Plant functional strategies of 13 co-occurring grass species explain their abundance and their coexistence in productive grasslands

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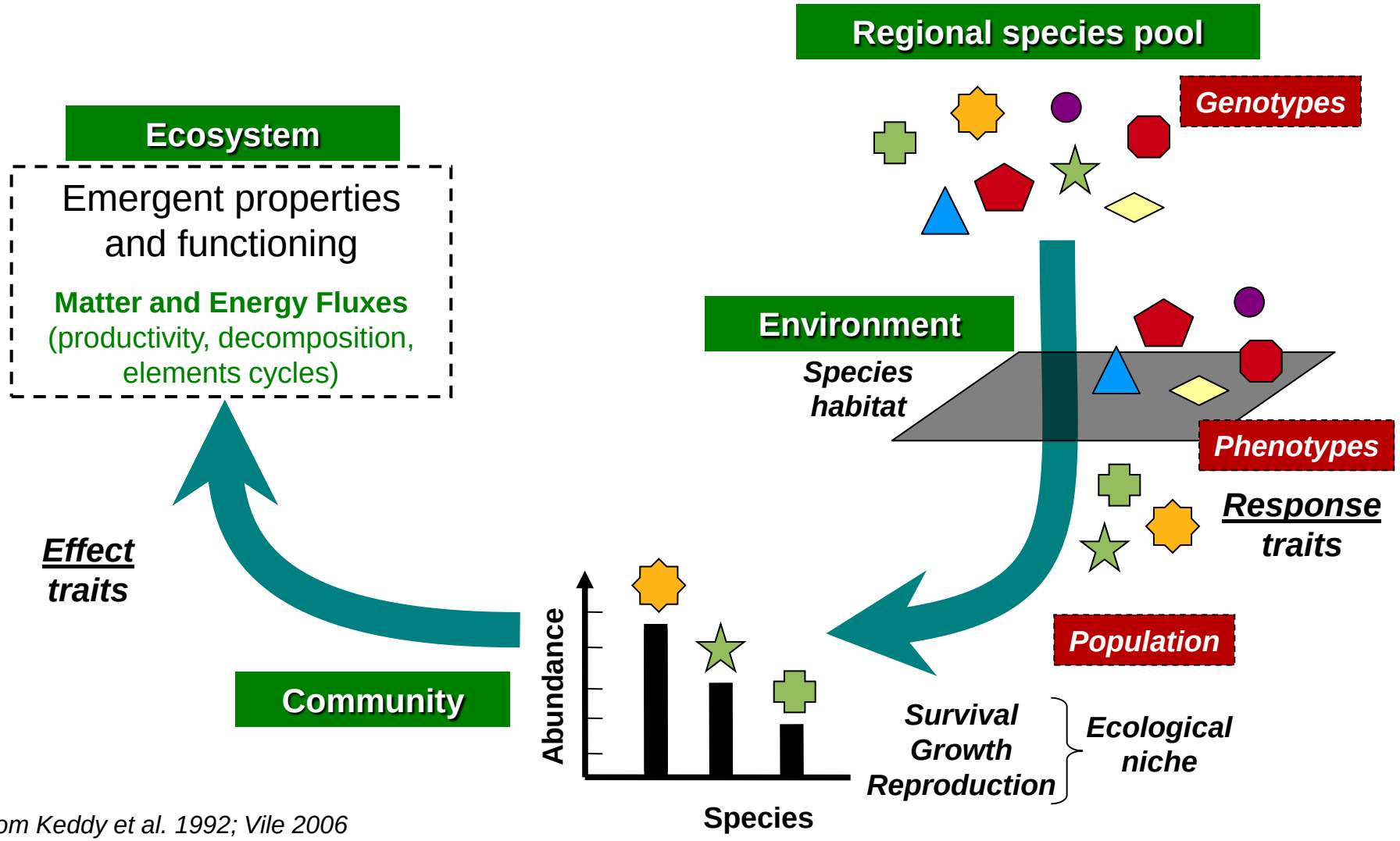
Context

