# Landscape Patterns and Ecosystems Processes in Agricultural Landscapes: Causes and Consequences

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# Landscape Patterns and Ecosystems Processes in Agricultural Landscapes: Causes and Consequences


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Terre, Écosystèmes et Sociétés
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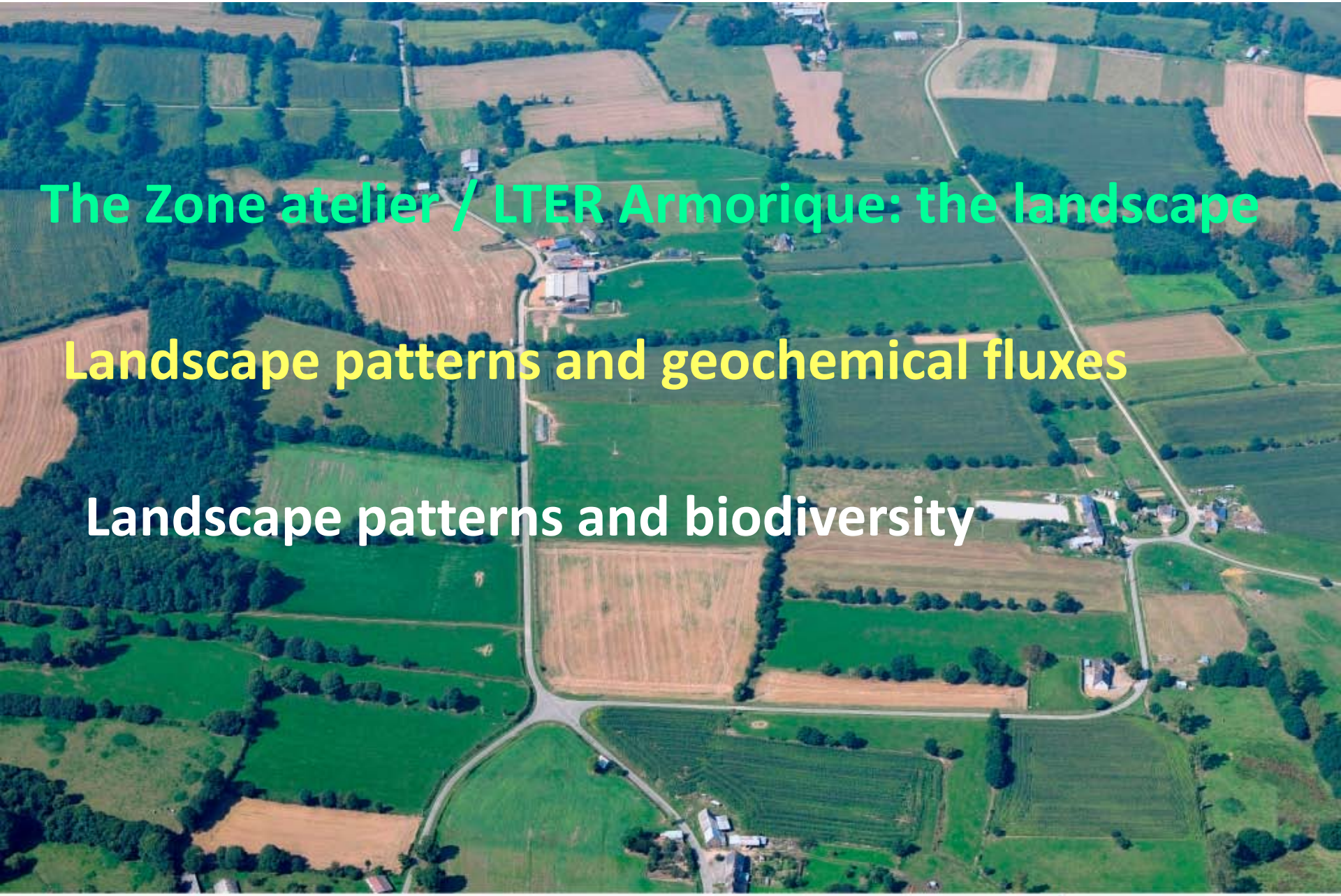
INRA

cnrs
dépasser les frontières


How an agricultural landscape has been designed over millennia to control ecological processes, therefore to provide services to the society.
How changes in landscape patterns induce changes in ecological processes.


The Zone atelier / LTER Armorique: the landscape
Landscape patterns and geochemical fluxes
Landscape patterns and biodiversity
Air Papillon
Pleine Fougères 2008
Launay Pinier (B)
Vieux Viel
30 août 2008
Perspective Oblique
B08_02_APU6644.jpg

# The Zone atelier / LTER Armorique: A man made landscape

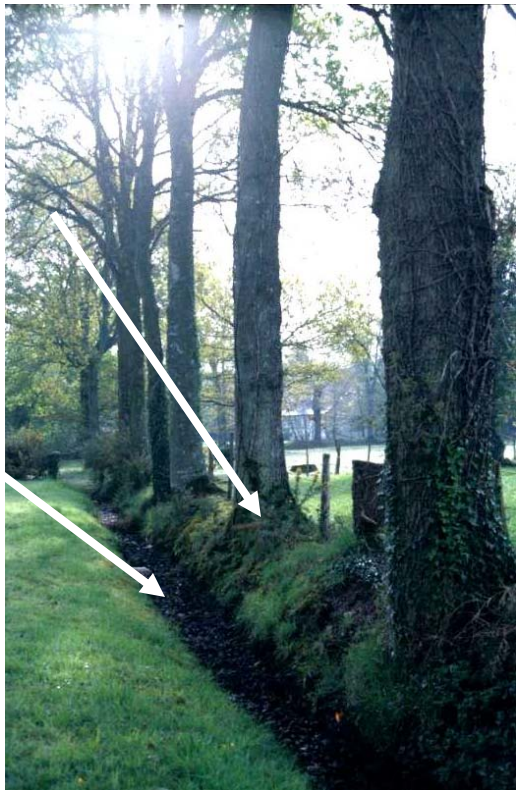

Gradient of hedgerow density/ land use

# The function of hedgerows

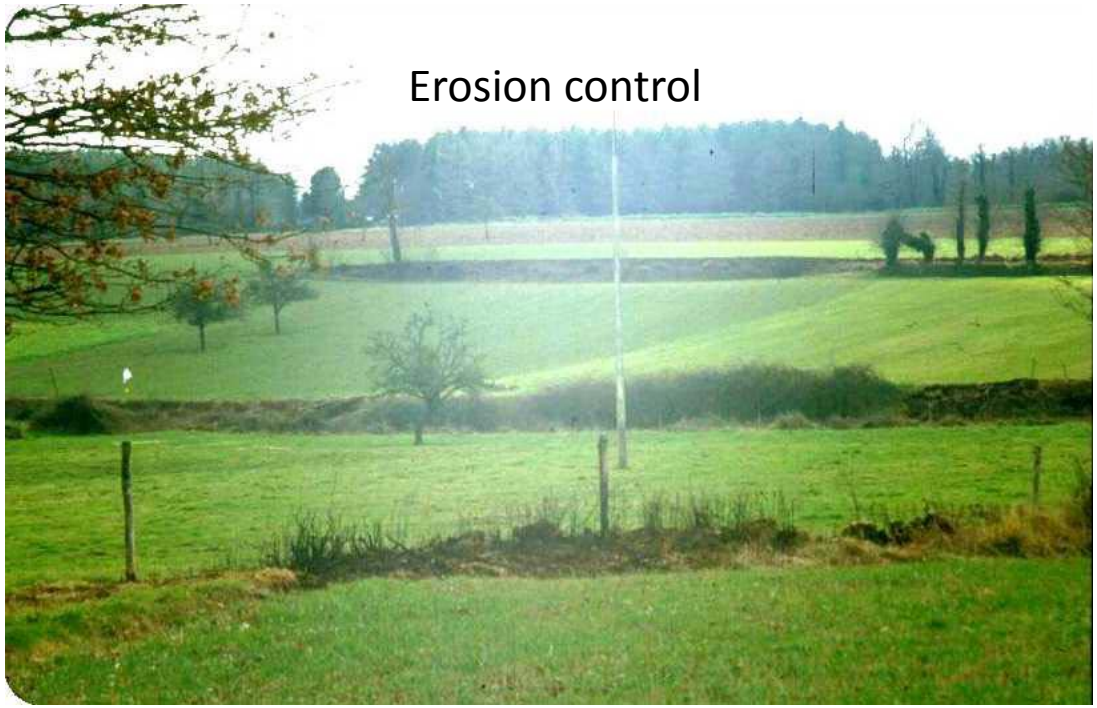
Firewood, timber
Fence
Etc.

