



## Crop Booster

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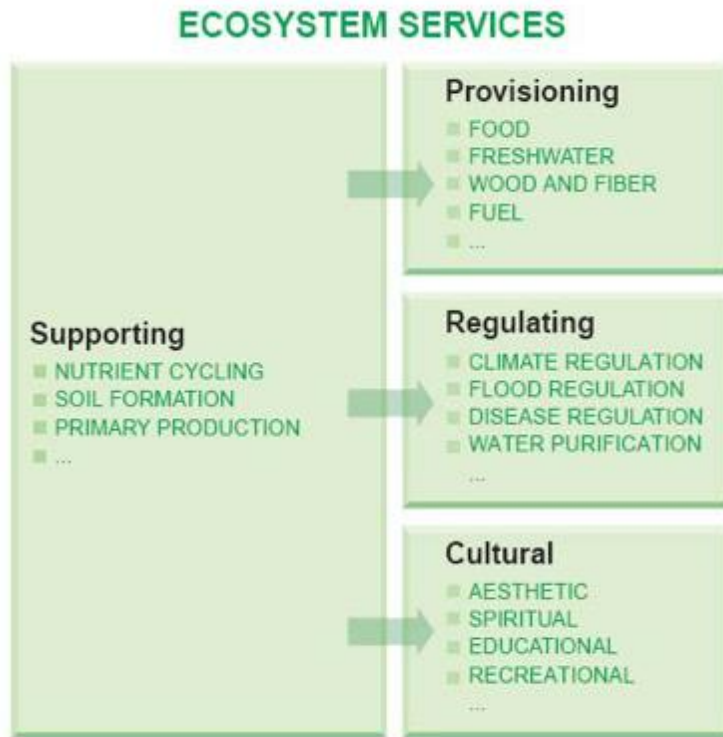
More species and functional diversity to boost provision of production and ecosystem services in agricultural systems

11-06-2021 / Christian Huyghe



# Sustainability transition

Maximisation of ecosystem services



Millenium Ecosystem Assessment (2005)

A need to meet the global challenges (HLPE, 2019)

- Food security
- Climate change : how to adapt, to mitigate and to reduce GHG emissions
- Restoring biodiversity
- Restoring quality of air and water

Are these services related?



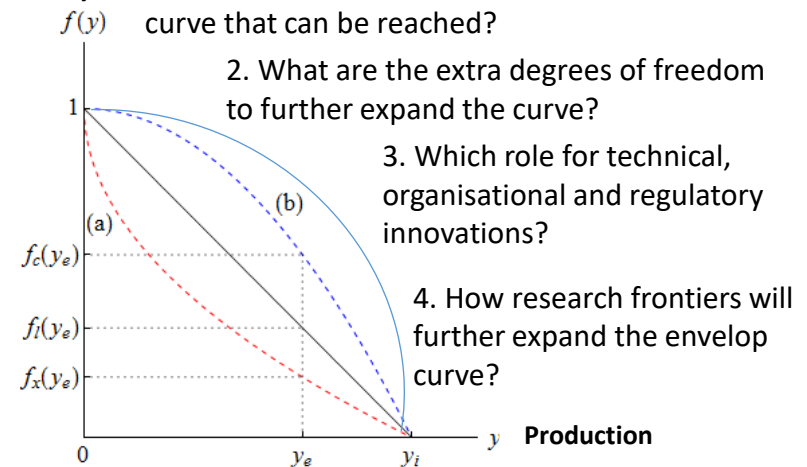
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When promoting SDGs, it gives the feeling that all combinations are possible:  
«A sedative concept» according to Eastes R-E et Pellaud F (2019, The Conversation)

**Biodiversity**



**The question becomes the exploration of convexity (Green et al, 2005)**

- An underlying hypothesis of land-sharing as the main land use regime
- Agroecology fits into a land-sharing perspective