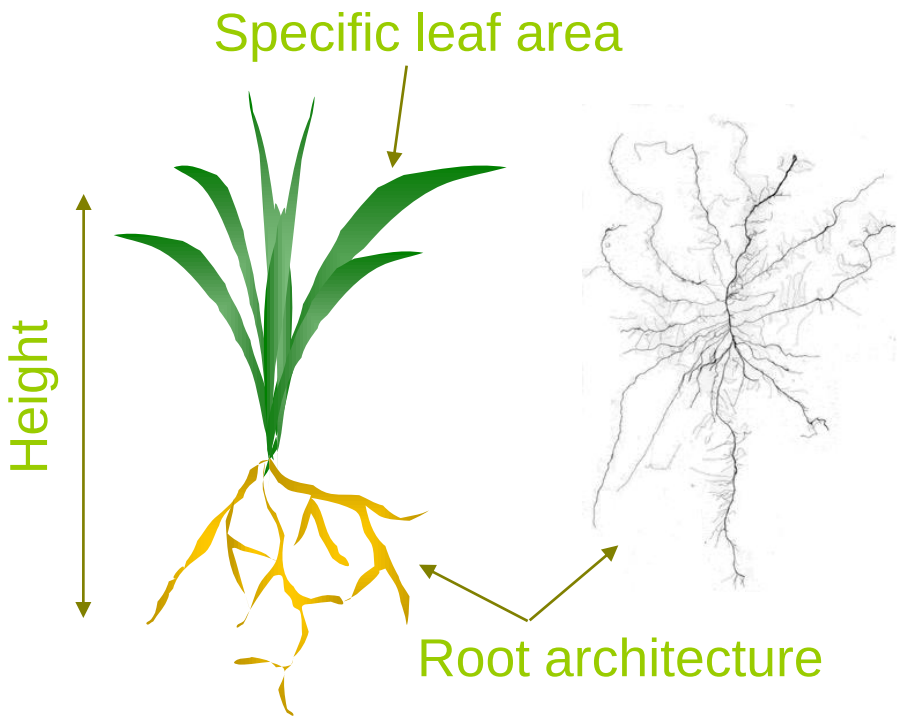
Functional paradigm in ecology



From Keddy et al. 1992; Vile 2006

Context

What is a plant functional trait?



Lavorel et al. 1997; Weiher et al. 1999

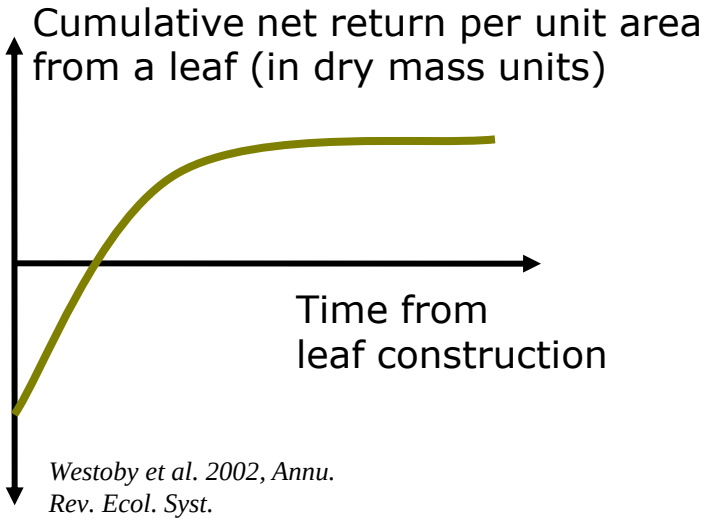
Trait	Function
Seed mass	Dispersal capacity, seed bank longevity
Dispersal type	Invasion capacity
Life history	Perturbation tolerance
Layering capacity	Colonizing capacity
Clonality, biomass	Space acquisition
Height	Competitive capacity
SLA, LDMC	Growth, plasticity
Leaf lifespan	Nutrient conservation

- Morphological, physiological, phenological or chemical characteristics of a species, which are more informative than species identity
- Driver of matter and energy fluxes
- All traits of a species defines its functional niche, i.e. the different strategies to survive, to grow and to reproduce in a particular environment

