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# Improving livestock sustainability requires more than controlling its environmental footprint

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## E.O. Wilson's law

“If you save the living environment, the biodiversity that we have left, you will also automatically save the physical environment, too [...] But, if you only save the physical environment, you will ultimately lose both.”

Source = Extract Interview NY times 2014

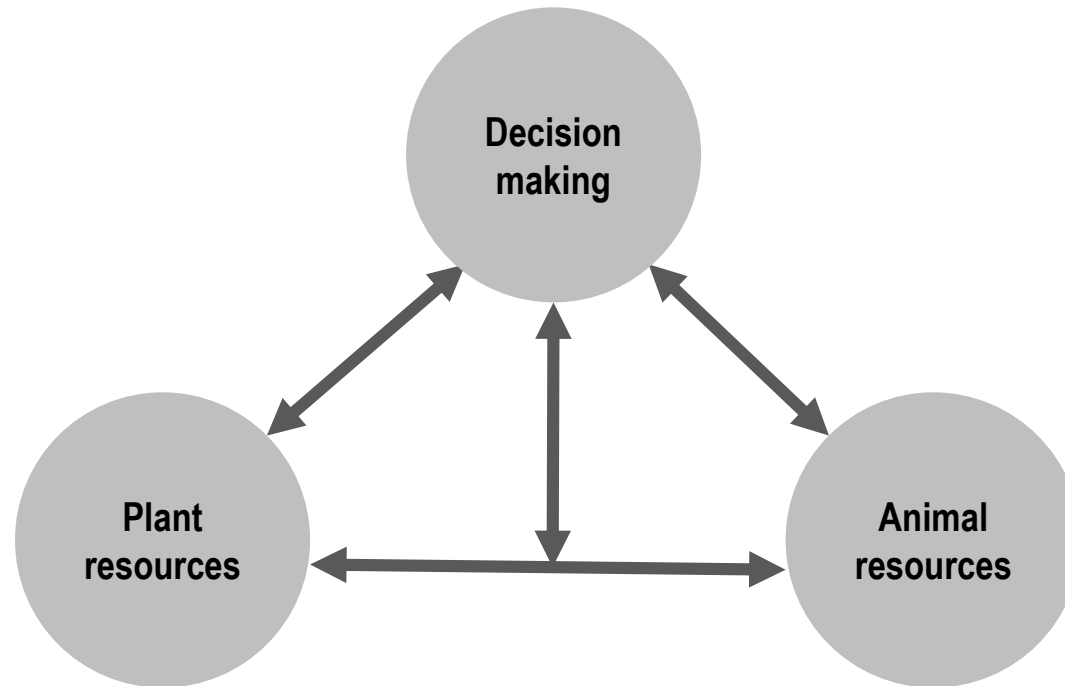
# Outline

- Sustainability of what ? defining livestock farming systems
- What has changed across time?
- Important features to account in sustainability assessment

Livestock farming system = a scientific concept aimed at understanding the complex reality of husbandry

- Several interacting sub-systems
- Dynamic systems
- Operate at several nested levels : farm, landscape, region, nation...
- Food provision + multiple functions that are important to society

# LFS made of three interacting sub-systems

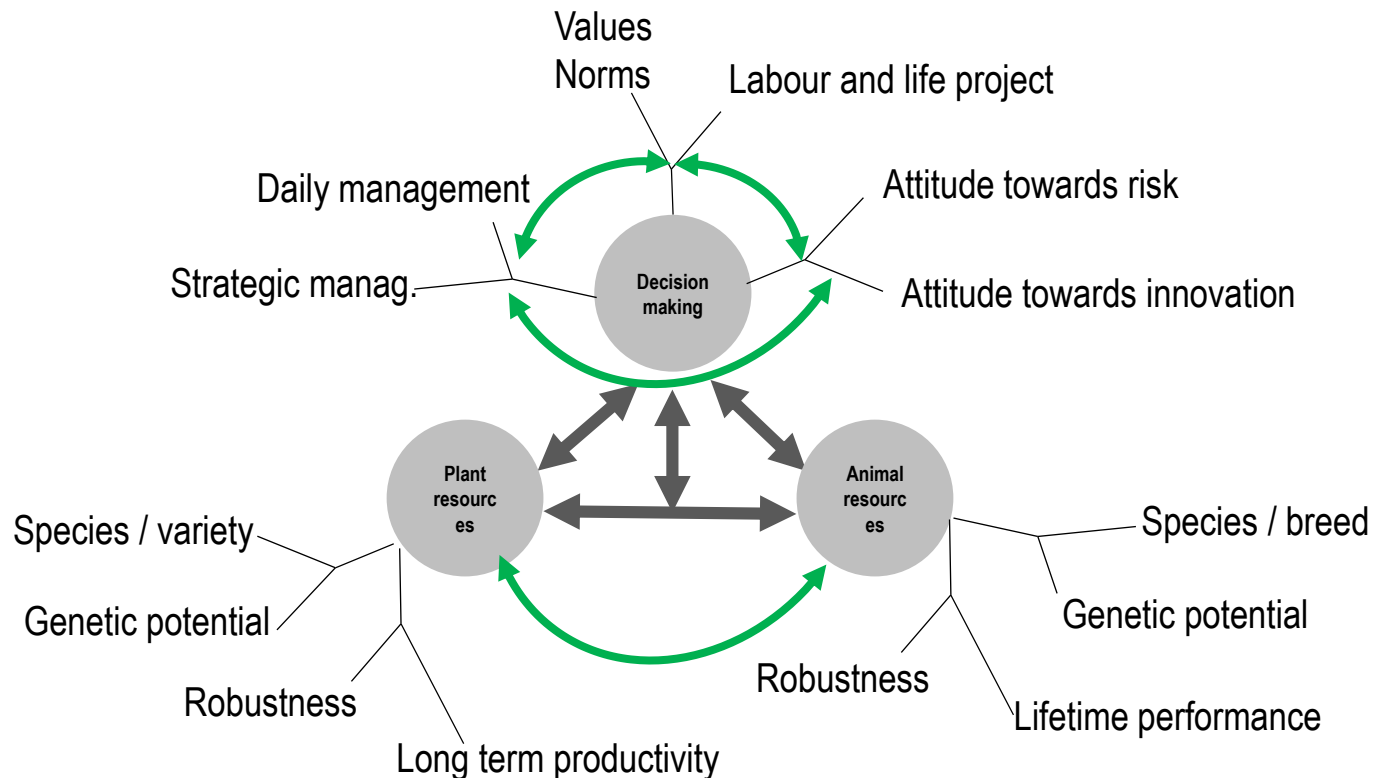


Landais 1987  
Gibon et al. 1988  
Béranger and Vissac 1994  
Gibon et al. 1999  
Gibon and Hermansen 2006  
Dedieu et al. 2008  
...

# Sustainability of what?

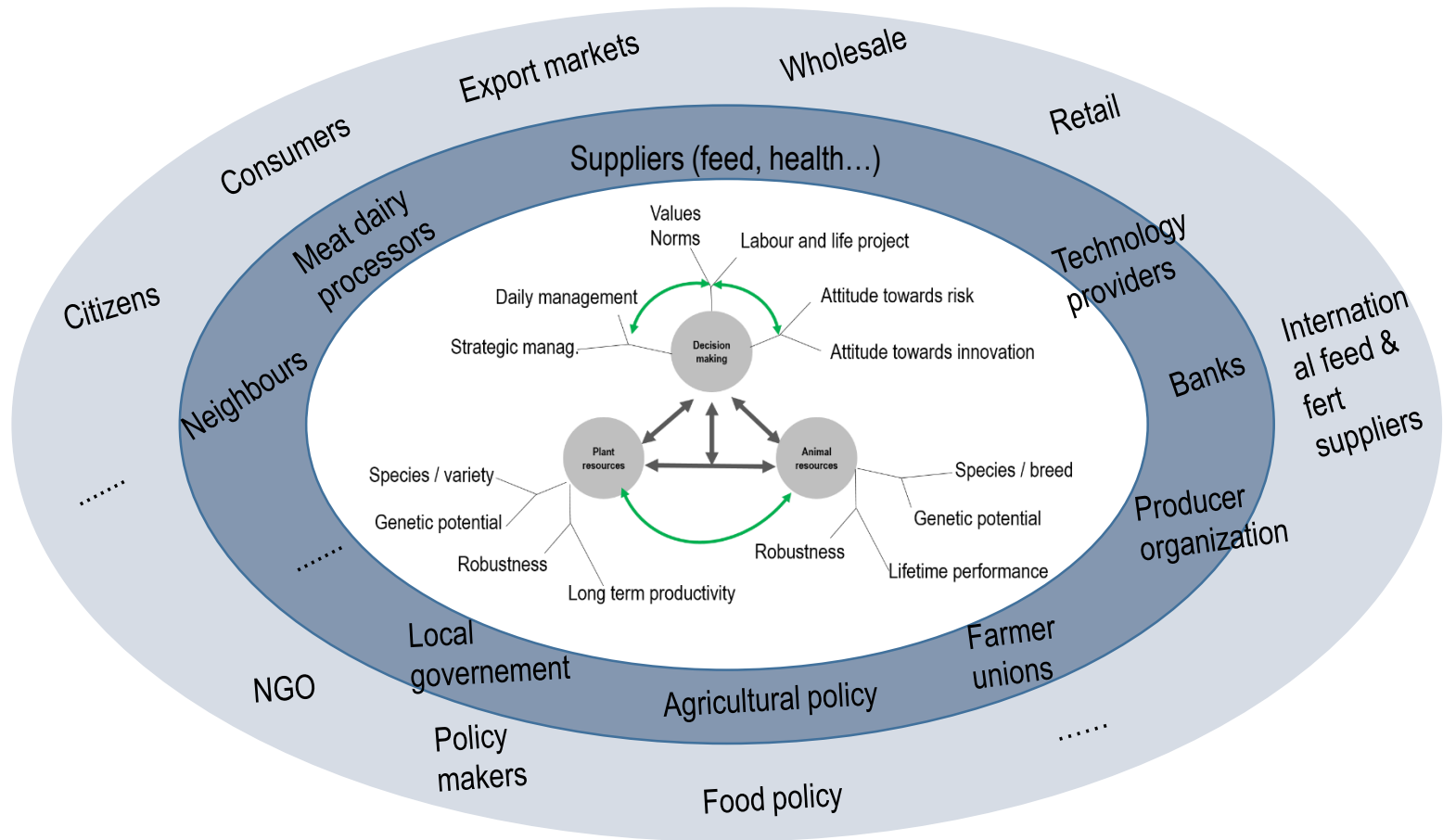
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Each sub-system has its own complexity due to many interdependencies



