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

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An aerial photograph of a rural agricultural landscape. The scene is dominated by large, rectangular fields. Some fields are a vibrant green, while others are a light brown, indicating they have been plowed. A small cluster of buildings, including houses and barns, is visible in the upper right quadrant. A road or path winds through the fields. The overall impression is one of a well-managed, productive agricultural area.

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.



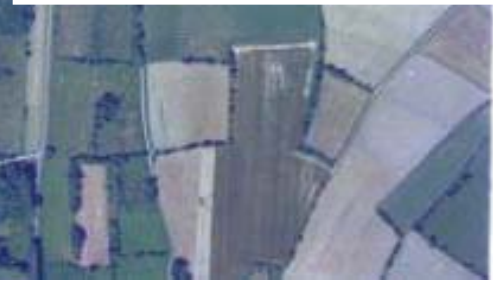
The Zone atelier / LTER Armorique: the landscape

Landscape patterns and geochemical fluxes

Landscape patterns and biodiversity

The Zone atelier / LTER Armorique: A man made landscape

Landscape patterns: riparian zones



Gradient of hedgerow density/ land use

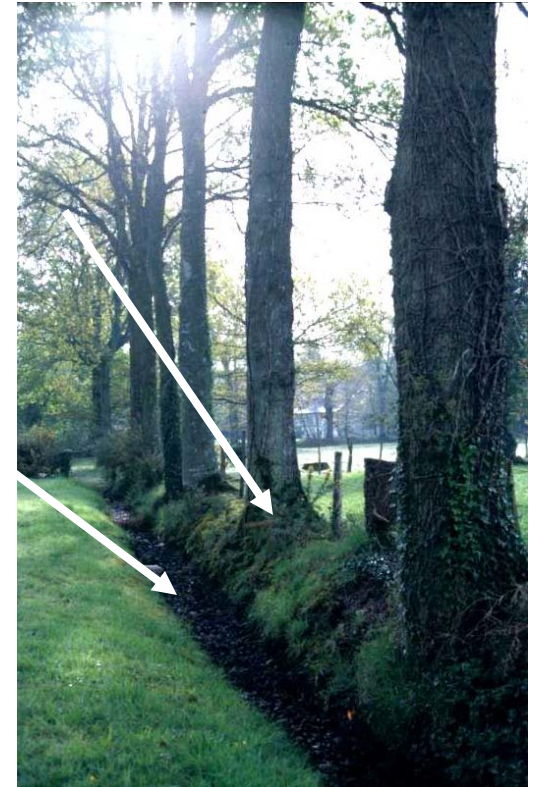


The function of hedgerows

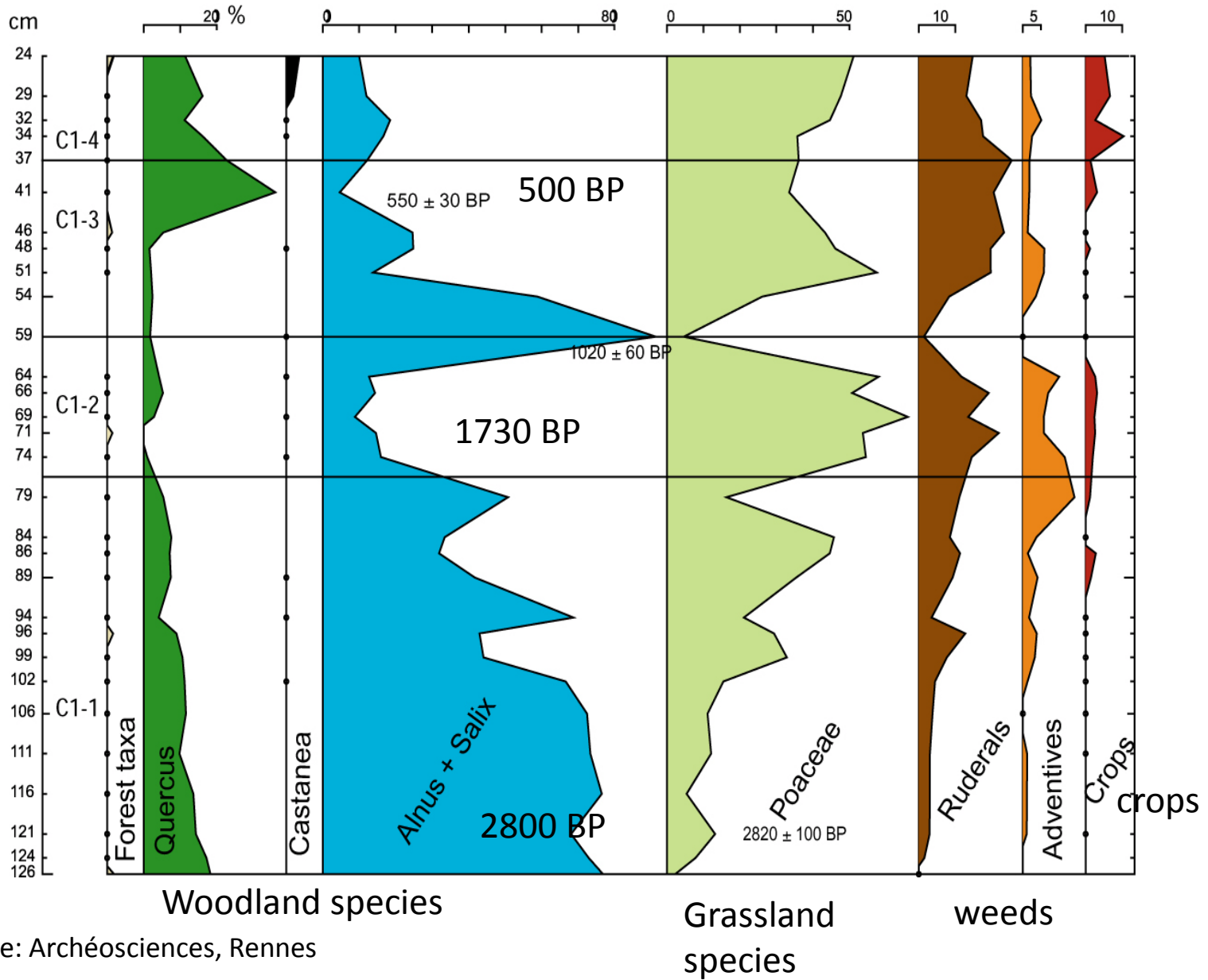
Firewood, timber
Fence
Etc.

