Nutrient recycling in organic farming is related to diversity in farm types at the local level

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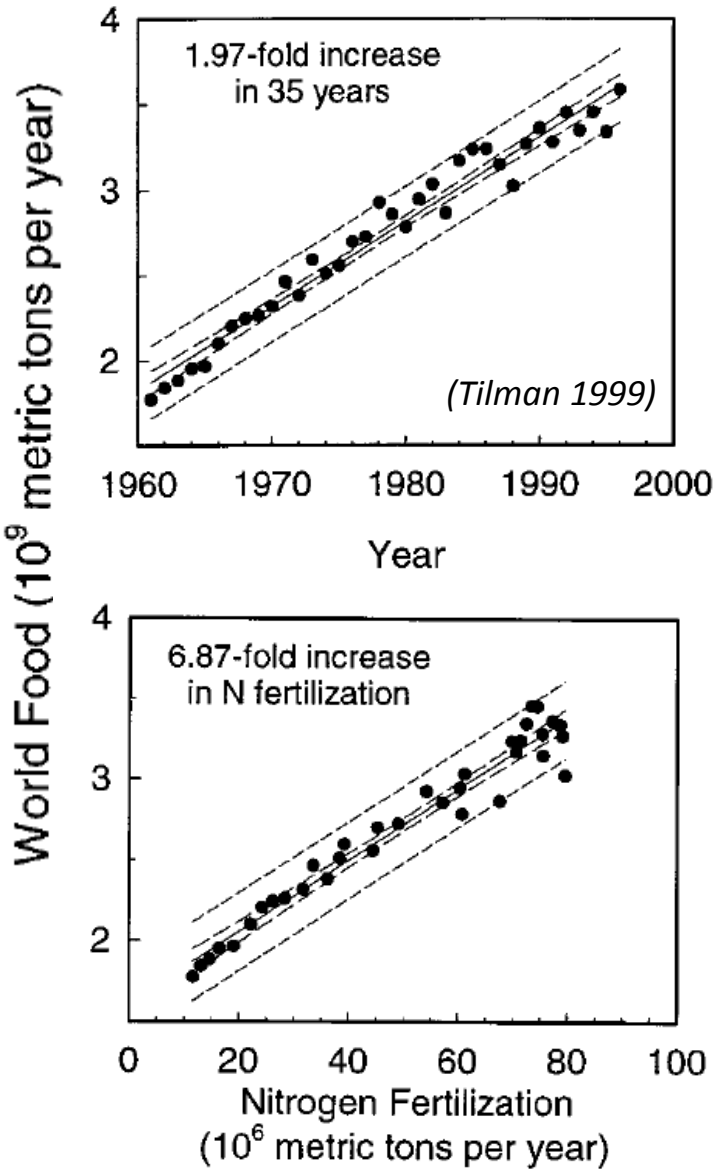
Introduction

Contribution of fertilisers to agricultural productivity



→ **Increasing use of artificial fertilisers since 1945…**

- N fertilisers due to the HB process and chemically treated P and K ores
- Doubling of production associated with 7 fold increase in N fertilisation
- N use efficiency decreasing from 80 to 20%

→ **…with negative consequences**

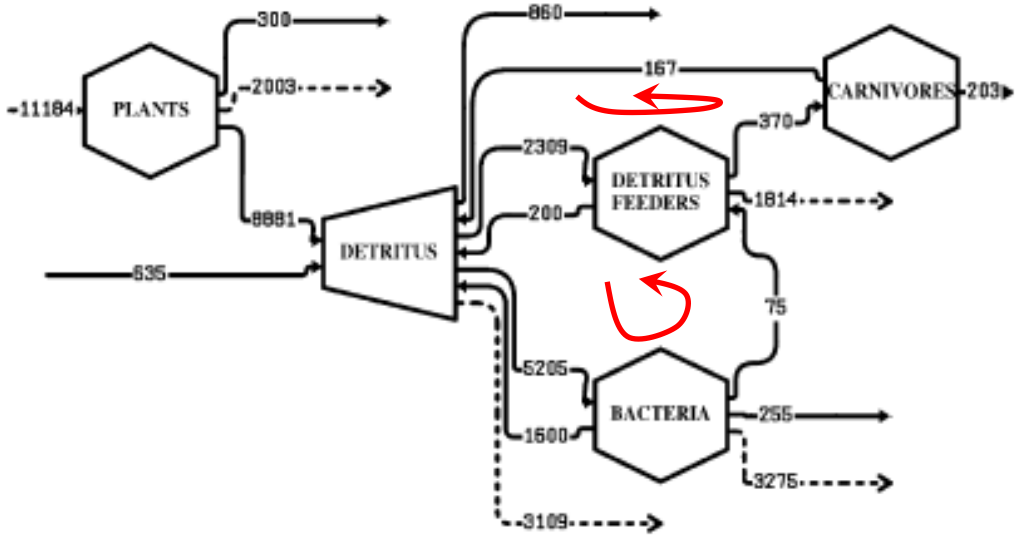
- Nutrient losses to natural ecosystems
- Consumption of fossil ressources