# Sustainability of what?

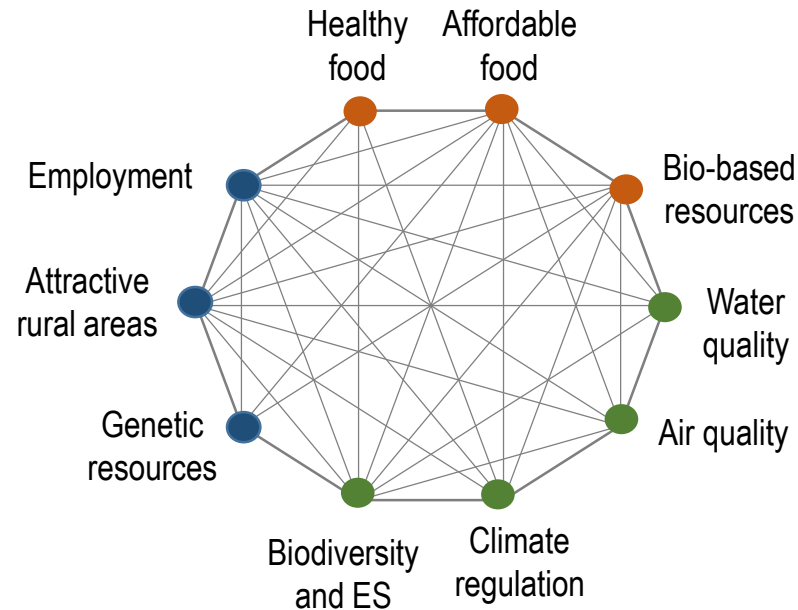
LFS are under the direct and indirect influence of a multitude of actors



## Sustainability of what?

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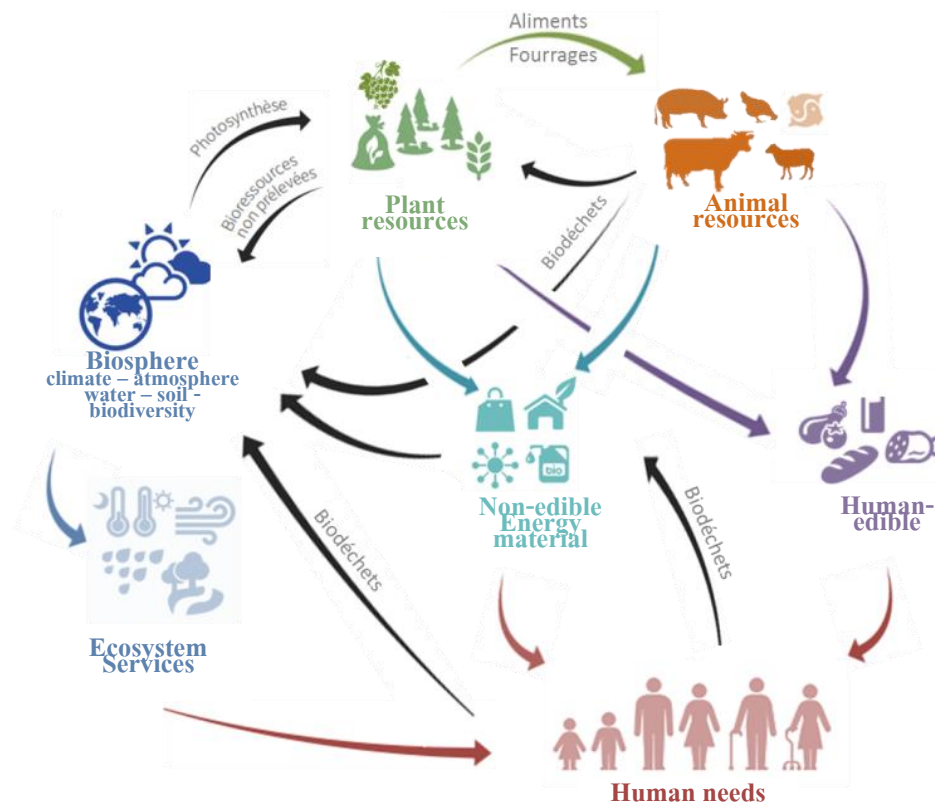
The interplay between the different sub-systems determine the capacity of LFS to provide multiple functions





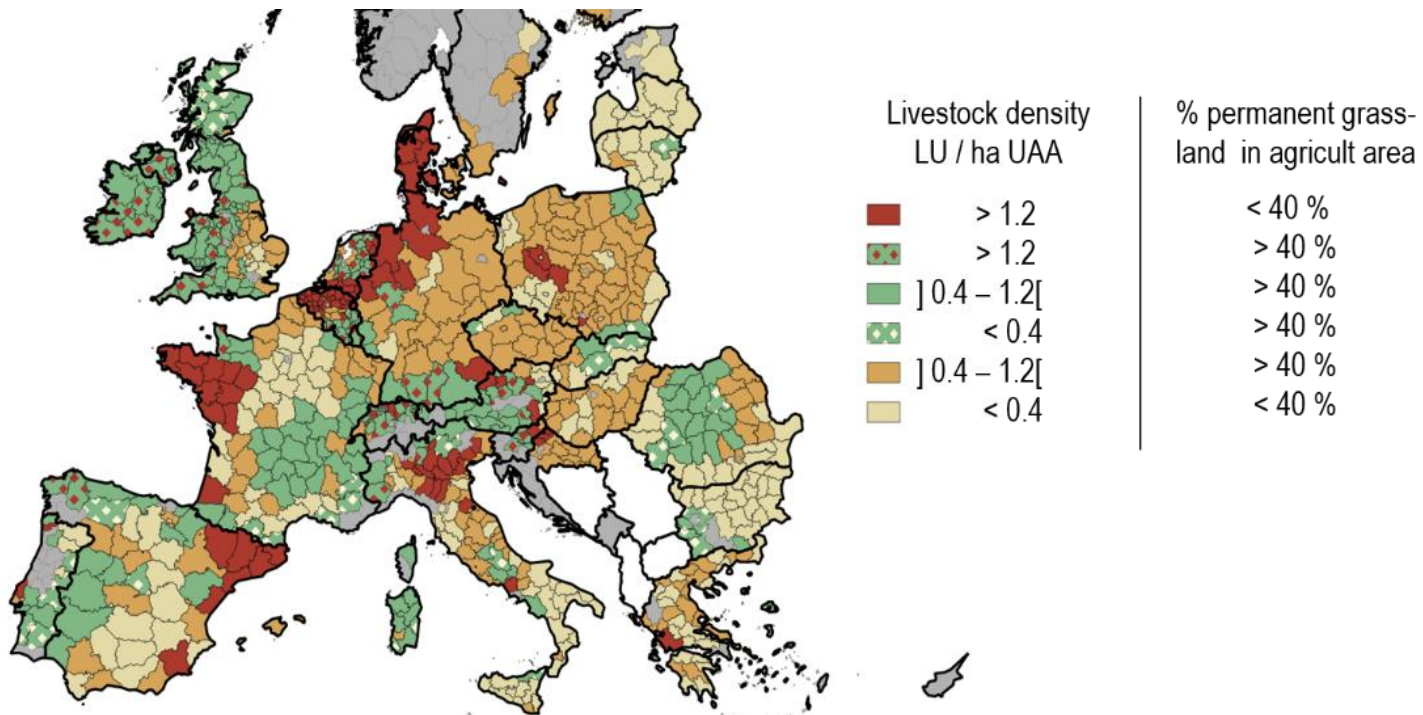
# Sustainability of what?

Livestock sustainability is about identifying the place of livestock in a sustainable food system



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- Sustainability of what ? defining livestock farming systems
  - **What has changed across time?**
  - Important features to account in sustainability assessment

## Current LFS are heterogeneous due to contrasted past intensification



# Changes occurred both in supply and demand sides

### Supply

- Animal productivity
- Resource use
- Labour productivity
- Input dependency
- Input/output price ratio
- Farmers value
- ...

