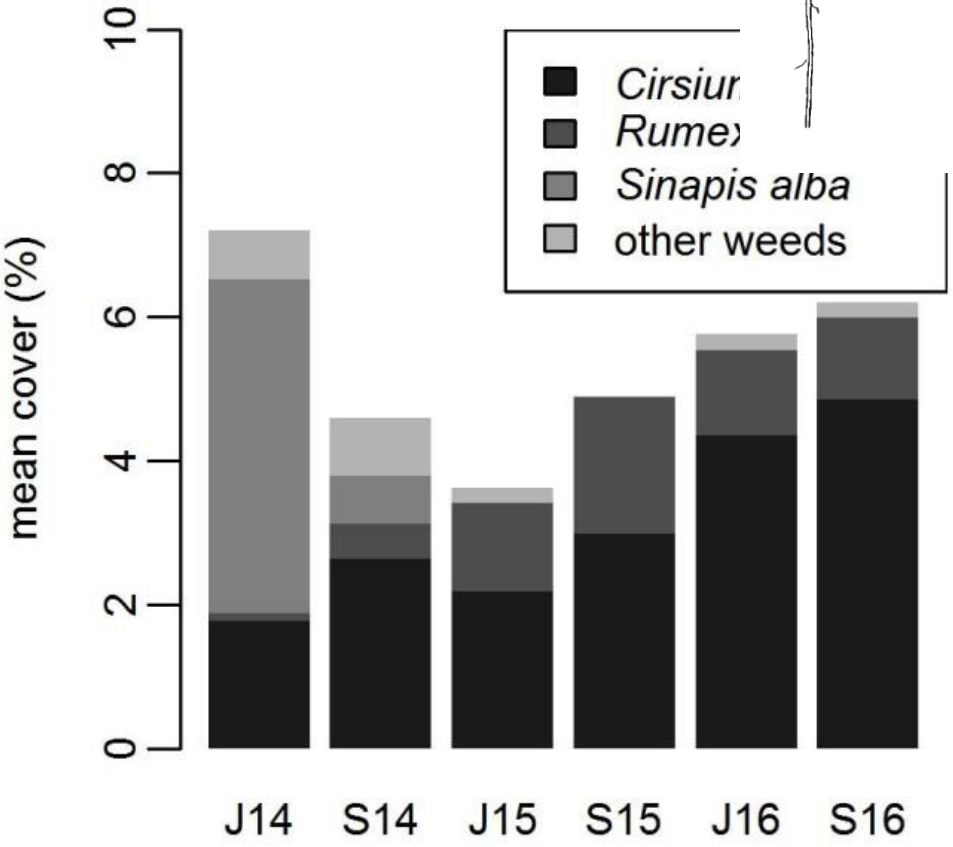
Results


mean cover (%)
0
2
4
6
8
10
J14
S14
J15
S15
J16
S16
Cirsium arvense
Rumex spp.
Sinapis alba
other weeds