→ **A better closure of nutrient cycles to reduce fertiliser consumption**

- Reducing losses
- **Improving nutrient recycling**

Designing sustainable farming systems

→ Studies concerning nutrient cycling in ecology



Flows of C (g.year^{-1}.m^{-2}) in the Cone Spring ecosystem (Iowa) (Allesina *et al.,* 2004)

- **1940's** : discovery of cycling patterns in trophic network
- **1970's** : first quantification of the proportion of throughflow that is recycled
- **2000's** : Adaptation of the cycling index (CI) in agronomy

→ Review of CI results taken from farm scale studies

References	Farm type	Finn cycling index (%)[a]		
		Nitrogen	Phosphorus	Potassium
Rufino et al. (2009)	Ethiopian mixed farms	5% (3)	-	-
Kobayashi et al. (2010)	Japanese dairy farm	12% (1)	11%	37%
Tabata et al. (2009)	Japanese rice-beef farms	20% (4)	17%	-
Alvarez et al. (2013)	Malagasy mixed farms	4% (4)	-	-

[a], *between brackets: number of farms sampled.*

Problematic

→ **Beyond farm-gate, what are the structure of farm material exchange networks and their consequences for phosphorus (P) recycling?**

→ **Focus on organic farms**

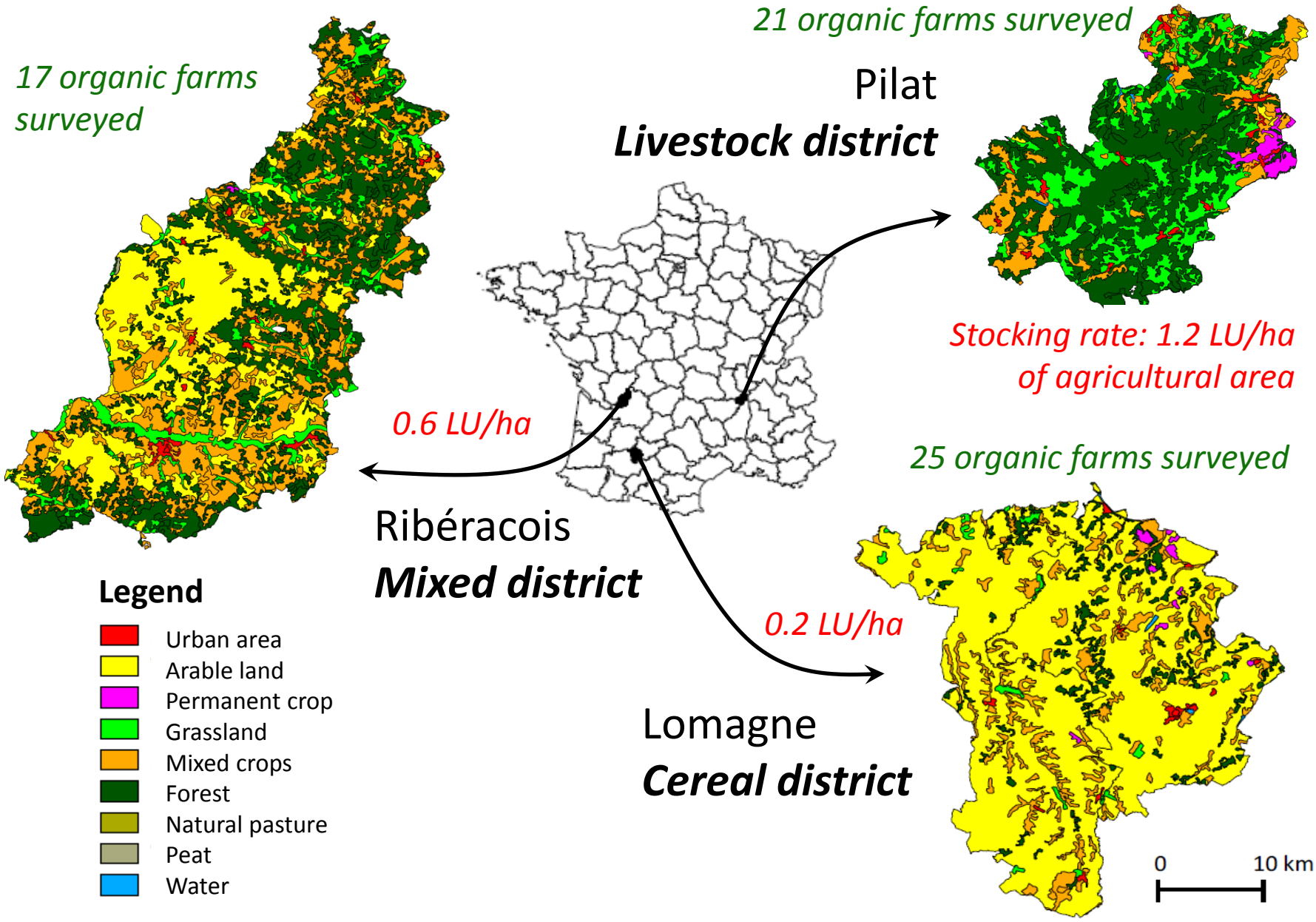
- Organic farming as a prototype of recycling agriculture
  - Principle of ecology : “based on living ecological systems and cycles rather than the use of inputs”
  - Artificial fertilisers are forbidden
- Trend toward specialisation in organic farming favoring material exchanges