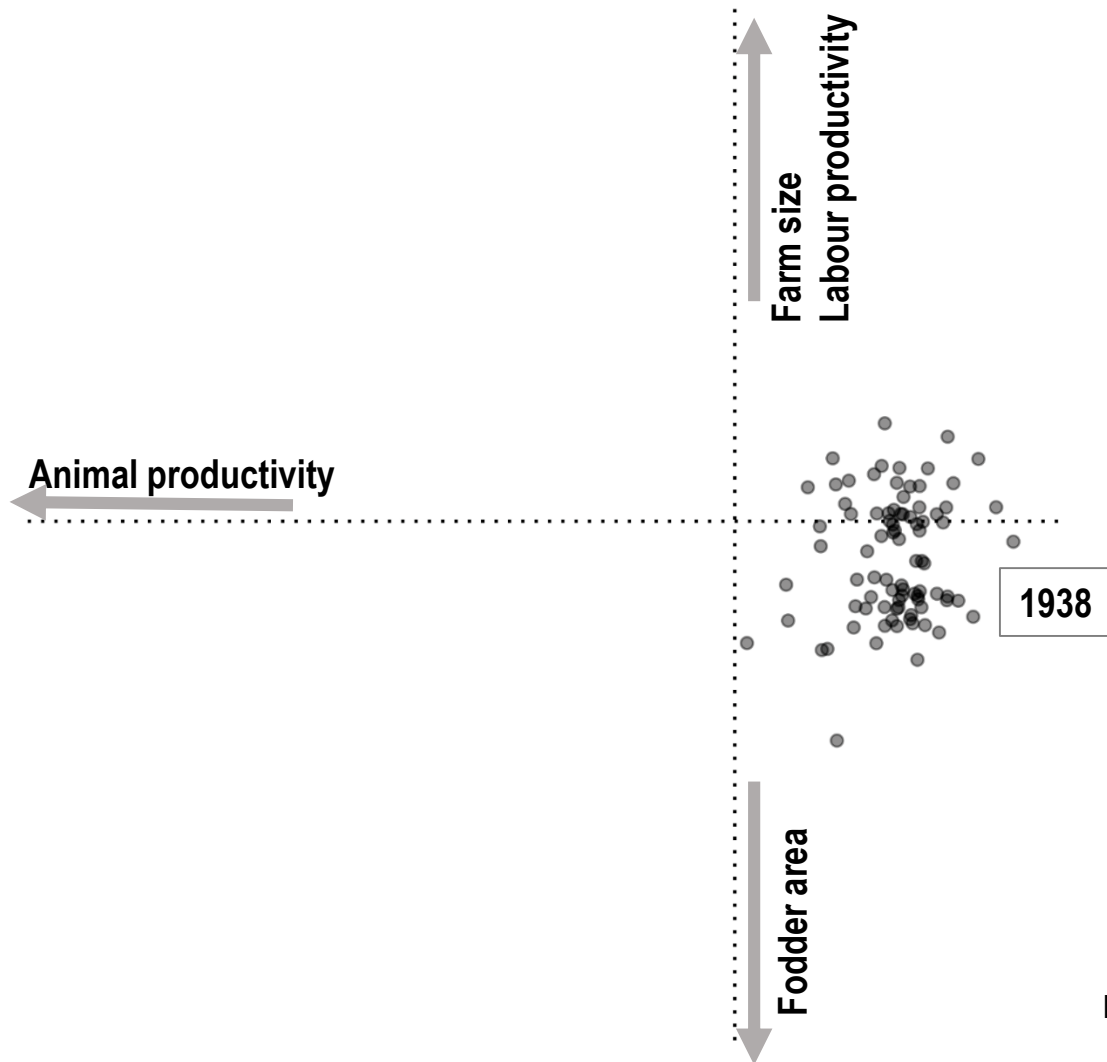
### Demand

- Diet / share of animal products
- Citizen expectations on animal welfare
- Citizen expectations environmental protection
- Consumer values
- Policy maker attention to these issues

## What has changed across time ?

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# LFS intensification btw 1938 and 2010 -- France



Domingues et al. 2017 Animal

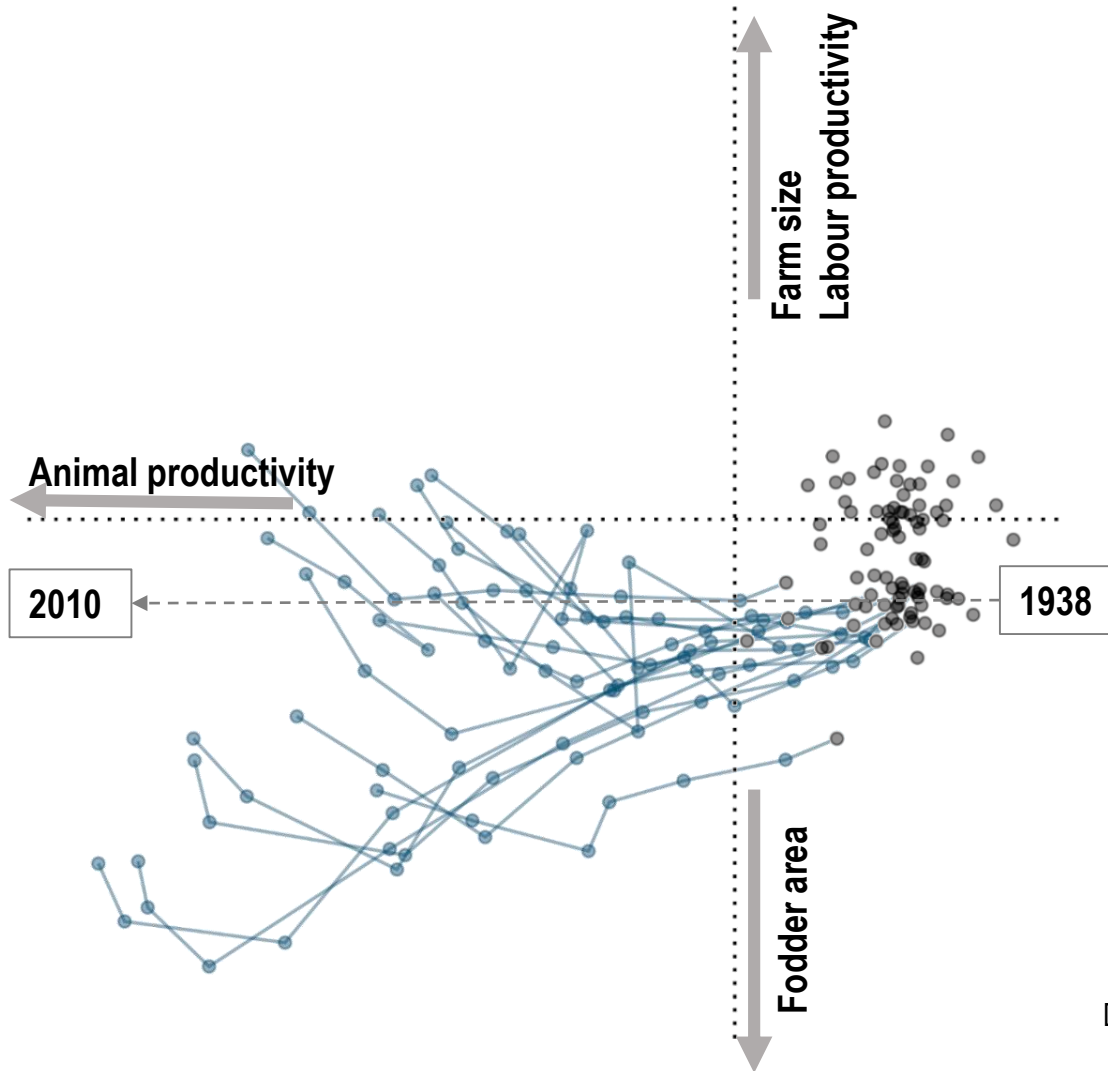
Each dot represents a land unit (France is divided into 94 NUTS3 land units)