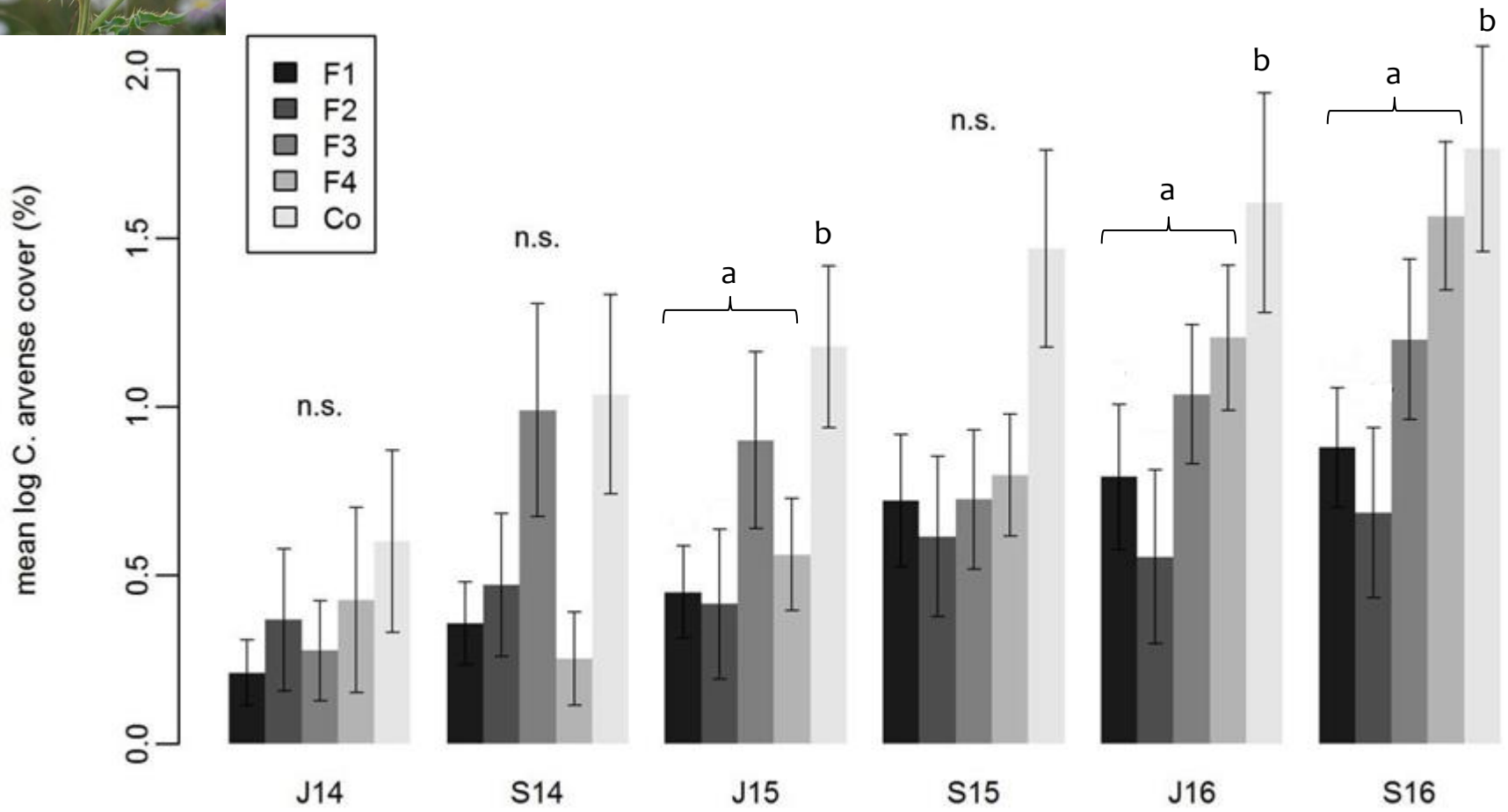
Results



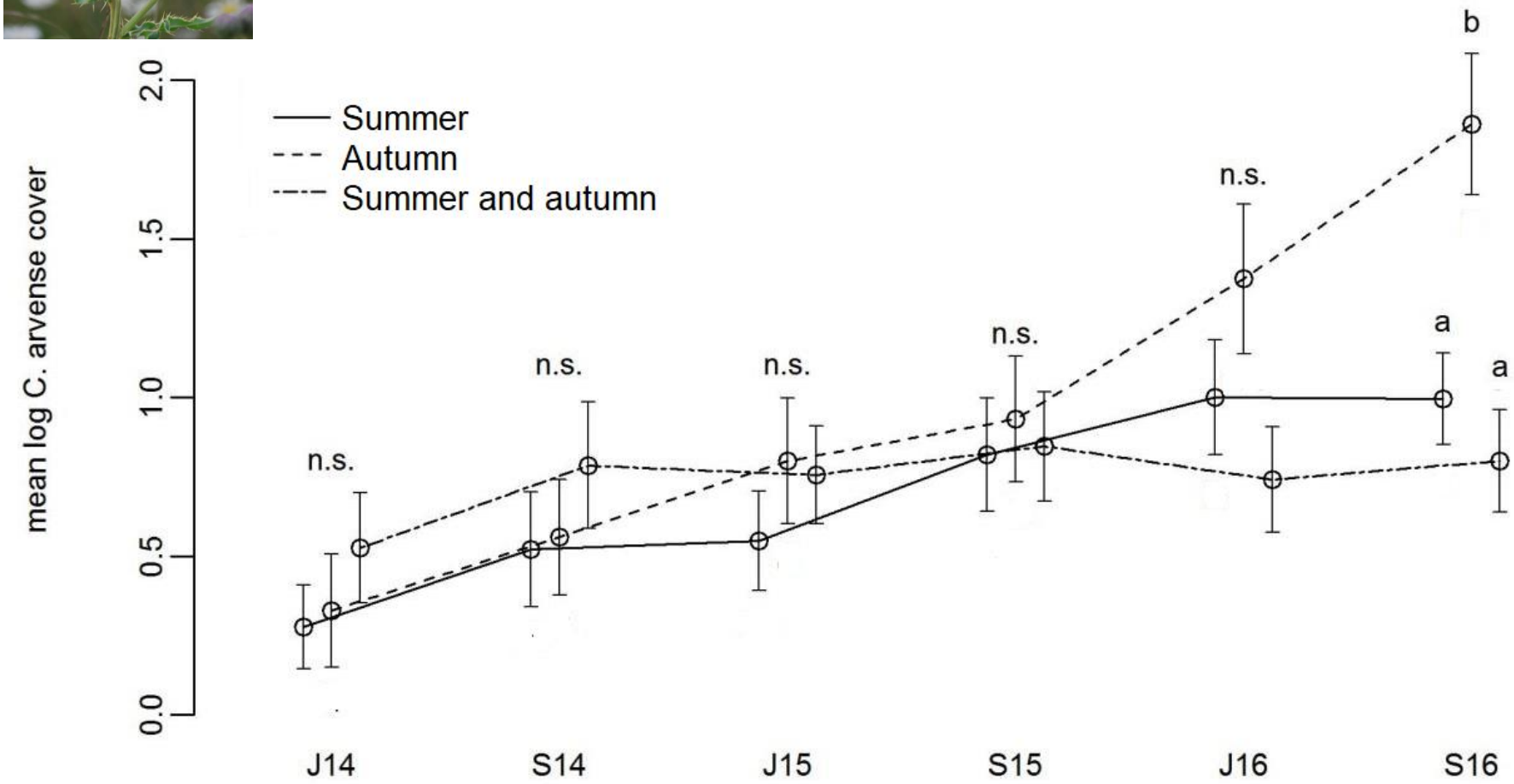
Tiley et al., J. Ecol. (2010)