Planted on a bank along a ditch

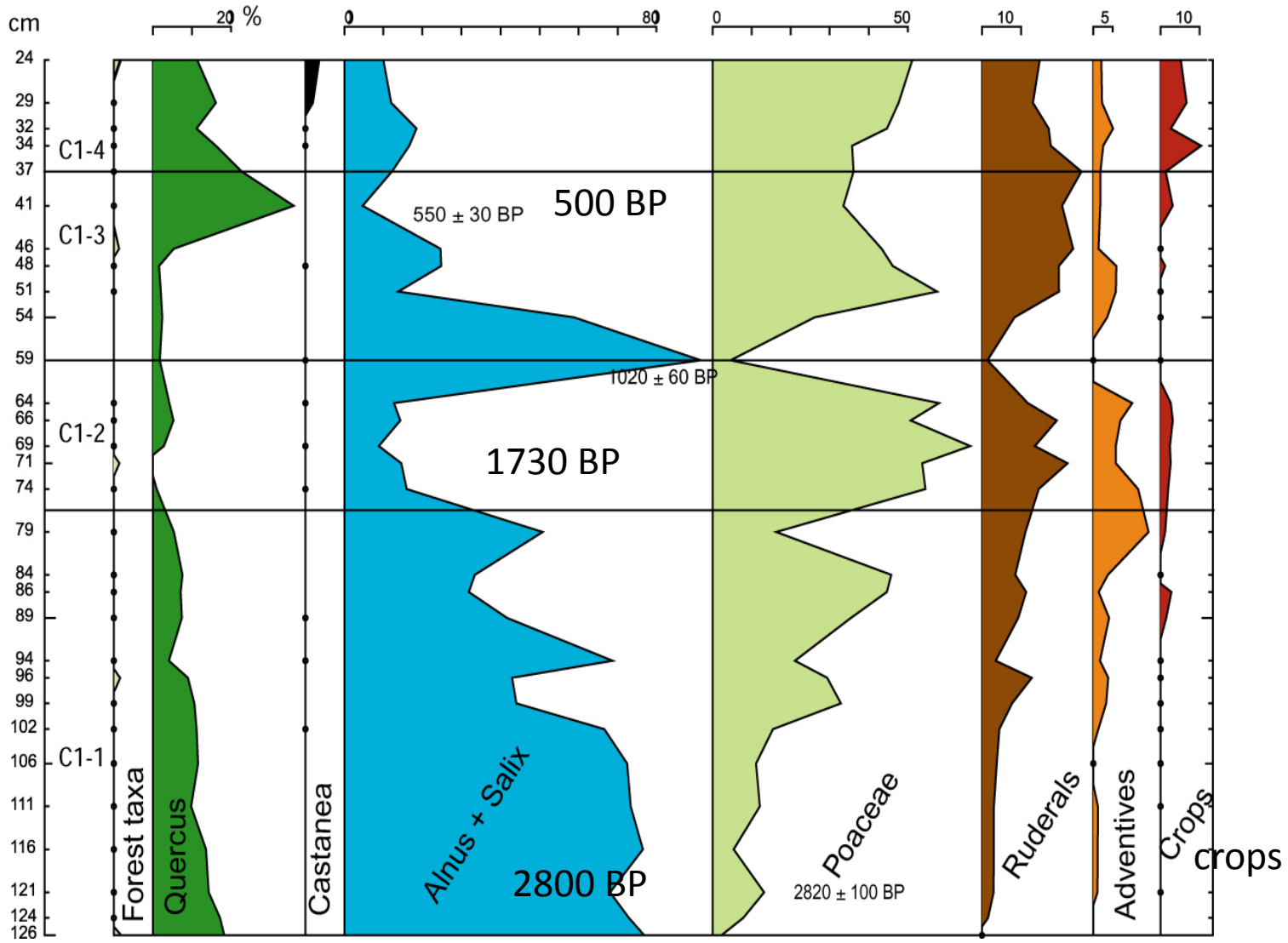
Control of water flow



Erosion control

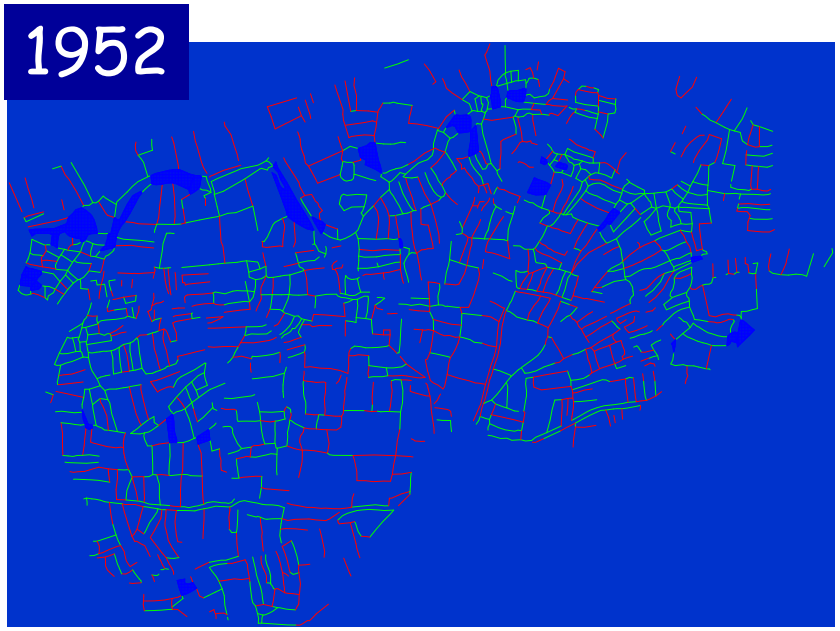


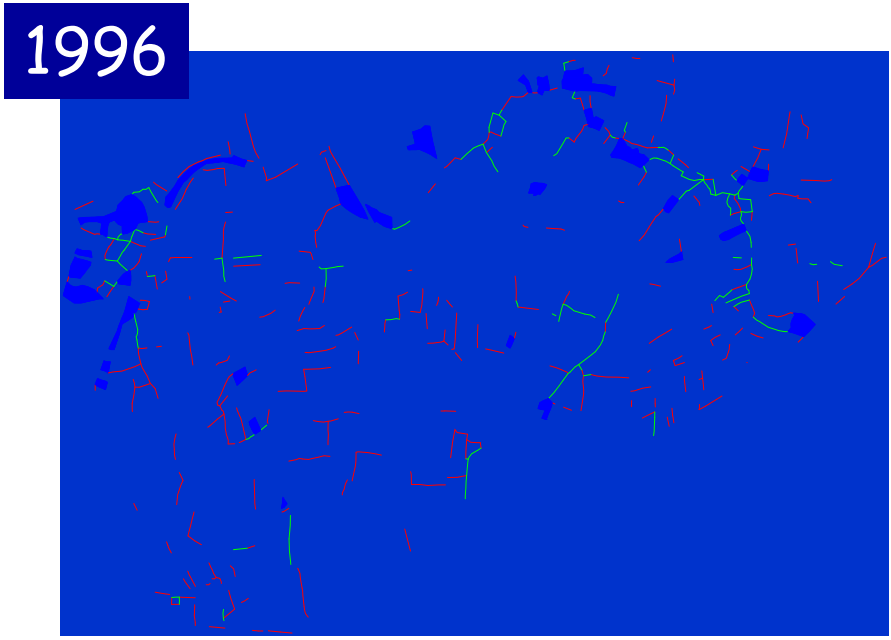
# The Zone atelier / LTER Armorique: a landscape with a long history




Source: Archéosciences, Rennes

# The Zone atelier / LTER Armorique: A fast changing landscape




North

***Hedgerows with continuous tree cover***

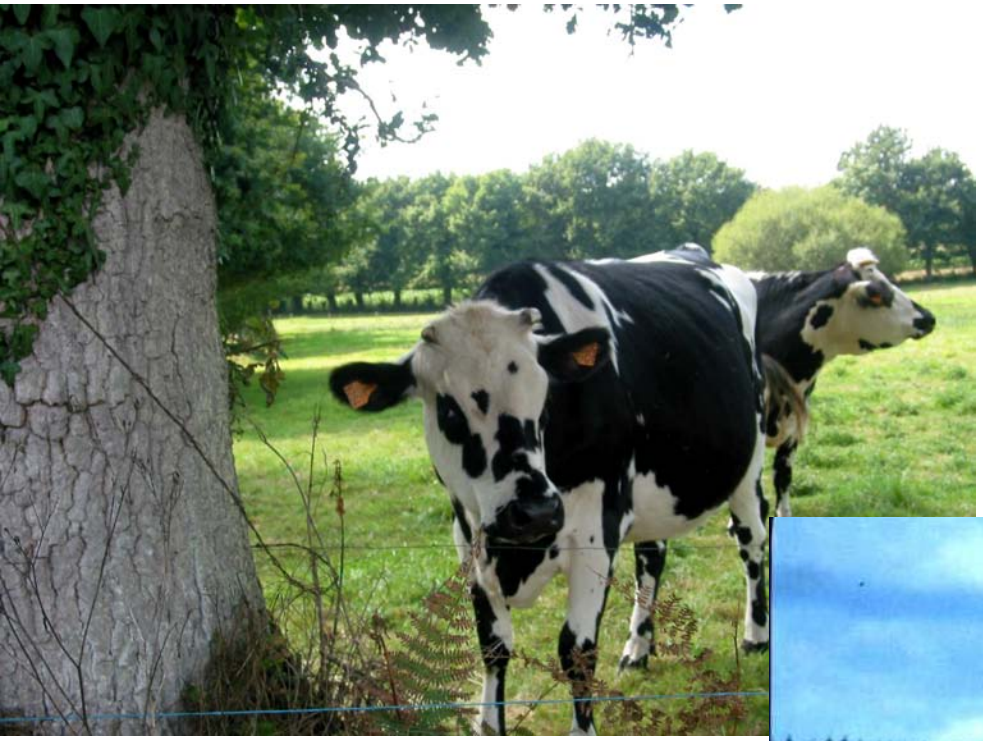
***Hedgerows with non-continuous tree cover***

| 1952 | 1966 | 1982 | 1990 | 1996 |
|---|---|---|---|---|
| 61,50 | 35,75 | 18,50 | 12,00 | 7,00 |
| 58,00 | 52,25 | 31,00 | 27,50 | 19,50 |
| 15,25 | 15,50 | 19,50 | 15,25 | 18,25 |