→ **Influence of the local context**

- Hypothesis : Local diversity of productions favours exchanges among farms and enhances local nutrient cycling

Material and Methods

Study areas


17 organic farms surveyed
21 organic farms surveyed
Pilat
Livestock district
Stocking rate: 1.2 LU/ha of agricultural area
0.6 LU/ha
Ribéracois
Mixed district
25 organic farms surveyed
0.2 LU/ha
Lomagne
Cereal district
Legend
Urban area
Arable land
Permanent crop
Grassland
Mixed crops
Forest
Natural pasture
Peat
Water
0
10 km

General approach

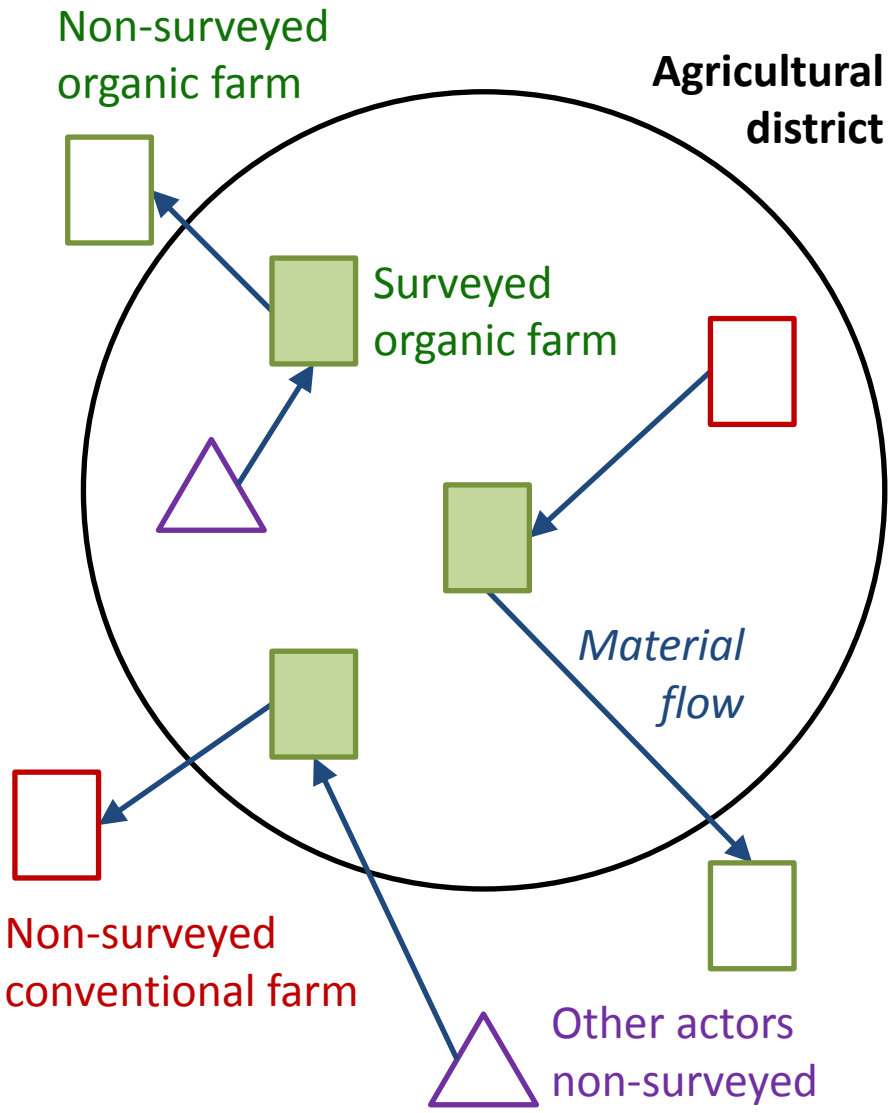
→ **Interviews with all the organic farmers of each district**