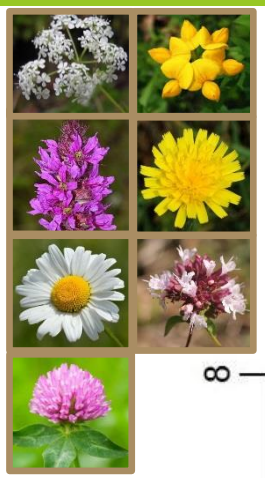


Forb competition

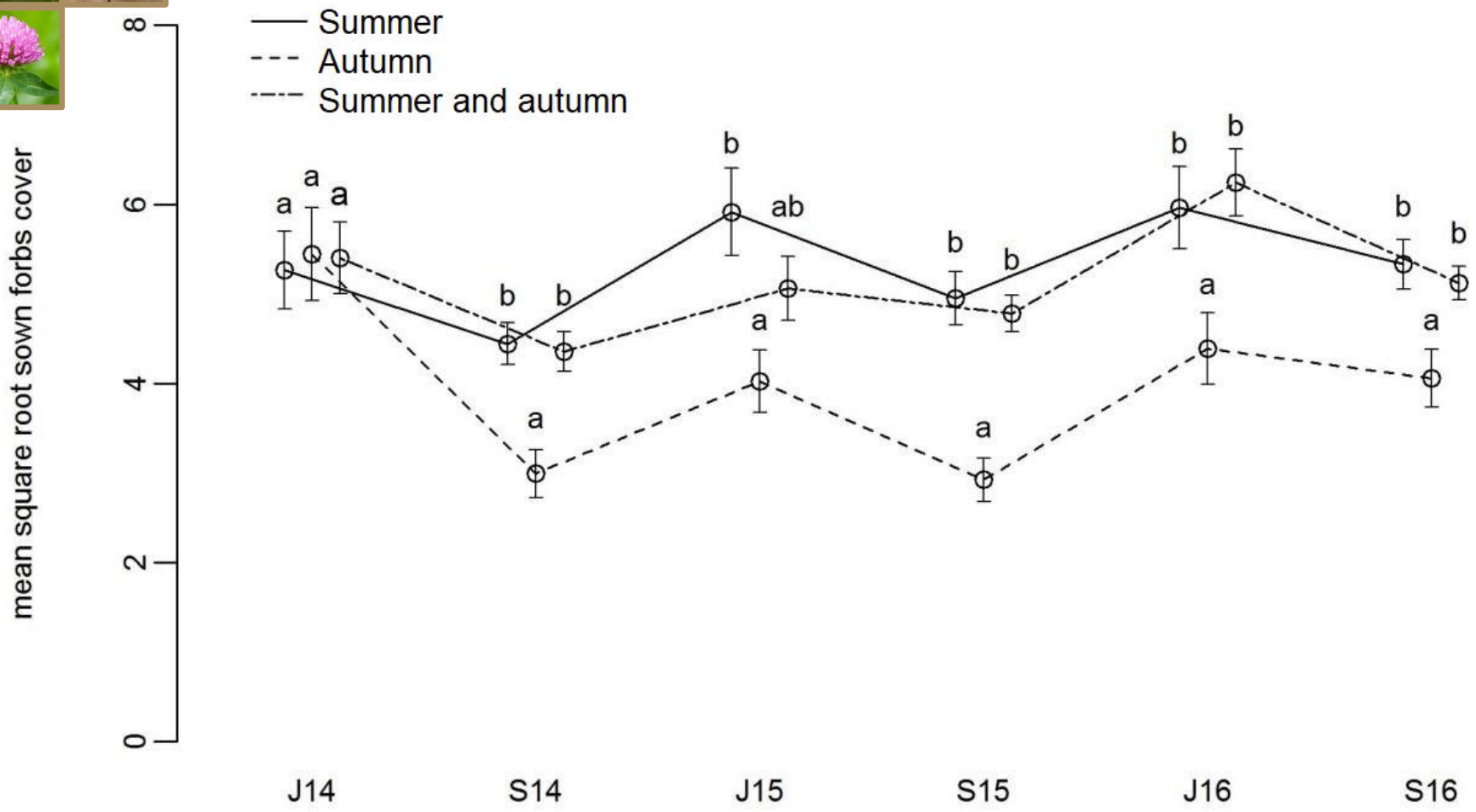


Mowing regime





Mowing regime and forb cover



Weeds in flower strips

DIRECT

INDIRECT

Key messages

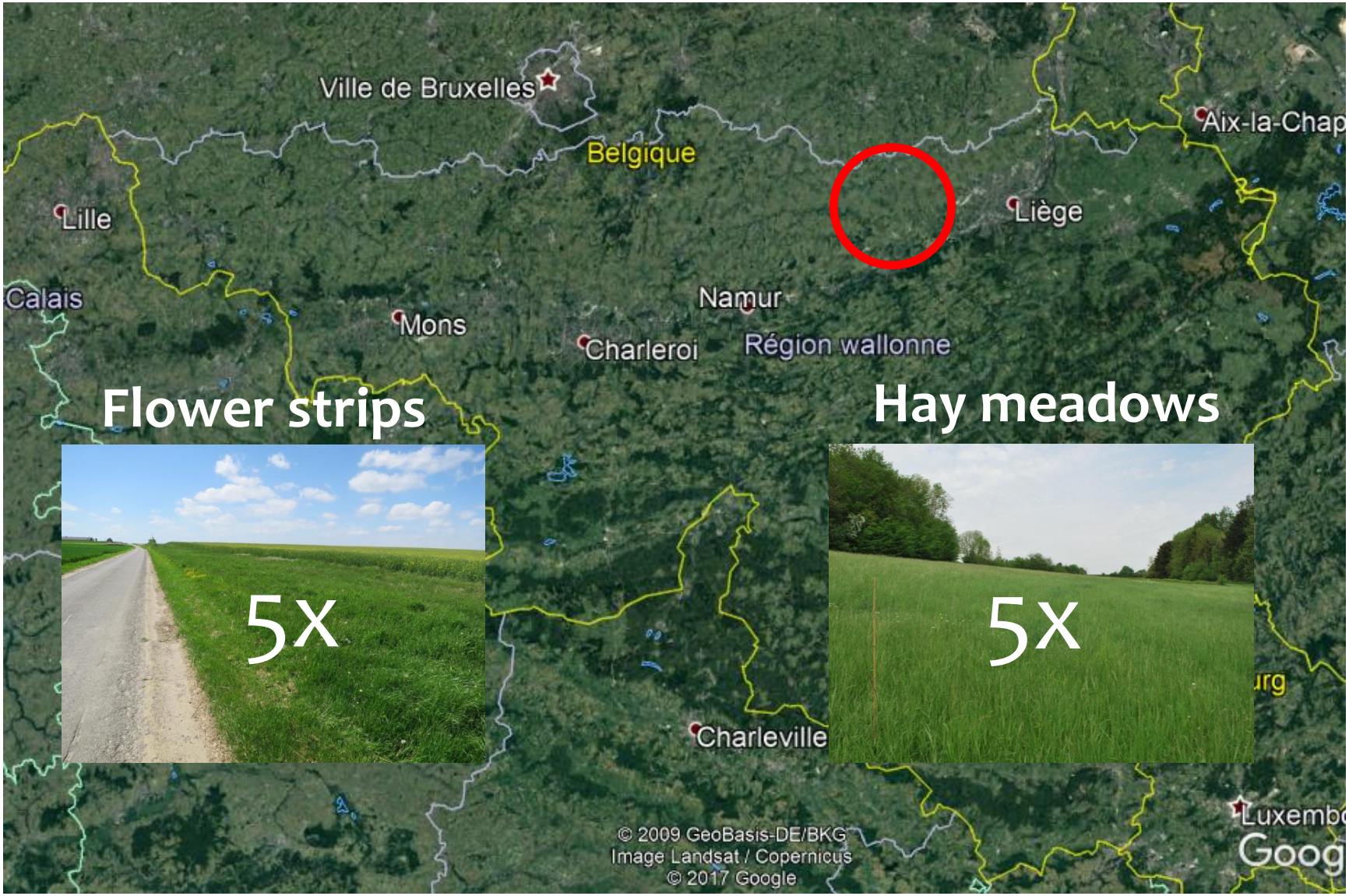
- Adding sown forbs can reduce *C. arvense* cover
- Summer and Summer/ autumn mowing better for:
  - Reducing *C. arvense* cover
  - Keeping sown forb cover
  - Possibly direct and indirect effect on *C. arvense*

5. ARE PERENNIAL FLOWER STRIPS A SURROGATE FOR HAY MEADOWS?

Paper in preparation

Q4: Are perennial flower strips a surrogate for hay meadows?