Planted on a bank
along a ditch

Control of water flow

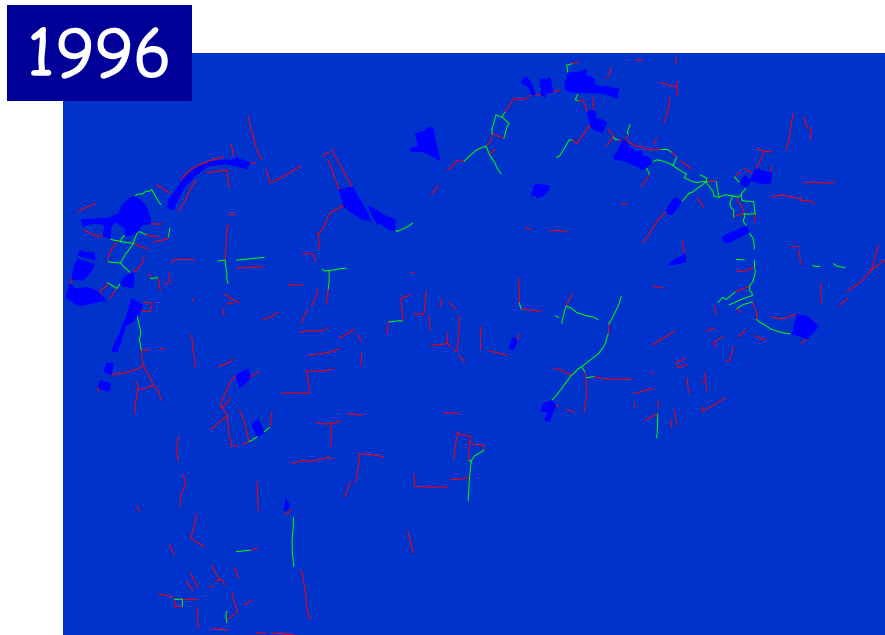


The Zone atelier / LTER Armorique: a landscape with a long history



Source: Archéosciences, Rennes

The Zone atelier / LTER Armorique: A fast changing landscape



 *Hedgerows with continuous tree cover*

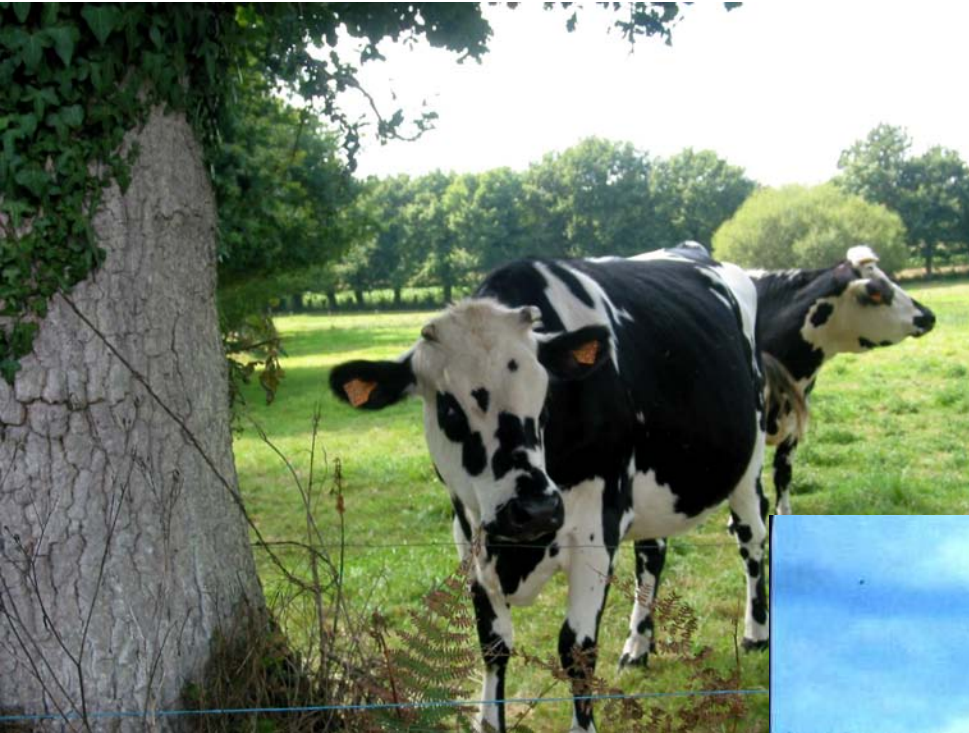
 *Hedgerows with non-continuous tree cover*