- Other farms and actors have been noted but not surveyed

→ **Data about material flows for years 2010 and 2011**

- Farmers notebook
- For fodders, cross checked with livestock requirement

→ **Mapping of exchanges and data treatment**



Two indicators to assess P recycling

→ **Local autonomy (LA):**

$$\frac{\text{Amount of P coming from exchanges with (non surveyed or surveyed) farms}}{\text{Total amount of P inflows}}$$

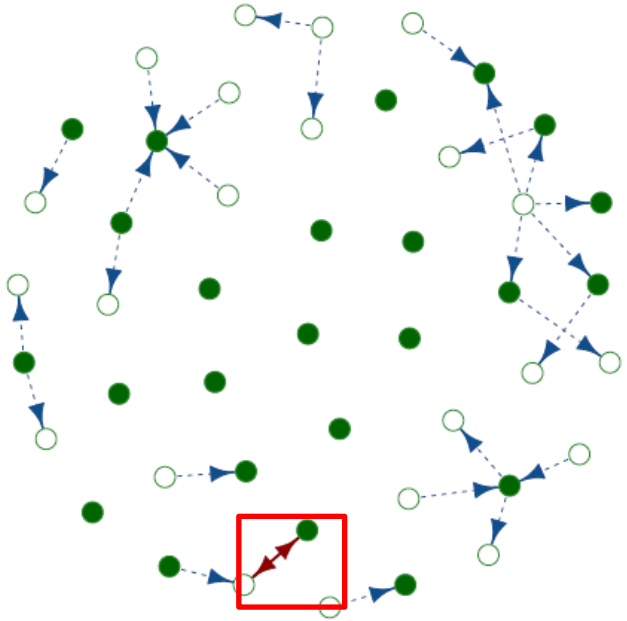
→ **Cycling index (CI):**

- Proportion of P flowing at least twice through the same farm (average for all the organic farms of the district)