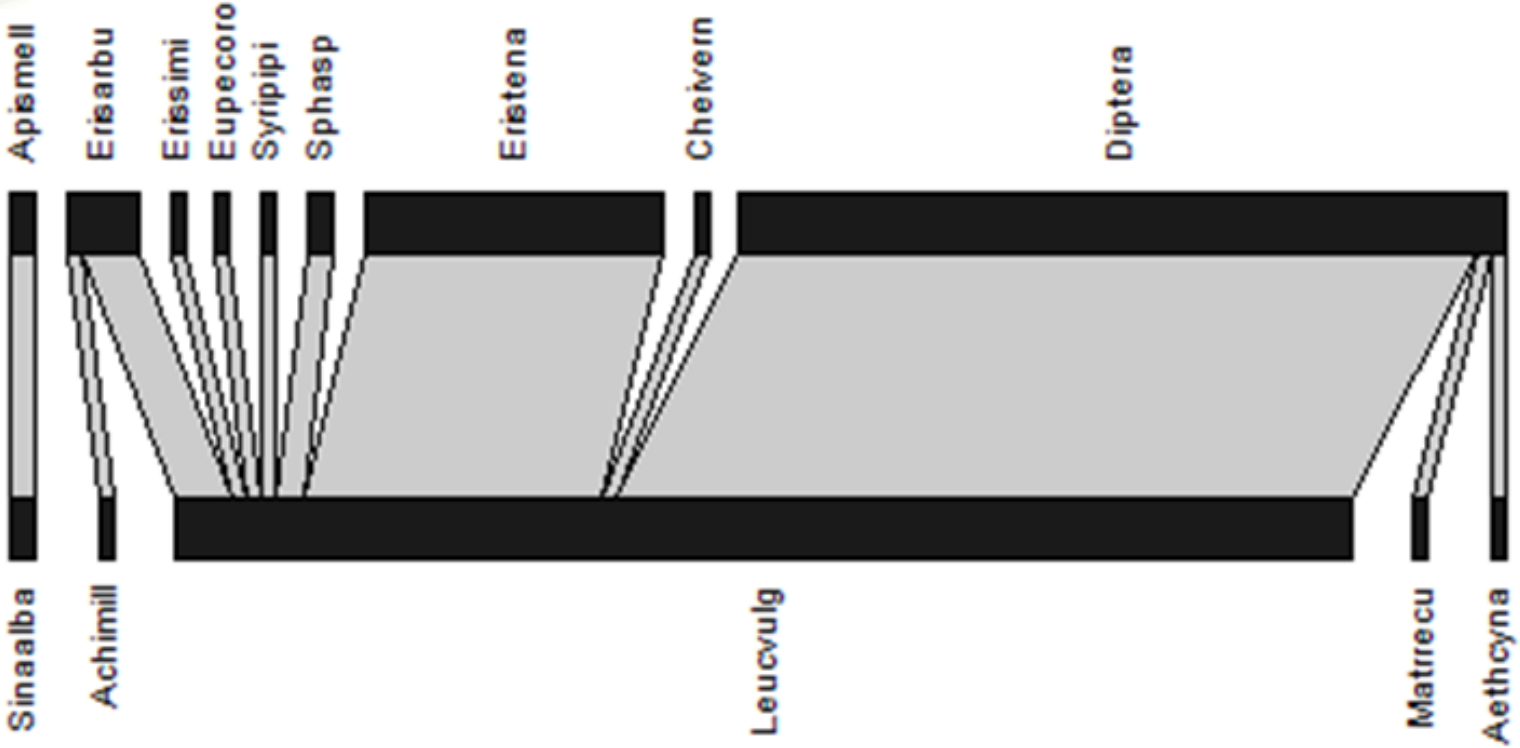
Flowers strips and hay meadows



Flowers strips and hay meadows



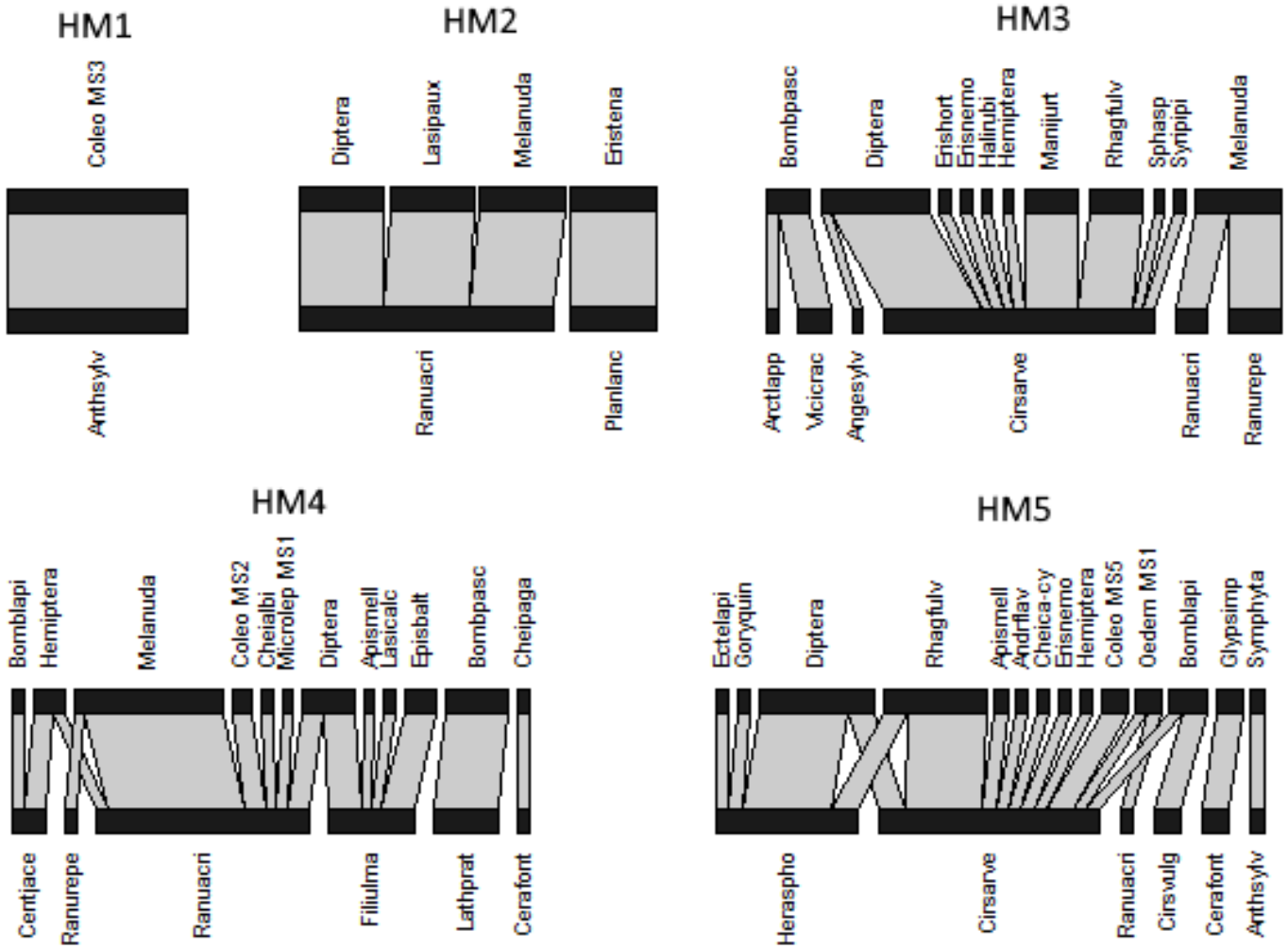

Pollinators



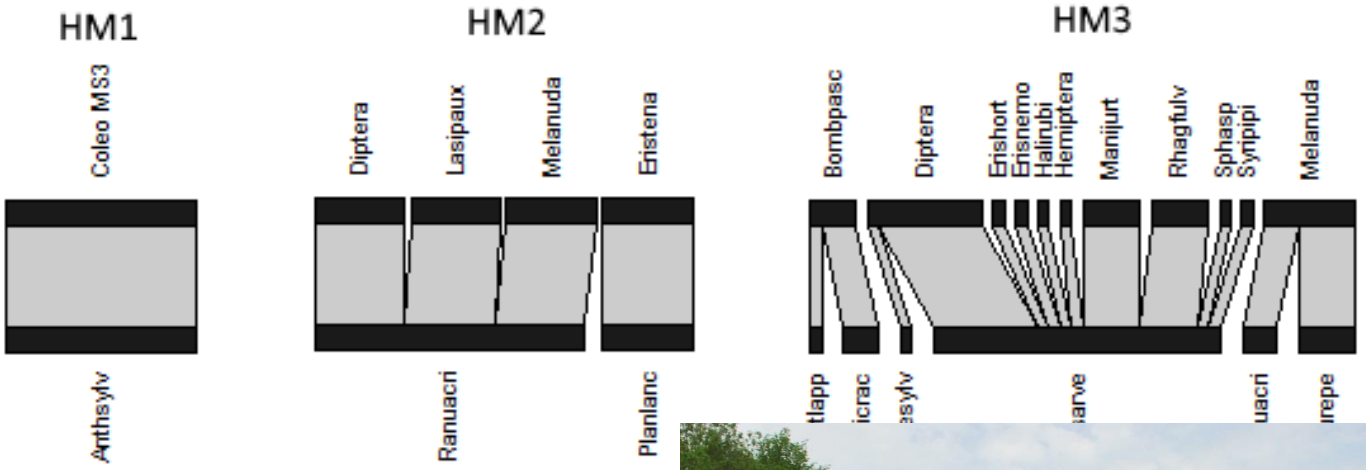
Plants




Hay meadows


HM1
Coleo MS3
Anthsylv
HM2
Diptera
Lasipaux
Melanuda
Eristena
Ranuacri
Planlanc
HM3
Bombpasc
Diptera
Erishort
Erisnemo
Halirubi
Hemiptera
Manijurt
Rhagfulv
Sphasp
Syripipi
Melanuda
Arctlapp
Mcicrac
Angesylv
Cirsarve
Ranuacri
Ranurepe
HM4
Bomblapi
Hemiptera
Melanuda
Coleo MS2
Cheialbi
Microlep MS1
Diptera
Apismell
Lasicalc
Episbalt
Bombpasc
Cheipaga