# What has changed across time ?

## LFS intensification btw 1938 and 2010 – France



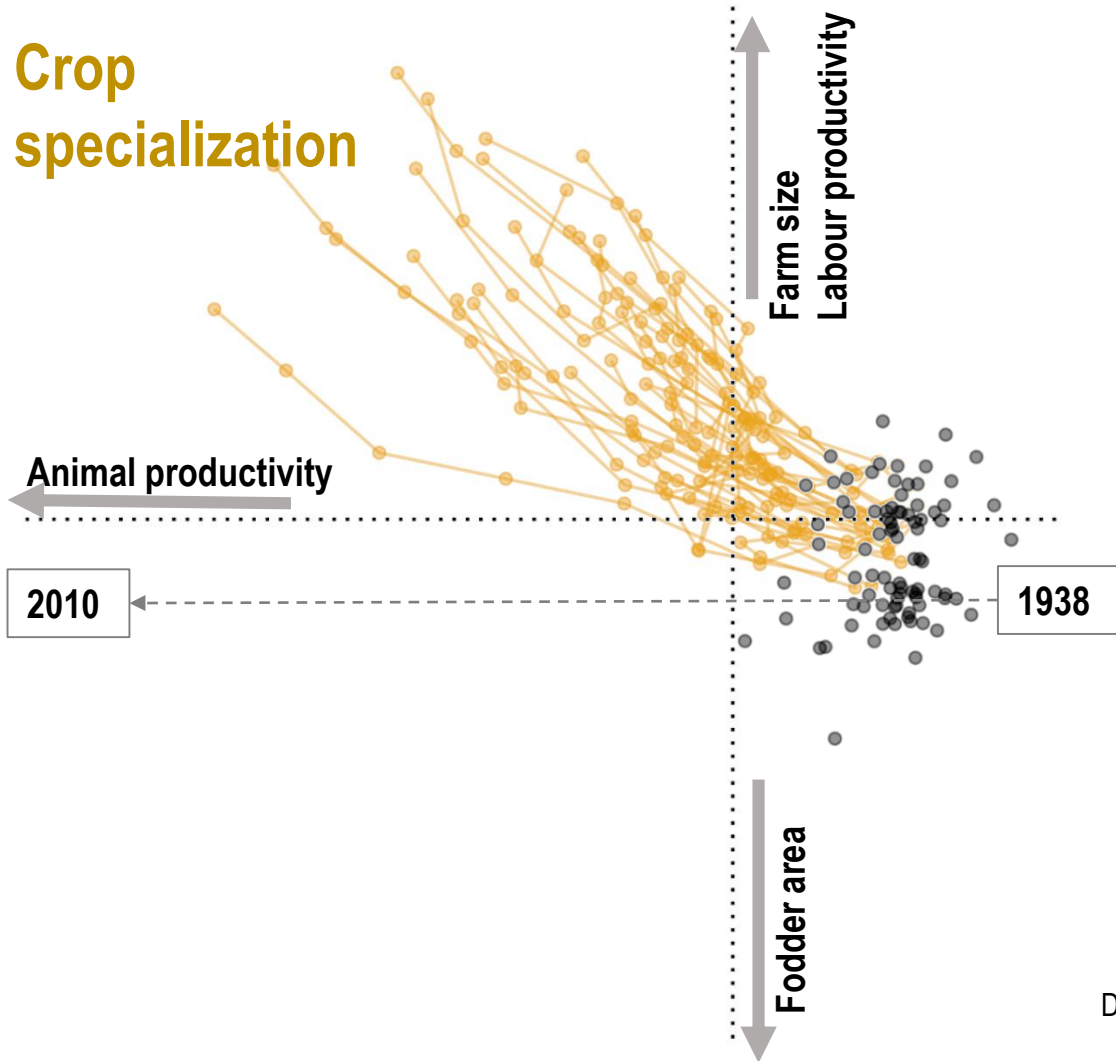
Ruminant and monogastric specialization



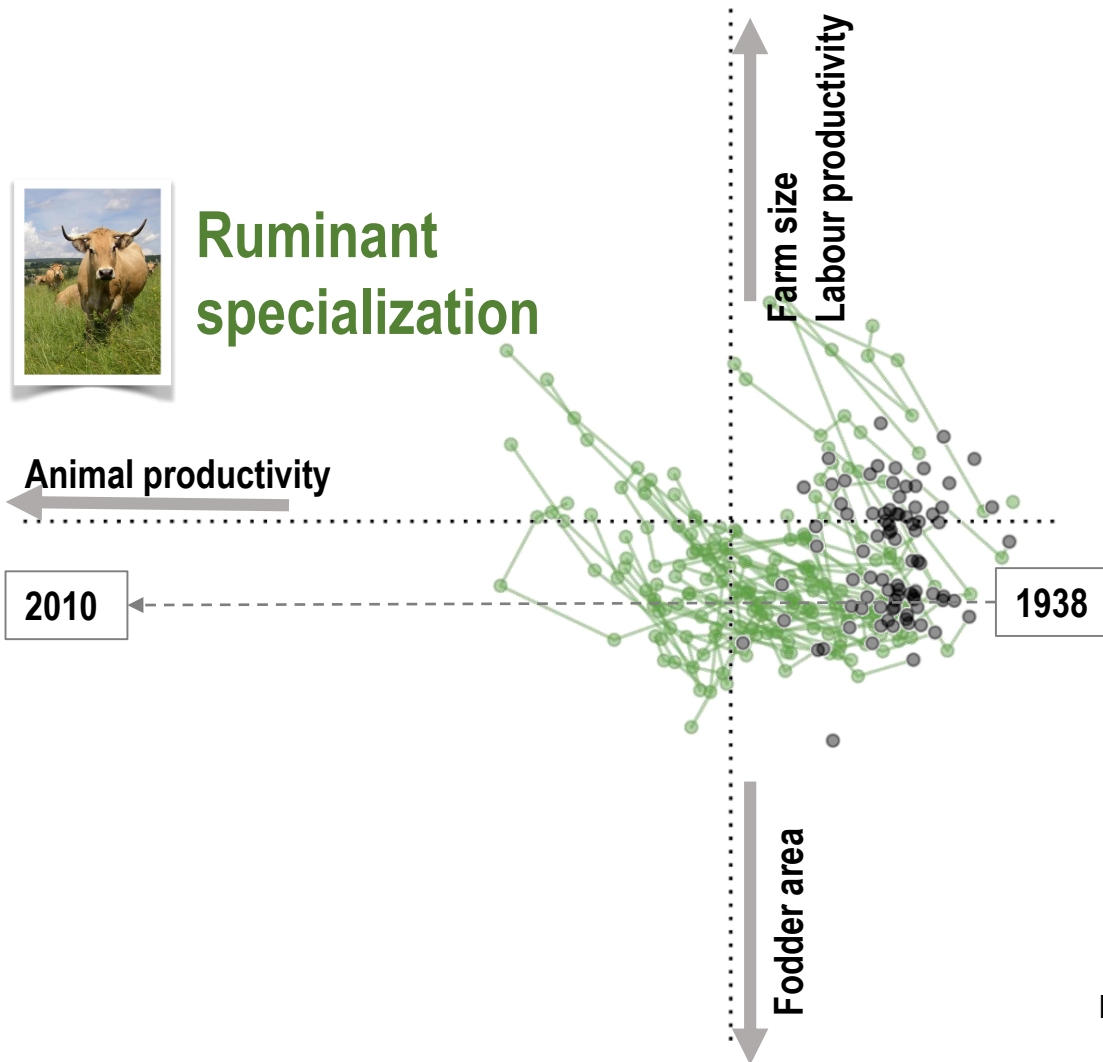
# What has changed across time ?



**Crop  
specialization**



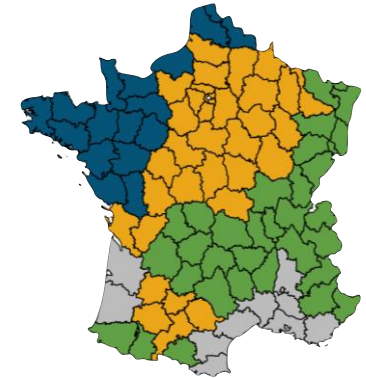
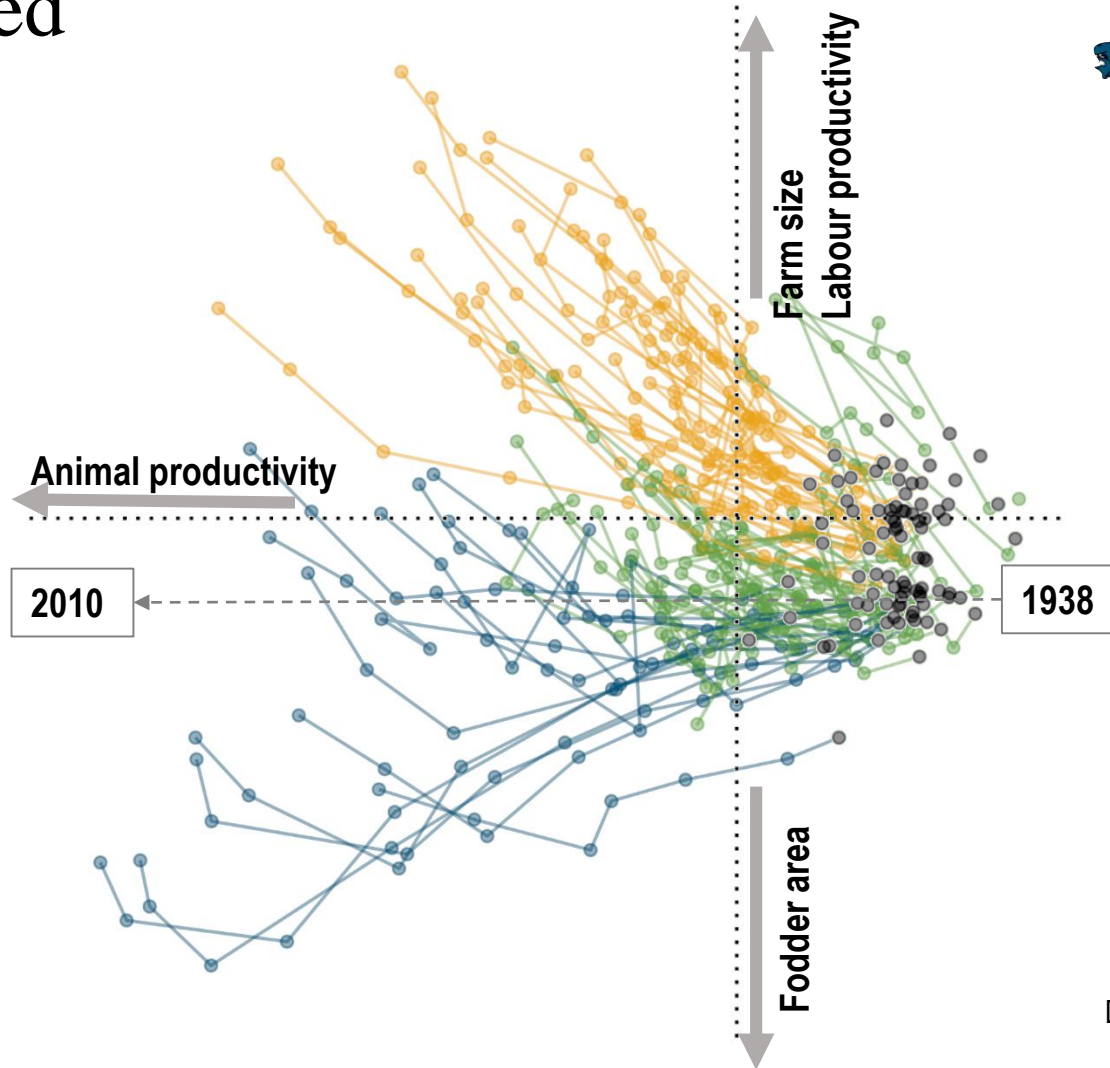
# What has changed across time ?





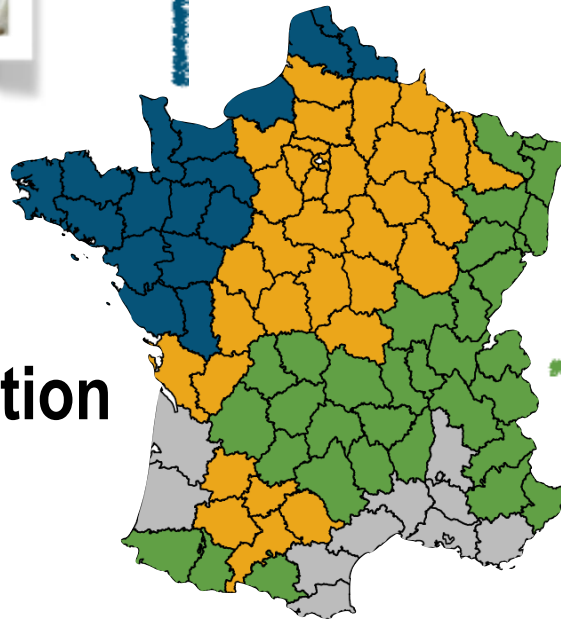
# What has changed across time ?