Results

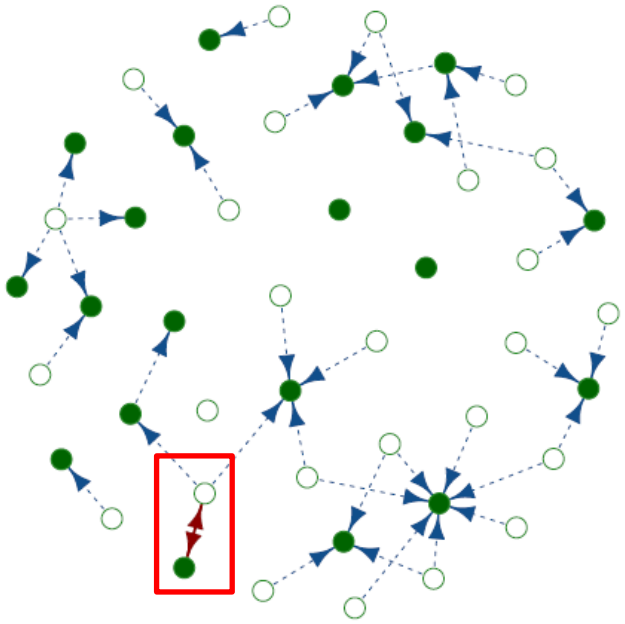
Connections among farms

« Cereal » district

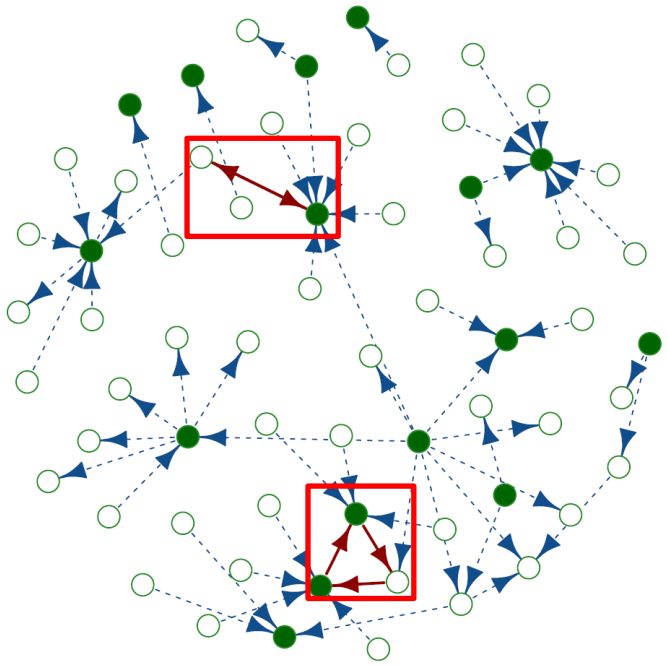


Average number of connections	
Cereal	1
Mixed	**4**
Livestock	2

« Livestock » district



« Mixed » district



Surveyed organic farm

Non-surveyed (conv. or organic) farm

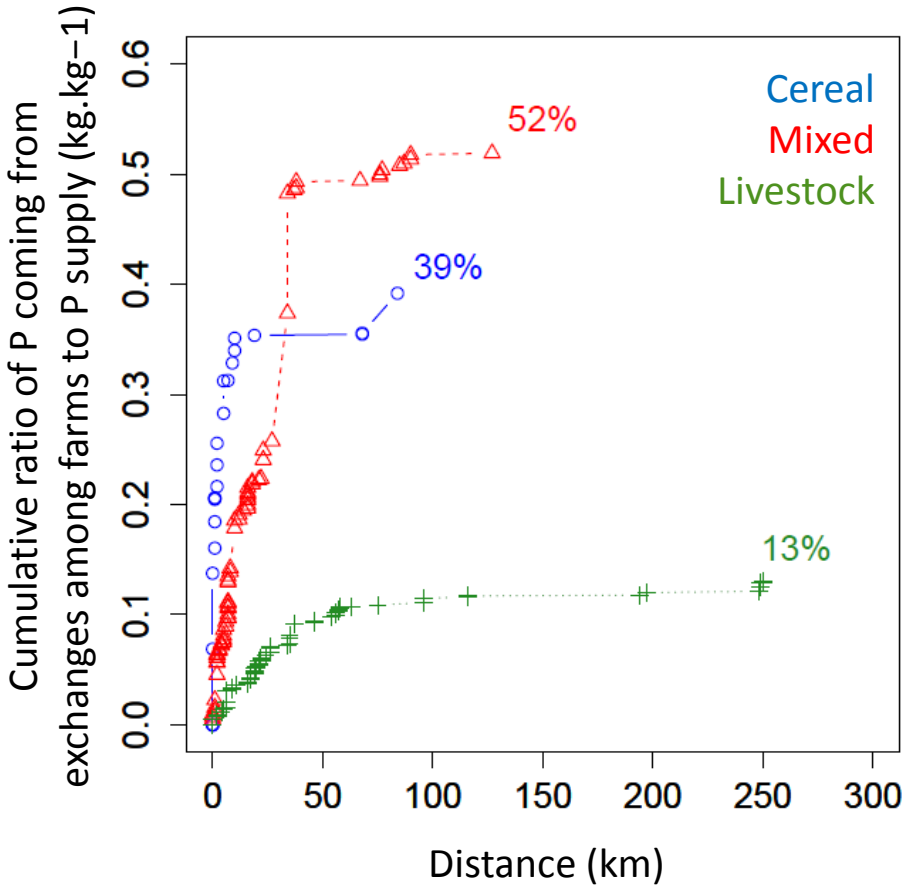
Material flow

Cycling pattern

Number of cycling patterns	
Cereal	1
Mixed	**2**
Livestock	1

Assessment of local autonomy

Contribution of exchanges among farms to P supply depending on distance of exchanges



→ **Local autonomy tended to be higher for the mixed district**

→ **Exchanges among farms were short distance exchanges**

Average distance	
Cereal district	10 km
Mixed district	26 km
Livestock district	36 km

→ **Exchanges with other actors were long distance exchanges**

- 1200km for feeds coming from retailers in the livestock district

Assessment of cycling index

	District		
	Cereal	Mixed	Livestock
Cycling index	0%	**20%**	0%

→ **Overall, cycling index lower than local autonomy**

- Maximum of 20%
- Low number of cycling patterns in exchange networks
- Similar as previous results at the farm scale

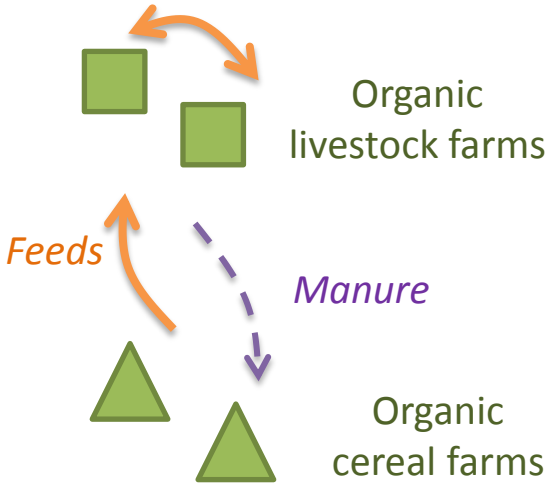
→ **Higher cycling index for the mixed district**