***Woodland (ha)***

Source: P. Morand

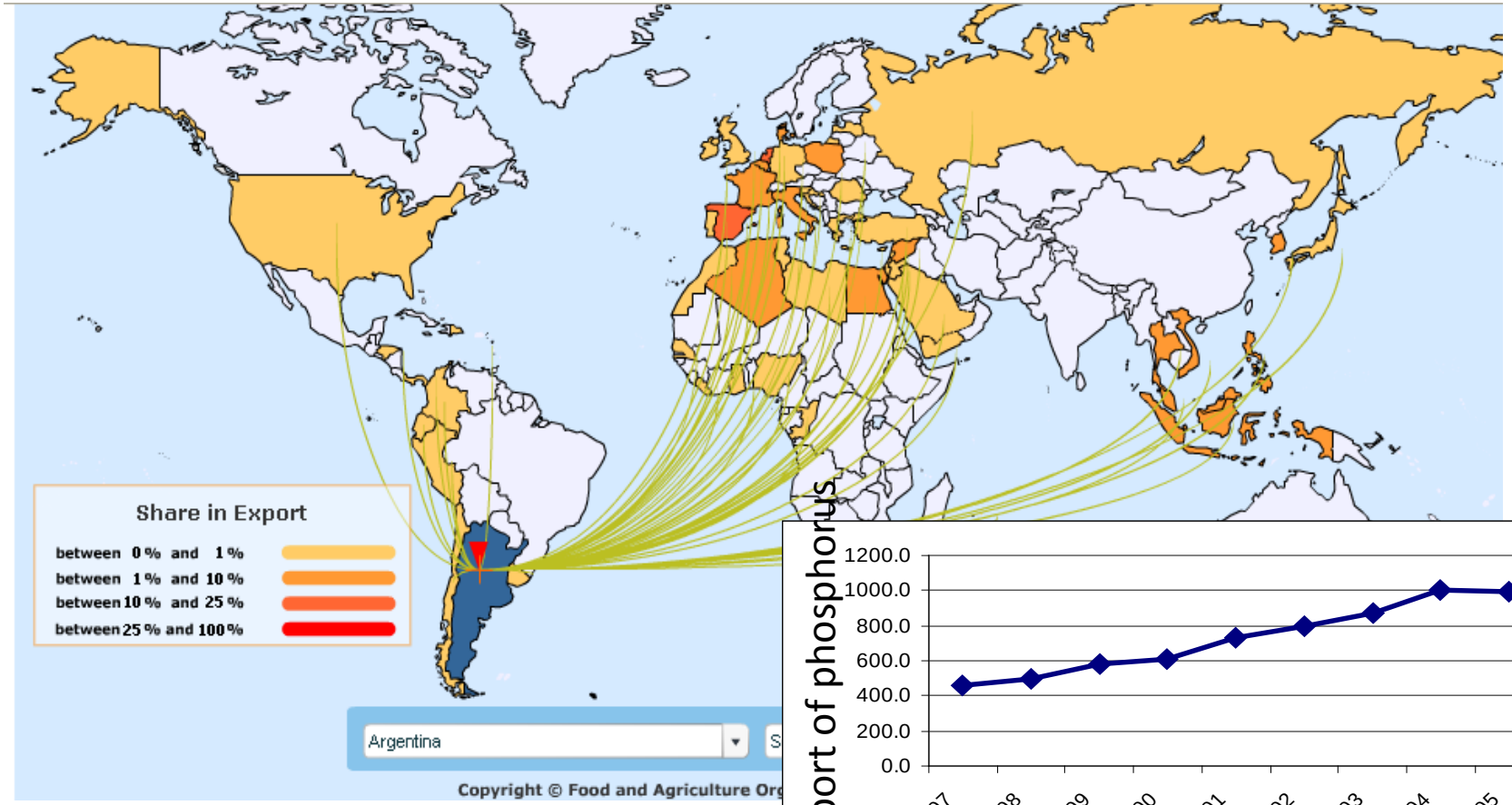
# From small “self-sufficient” farms



To highly productive industrial farms embedded in the global food market

# The Zone atelier / LTER Armorique: A landscape connected to the world

## World trade: Export of soybean from Argentina

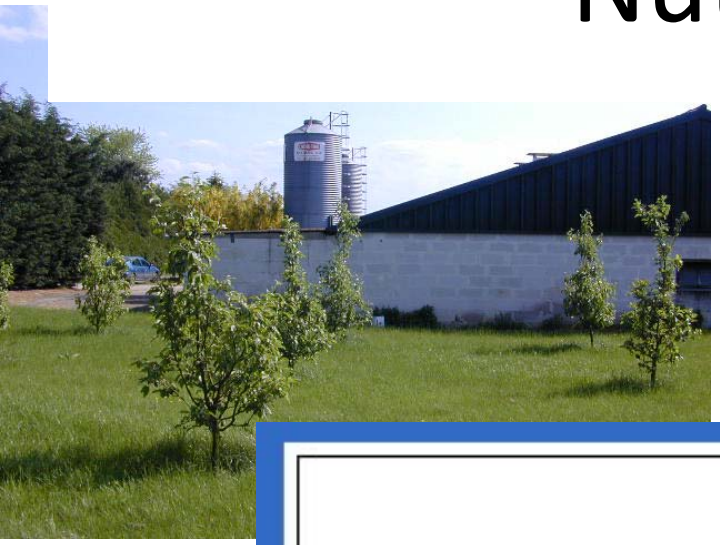


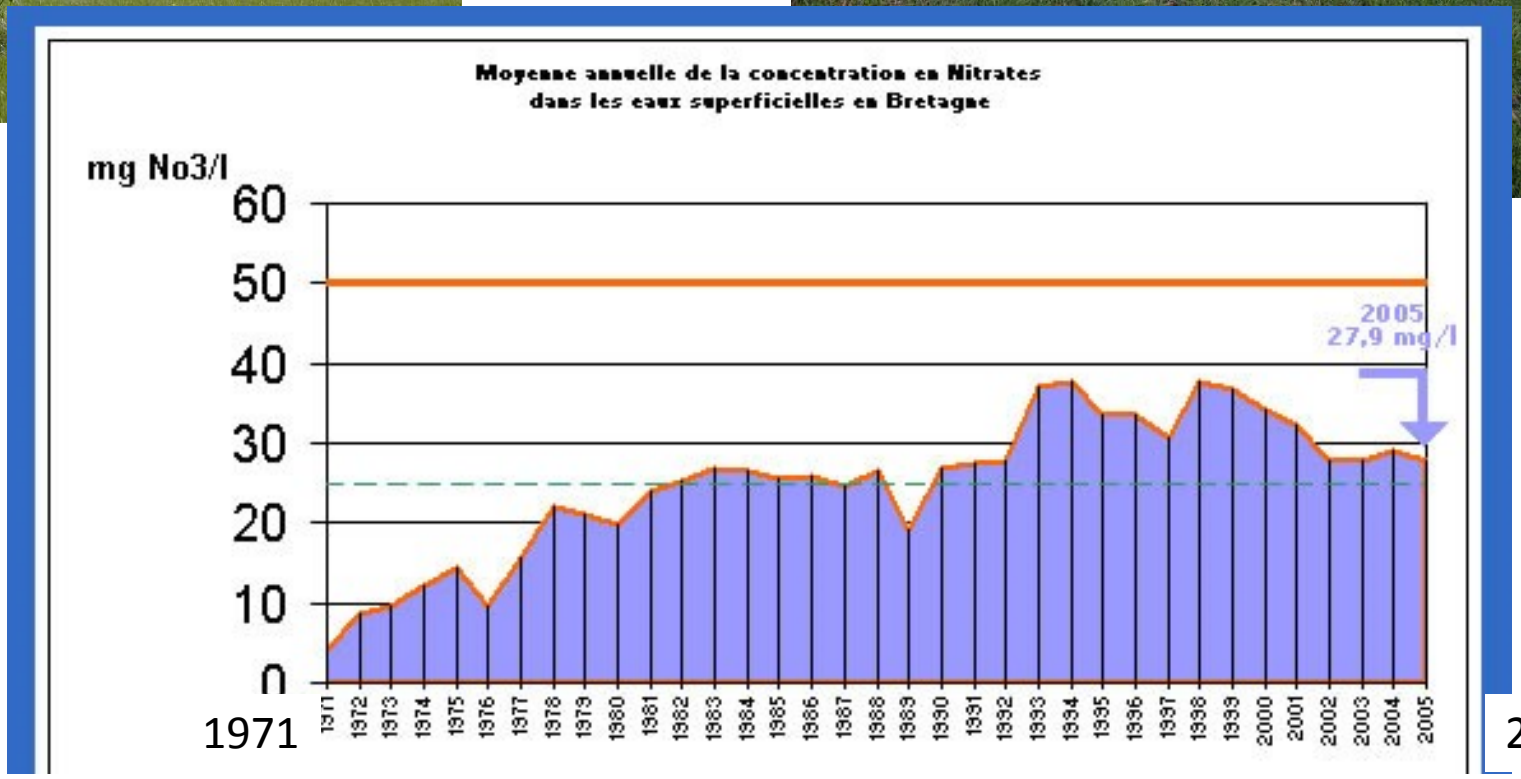




Nutrient flows

# Nutrient flows






1971 2005

**Annual average level in Brittany (from DIREN and Agence de l'eau)**

# The Armorique LTER: hydrology, nutrient fluxes as related to landscape patterns

Do some elements have a specific role in the control of biogeochemical fluxes?

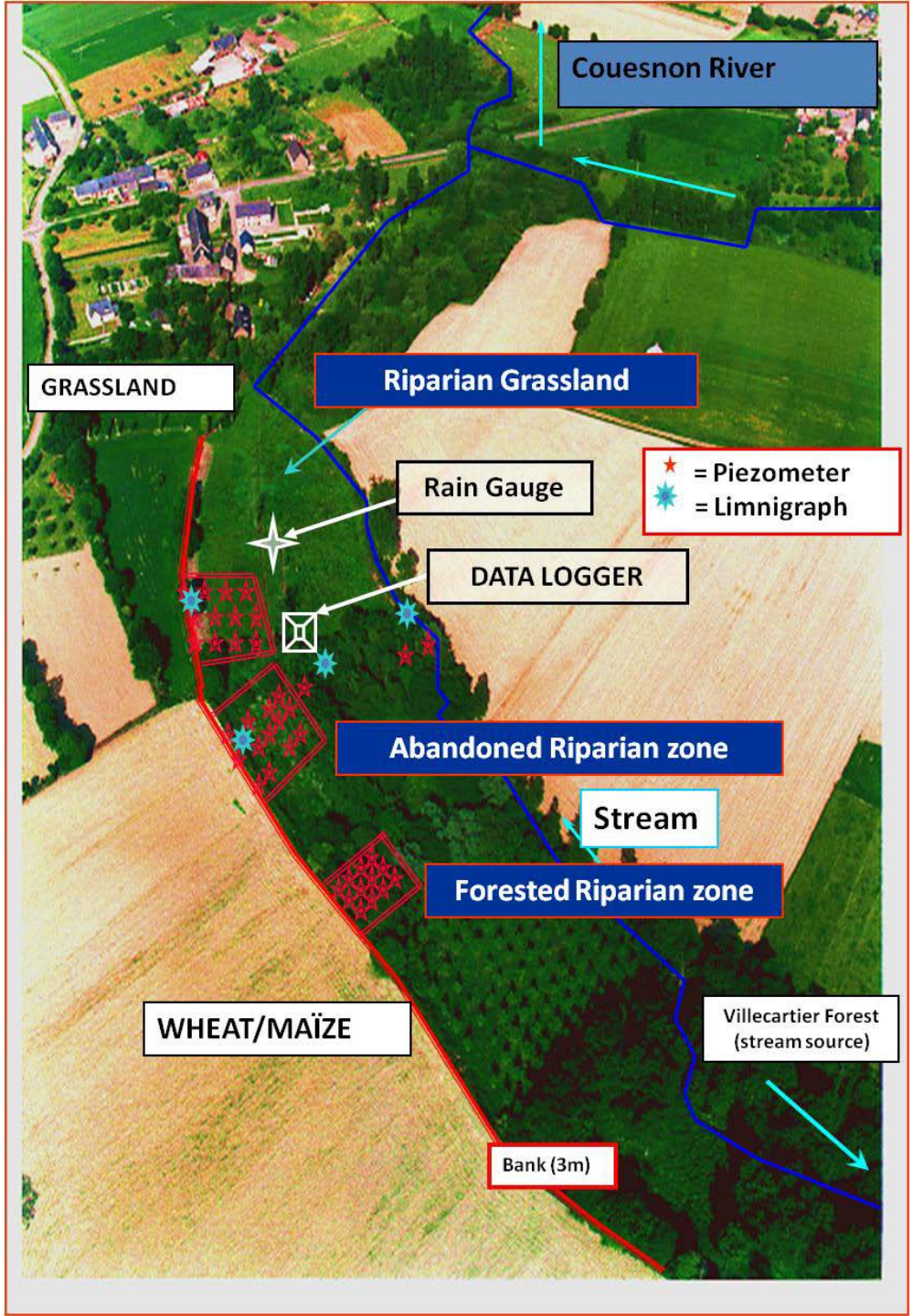
Riparian zone
Hedgerow

Does that translate at the landscape level?