## Intensification trajectories are spatially structured



# What has changed across time ?

## Different links to local / global resources



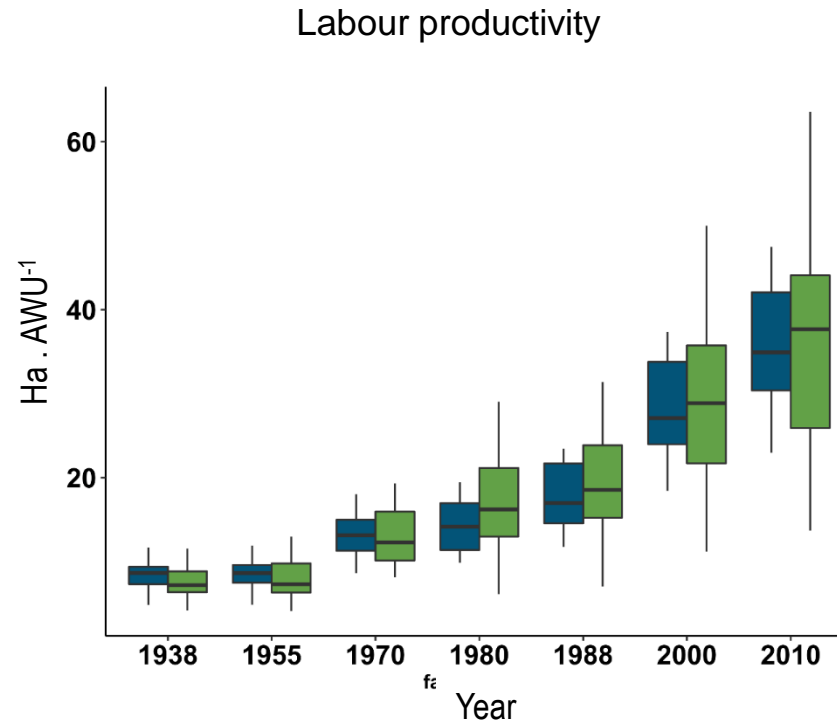
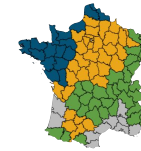
**23% of protein production on 27% UAA**

**57% of protein production (meat, milk, eggs) on 25% UAA**



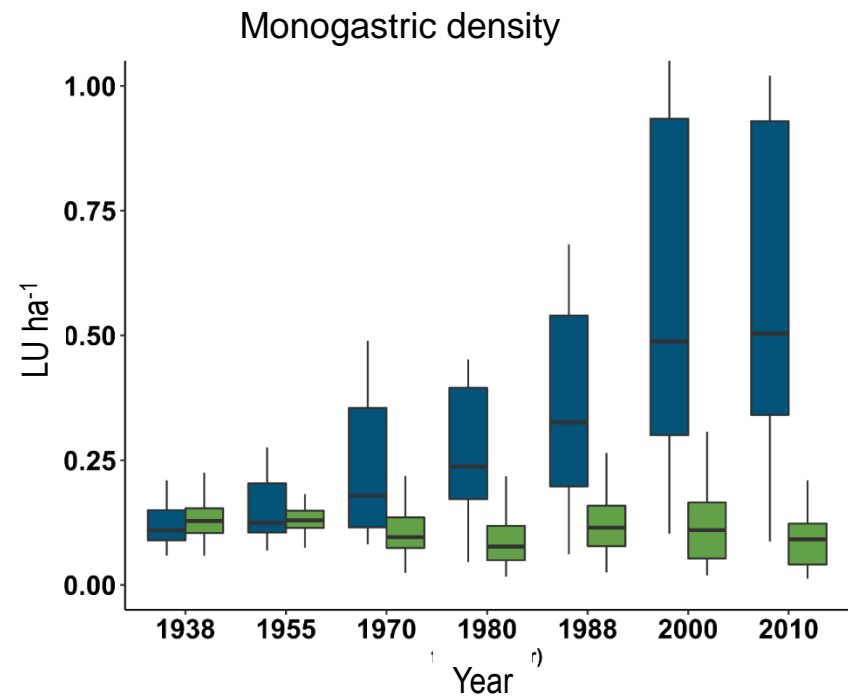
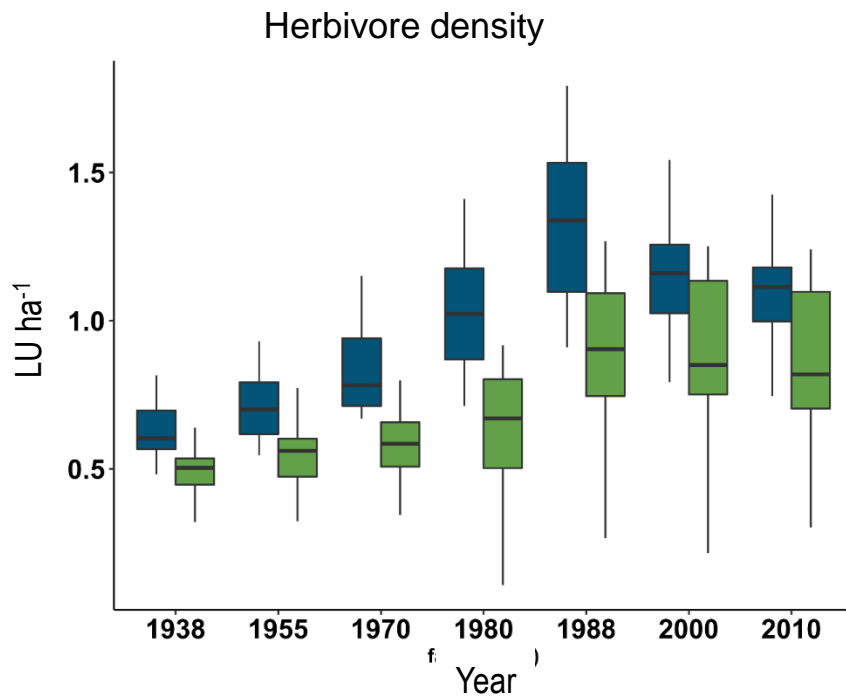
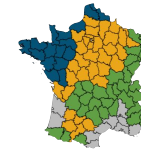
# What has changed across time ?

## Major changes in (1) labour productivity



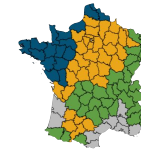
# What has changed across time ?

## Major changes in (2) monogastric density

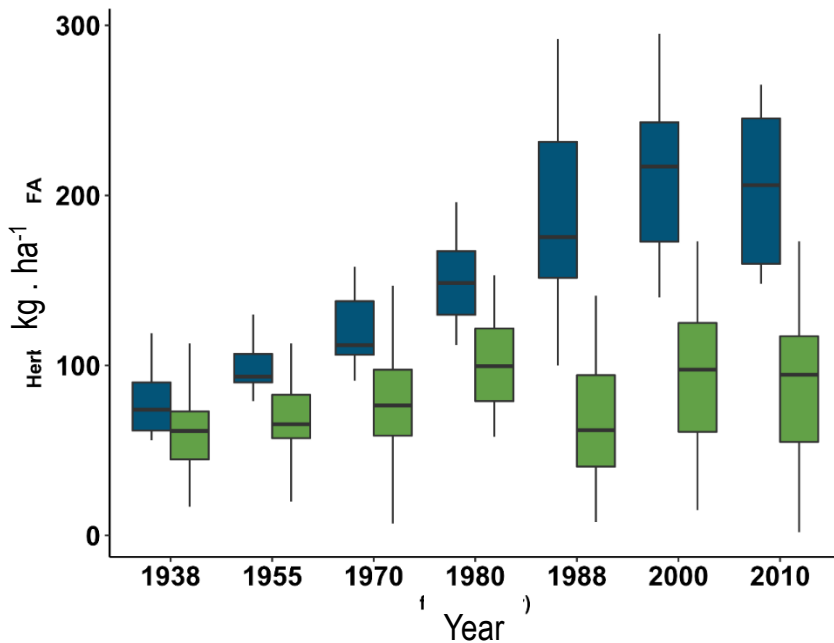


# What has changed across time ?

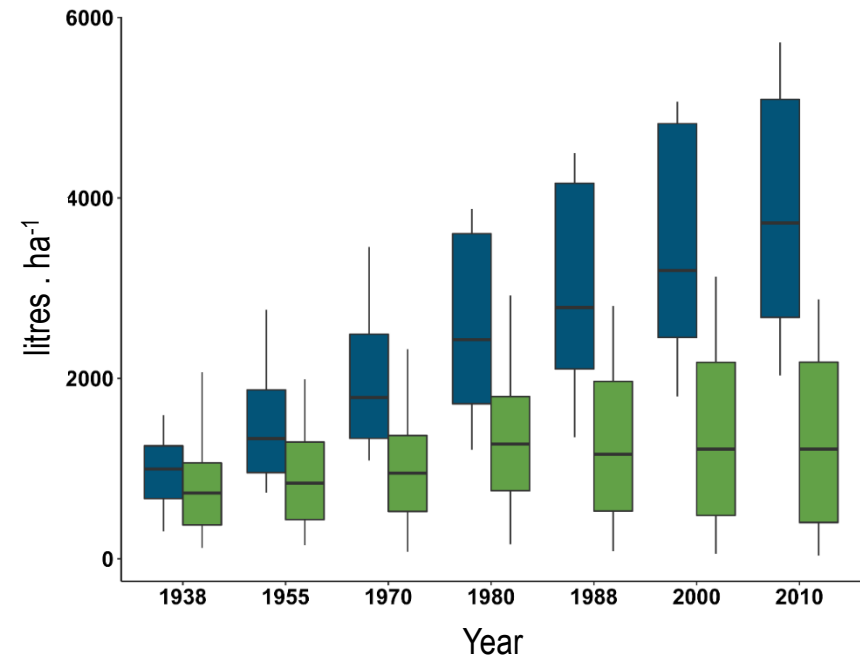
## Major changes in (3) milk productivity