Centjace
Ranurepe
Ranuacri
Filiulma
Lathprat
Cerafort
HM5
Ectelapi
Goryquin
Diptera
Rhagfulv
Apismell
Andrflav
Cheica-cy
Erisnemo
Hemiptera
Coleo MS5
Oedem MS1
Bomblapi
Glypsimp
Symphyta
Heraspho
Cirsarve
Ranuacri
Cirsvulg
Cerafort
Anthsylv

Hay meadows


HM1
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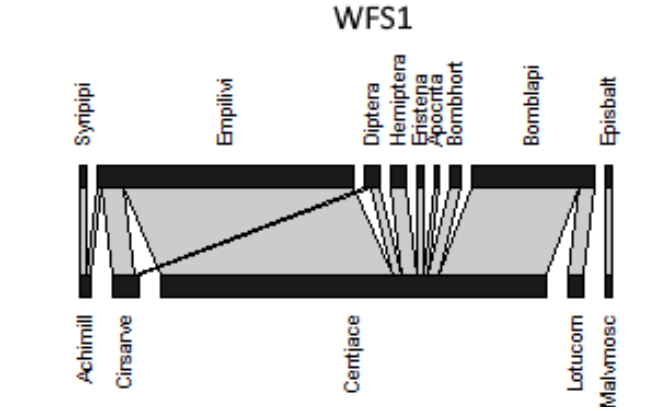
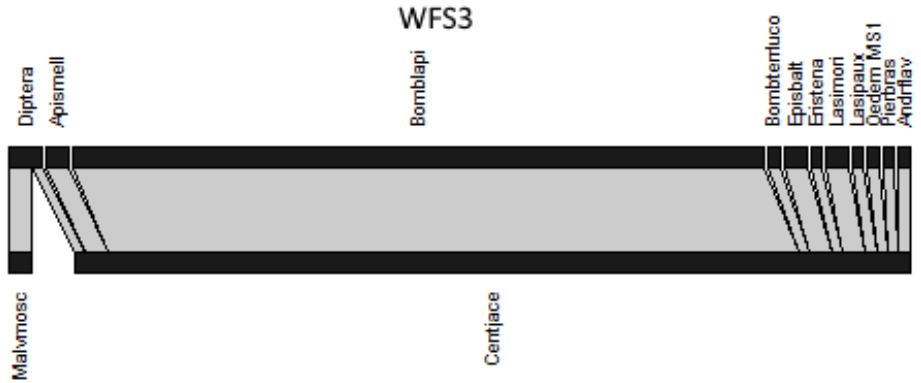
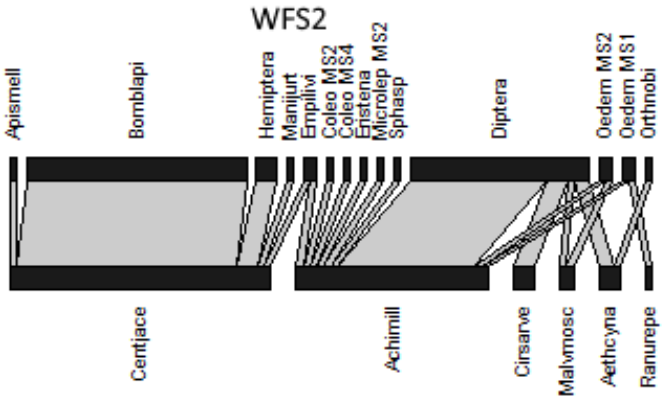
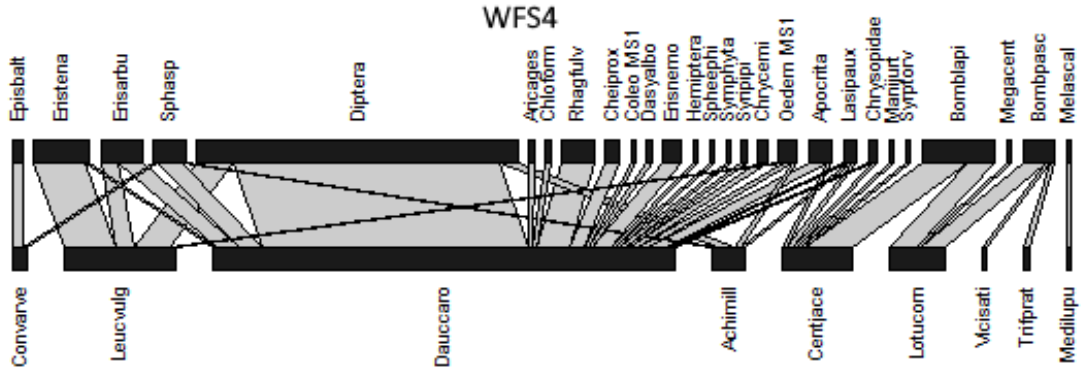
Apismell
Lasicalc
Episbalt
Bombpasc
Cheipaga
Certjace
Ranurepe
Ranuacri
Filiulma
Lathprat
Cerafort