Watershed

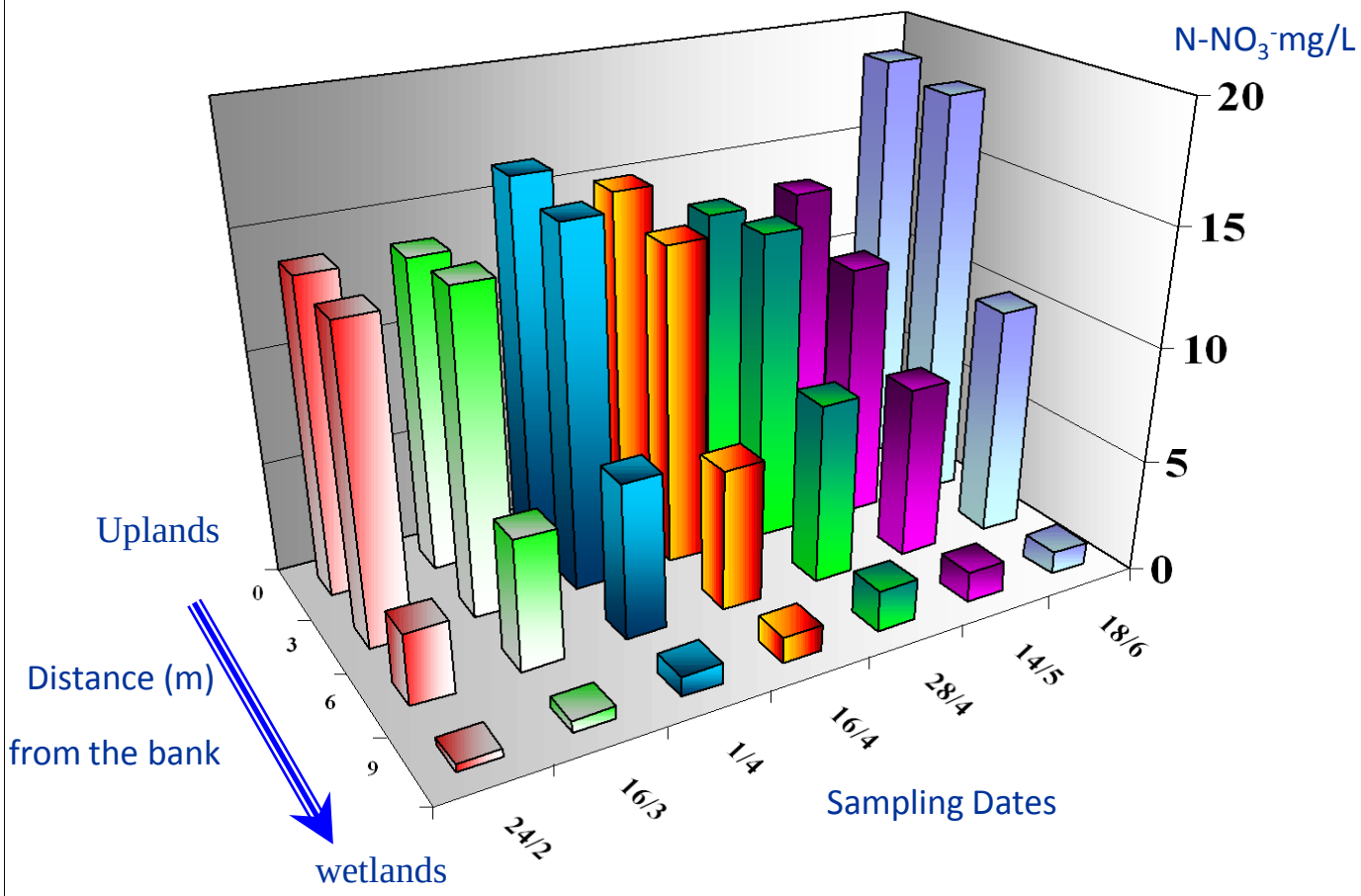


# (1) Riparian zone



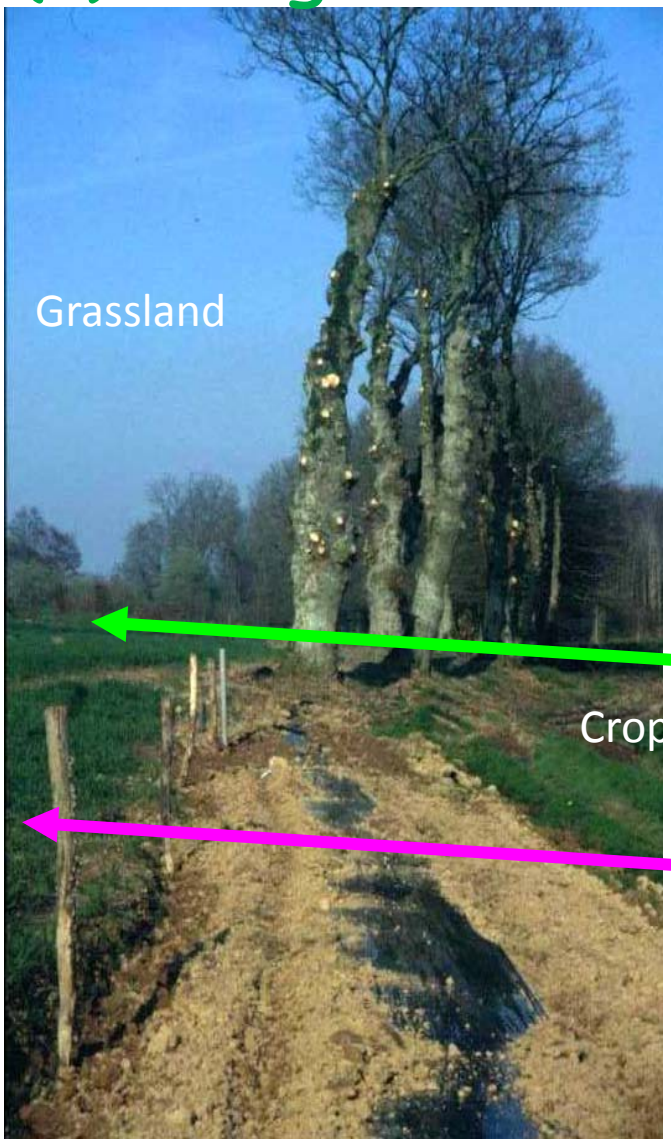

Clément, Pinay et al

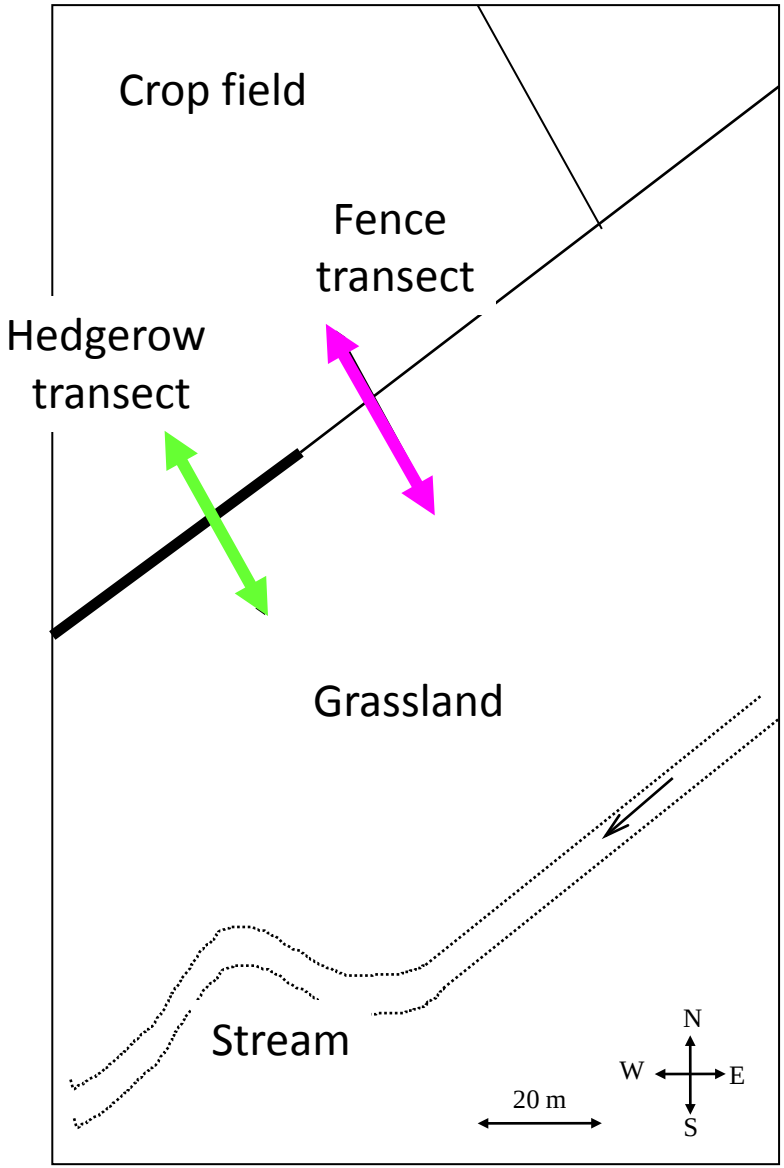
# N-NO3- concentrations along the riparian flowpath




Clément, Pinay et al

# (1) hedgerow

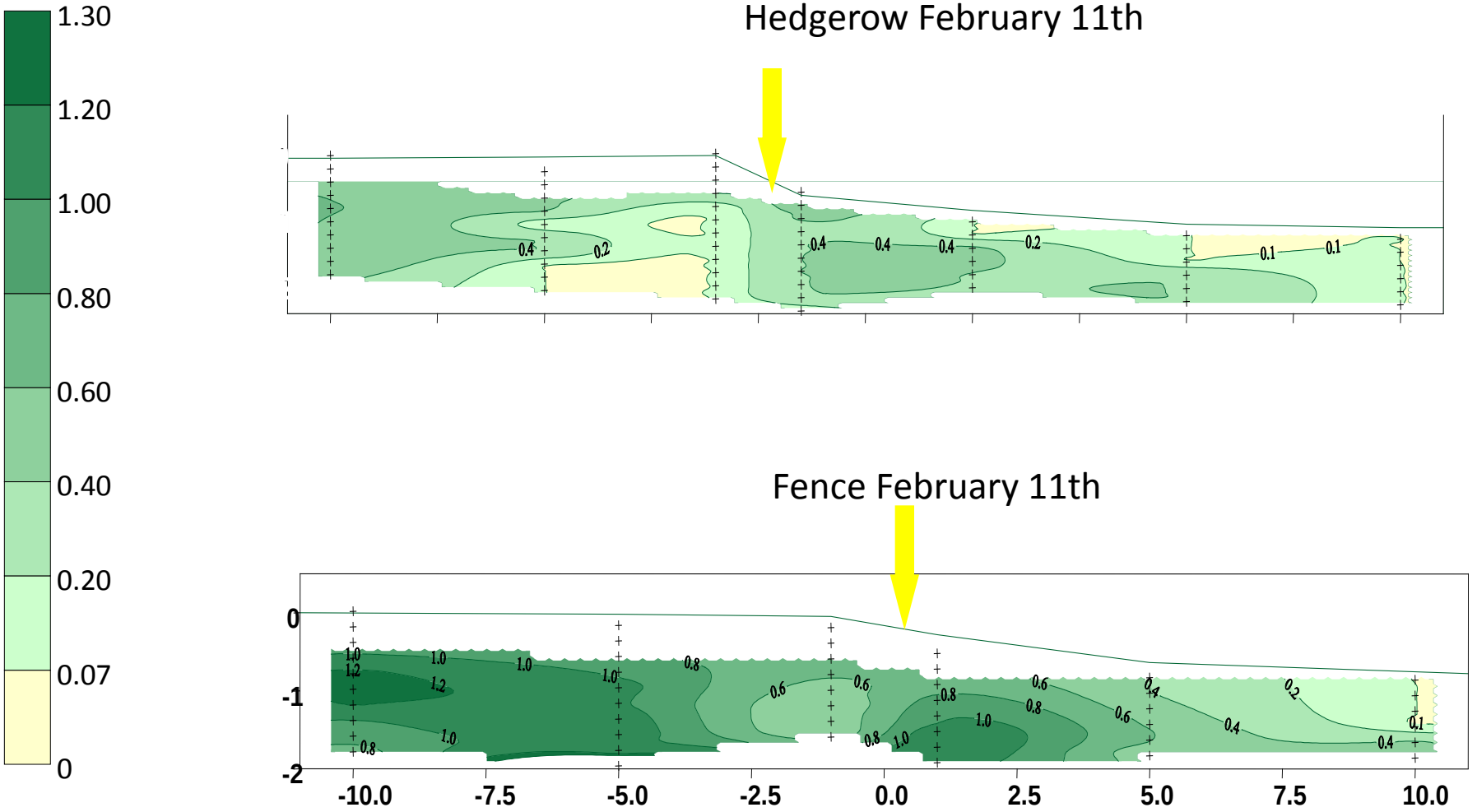



Caubel, Mérot, Grimaldi

# Hedgerow as a buffer

Nitrate concentration in soil (mM/liter)