 *Woodland (ha)*

North
↑

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

From small “self-sufficient” farms

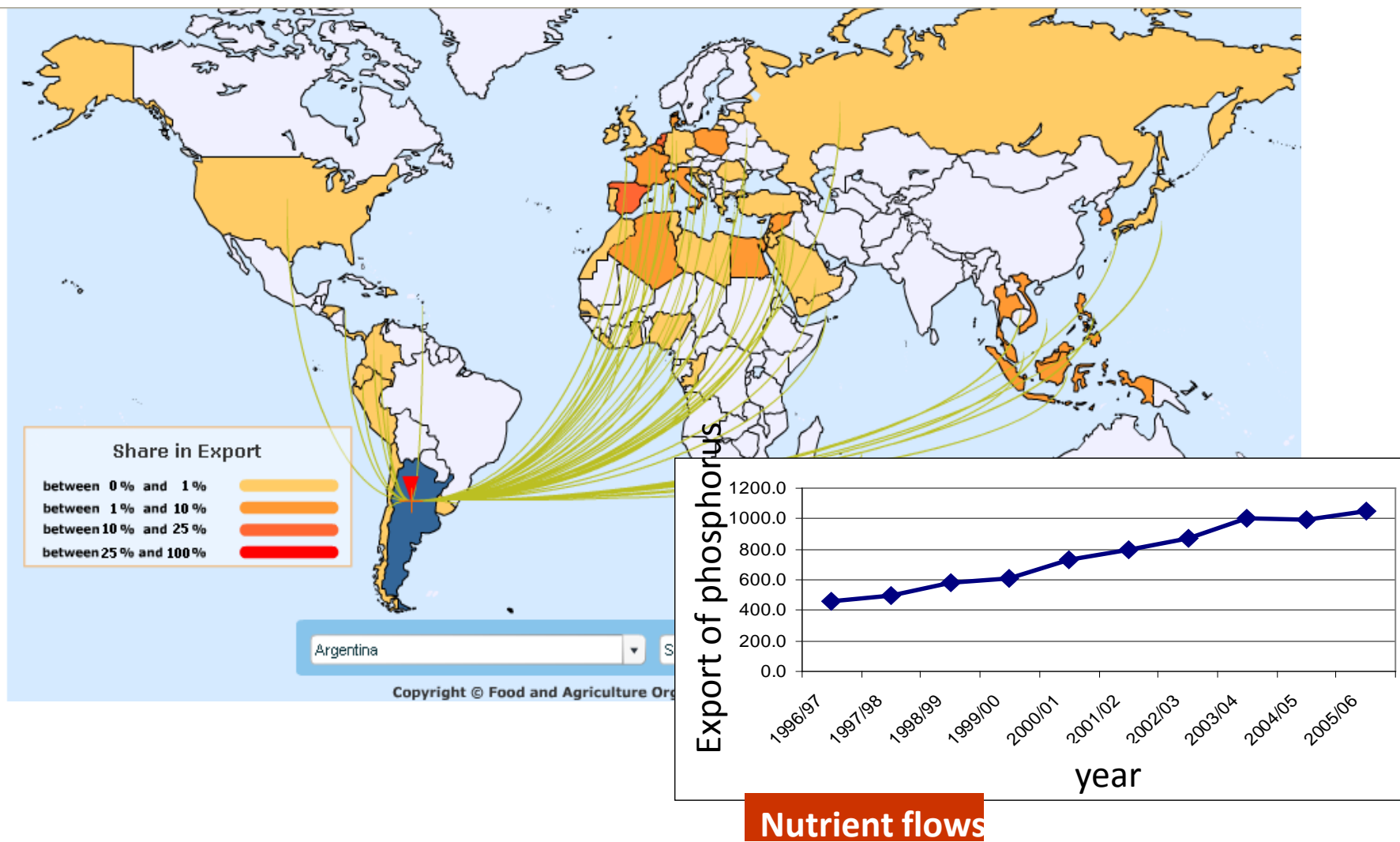


To highly productive
industrial farms
embedded in the global
food market

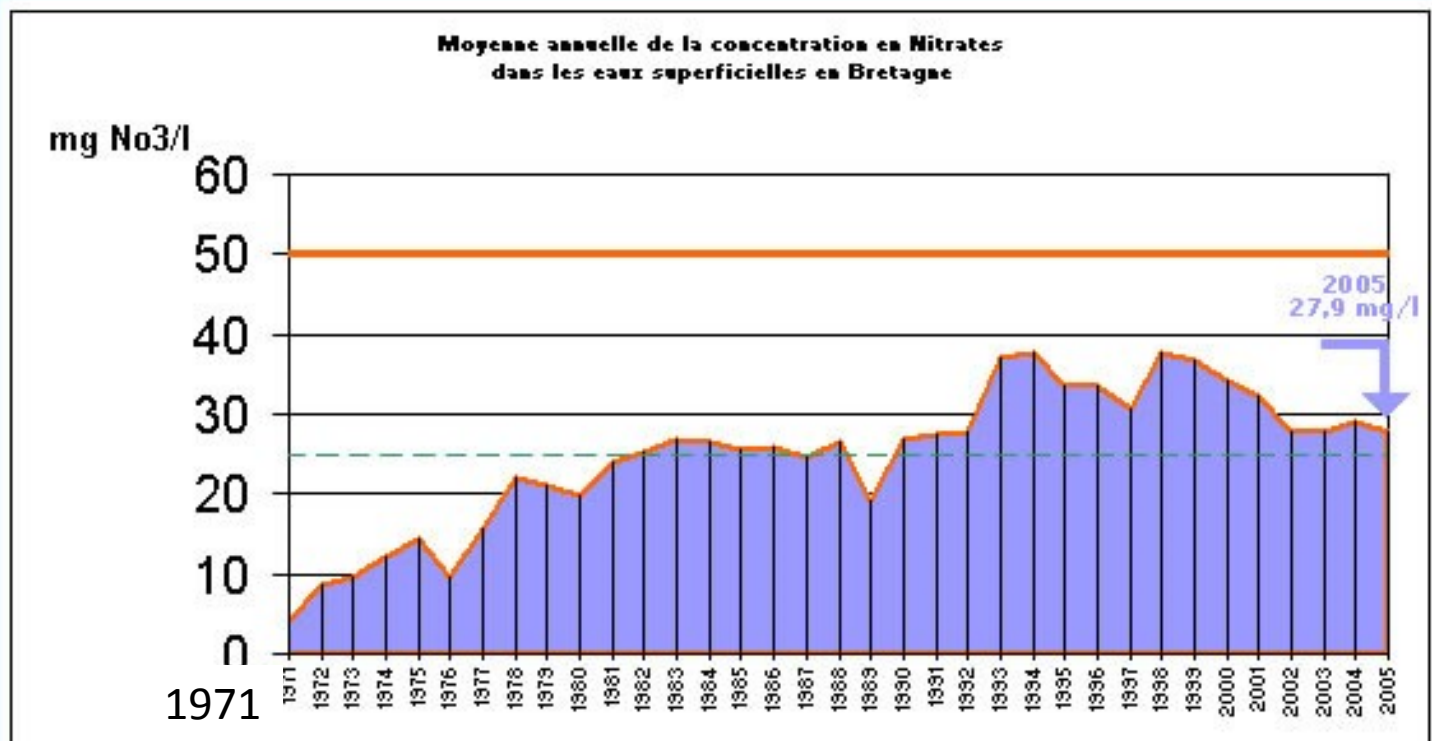


The Zone atelier / LTER Armorique: A landscape connected to the world

World trade: Export of soybean from Argentina



Nutrient flows



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



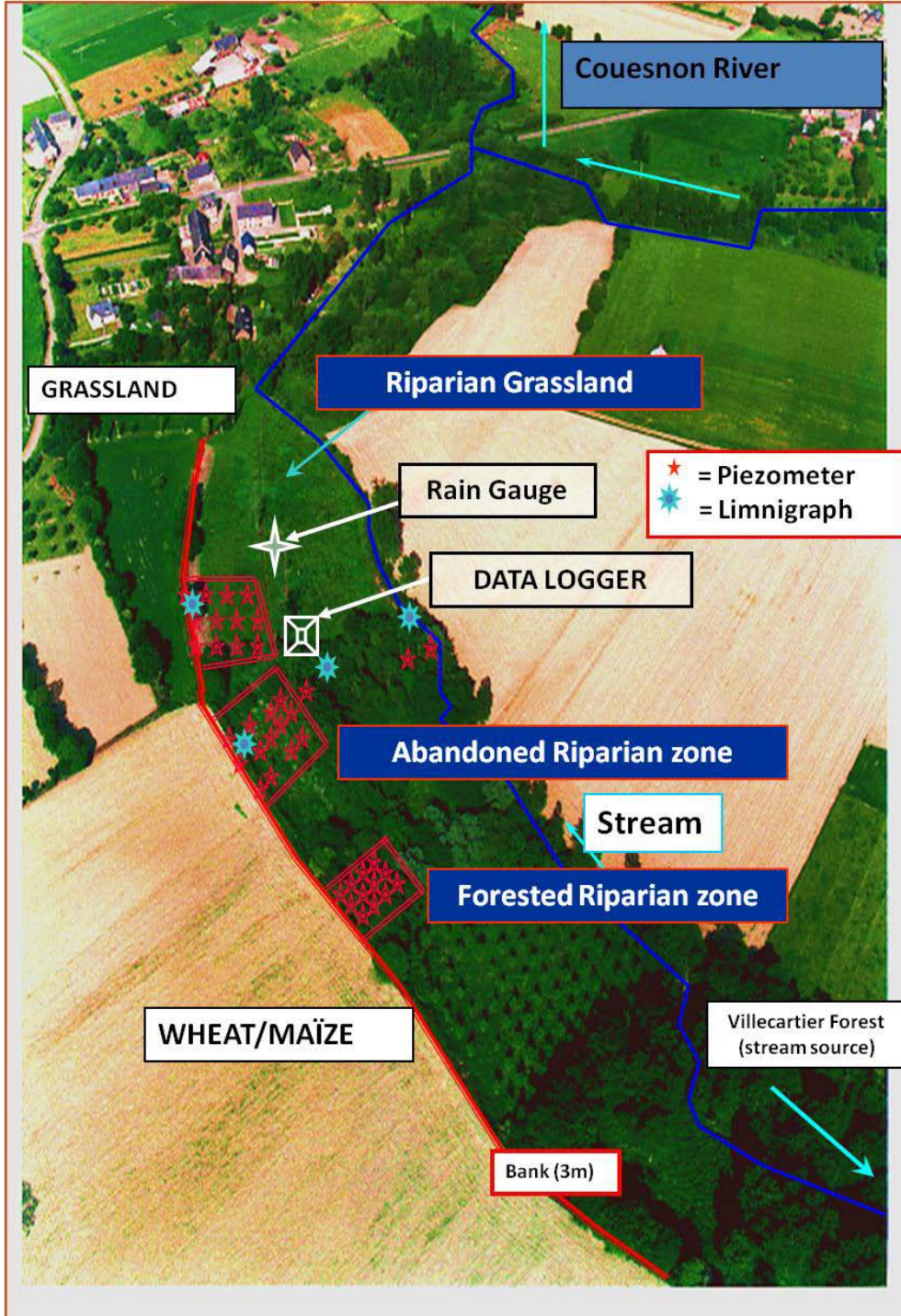
summer



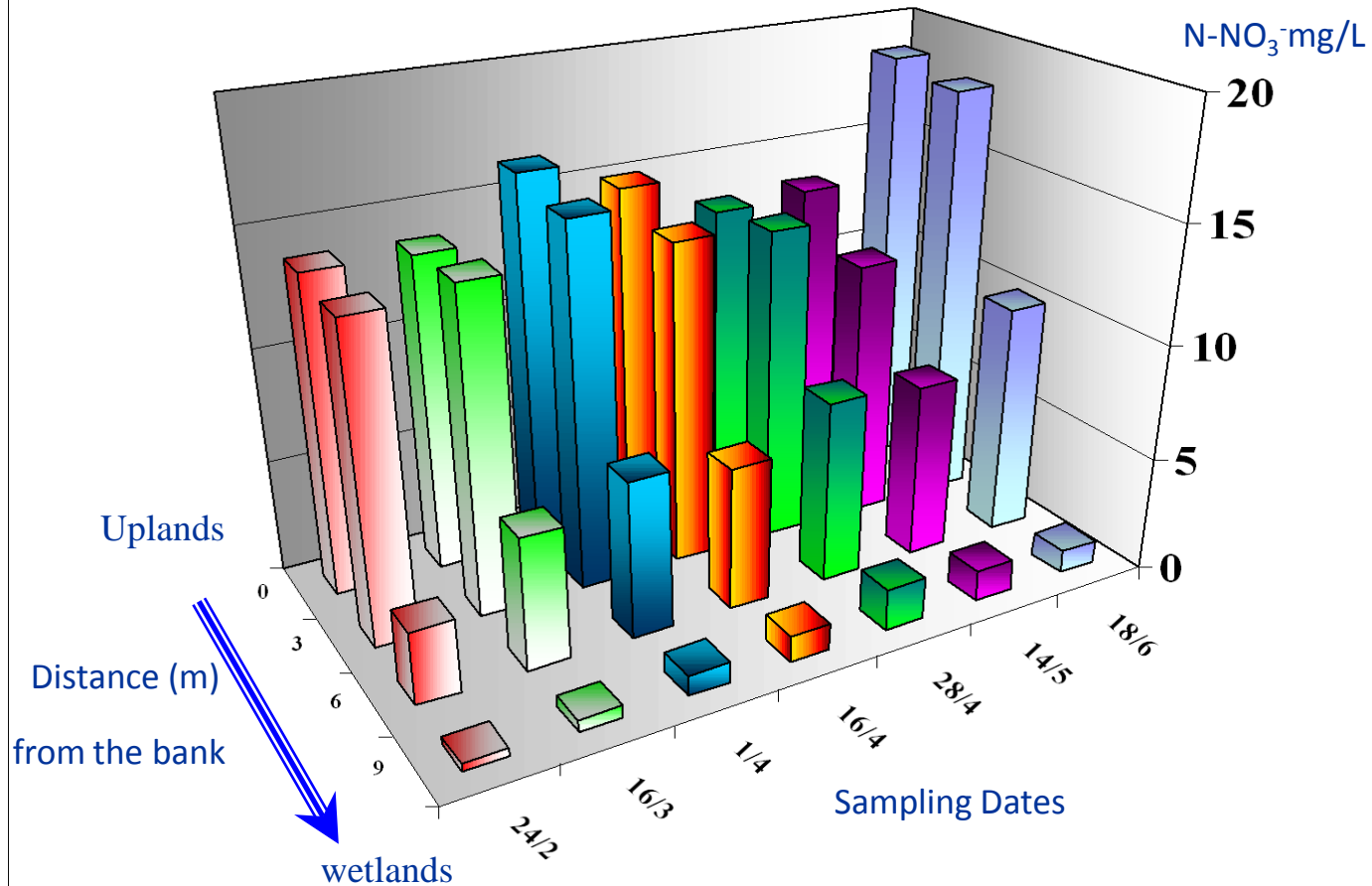
winter

Denitrification ?