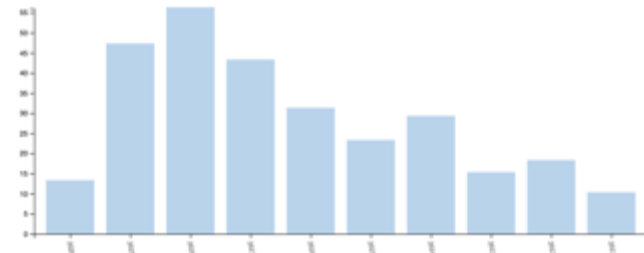


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# ➤ Agroecology concept: one word, several meanings

(Wezel et al, 2009, ASD, 29, 503-515)



## Agroecology

### Scientific discipline

Ecology at plot, field and herd scales

Ecology of food systems

Ecology of agrosystems

### Practices

Techniques

### Social movement

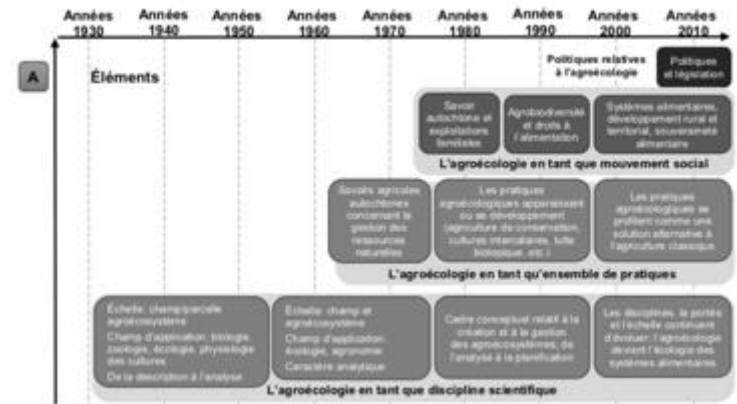
Sustainable agriculture

Environmentalism

Rural development

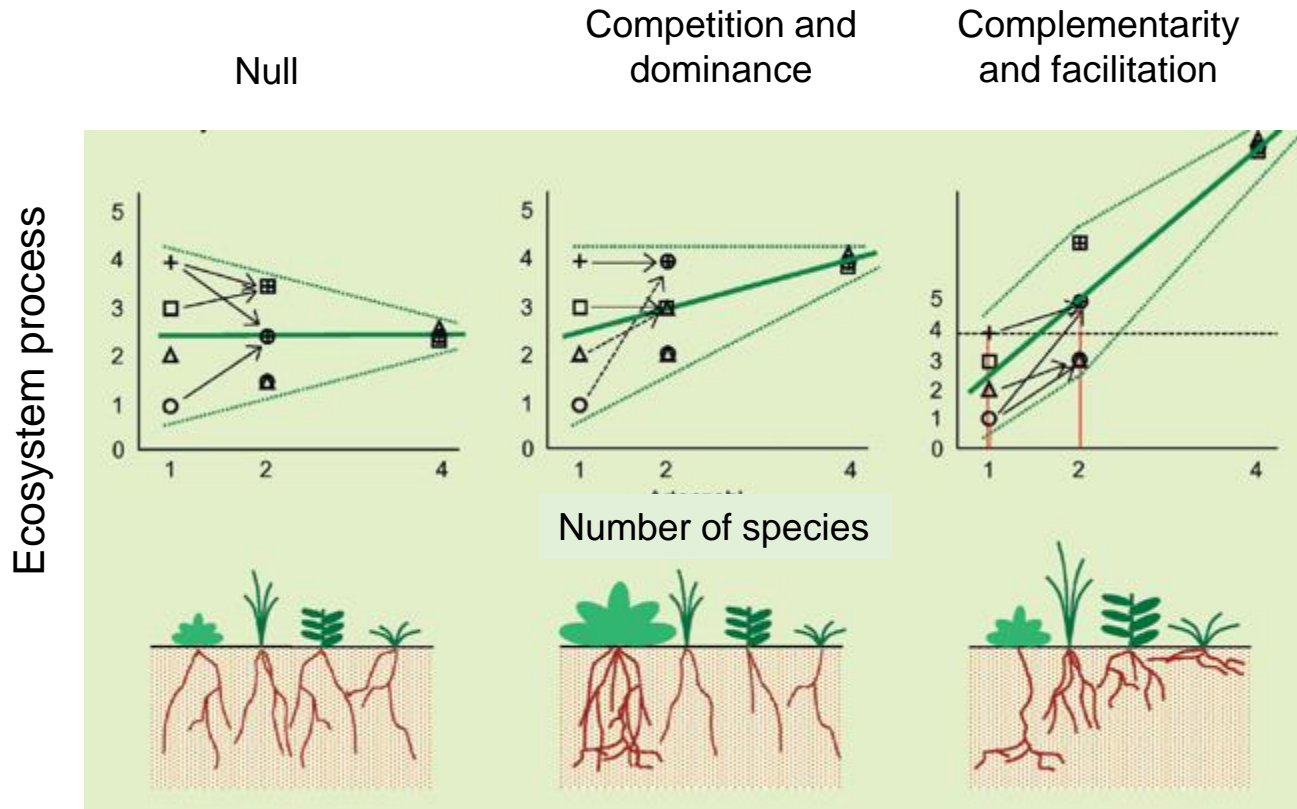
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# > Agroecology