Herbivore meat production per ha main fodder area

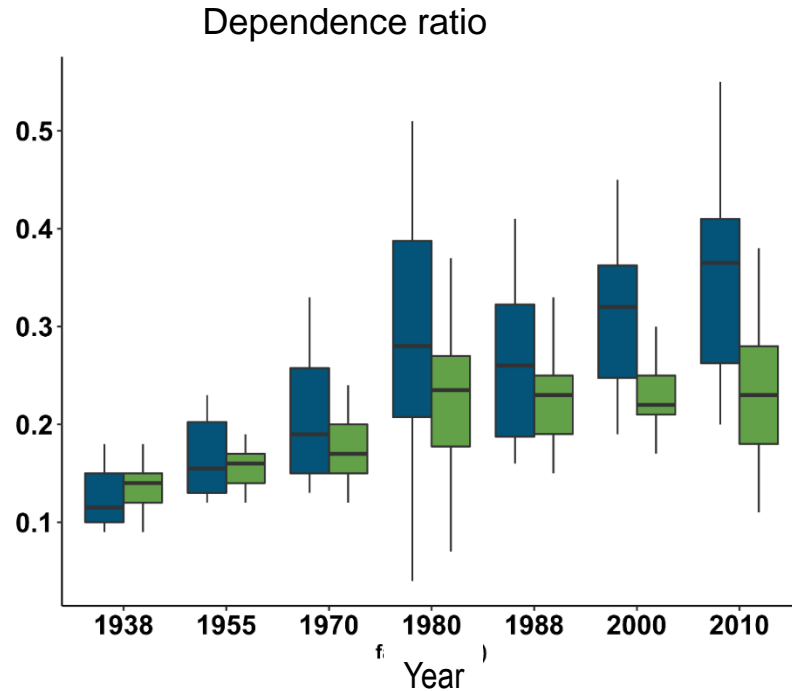


Milk production per ha main fodder area



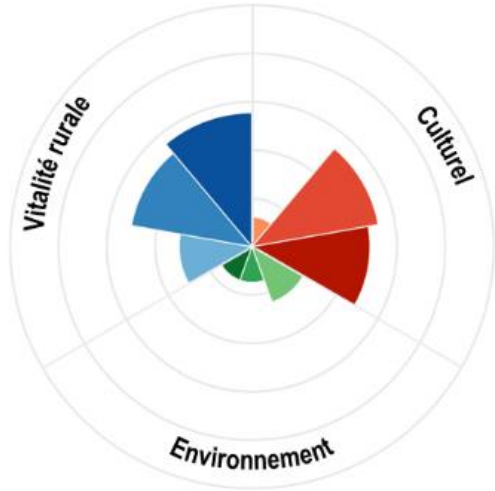
# What has changed across time ?

## Major changes in (4) dependence to purchased feed

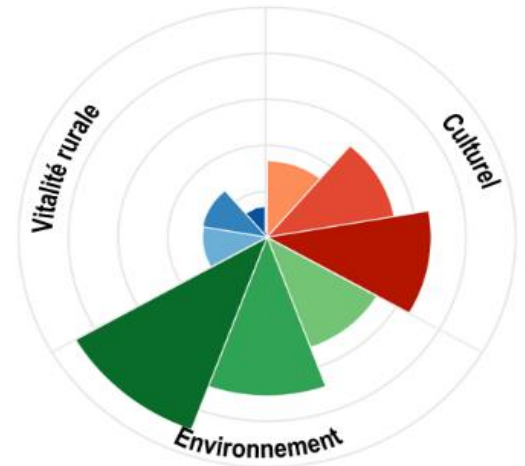
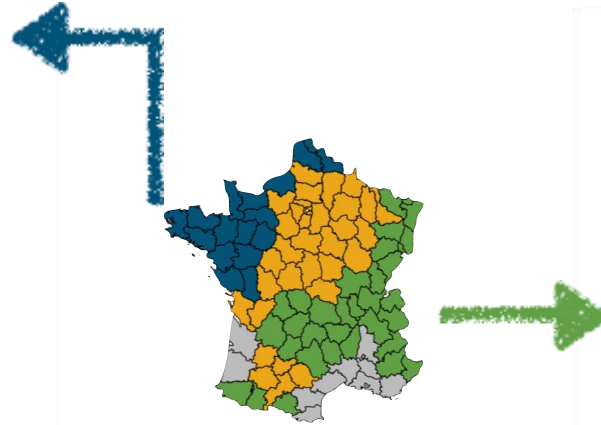


# What has changed across time ?

Past changes have led to contrasted bundle of services in 2010



+  
57% of protein  
production (meat,  
milk, eggs)



+  
23% of protein  
production  
(meat, milk,  
eggs)



- 
- Sustainability of what ? defining livestock farming systems
  - What has changed across time?
  - **Important features to account in sustainability assessment**

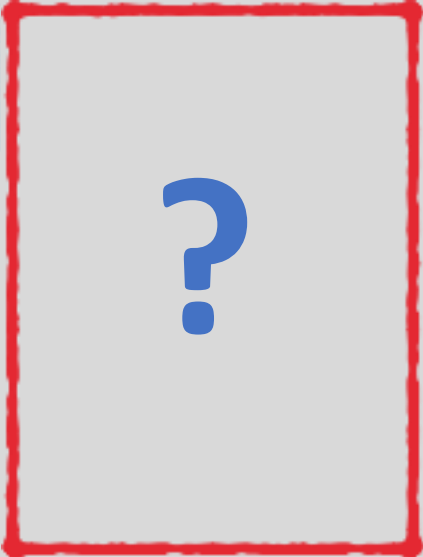


## Important features in sustainability assessment

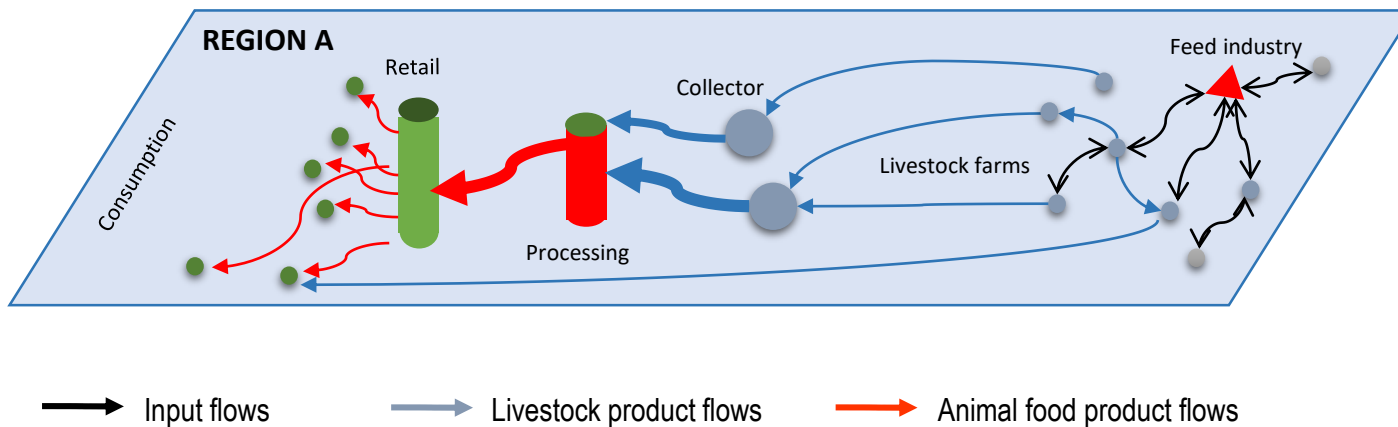
- Sustainability is a multi level problem
- Multidimensional nature of LFS performance
- and their tradeoffs / synergies
- Irreversibilities
- ...

# The research effort has concentrated on animal and farm levels

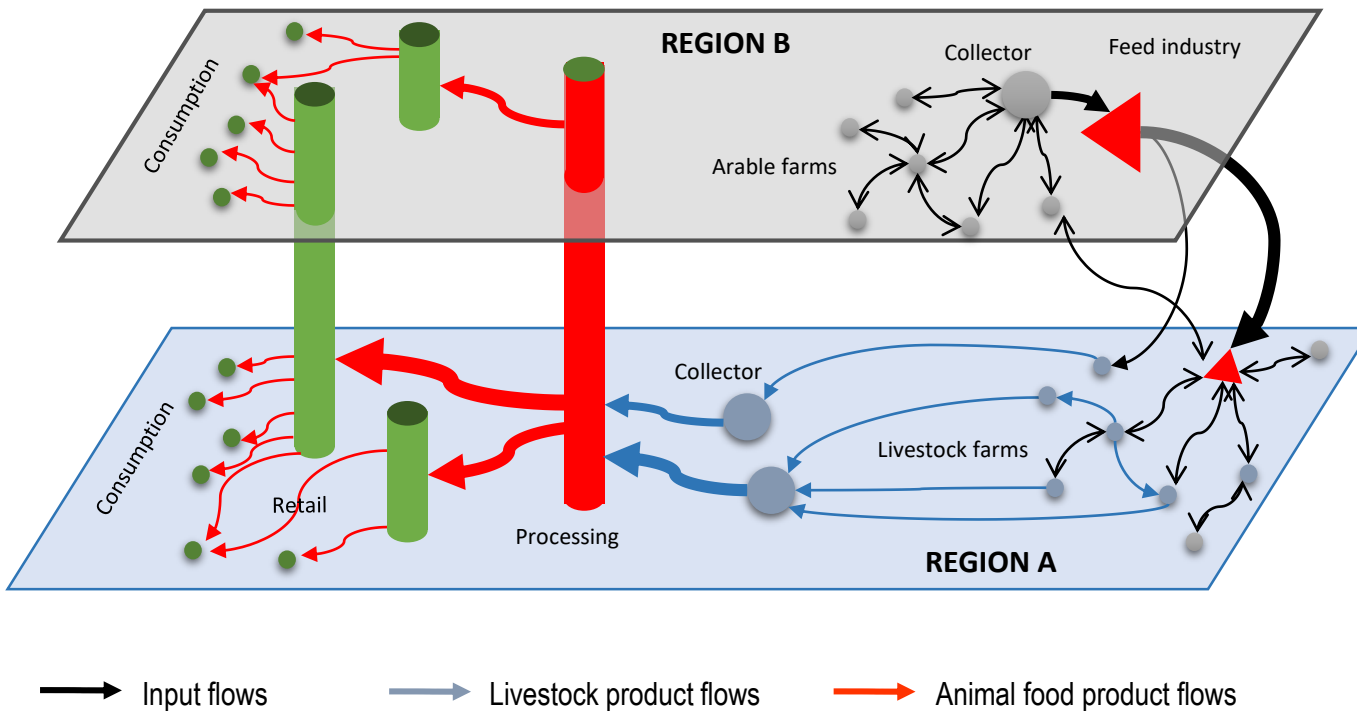
## Summary of Nitrogen Use Efficiency % results found in the literature