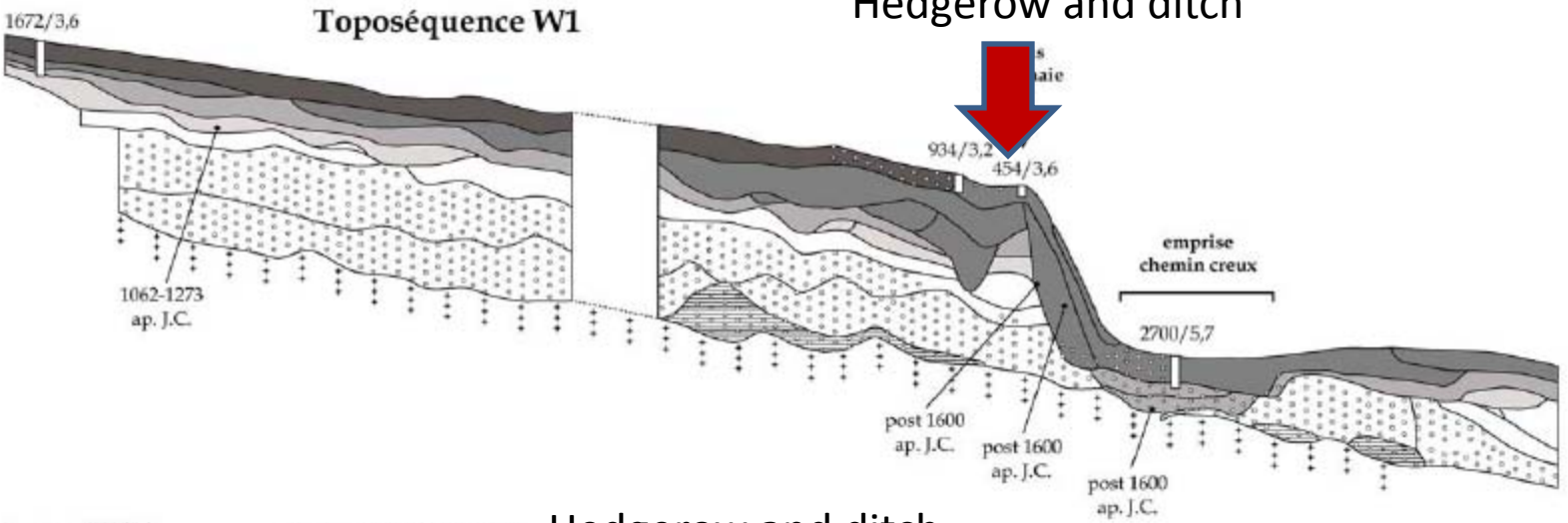



1 millimole NO3 = 62 mg/l

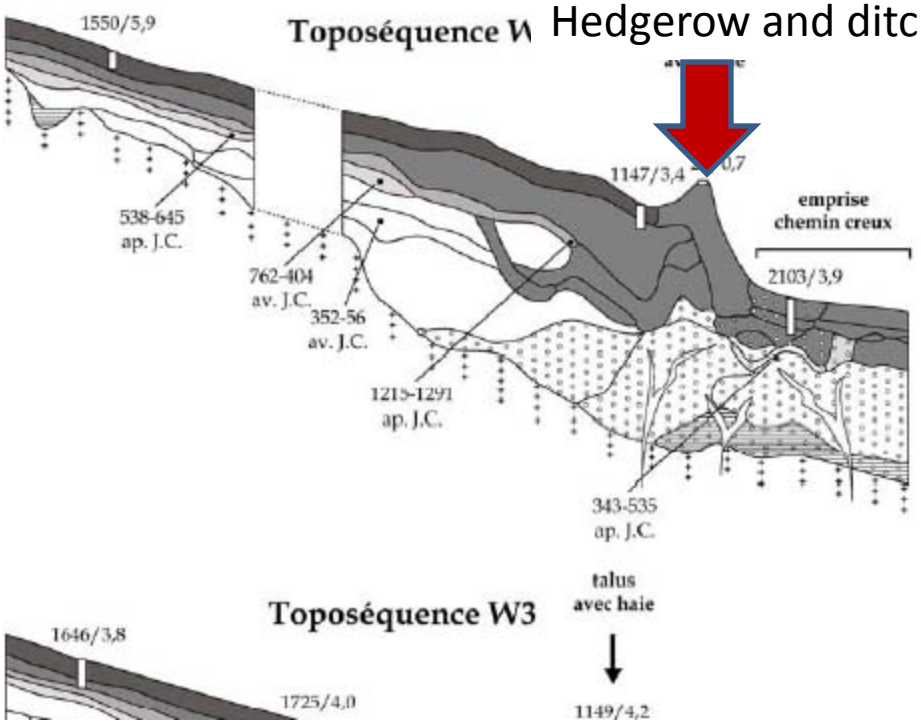
Caubel, Mérot, Grimaldi

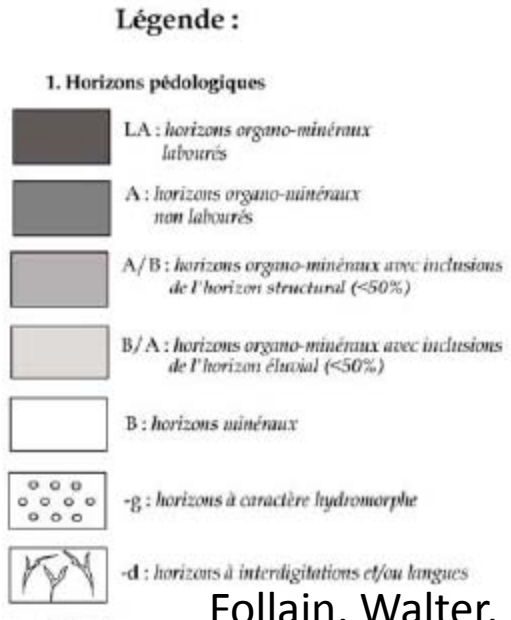
# Accumulation of organic matter

Hedgerow and ditch



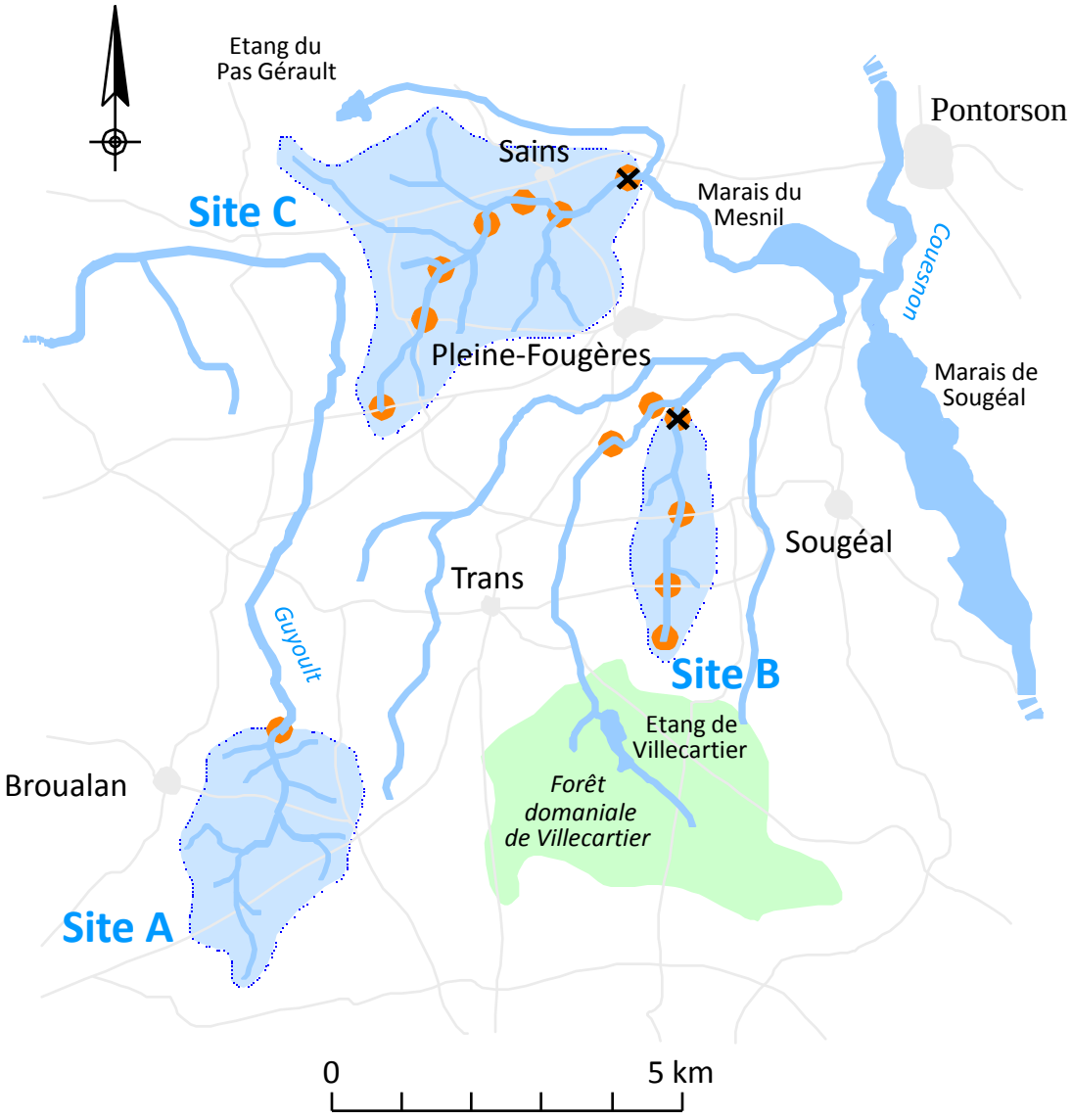

Hedgerow and ditch




Follain, Walter, Marguerie

# At the watershed scale



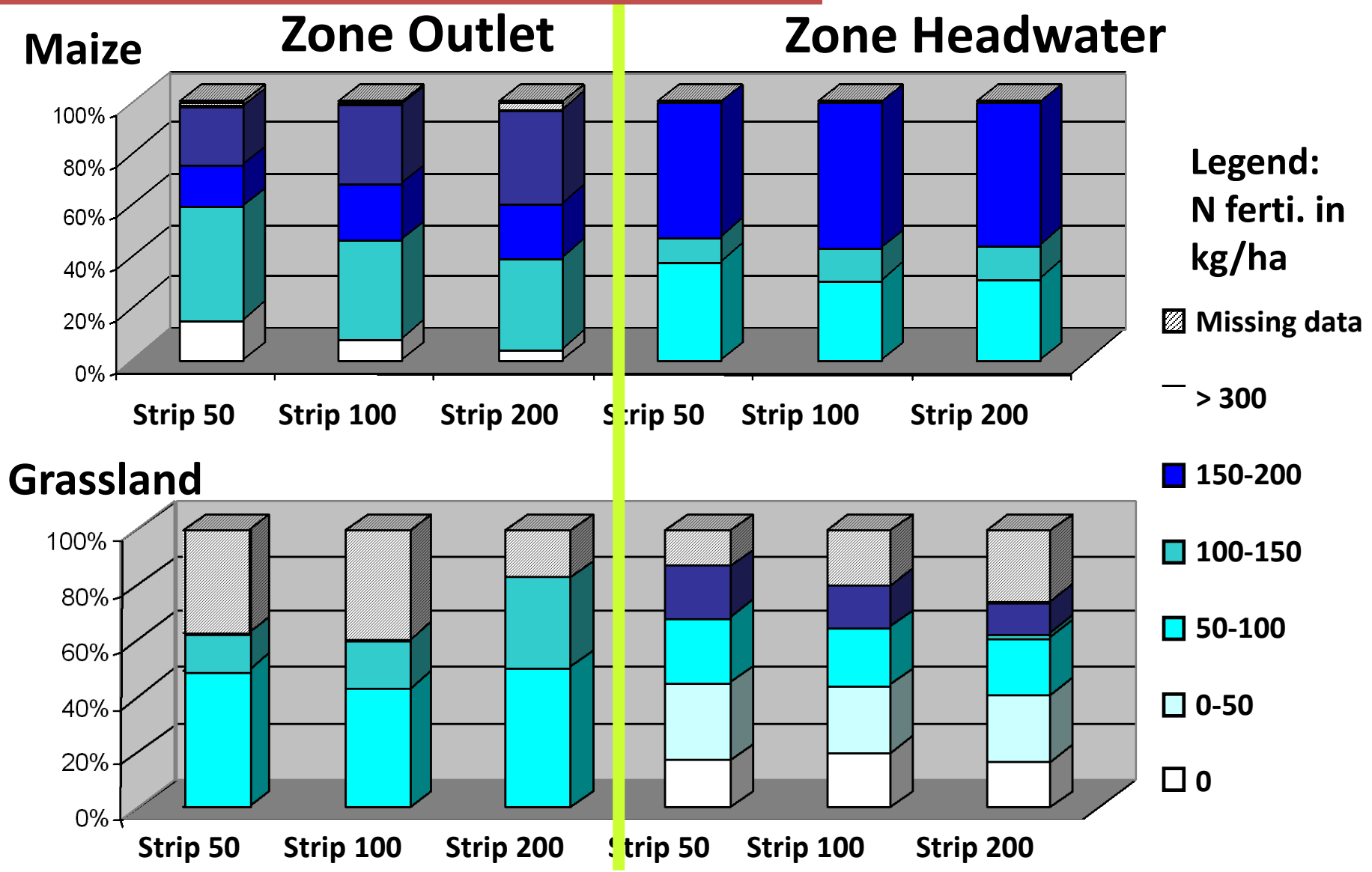

**Site A:**
granit
area = 647 ha
Beven = 17,5%

**Site B:**
Shale and silt
area = 227 ha
Beven = 20,7%

**Site C:**
Shale and silt
area = 1082 ha
Beven = 20,5%

- Suivis bi-mensuels
- Suivis asservis aux régimes d'écoulement

# Heterogeneity of fertilization level




**N fertilization, by land cover, and distance from a stream**

## At the watershed scale

**Estimated nitrogen input**

**1** → **2.5**

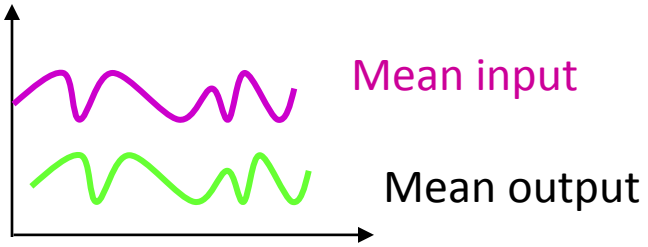
| **Catchments** | **A** | **B** | **C** | **D** | **N** |
|---|---|---|---|---|---|
| **Area (km²)** | 6.37 | 2.09 | 4.61 | 2.91 | 4.95 |