In the concept of agroecology, a major importance is given to complementarity and facilitation

This opens fully new prospects for reconsidering the production systems

- Mixtures of species
- Companion species
- Relay cropping
  - 2 crops a year
  - Overlapping growing seasons

More species, more functional diversity

## The chemical ecology and new species ?

- The concept of odor landscape
  - Plants are producing Volatil Organic Compounds (VOC)
    - Mainly studied in relationship with taste (tomatoes, da Silva Souza et al, 2020) or perfume (rose, Sun et al, 2019)
    - Modification for either limiting insect damages (Villamar-Torres et al, 2018) or for attracting predators (Xu et al, 2019)



# ➤ Agroecology

## Mixtures of varieties

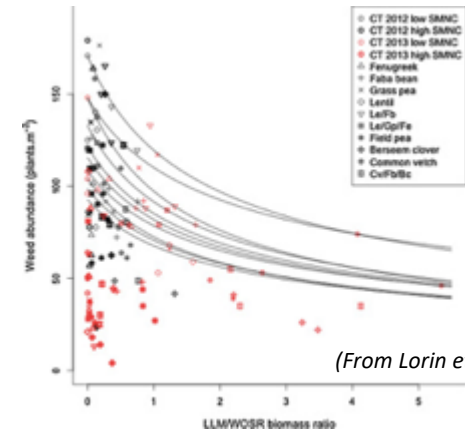
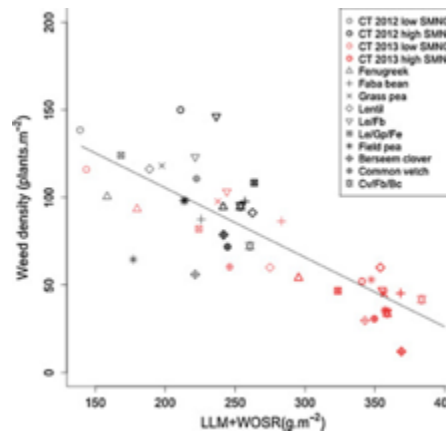
- Mixtures of varieties to reduce the use of fungicides and to achieve a more stable grain quality
  - A better tolerance to drought (wheat) (Qin et al, 2019, Plant and Soil)
  - Landscape-dependent effects (rapeseed) (Snyder et al, 2021, Ecological Applications)
  - Towards ecological assembly rules for variety mixtures (wheat) (Montazeaud et al, 2020, J. Appl Ecol)
- Mixing productive rapeseed varieties with a very early flowering one to control *Meligethes aeneus* (common pollen beetle)