Context

Traits co-vary along specialization axes

- Some traits are in nature strongly correlated along ecological gradients
- Trade-off among traits correspond to cost – benefit law
- Up to day, different axes of specialization are known, each of them defining a new strategy for species to grow, to reproduce, to coexist…

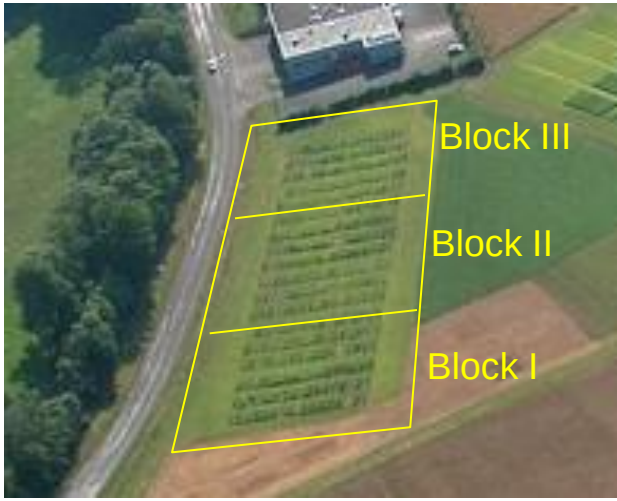


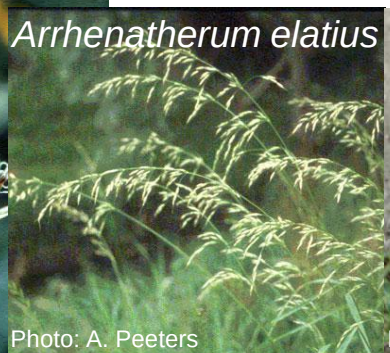
Questions

- Which plant strategies are used by a species pool to structure a productive grassland community?
  - Is there one or several plant strategies in a given environment?
  - Are used strategies dependent on environment severity?

Method
Experimental design in French 'Massif Central'

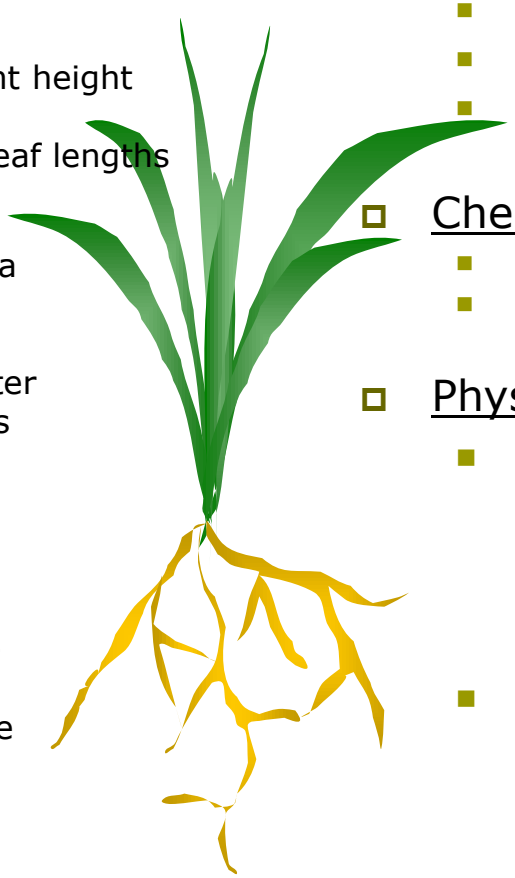
- 13 perennial pasture grass species
  - Widespread grasses in French Massif Central
  - Seeds collected in regional grasslands
- Species diversity
  - Monocultures of all species
  - 6 species mixtures (same initial species density)
- Disturbance and nutrients factors
  - Two cutting frequencies (3 & 6 cuts yr^{-1})
  - Two N fertiliser supplies (120 & 360 kgN ha^{-1} yr^{-1})
  - 288 micro-plots