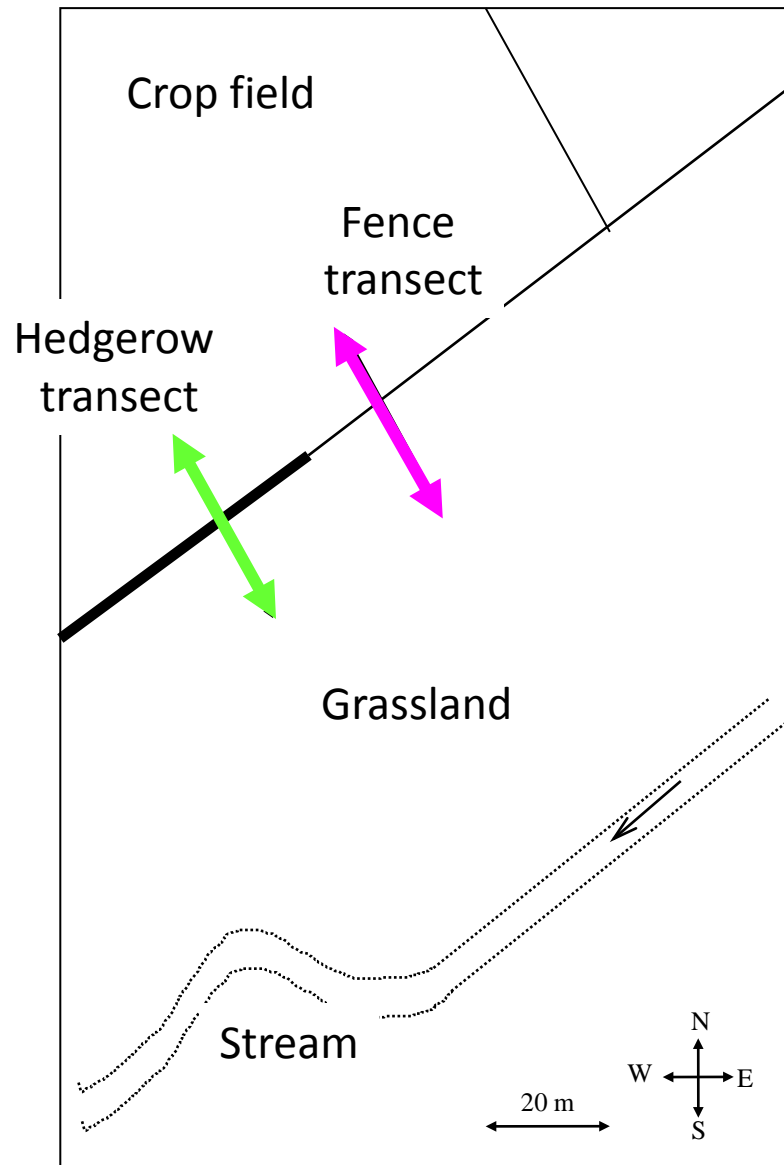
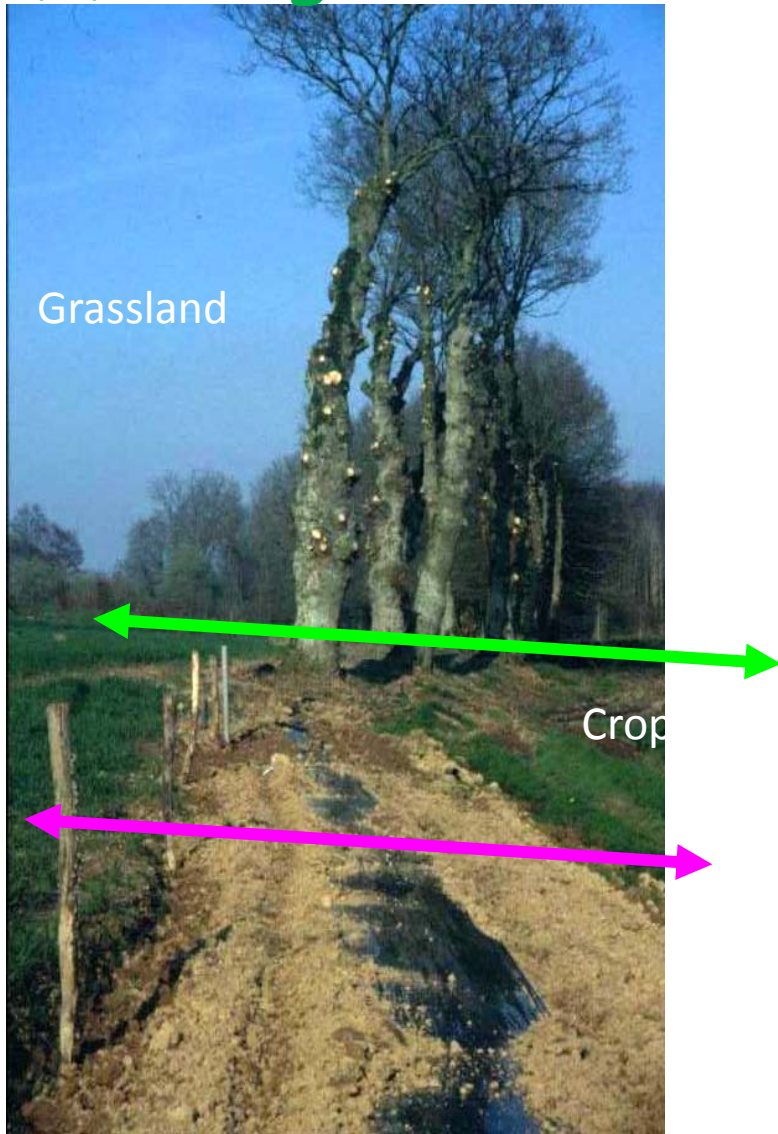
(1) Riparian zone



N-NO₃⁻ concentrations along the riparian flowpath



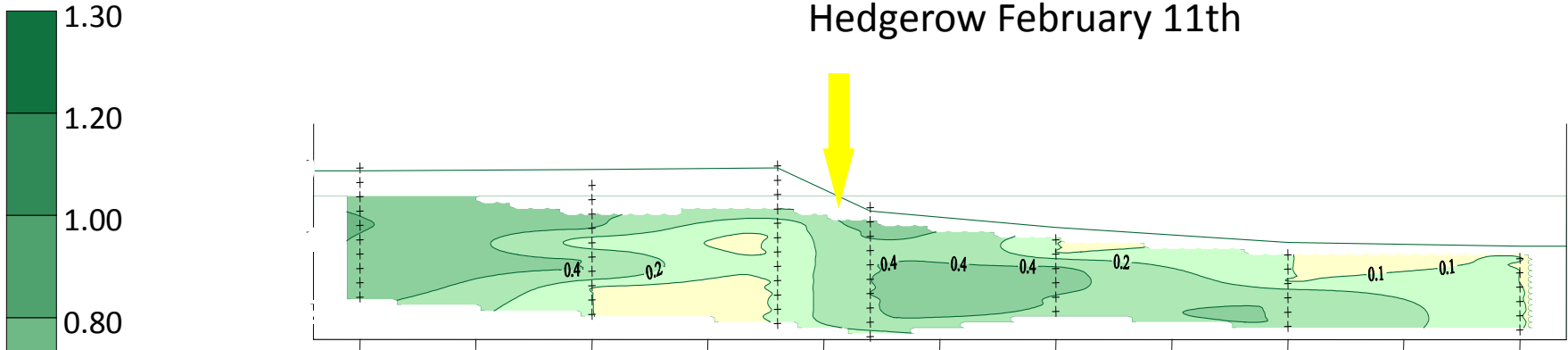
(1) hedgerow



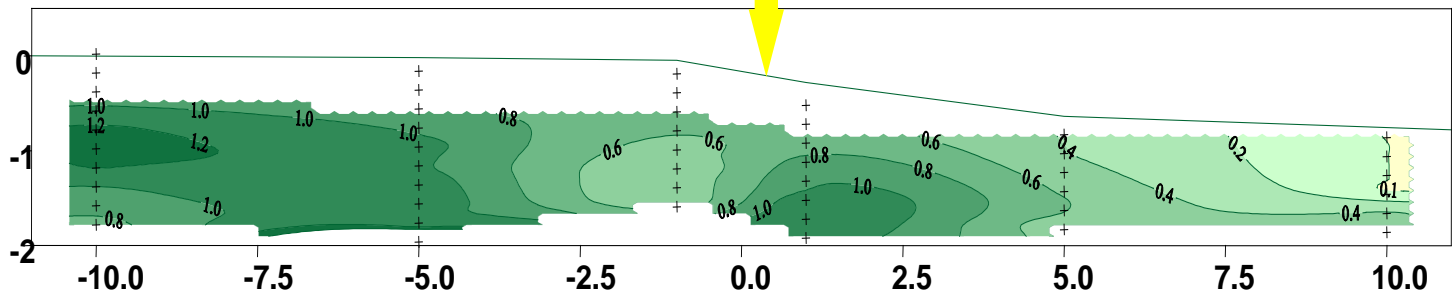
Hedgerow as a buffer

Nitrate concentration in soil (mM/liter)