# ➤ Agroecology

## Intermediate and Companion crops

- Cropping winter rapeseed with frost susceptible legumes
  - No herbicide in autumn and winter
  - 40-60 kg N provided by legumes
  - No insecticide required to control *Psylliodes chrysocephalus* (cabbage-stem flea beetle) in autumn (chemical ecology)
  - What are the best legumes to succeed: **lentil, vetch, fenugreek, Lathyrus (grass pea)?**



(From Lorin et al, 2015)



# ➤ Agroecology concept: New challenges for research – some examples

## New species and new swards for producing ecosystem services

- New species
  - To meet new market demands
    - Dietary changes in Europe and demand for more protein-rich plant products. A new market for grain legumes?
    - Bioeconomy and renewable biomass for non-food use
      - Bio-Based Industries Joint Undertaking and Partnership «Circular Bio-based Europe»



# ➤ Agroecology concept: New challenges for research – some examples

## New species and new swards for producing ecosystem services

- New species
  - To meet new market demands
  - Perennial crops for biomass production: Miscanthus, Switchgrass, Silphium
    - What are the markets?
    - How to organise the downstream supply chain?
    - Any negative service?



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### New species and new swards for producing ecosystem services

- New species
  - To meet new market demands
  - Perennial crops for biomass production: Miscanthus, Switchgrass, Silphium
  - Towards multi-service covers to control weeds, provide C (and N) to soil, provide extra resources to pollinators
    - Questions regarding their destruction before planting



# ➤ Agroecology concept: New challenges for research – some examples

## New species and new swards for producing ecosystem services

- **New species**

- To meet new market demands
- Perennial crops for biomass production: Miscanthus, Switchgrass, Silphium
- Towards multi-service covers to control weeds, provide C (and N) to soil, provide extra resources to pollinators
- Intermediate covers for preservation of environment or for biomass and renewable gas (methane) production
  - Questions regarding the right balance between production and environmental services



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## ➤ Agroecology concept: New challenges for research – some examples

New species and new swards for producing ecosystem services

- New cropping systems





# ➤ Agroecology concept: New challenges for research – some examples

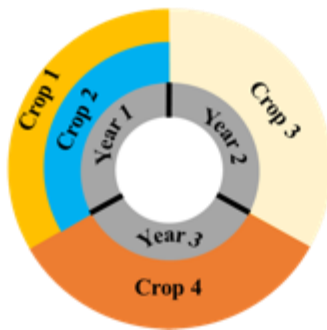
## Diversification with an increasing complexity (Source: A. Messean, H2020 DiverImpacts)

**Low diversity rotation**

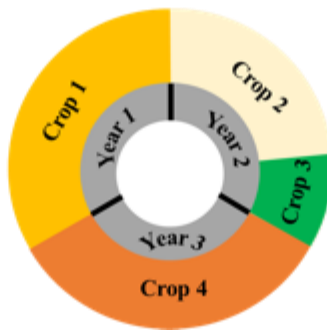


Combining species in a plot

**Intercropping:**  
increasing the number of crops that are grown in close proximity within the same land-area



**Multiple cropping:**  
increasing the number of crops that are grown on the same land-area within a year



More than 1 crop per year

**Rotation extension:**  
increasing the number of crops that are grown in successive years on the same land-area



**Combining crop practices:**  
using several diversification practices on the same land-area and over time



And many others, from mixtures of species to agroforestry



Association of herbaceous species and trees

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## ➤ Agroecology concept: New challenges for research – some examples

### New species and new swards for producing ecosystem services

- New cropping systems
  - Longer crop rotations in a diversification process: where the so-called 'minor' species play a key role





## Agroecology concept: New challenges for research – some examples

### New species and new swards for producing ecosystem services

- **New cropping systems**

- Longer crop rotations in a diversification process: where the so-called 'minor' species play a key role
- Production with living mulchs
  - Successful experiences with alfalfa or clover living mulchs