Method
Measurements of 28 plant functional traits in an optimal growth condition

- Morphology
  - Plant
    - Vegetative elongated plant height
    - Tiller density
    - Ratio between sheath & leaf lengths
  - Leaf
    - Individual leaf lamina area
    - Leaf dry matter content
    - Leaf length
    - Individual leaf lamina water
    - Number of growing leaves
    - Number of mature leaves
    - Sheath length
    - Specific leaf area
  - Root
    - Root area per soil volume
    - Root dry matter content
    - Root mass per soil volume
    - Specific root area
    - Root diameter

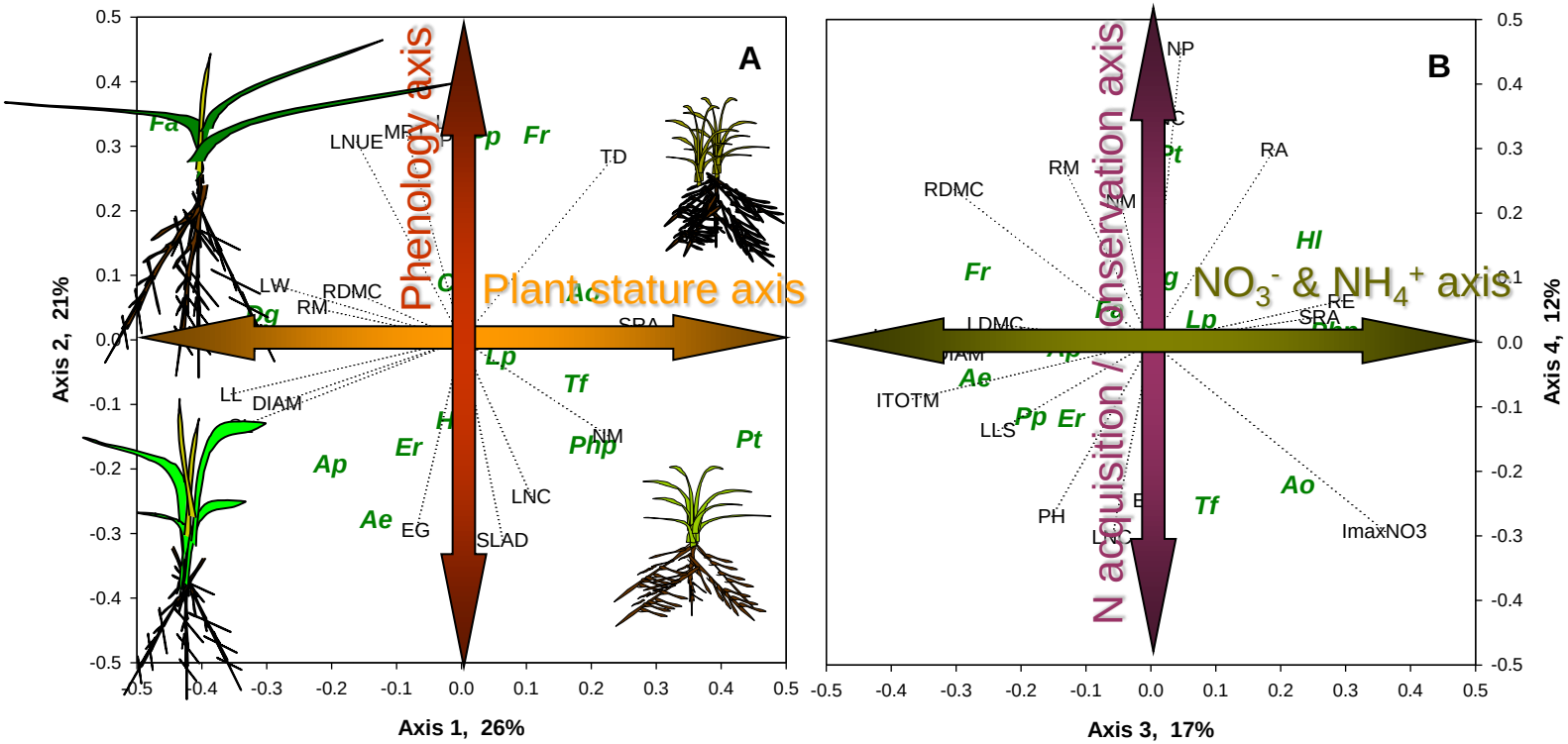


- Phenology
  - Leaf lifespan
  - Phyllochron
  - Earliness of growth
- Chemical Composition
  - Leaf N content
  - Root N content
- Physiology
  - Shoot
    - Leaf N use efficiency
    - Leaf N resorption rate
    - Shoot mean residence time of N
    - Shoot N productivity
  - Root
    - Maximal uptake capacity for NH_4^+
    - Maximal uptake capacity for NO_3^-
    - Maximal uptake capacity for N_{tot}