	Animal level NUE		Farm and system level		Higher levels
	Range	References	Range	References	
Dairy cattle	15 to 35 <sup>b</sup>	[25,26,29, 51-57]	15 to 41 <sup>d</sup> 15 to 55 <sup>e</sup>	[2*,19,21**,29,30, 51,55,60,61*,62] [19,30,61*,62,65]	
Beef cattle	4 to 8 <sup>b</sup>	[51,66]	7 to 38 <sup>d</sup> 26-34 <sup>e</sup>	[21**,67] [19]	
Pig	10 to 44 <sup>b</sup>	[51,62,65]	50 <sup>d</sup> 41-45 <sup>e</sup>	[51] [18,20]	
Poultry	25 to 62 <sup>b</sup>	[51,62,65, 67-69]	39 <sup>d</sup> 35 to 48 <sup>e</sup>	[69] [20]	
All species combined	7.1 to 10.5 <sup>b</sup> 74.1 <sup>c</sup>	[8*,70]	5 to 45 <sup>e</sup>	[20,71]	

We need to understand how individual farms interact with other farms and up and downstream actors

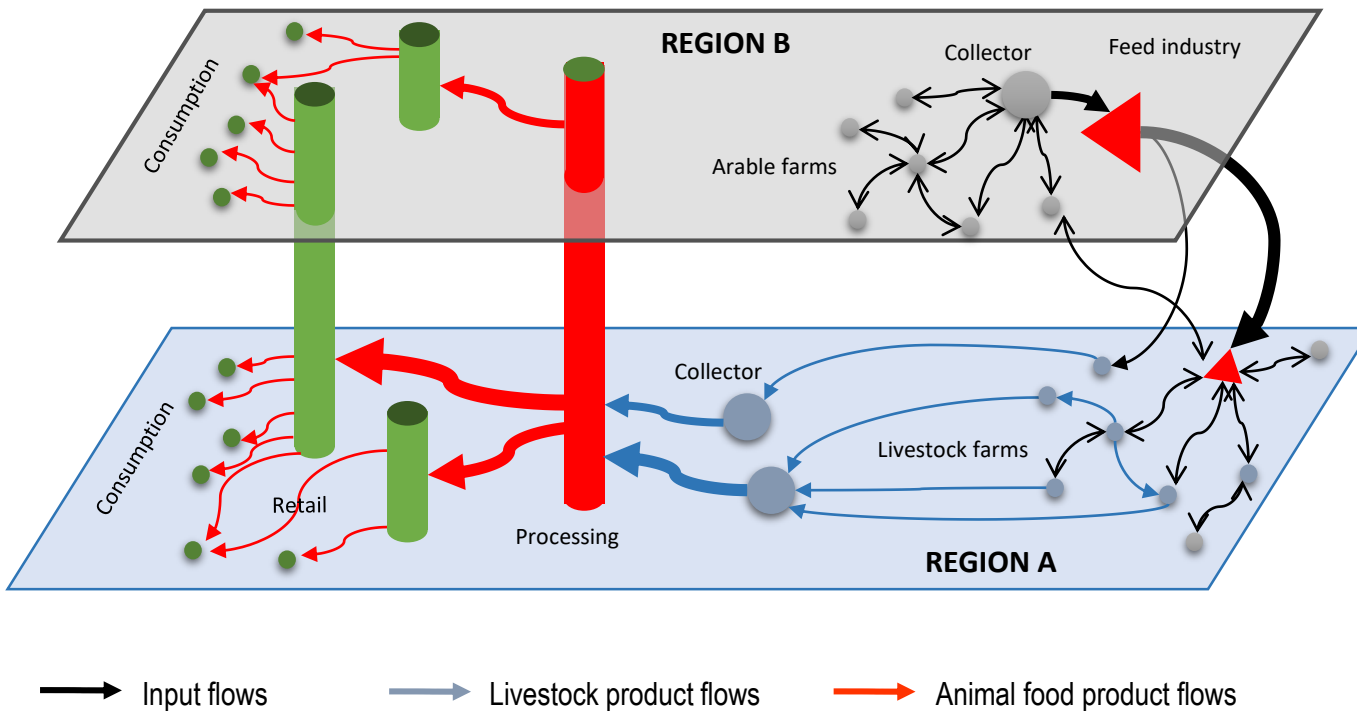


## We need to understand interdependencies btw regions



# Important features in sustainability assessment

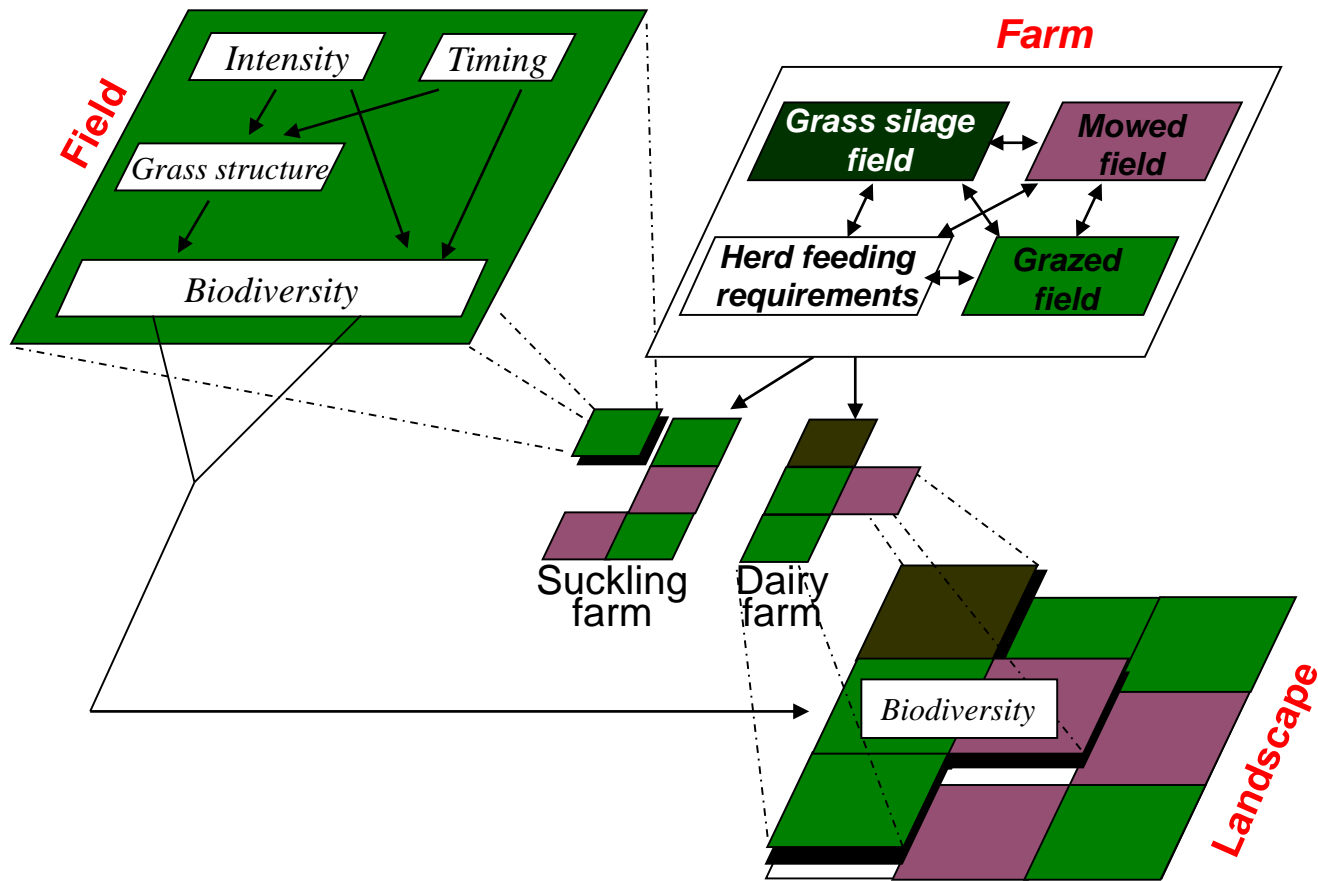
Farm sustainability is a necessary but not sufficient condition for regional sustainability



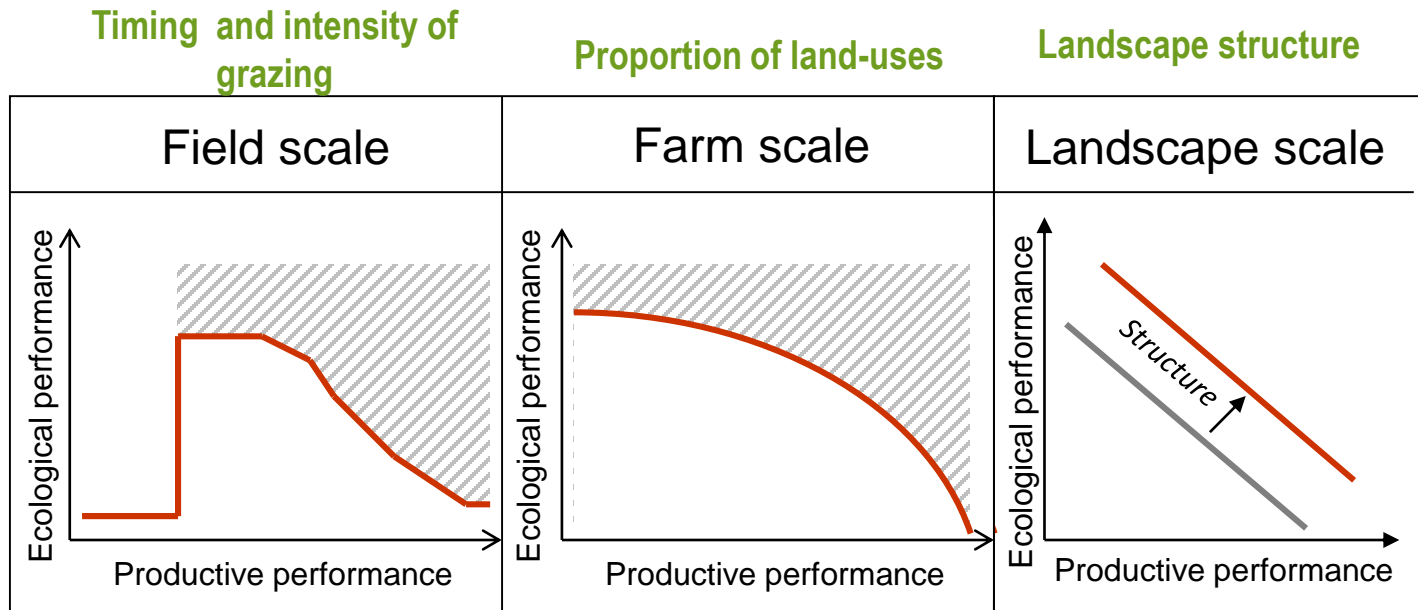
Sustainability is about multidimensionality we thus need to pay attention to tradeoffs