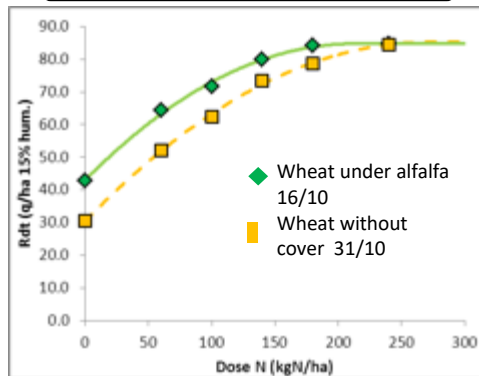


# BRIVES (36) 2013, wheat under alfalfa

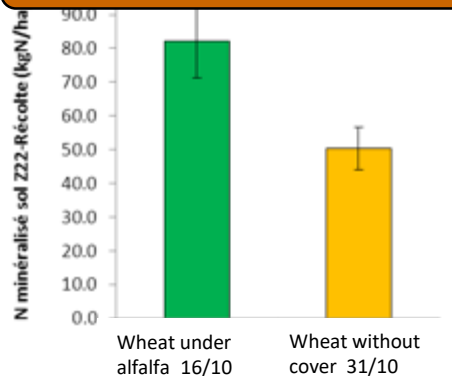
Charpentier's farm

## Yield

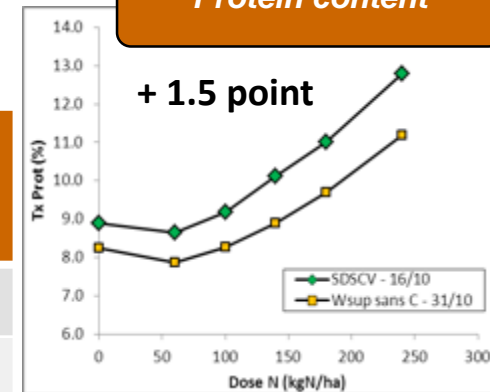
### Nitrogen Response curves



### Quantity of mineralized N in sol (from Z22 to harvest)



## Protein content



|                  | W without C – 31/10 | Wheat under alfalfa 16/10 |
|------------------|---------------------|---------------------------|
| Nopt (kgN/ha)    | 272                 | 213***                    |
| Yield opt (q/ha) | 85.3                | 84.7NS                    |

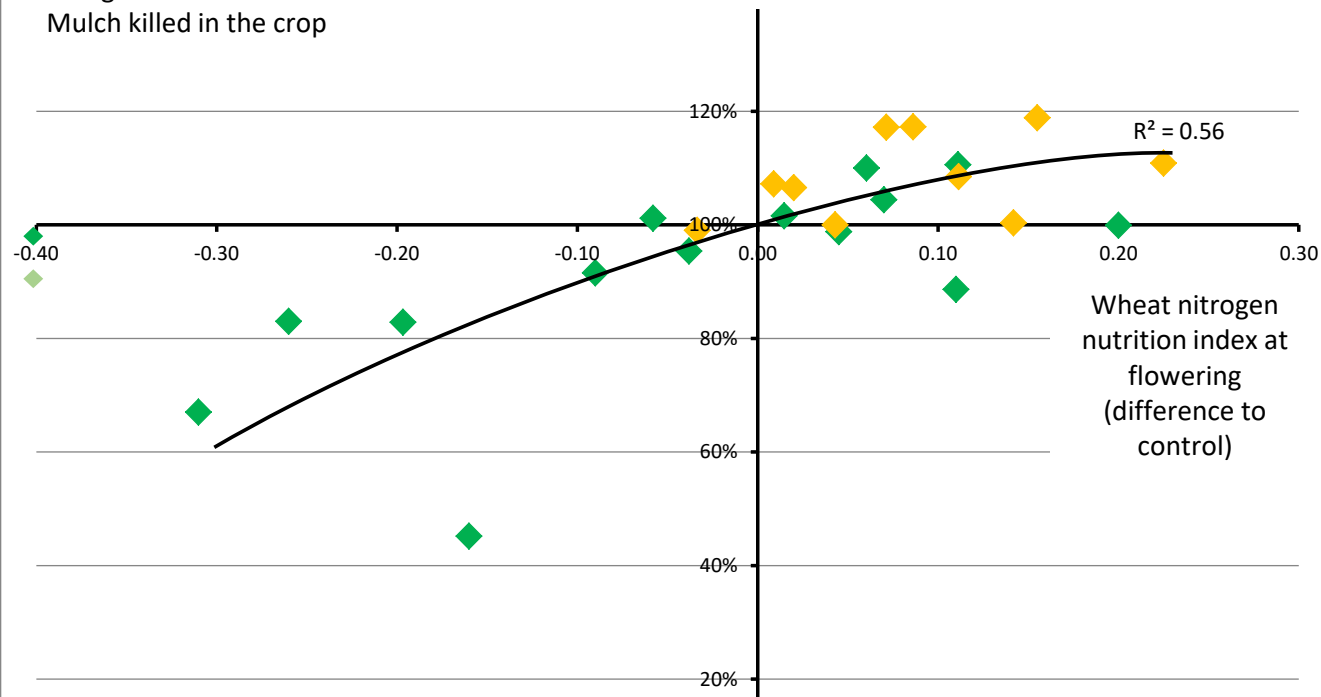
### Conclusion : Main services from alfalfa cover