Results

Plant strategies of 13 grass species

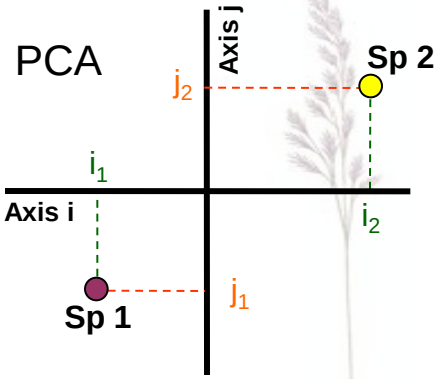
- Axes 1 & 2 highlighted four classic plant strategies opposing:
  - Competitive *vs.* cut resistant species (avoidance)
  - Late *vs.* early species for vegetative growth (phenology)
- Axes 3 & 4 increased the degree of freedom of species differentiation:
  - Trade-off between NO_3^- *vs.* NH_4^+ root uptake capacities
  - Exploitative *vs.* conservative species for nitrogen

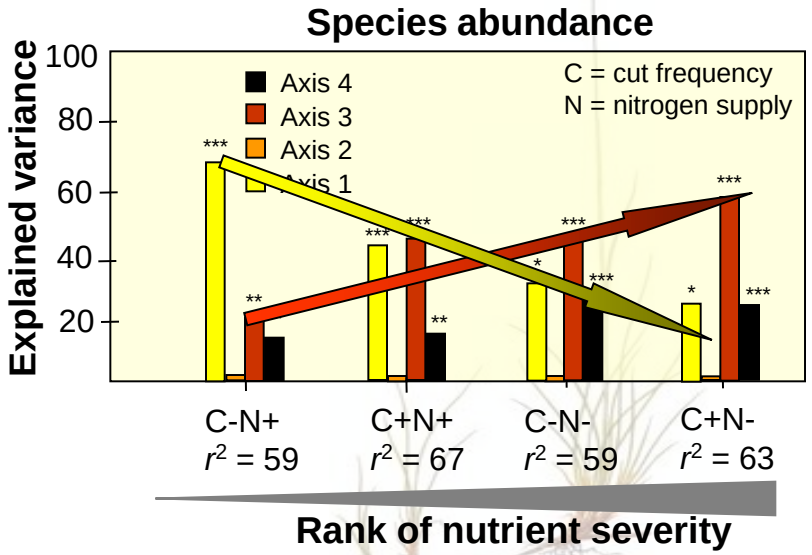


Results

Functional strategies and species abundance

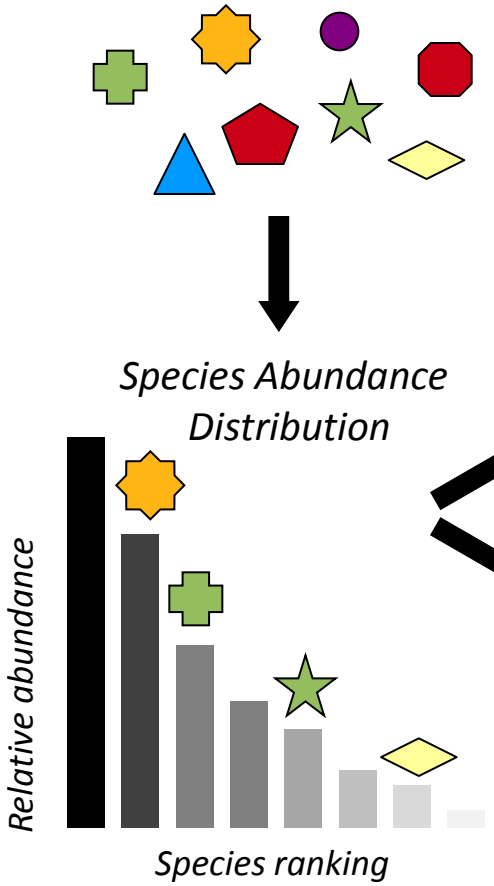
- Using species coordinates on each PCA axis in multiple regressions
- The plant stature axis (Axis 1) explained
  - in C-N+ the major part of variance,
  - which declined strongly with nutrient severity
- The NO_3^- / NH_4^+ root uptake capacity trade-off (Axis 3)
  - explained in C-N+ a significant part of variance,
  - which increased strongly with environment severity
- The N conservation / acquisition trade-off (Axis 4)
  - explained in C-N+ a significant part of variance,
  - which increased with environment severity
- The axis 2 was never significant