| **Bedrock** | granite | schist | schist | schist | schist |
| **Hedgerows (m.ha $^{-1}$)** | 100 | 103 | 66 | 47 | 37 |
| **Bottom wetlands (km²)** | 1.75 | 0.37 | 0.40 | 0.52* | 0.40** |
| **Land-use (%)** | | | | | |
| Cultures and rotational grasslands | 52 | 66 | 78 | 75 | 88 |
| Permanent grasslands | 41 | 29 | 18 | 20 | 5 |
| Other land-use | 7 | 5 | 4 | 5 | 7 |
| **Nitrogen input (kg N. ha $^{-1}$)** | 190*** | 230*** | 232*** | 201**** | 350**** |

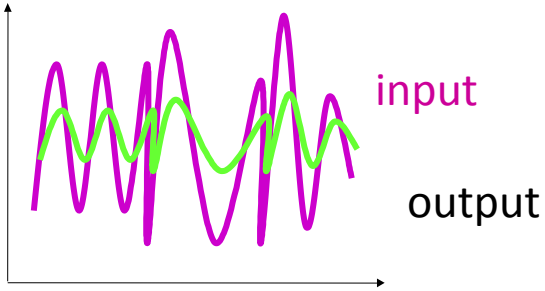
Viaud,
Mérot,
Baudry

## At the watershed scale

concentration of NO3 in streams

### Buffer effects




### Measured nitrogen output (concentration)

1

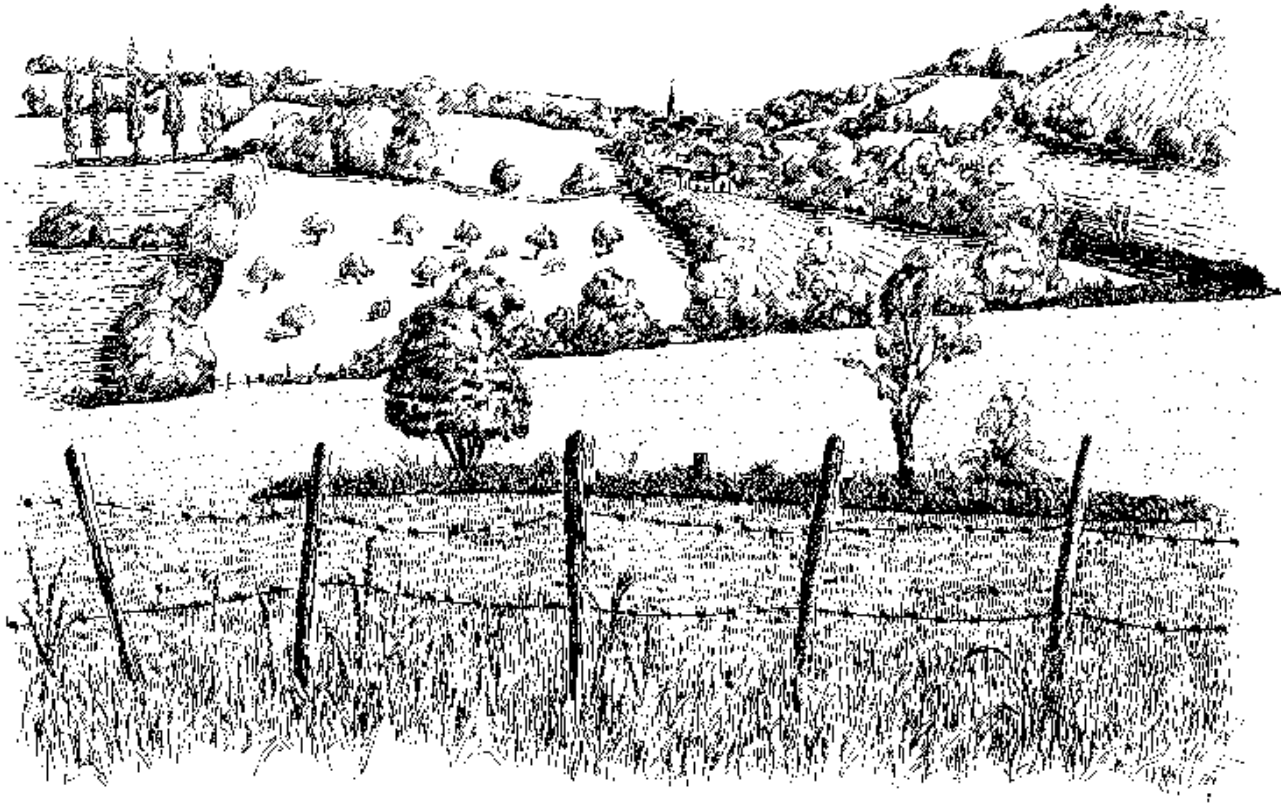
5.5

| Catchment | $NO_3^-$ | |
|---|---|---|
| | Mean | Standard-deviation |
| A | 12.3 | 3.5 |
| B | 31.3 | 3.1 |
| C | 33.7 | 6.8 |
| D | 35.9 | 6.0 |
| N | 68.5 | 12.9 |

Viaud, Mérot, Baudry

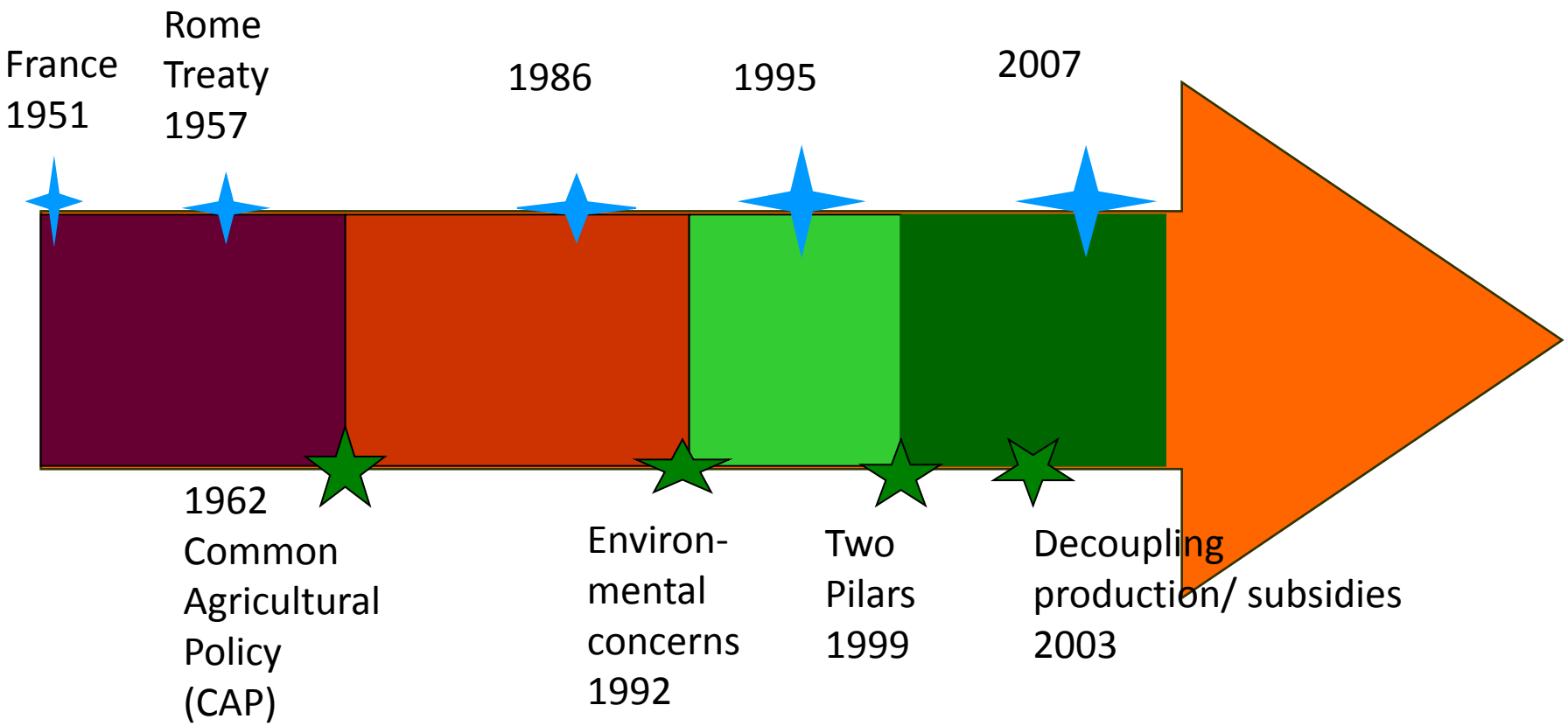
# Hedgerow density or hedgerow network patterns?