- Exchanges among organic farms in the mixed district (+1 cycling pattern)
- Imports of manures from conventional farms in the cereal district
- Imports of feeds from retailers in livestock district

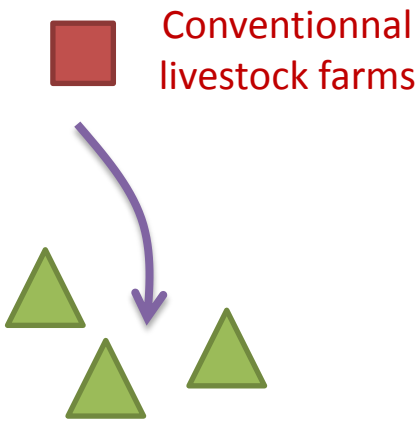
Discussion

To summarize…

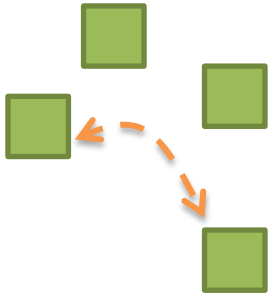
→ **Diversity among productions at the district level favoured local P cycling**



Mixed district
High autonomy
Moderate cycling



Cereal district
Moderate autonomy
No cycling



Livestock district
Low autonomy
No cycling

→ **Most of fertilising materials came from conventional farming**

- Limit for P cycling
- Indirect reliance on artificial

Perspectives

→ **First results are rather obvious…**

- Proximity favoured exchanges
- Limits for recycling in agriculture due to exports of production

→ **… but the question is relevant**

- Farming system design to optimize nutrient flows?
- Drawong lessons from industrial ecology

→ **Application of these methods to the case of collective anaerobic digester in Dordogne**

- Projects involving farmers, industrial actors and local communities
- Allocation of carbon, nitrogen, trace elements… among actors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