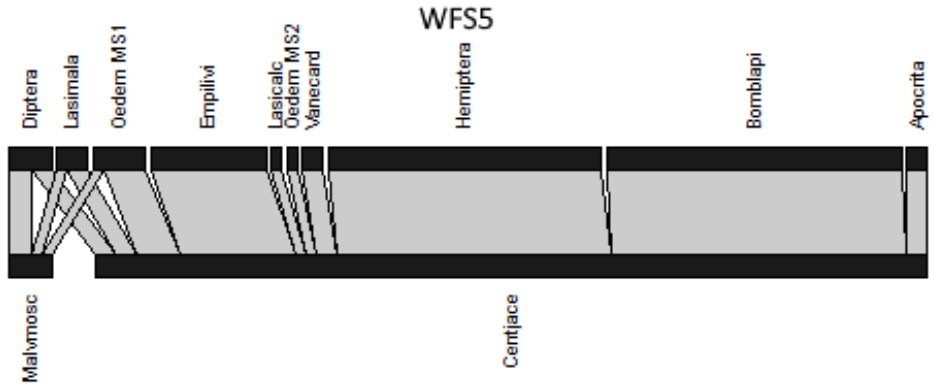
Flower strips



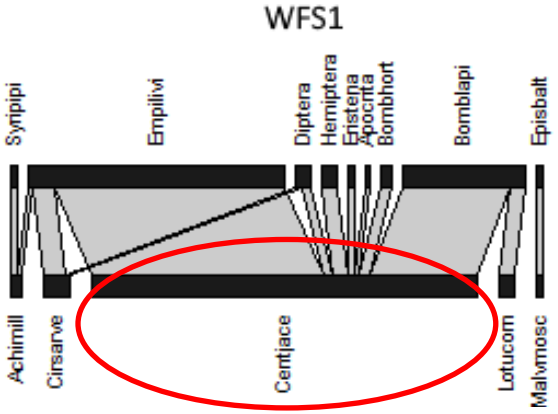


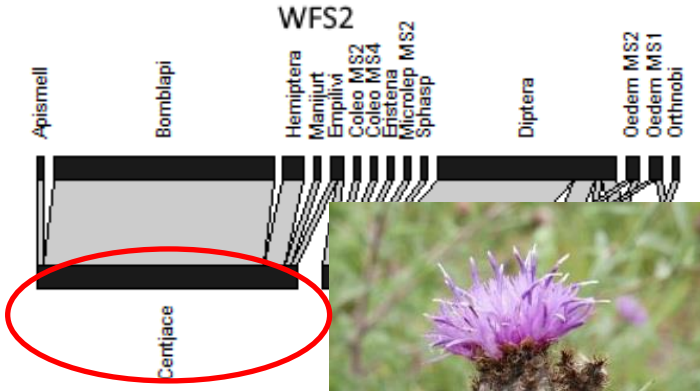


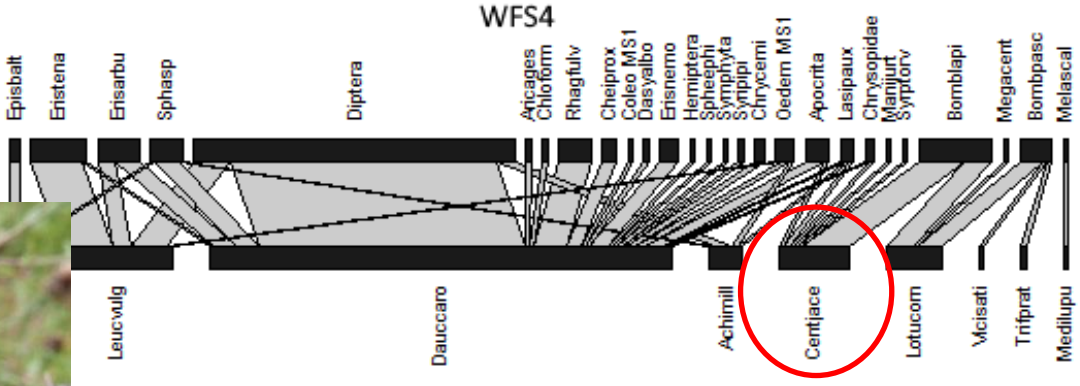


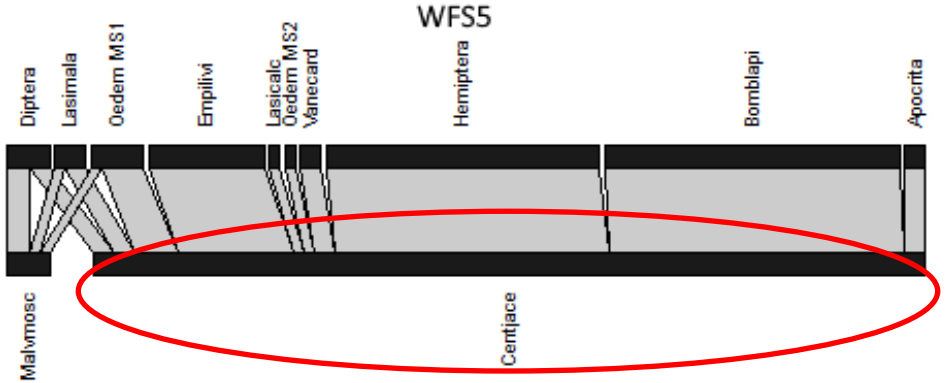


Flower strips

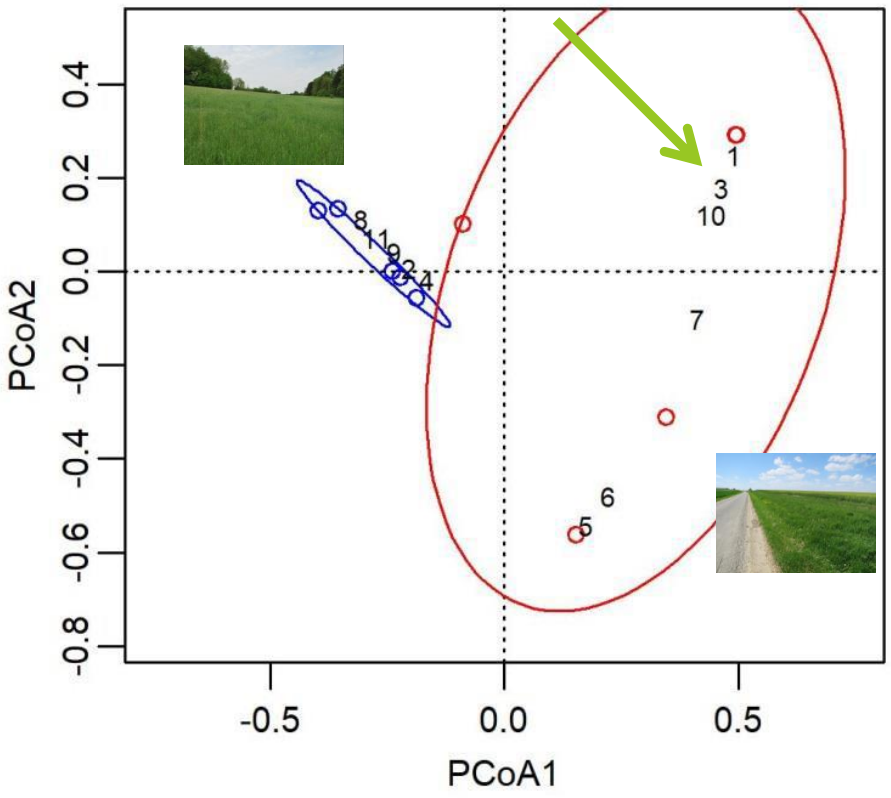


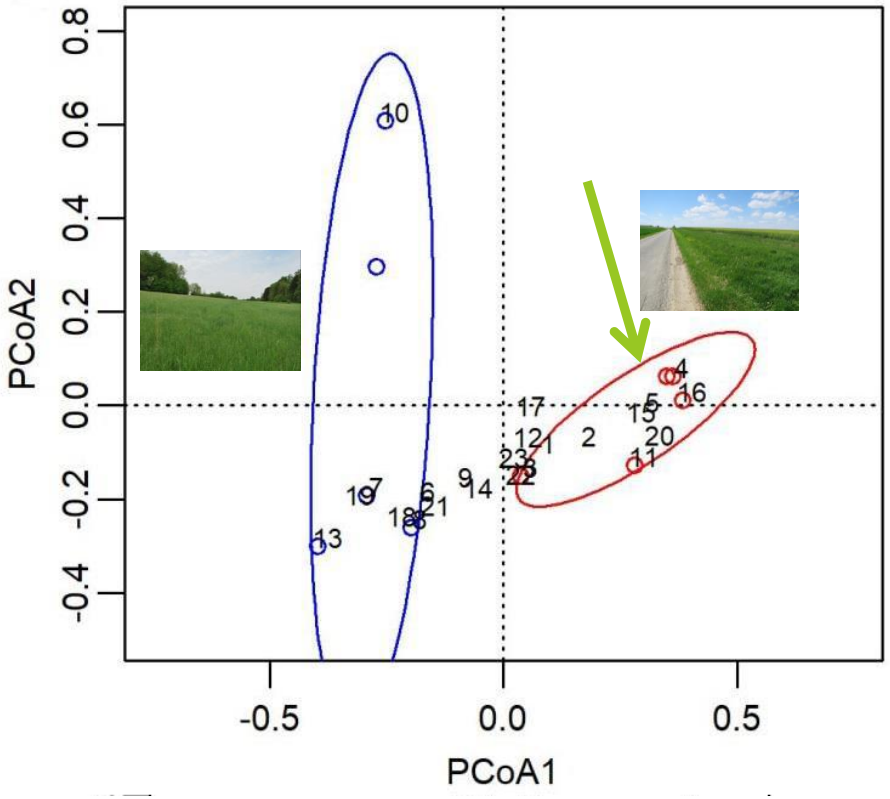




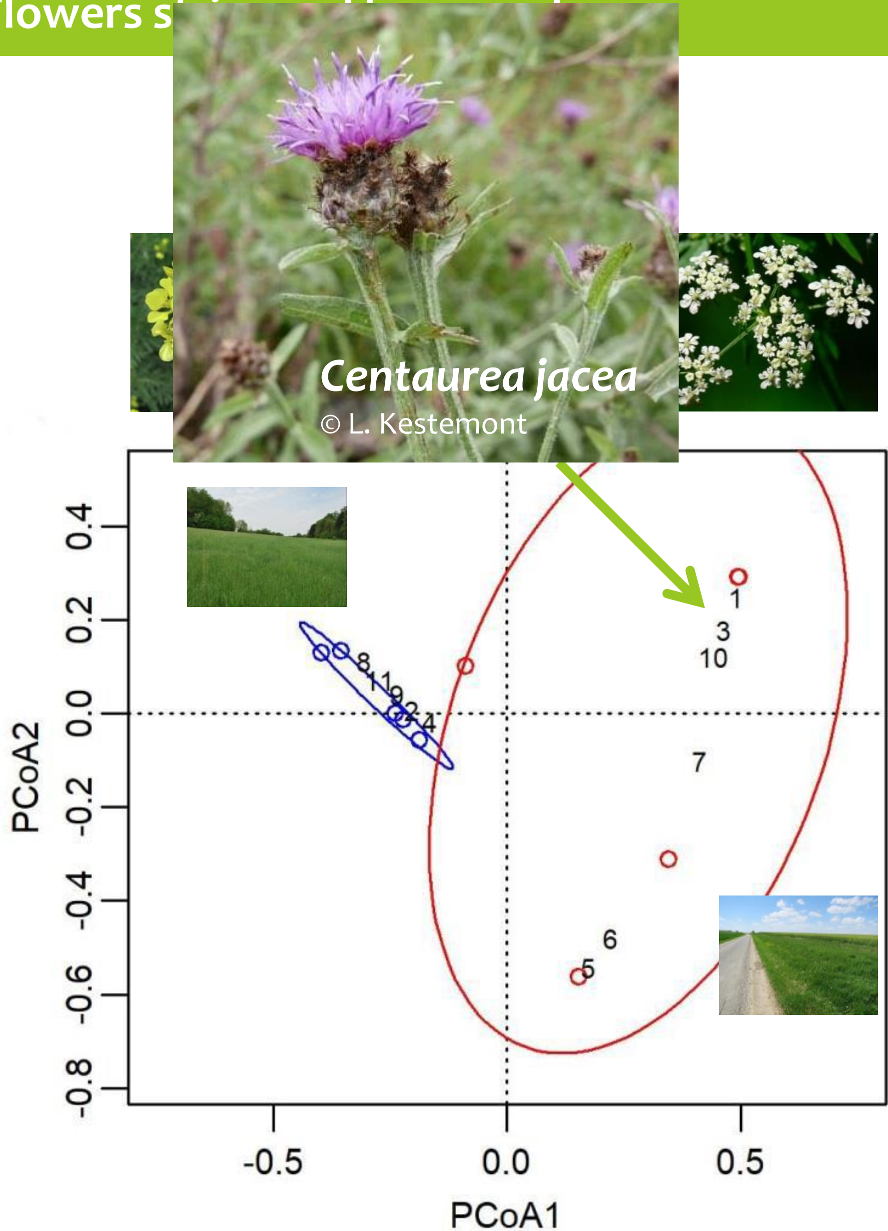


Flowers strips and hay meadows

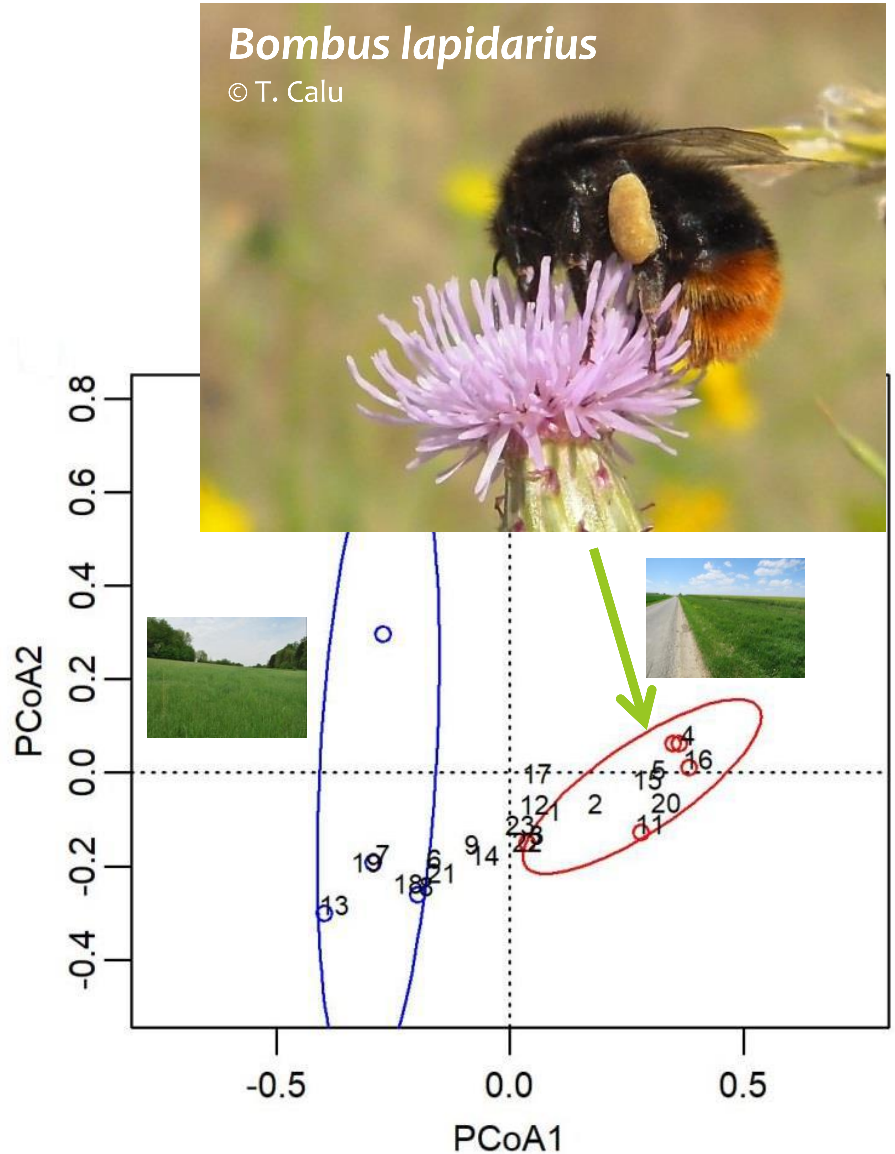




Flowers s



Centaurea jacea
© L. Kestemont
PCoA2
PCoA1
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-0.5
0.0
0.5



Bombus lapidarius
© T. Calu
PCoA2
PCoA1