- No difference in grain yield.  
- it requires a good control of alfalfa growth).
- Saving 60 kgN/ha
- Additional 1.5 points of proteins
- Improved nitrogen minéralisation

Less nitrogen fertilisers for a better quality with the same yield

Living mulch  
Mulch killed in the crop

Grain yield (in % of control)



Over a wide range of farm trials (from Labreuche et al, 2017)

The key issue is the ability to control the competition induced by alfalfa



**Developing new cropping systems requires the associated equipments**



# ➤ Agroecology concept: New challenges for research – some examples

## New species and new swards for producing ecosystem services

- New cropping systems

- Longer crop rotations in a diversification process: where the so-called 'minor' species play a key role
- Production with living mulchs
- Relay-cropping (crop  $n+1$  is sown before harvest of crop  $n$ ) to achieve a Land Equivalent Ratio (LER)  $\gg 1$ .
  - *Here soybean sown in winter barley*
  - Changing the phenology and architecture of genotypes



## In human and social sciences

- How to boost the transitions to agroecology-based production and food systems with more species and diversity? The underlying values
  - AgroecologyNow
  - Anderson et al, 2020 (Agroecology and Sustainable Food System 44, 561-565)
- The conditions for transition in the production systems towards more functional diversity
  - Adoption and changes in the advisory systems
  - Agroecology for provision of production and ecosystem services maximizes the dependency to local conditions