Hedgerow February 11th



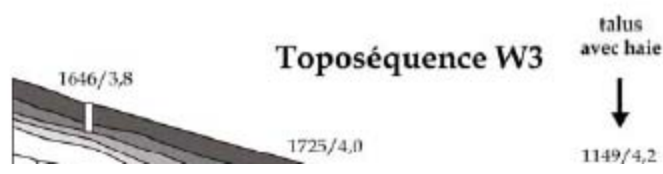
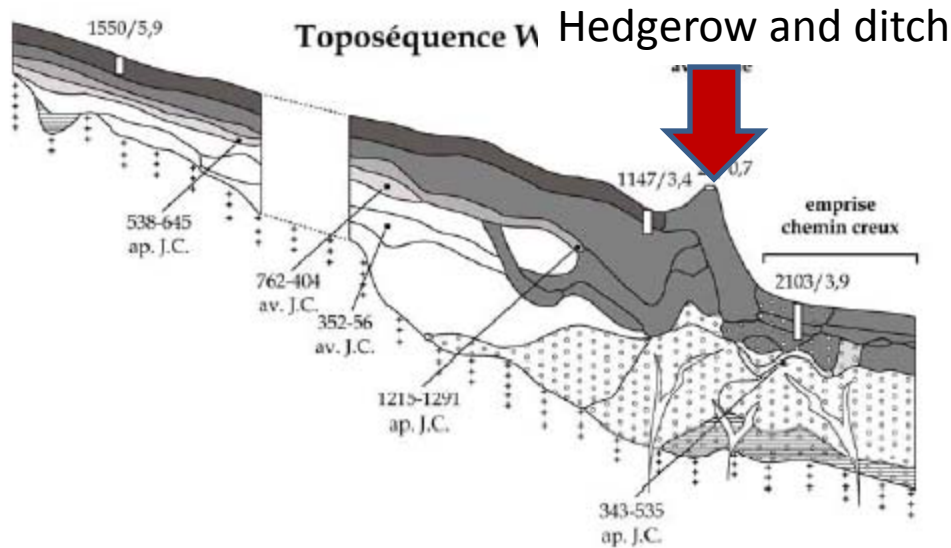
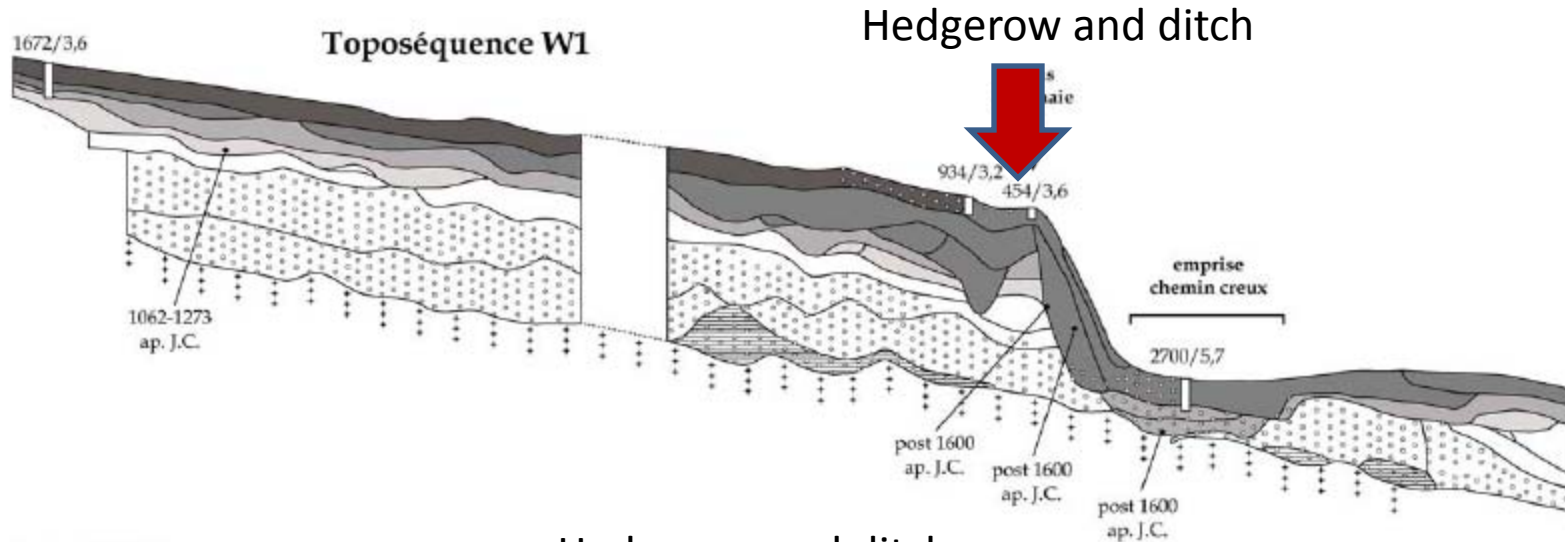
Fence February 11th



1 millimole NO₃ = 62 mg/l

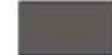


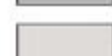

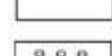

Caubel, Mérot, Grimaldi

Accumulation of organic matter

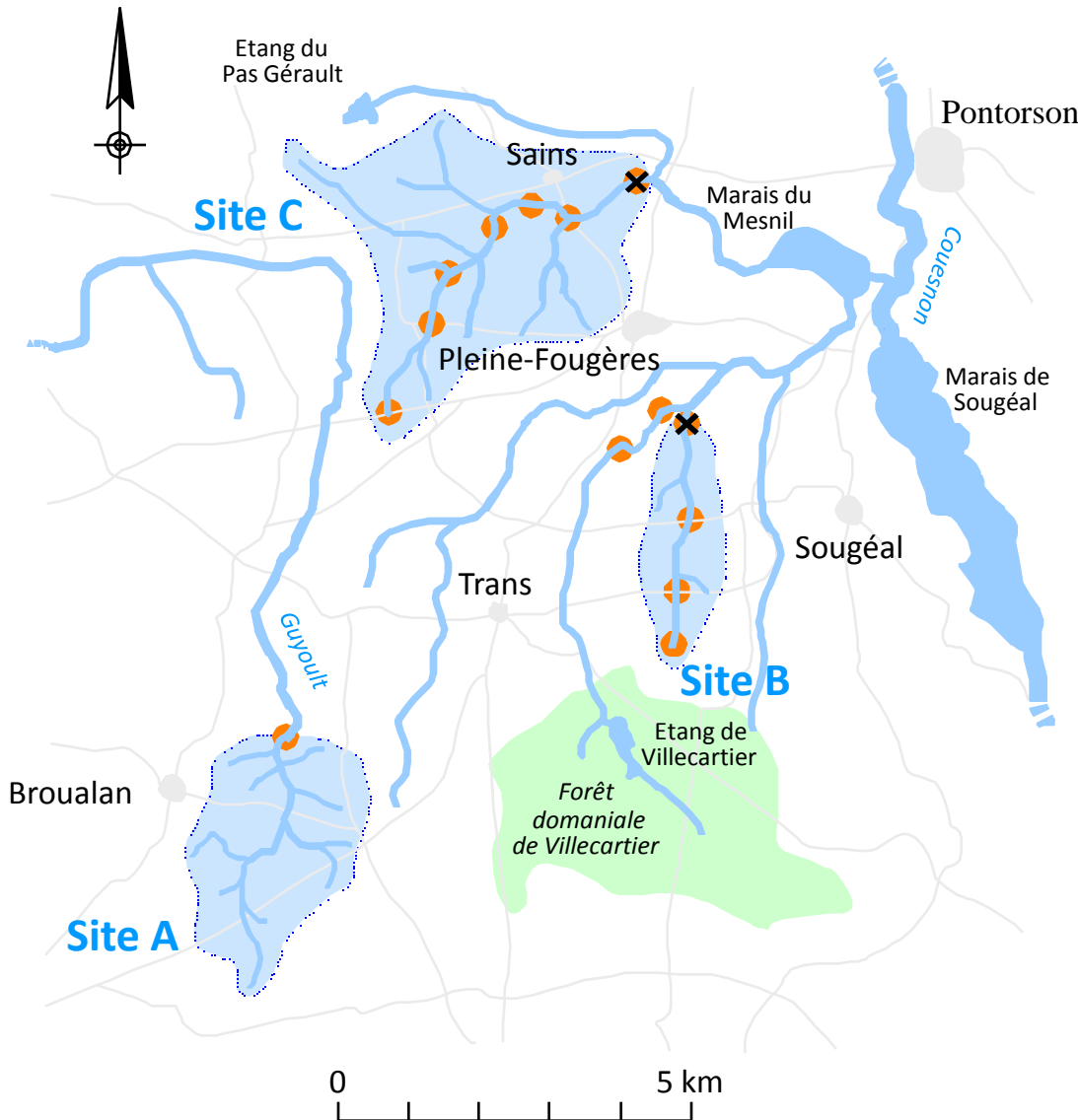


Légende :

1. Horizons pédologiques

-  LA : horizons organo-minéraux labourés
-  A : horizons organo-minéraux non labourés
-  A/B : horizons organo-minéraux avec inclusions de l'horizon structural (<50%)
-  B/A : horizons organo-minéraux avec inclusions de l'horizon éluvial (<50%)
-  B : horizons minéraux
-  -g : horizons à caractère hydromorphe
-  -d : horizons à interdigitations et/ou langues