Context

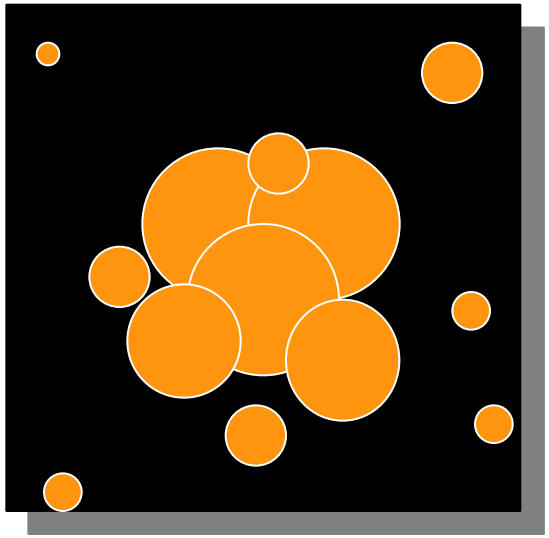
Community assembly rules

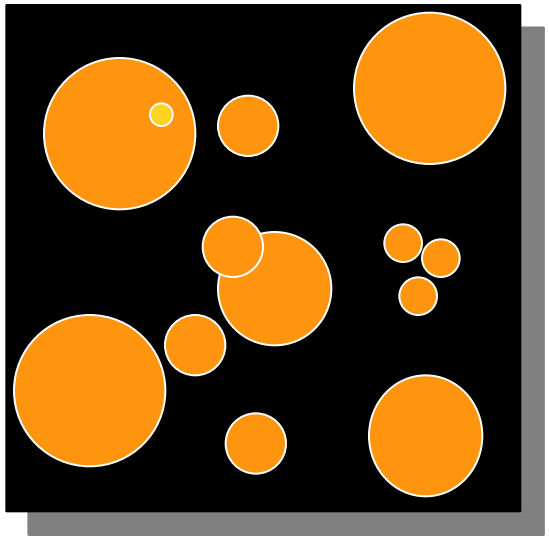


Two contradictory hypotheses:

Habitat filtering hypothesis

Niche differentiation hypothesis



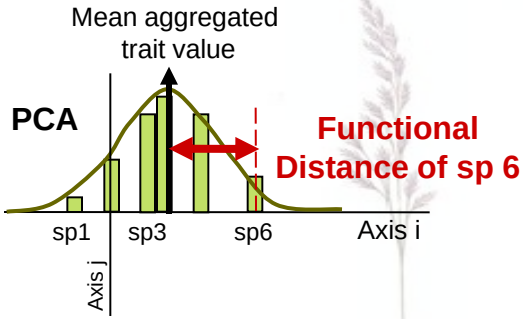


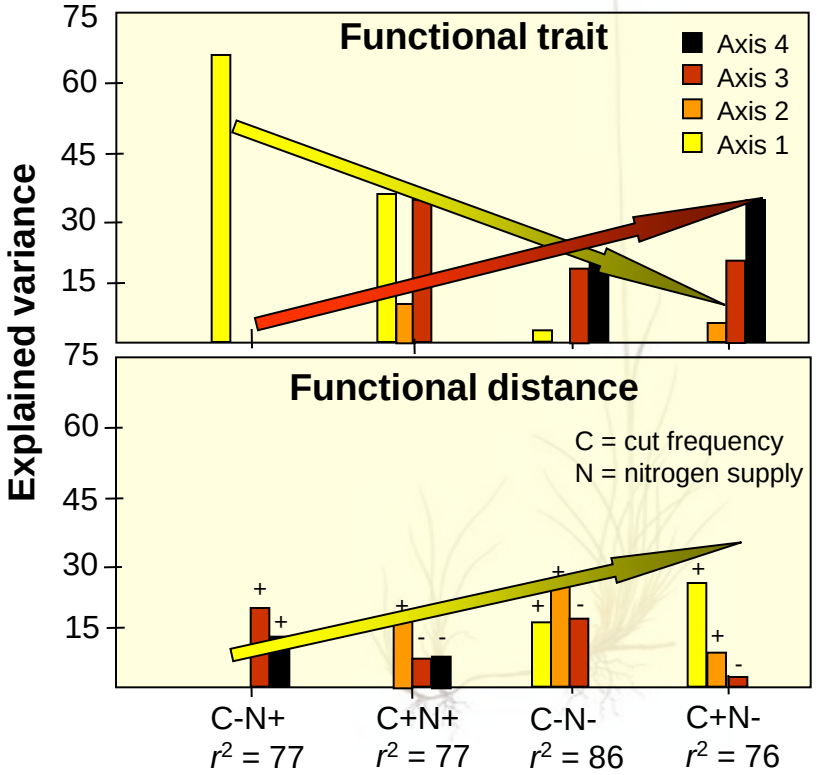
From Mouillot et al. 2007

Results

Functional strategies and species abundance

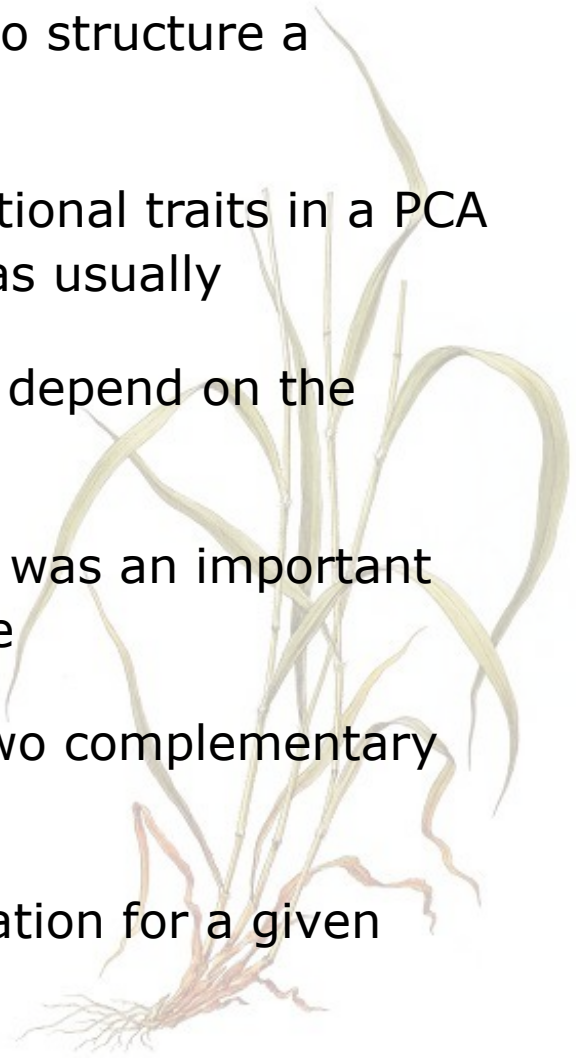
- Using step-wise multiple regressions to explain species abundance
  - Species coordinates on each PCA axis
  - Distance between species coordinate and mean aggregated coordinate of community on each PCA axis
  - Akaike criterion (AIC) selecting relevant variables in each regression
- Functional trait:
  - Axis 1 was the main strategy in favorable environment
  - Axes 3 and 4 were the main strategy in more severe environment
- Functional distance:
  - Explained a significant part of variance
  - Divergence was observed on axes which were not kept by step-wise procedure