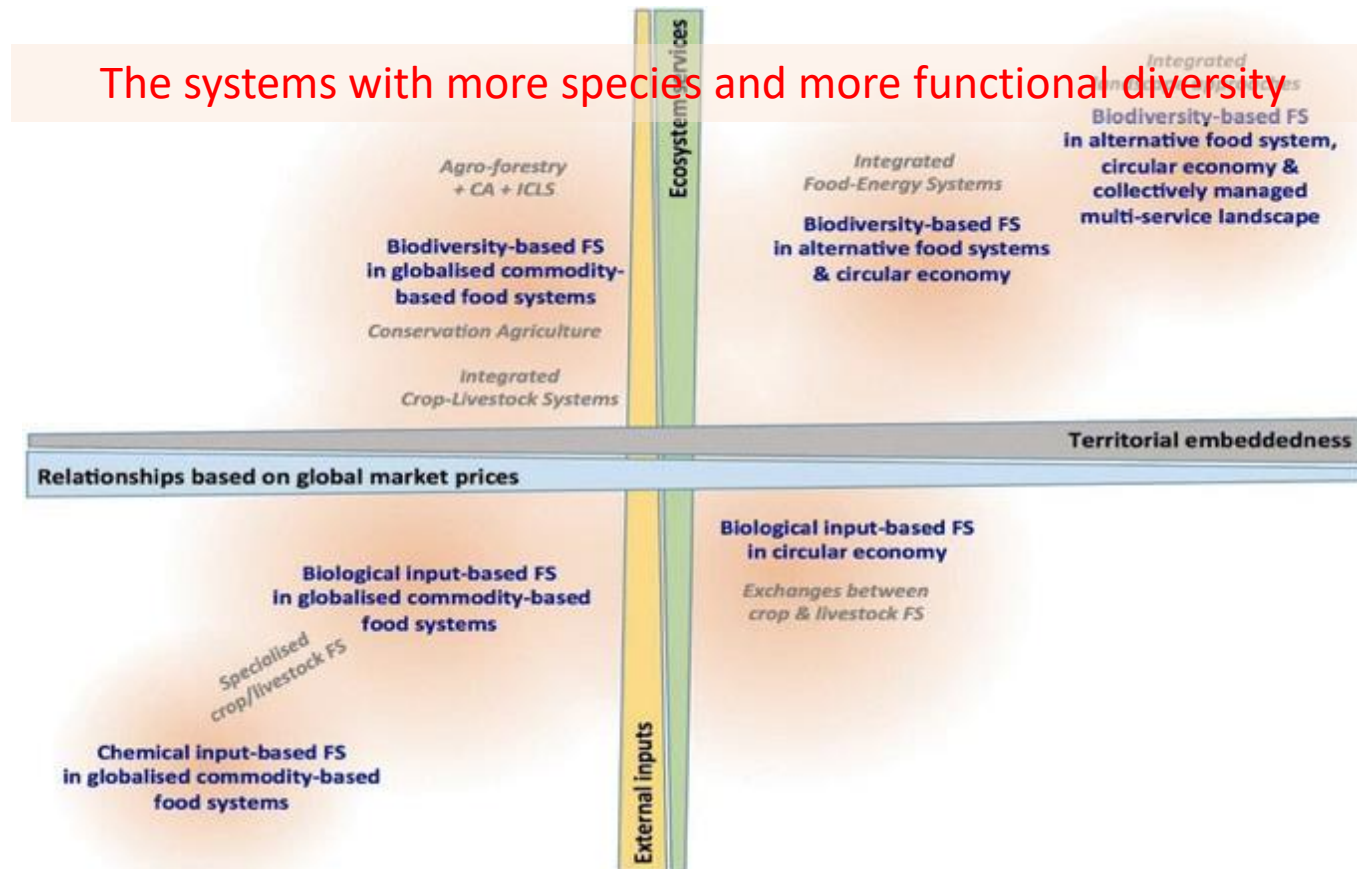


➤ An underestimated feature of agroecology: the strong dependency to local conditions

- **Optimalities et sub-optimalities (A. Cognet and O. Hamant, ENS Lyon)**
  - How to be optimal in a limited range of variation?
  - How to be (quasi) optimal while being adaptable?



## ➤ Production and food system transitions



Agri-food models according to the degree of ecosystem services vs external inputs (Y-axis) and the relationships with socio-economic contexts (global market prices vs territorial embeddedness- (X-axis).

## ➤ Concluding remarks

- A considerable resource to include and use more species and more functional diversity in sustainable farming systems
- Possibility to further expand the diversity through breeding, whatever the technologies to be used
- From a plant/sward approach to the holobiont concept? (Lyu et al, 2021, Microorganisms 9, Art. 675)
- A need to explore all incidences of higher complexity: for farmers (work and mental load), for supply chains, for breeders
- Importance of the dependency to local conditions
  - How to breed and to evaluate?
  - How to advice and to train?
  - A possible role for participatory approach?





Thank you for your attention



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