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%

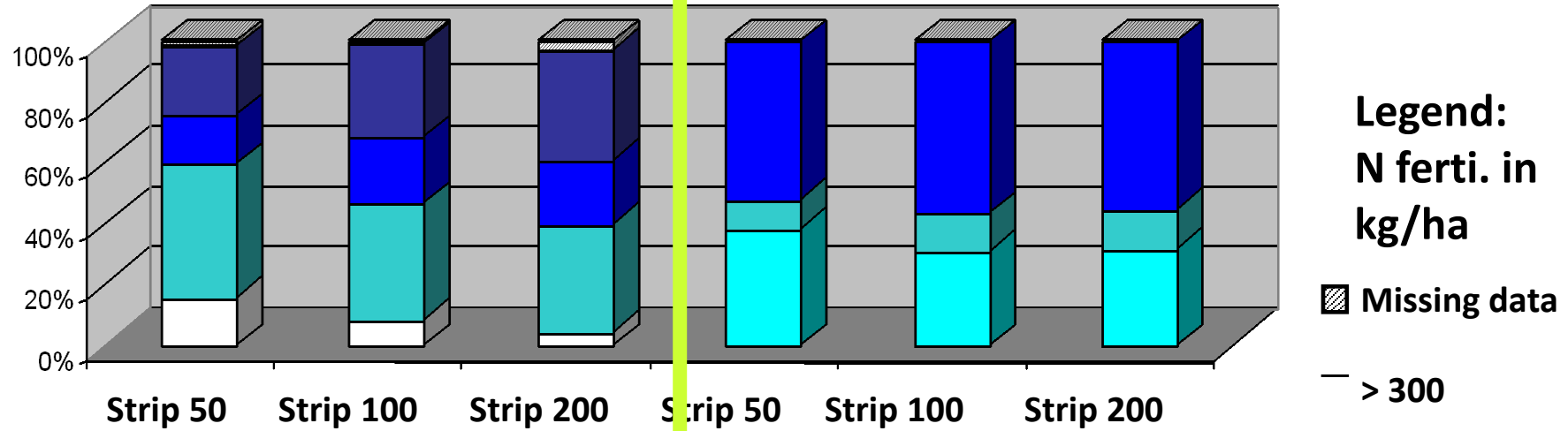
- Suivis bi-mensuels
- ⊗ Suivis asservis aux régimes d'écoulement

Heterogeneity of fertilization level

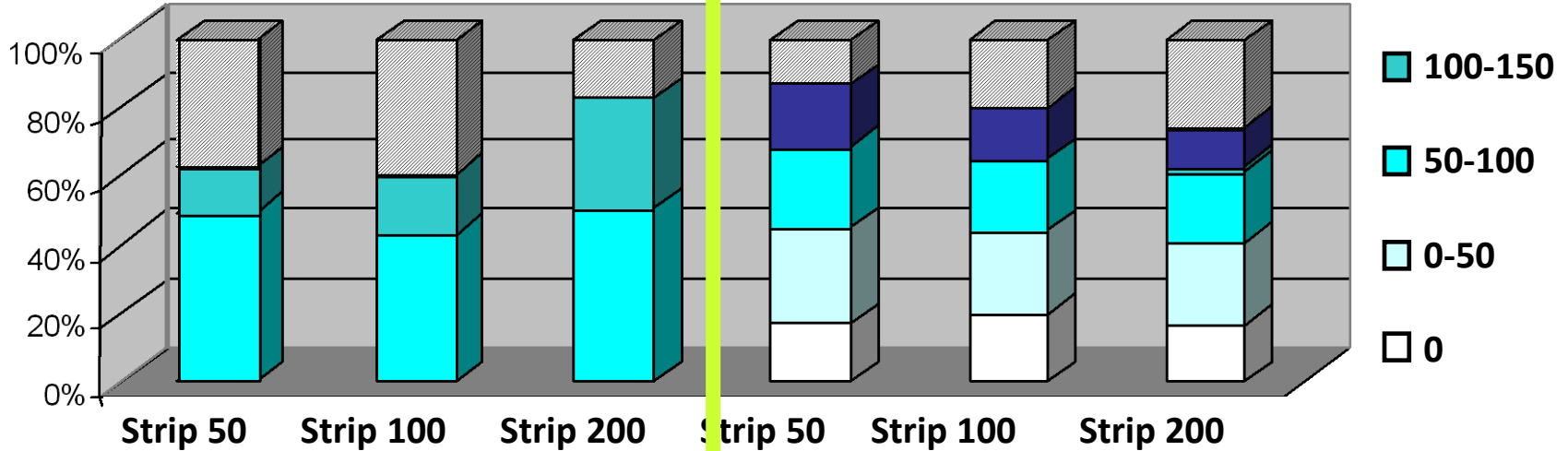
Maize

Zone Outlet

Zone Headwater



Grassland



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

Estimated nitrogen input

At the watershed scale

1



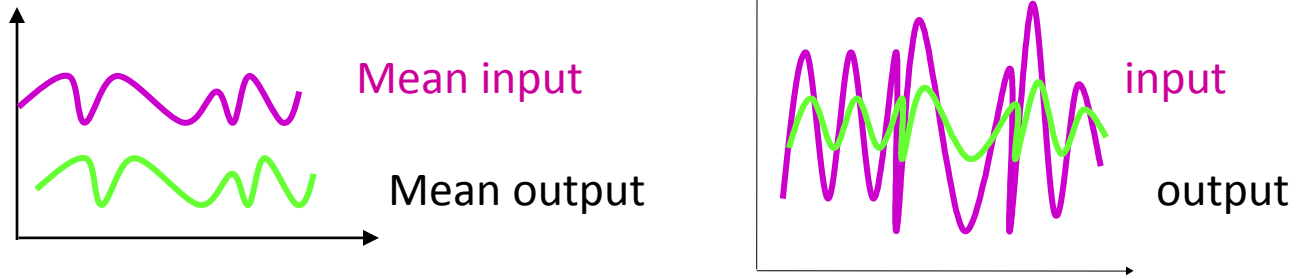
2.5

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

concentration of NO₃ in streams

Buffer effects



Measured nitrogen output (concentration)

NO₃⁻

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

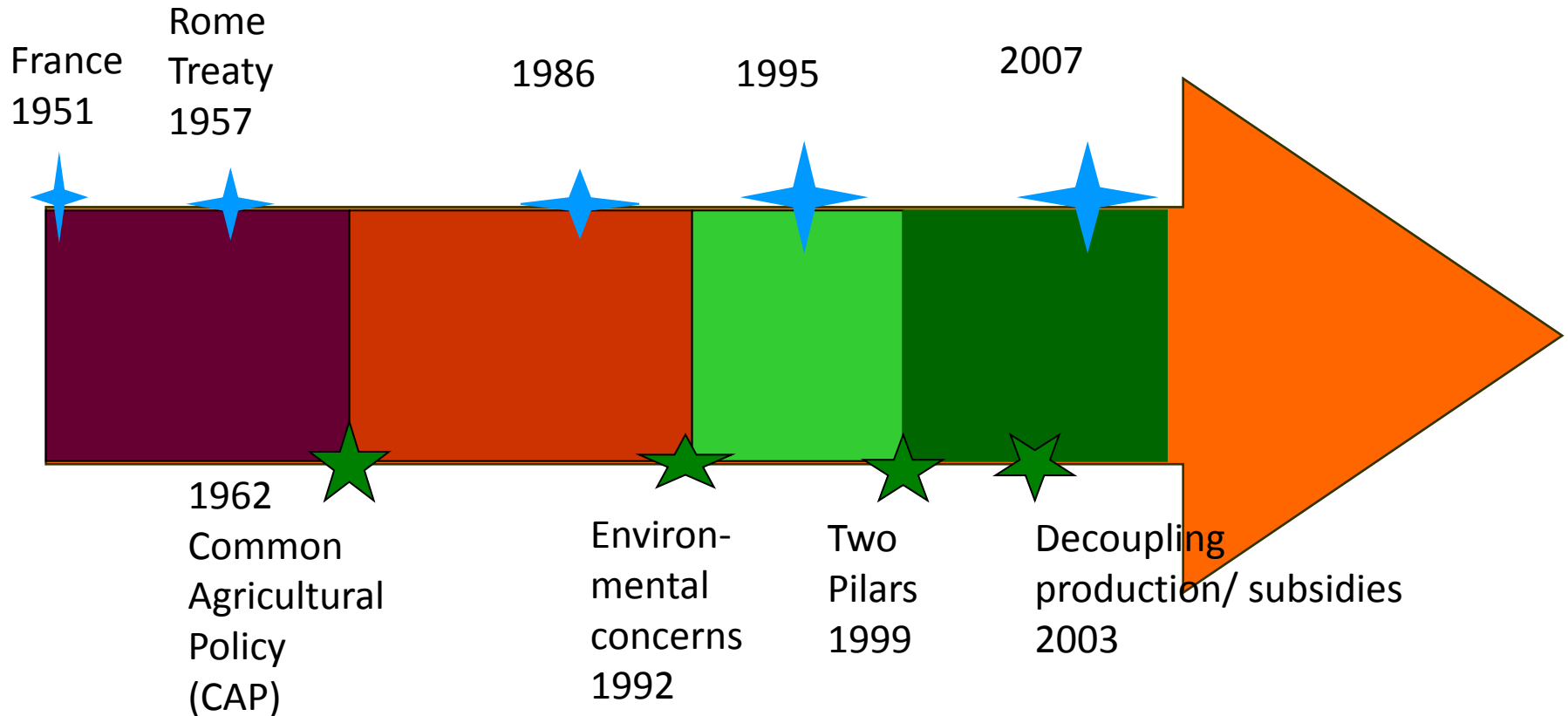
Hedgerow density or hedgerow network patterns?