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.5
0.0
0.5

Key message

- Perennial flower strips are not a surrogate habitat for hay meadows

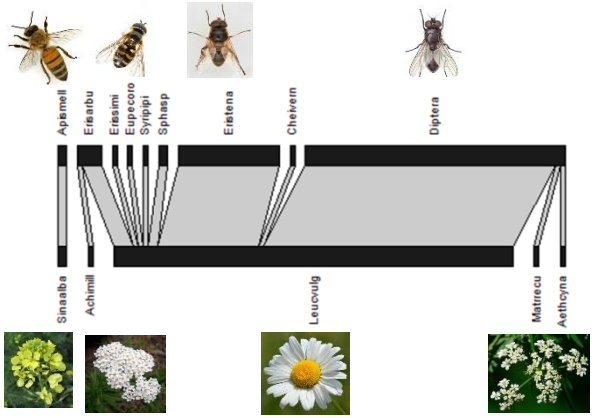
6. CONCLUSIONS AND PERSPECTIVES

What you seed is what you get?

- Creating contrasting levels of FD = possible
- However:
  - Spontaneous species
  - Species not germinating
  - Species more or less abundant

  ⇒Adapt seed proportions?

- No or negative effect on pollinators



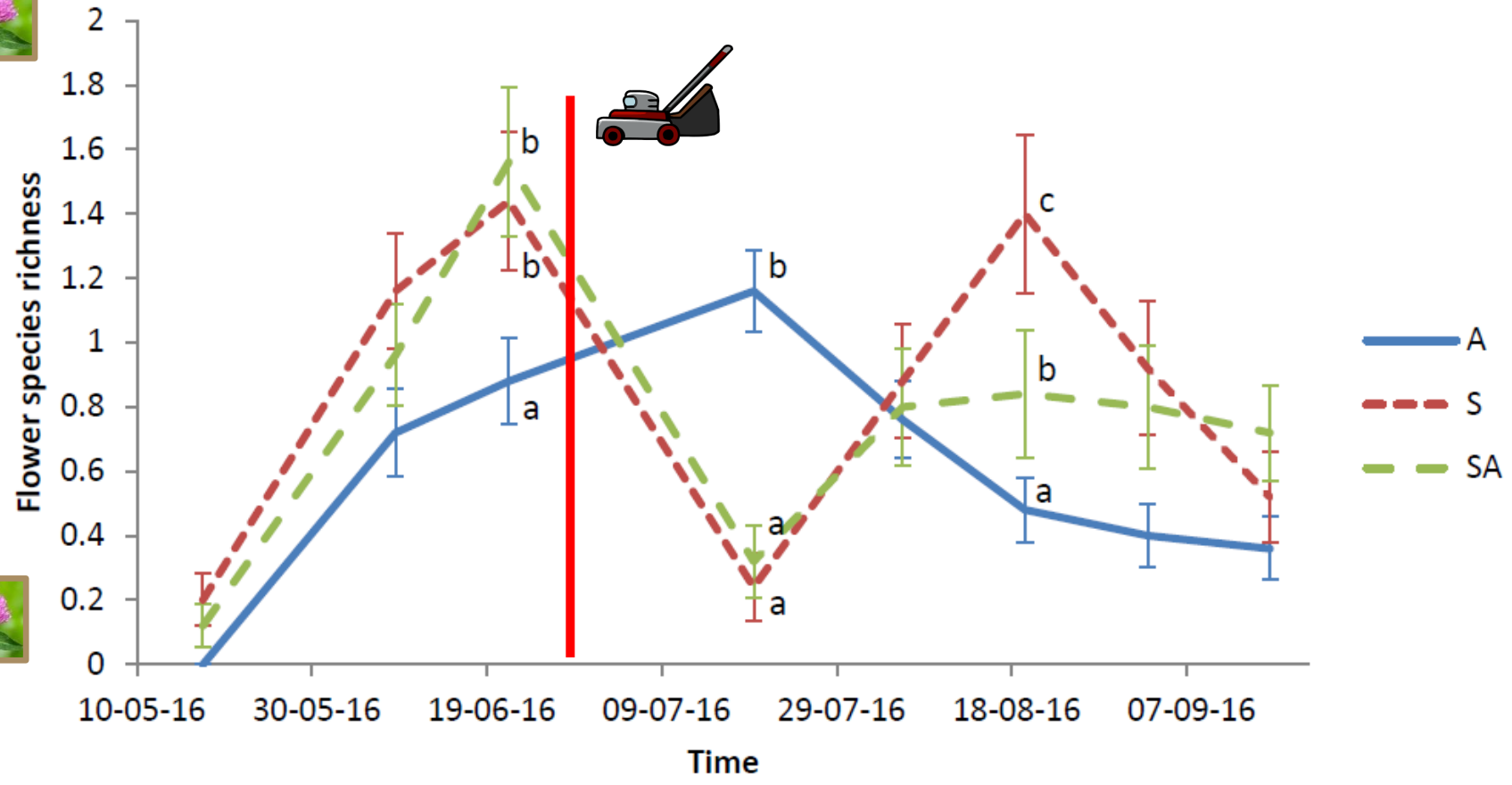
Mowing for services and disservices

- Mowing to reduce noxious weeds:
  - Summer mowing => *C. arvense* cover
  - Summer mowing => forb cover

- Mowing and pollinators
  - Flower resources?

Refuge strip

Flowering plants



Flower strips, a new habitat?

Hay meadow was not a habitat with similar pollinator and plant community

- Adapt seed mixture composition to local hay meadow species?
- Consider flower strips as new complementary habitat?

Perspectives

- Key species
  - Structure networks
  - Include in mixtures
- Functional complementarity or redundancy?
  - Insurance species or diverse niches?
- Flower strips as a part of an ecological network in agroecosystems

THANK YOU FOR YOUR ATTENTION

Agriculture Is Life.be

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