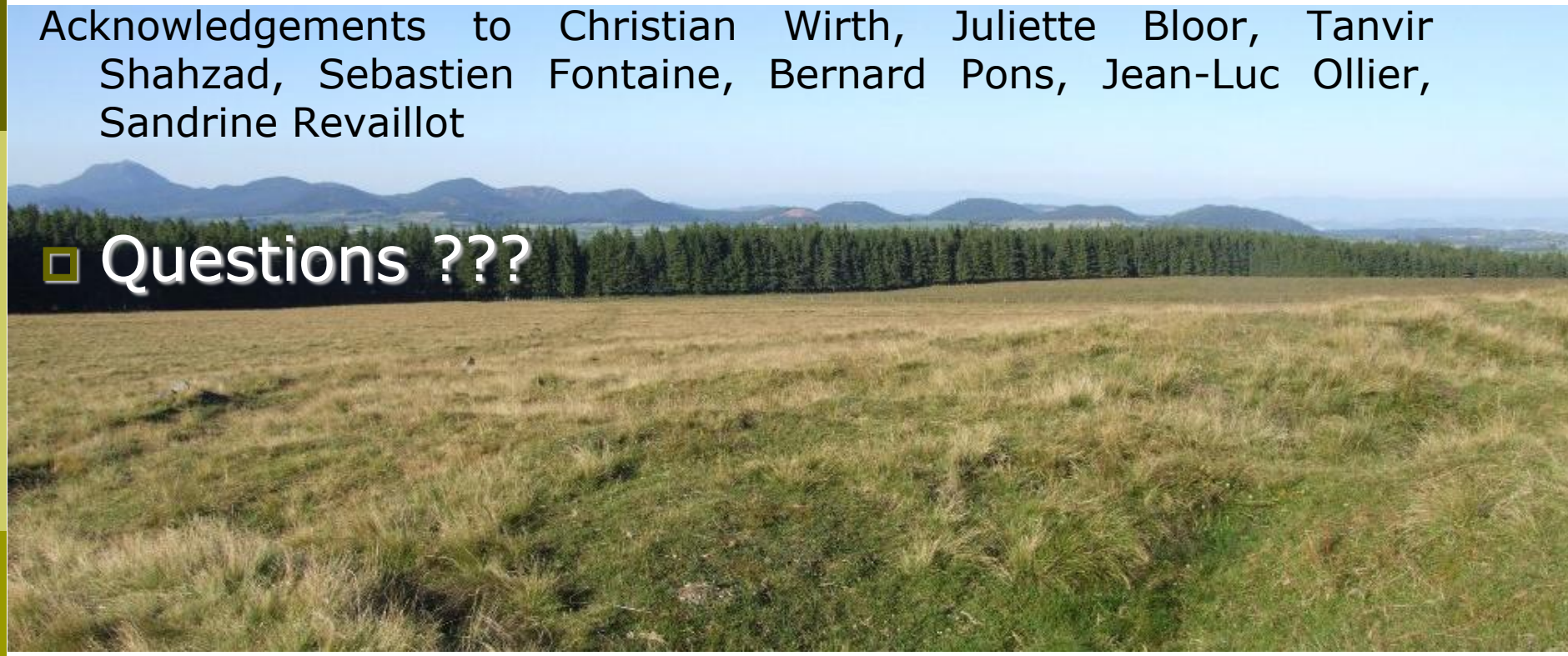
Conclusion

- Several strategies have been used by species to structure a community of productive grassland
- These strategies can be revealed by plant functional traits in a PCA provided that accounting more than two axes as usually
- For the same species pool, the used strategies depend on the environment
- The NO_3^- / NH_4^+ root uptake capacity trade-off was an important axis in our study and is rarely used in literature
- Habitat filtering and niche differentiation are two complementary mechanisms to structure a community
- They did not act on the same axes of specialization for a given environment



Thank-you

Acknowledgements to Christian Wirth, Juliette Bloor, Tanvir Shahzad, Sebastien Fontaine, Bernard Pons, Jean-Luc Ollier, Sandrine Revaillot



- Questions ???