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

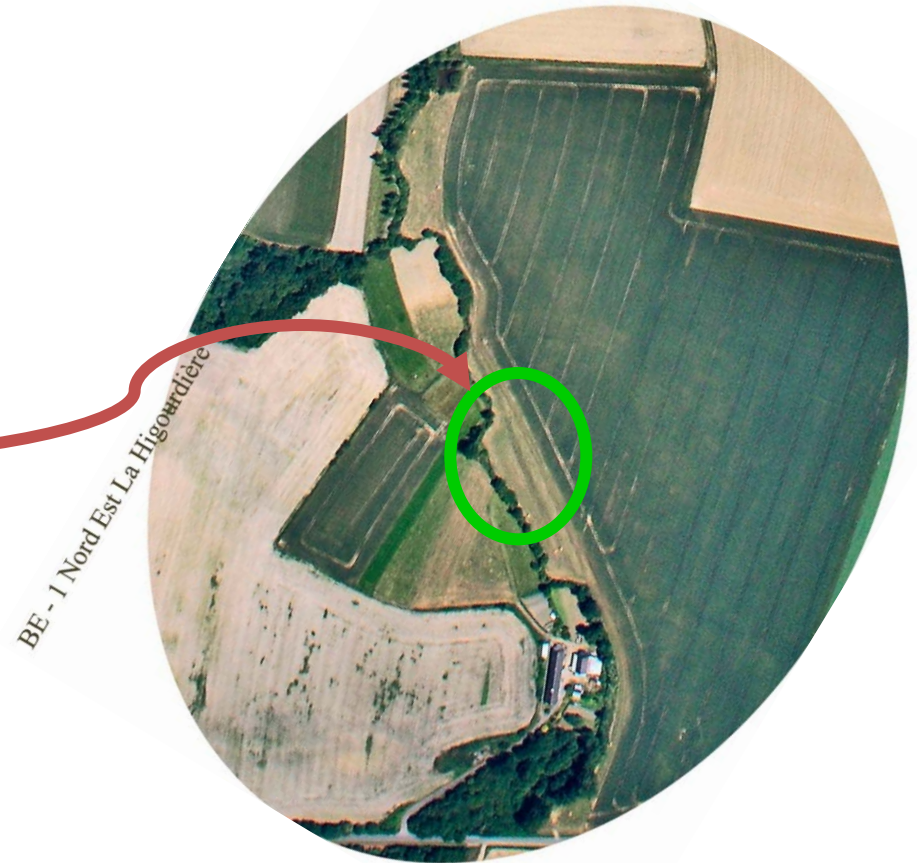
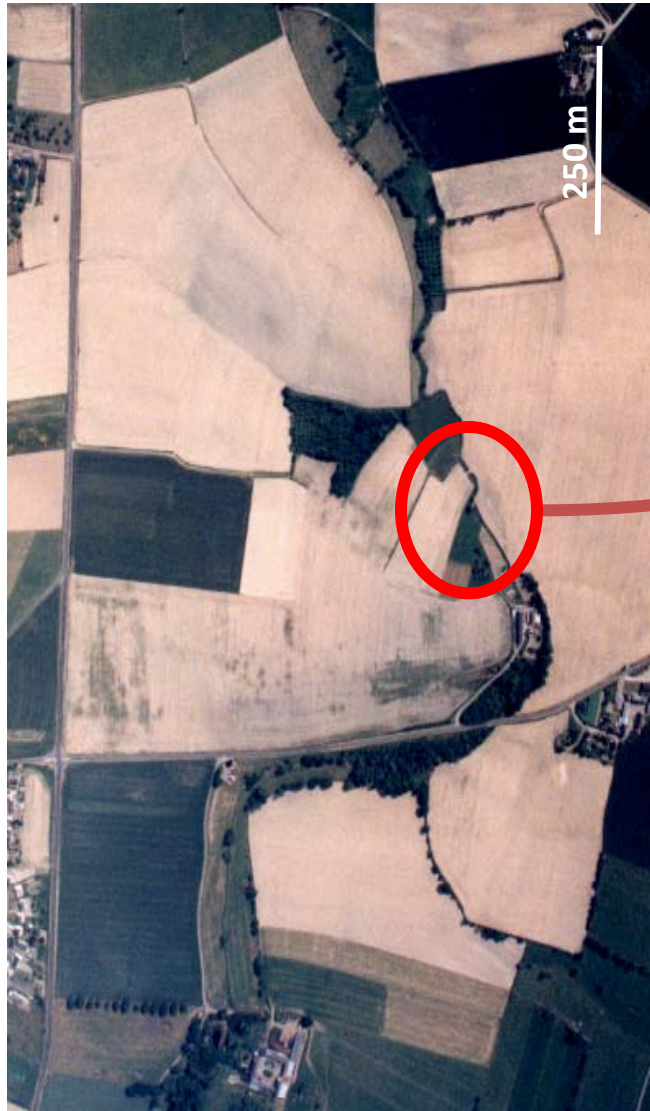


Regional drivers/ responses - EU

EU: the Common Agricultural Policy



RESPONSE for water quality



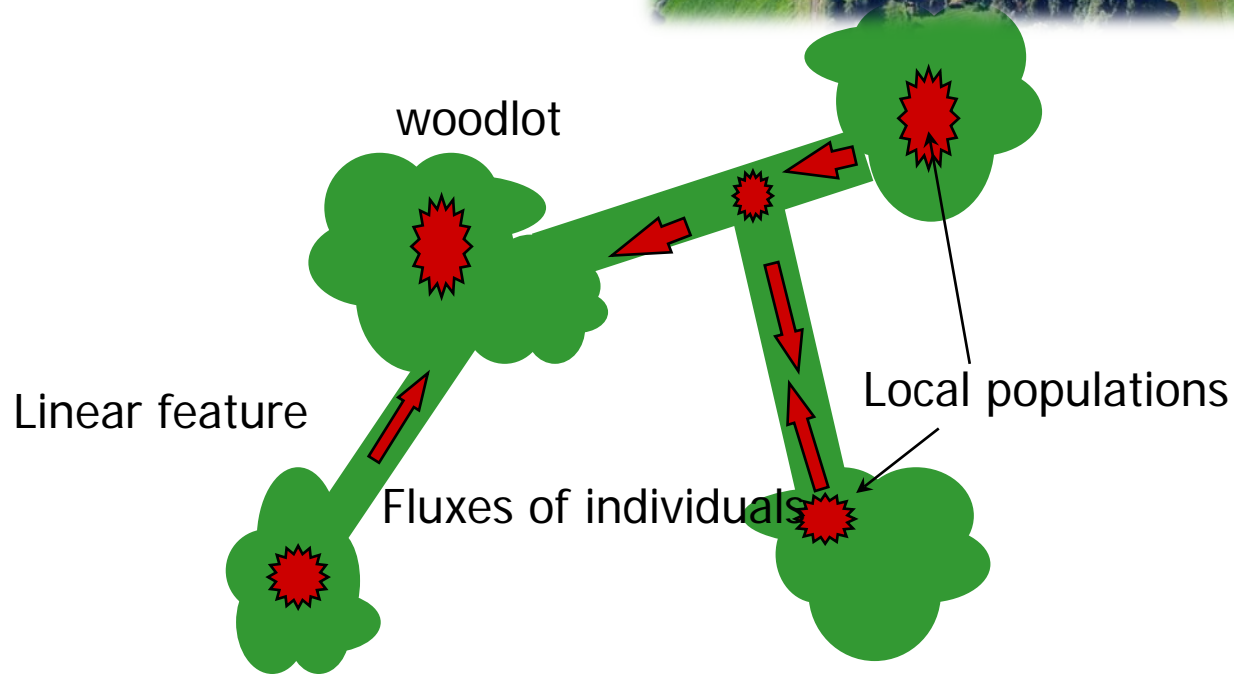
Implementation of grassy strips: nitrate directive, cross-compliance