**The position of hedgerows: parallel or perpendicular to the slope is a key factor**

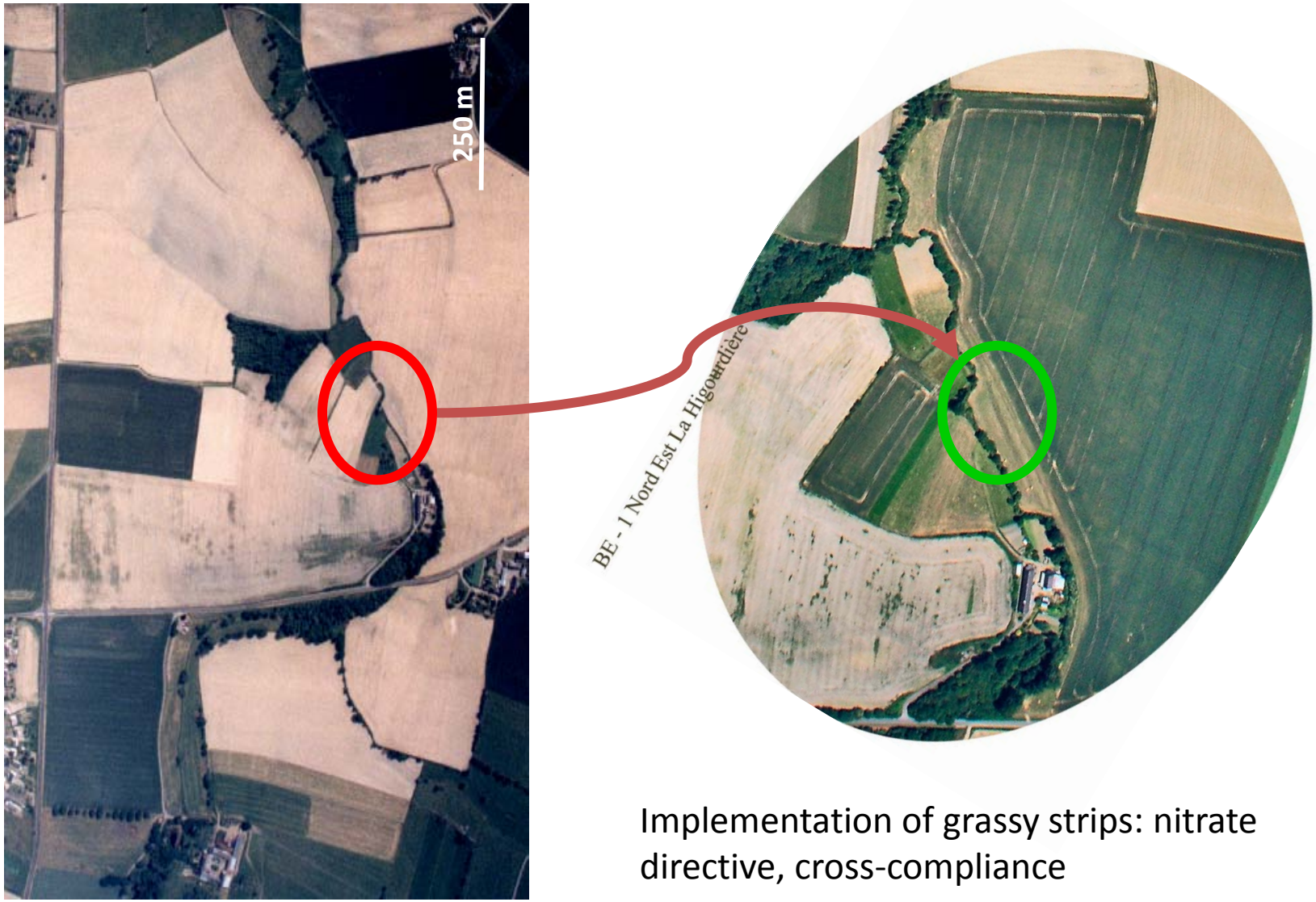


# Regional drivers/ responses - EU

EU: the Common Agricultural Policy



# RESPONSE for water quality

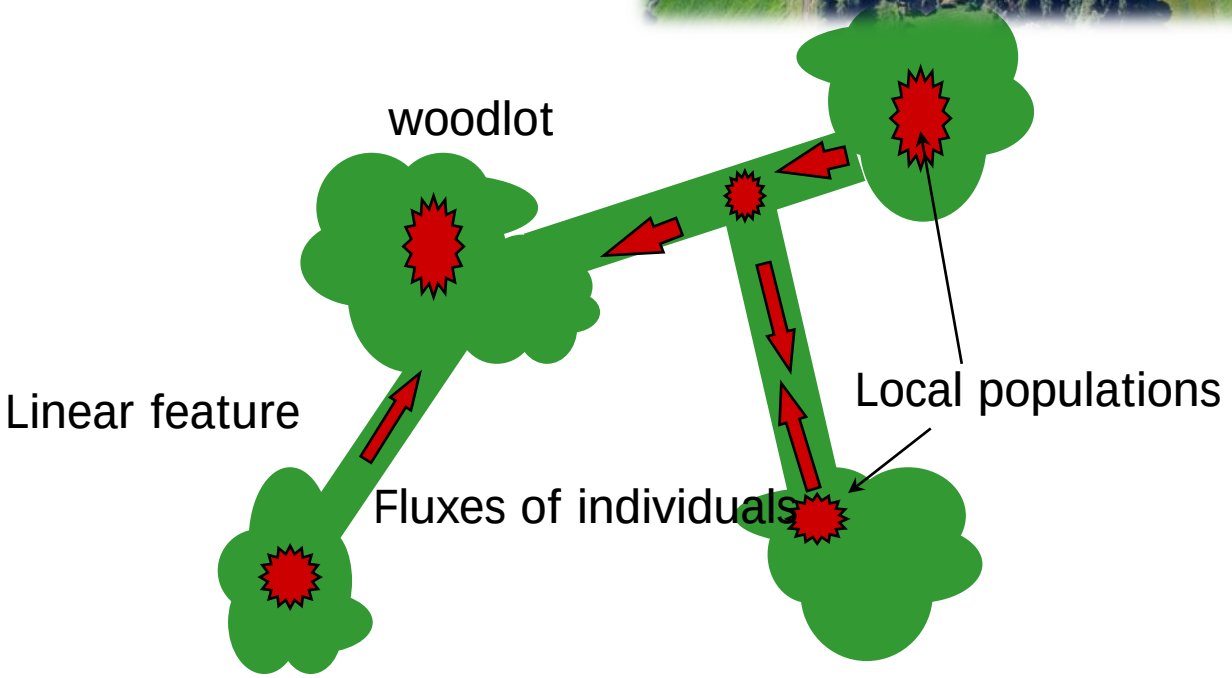



Implementation of grassy strips: nitrate directive, cross-compliance

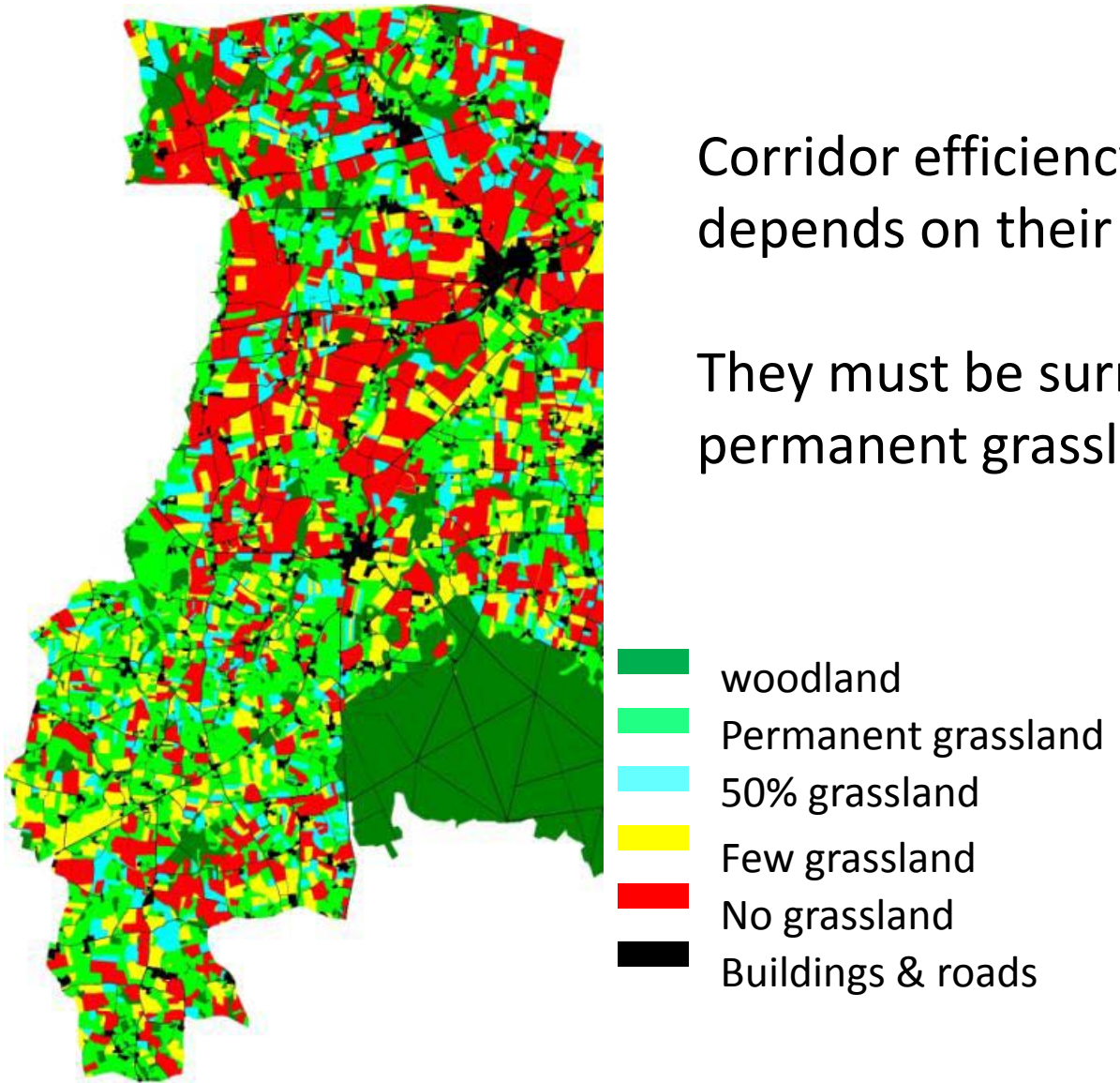
# The Armorique LTER: biodiversity

How the landscape patterns that control biogeochemical flows affect biodiversity patterns?

# Hedgerows act as corridors forest carabid beetles




Crop succession 2002-2006




Corridor efficiency of hedgerows depends on their surroundings

They must be surrounded by permanent grasslands and woodlots

# The effects of landscape structure and composition on wild bees

Many agricultural crops and natural plant populations are dependent on **pollination by insects**.

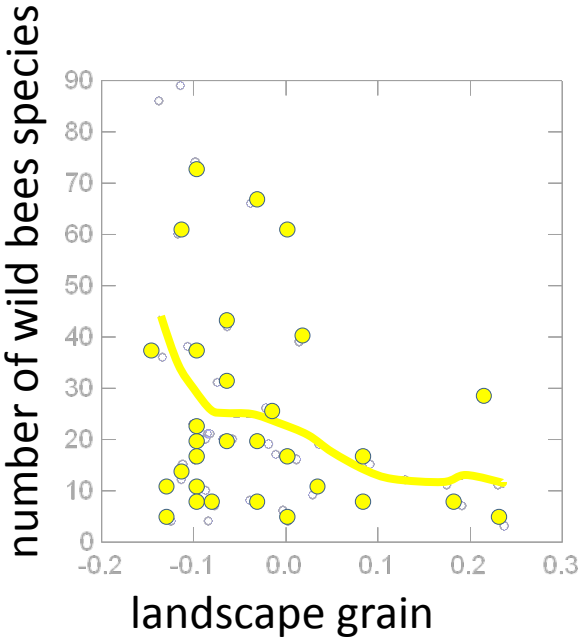
Alarming **declines in wild bee populations** have been reported for various countries all around the world.