- Tradeoff occurs when there is a conflict between two objectives (A,B)
- On the tradeoff frontier, any improvement in objective A will lead to a decline in objective B
- The shape of the tradeoff curve informs on the severity of the conflict between the two objectives
- Essential to understand underlying drivers of tradeoffs

# A multi level modelling framework for tradeoff analysis in grassland landscapes



# Tradeoff shape changes from one level to another



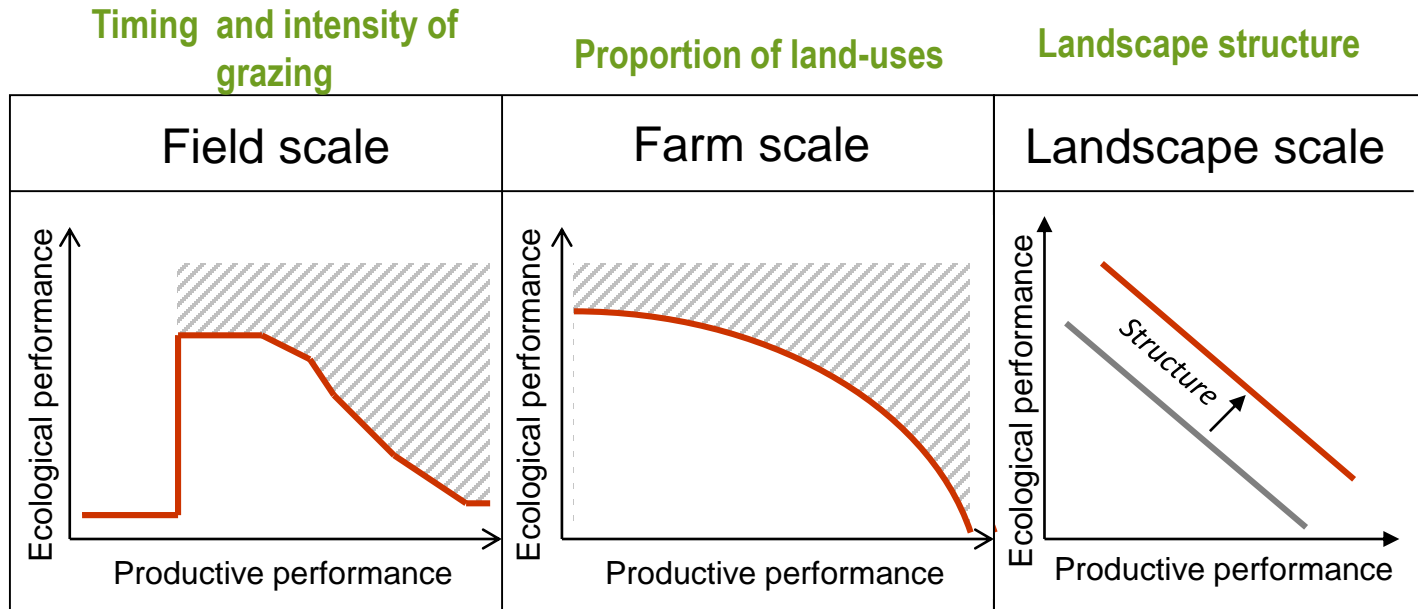
*Sabatier et al. 2010 Ecol.Mod*

*Sabatier et al. 2014 Animal*

*Sabatier et al. 2013 Agric Syst*



# Levers for softening tradeoffs also changes from one level to another



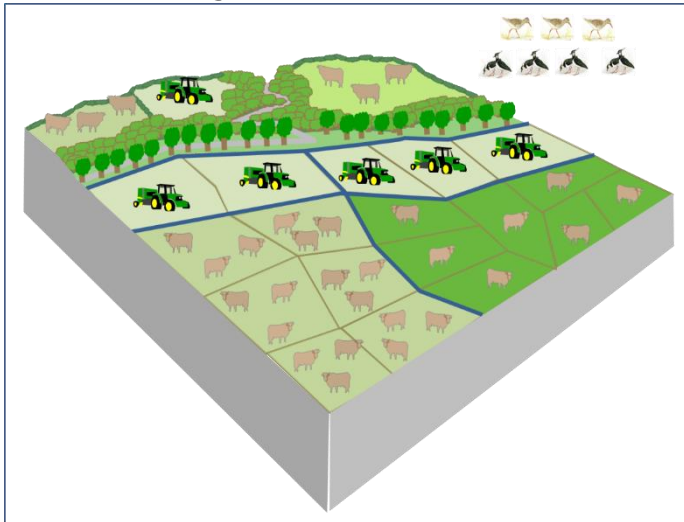
*Sabatier et al. 2010 Ecol.Mod*

*Sabatier et al. 2014 Animal*

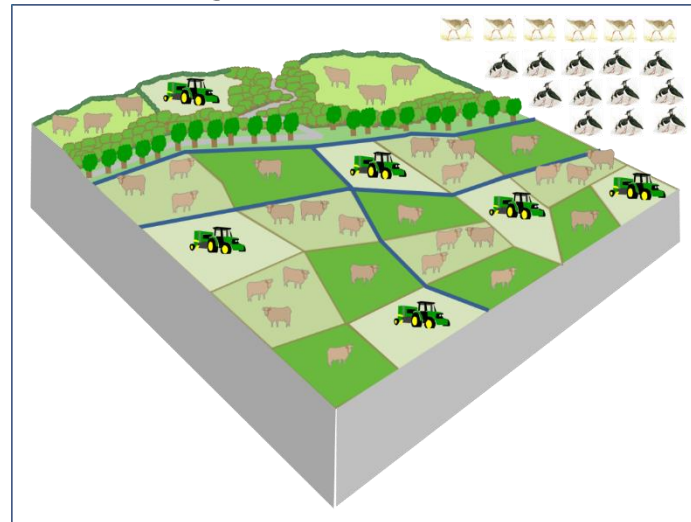
*Sabatier et al. 2013 Agric Syst*

# Landscape heterogeneity can help achieving win-no loss solutions

Homogeneous landscape

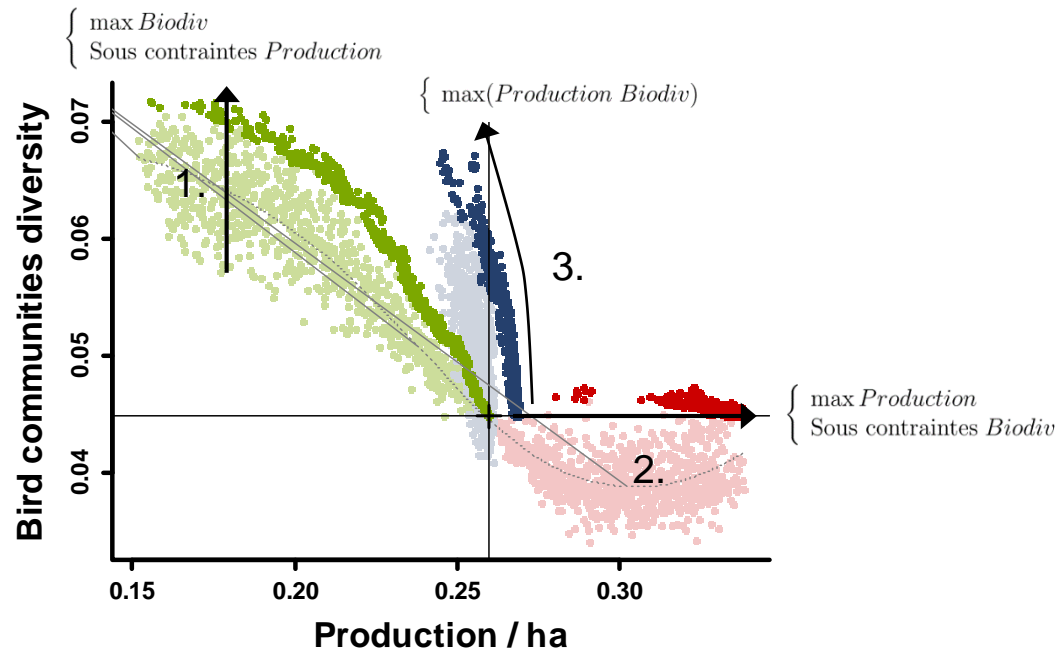


Heterogeneous landscape



# At regional level, the allocation of farming intensity helps achieving win-no lose solutions

## Three scenarios of farming intensity allocation





### In a nutshell

Livestock sustainability means the ability to understand intricacies of connected sub-systems and from that understanding being able to take decision that will maintain LFS into a safe operating space



# STEERING ANIMAL PRODUCTION SYSTEMS TOWARDS SUSTAINABLE FUTURE