Principal causes are linked to destruction and fragmentation of habitats through agricultural intensification

- decrease of **floral resources** (abundance and diversity)
- rarefaction of suitable **nesting sites** and **larval food**
- potential direct impact of **pesticides**
- effects of **climate changes**



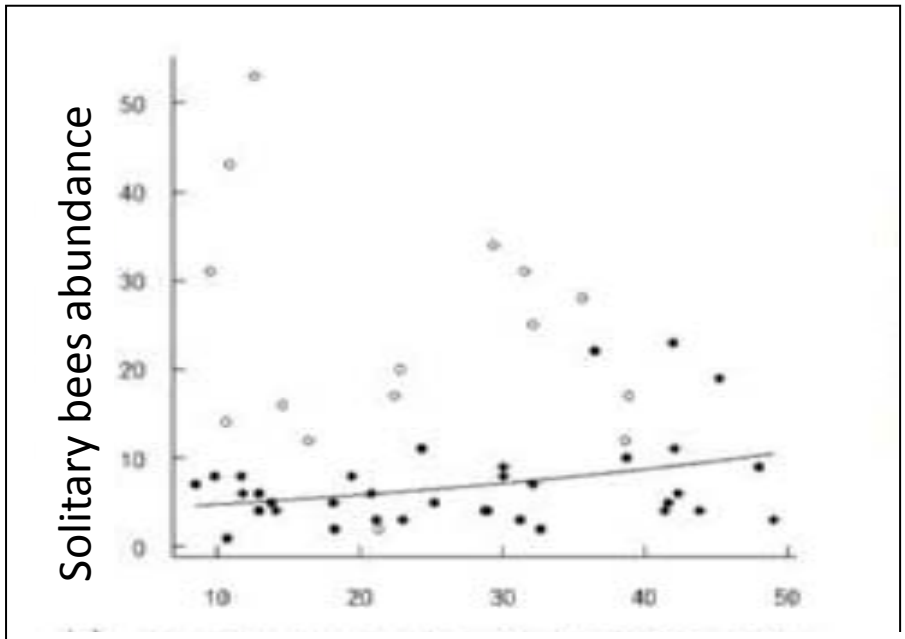
# Landscape structure and wild bees diversity




Fine grain landscape

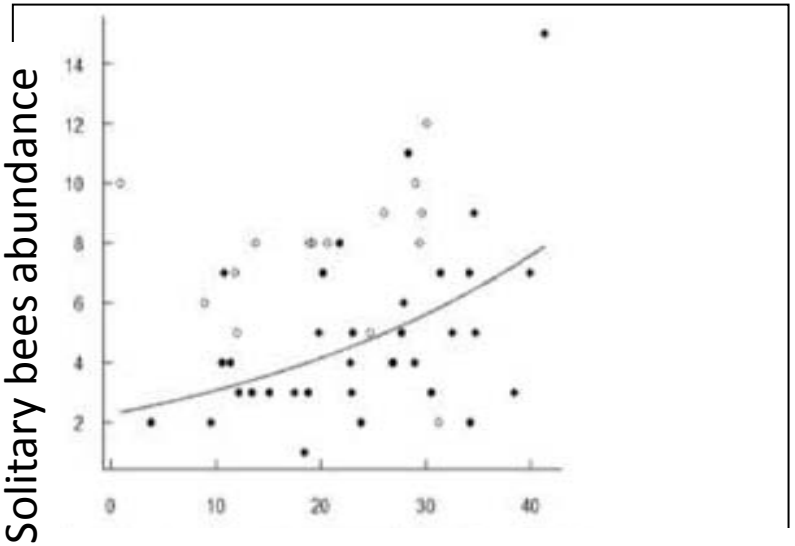
Coarse grain landscape

*PhD Le Féon, Caren*




Proportion of permanent grassland in 1200m windows

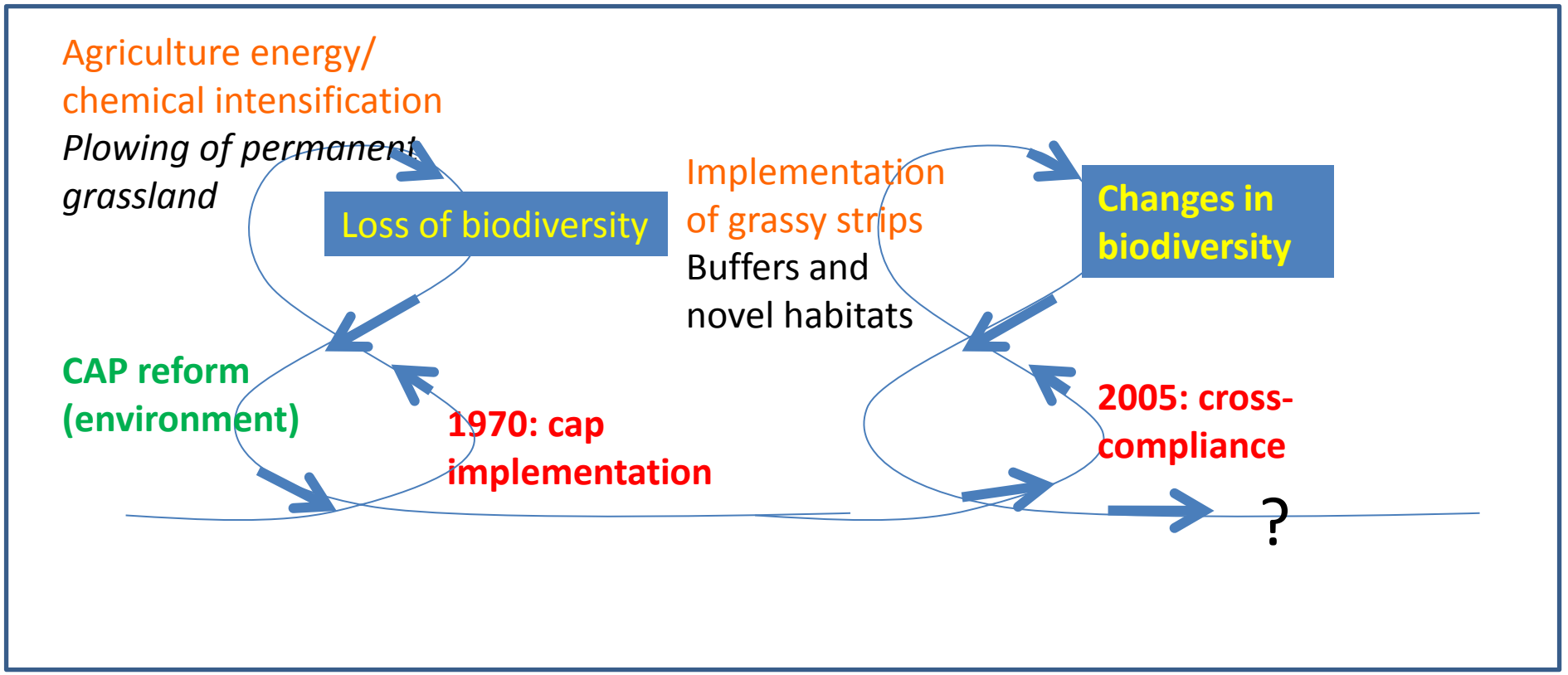
Both hedgerows, as nesting sites, and crops/ grass, as food resource play a role




Proportion of fields with grass in a five year crop succession in 800m windows

Le Féon, Burel, Baudry

# The adaptative cycle of the resilience of biodiversity management to agricultural intensification



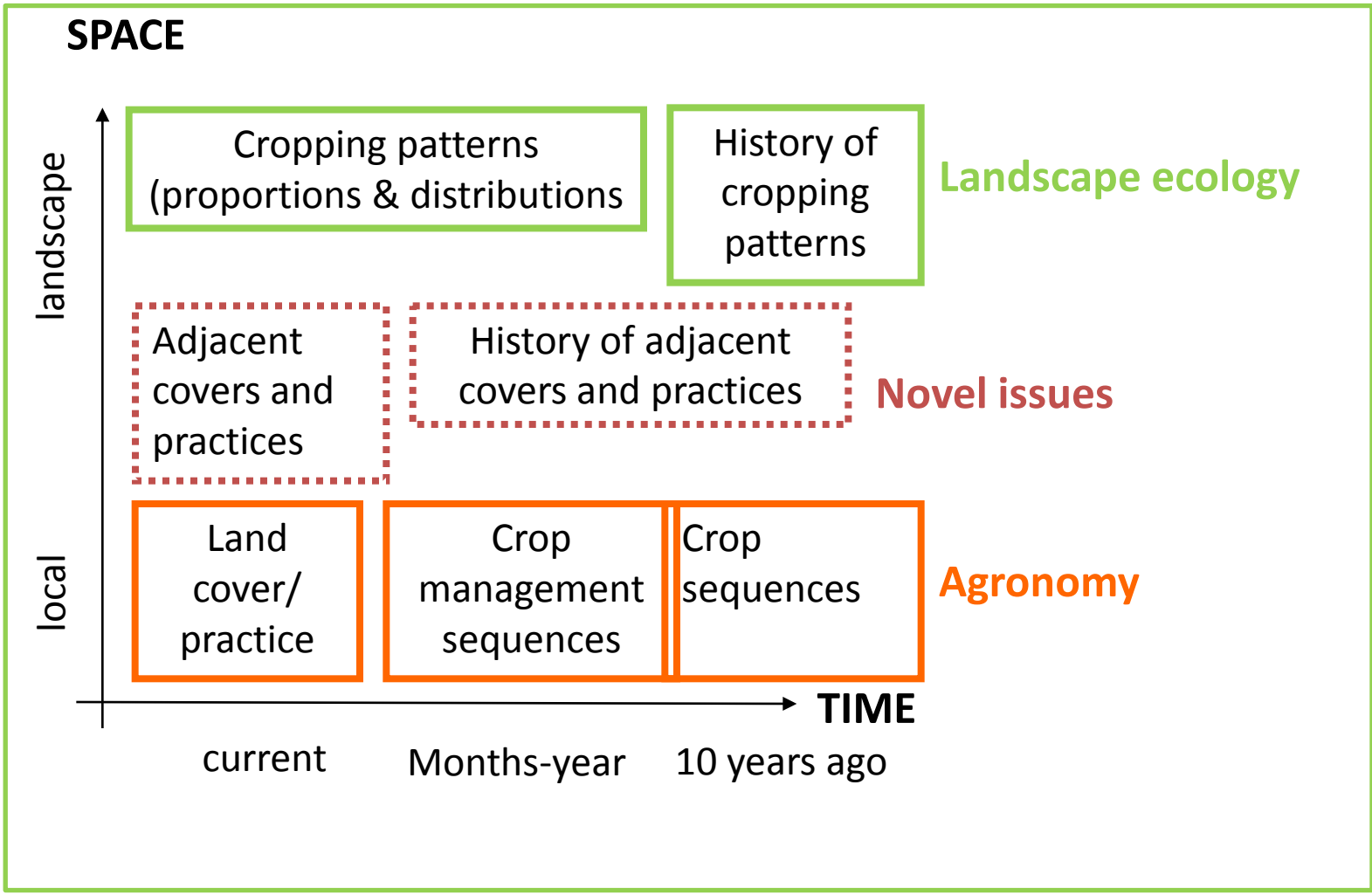
Hedgerows have a profound effect on fluxes, those fluxes change landscape patterns

Hedgerow removal led to the rise of many disservices, which was a cause of changes in policies

Biodiversity, and the services it provides depends on landscape patterns

The paradigm that prevailed in agronomy that every thing can be control by management at field scale is no more acceptable

# At stake: a framework to further analyze resilience in agricultural landscapes




Vasseur et al, 2008


Thank you for your attention