The Armorique LTER: biodiversity

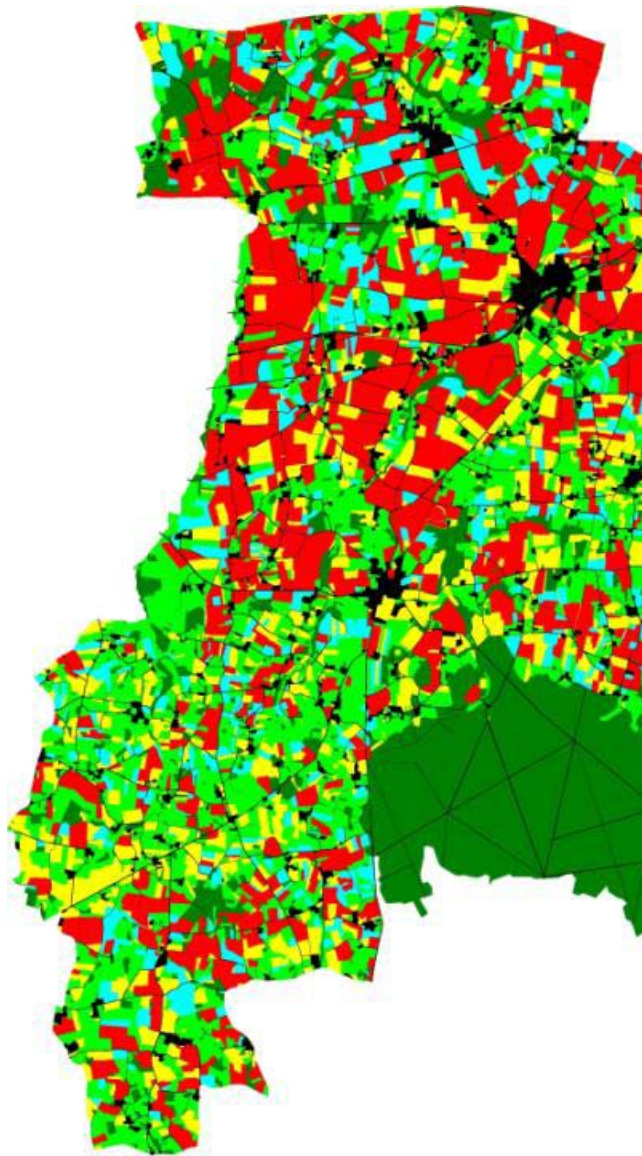
How the landscape patterns that control biogeochemical flows affect biodiversity patterns?



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**.

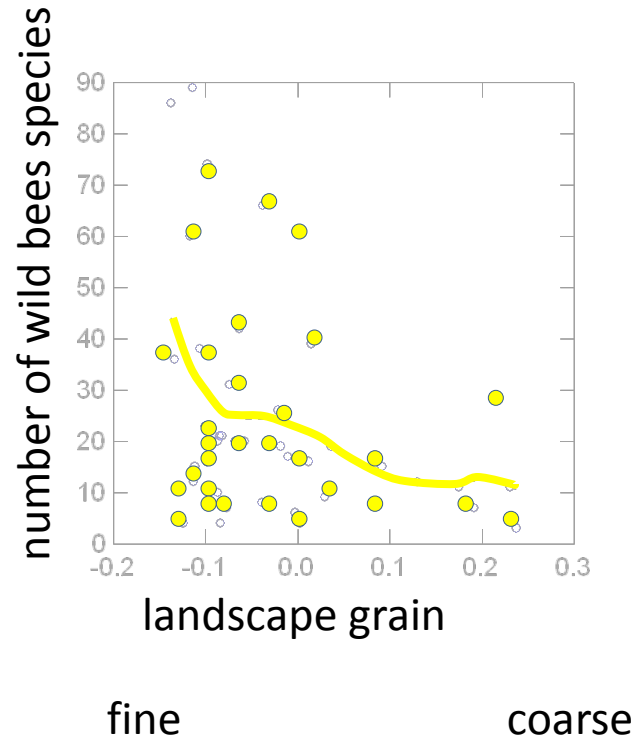
Alarming **declines in wild bee populations** have been reported for various countries all around the world.

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**



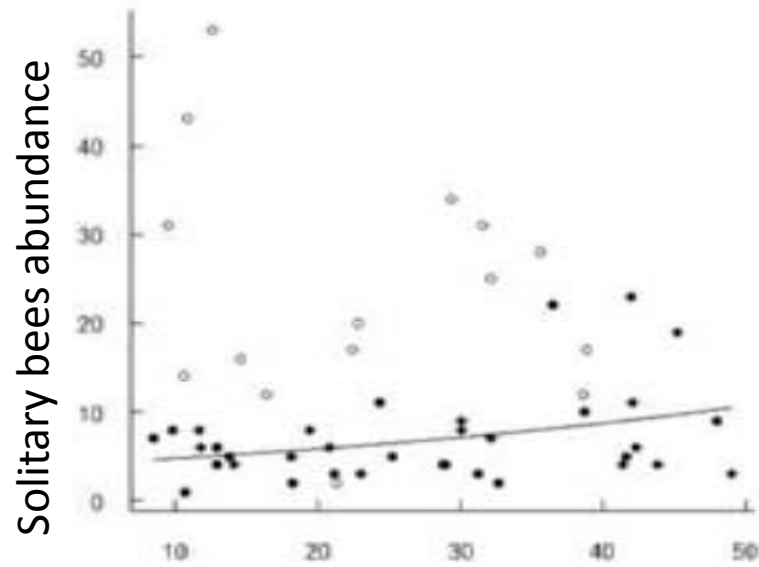
Landscape structure and wild bees diversity



Fine grain landscape

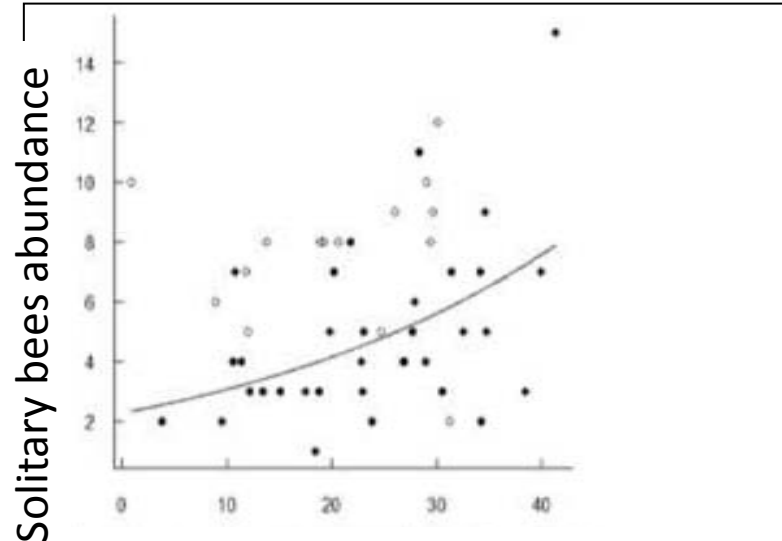


Coarse grain landscape



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

Proportion of permanent grassland in 1200m windows



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

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

Agriculture energy/
chemical intensification

*Plowing of permanent
grassland*

Loss of biodiversity

Implementation
of grassy strips
Buffers and
novel habitats

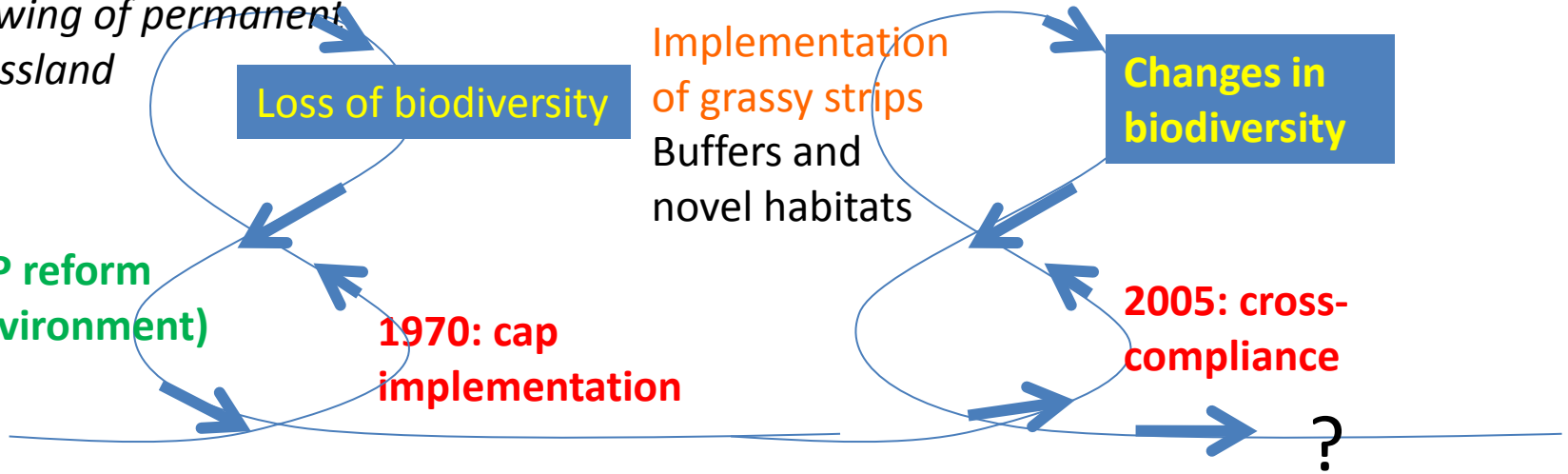
Changes in
biodiversity

CAP reform
(environment)

1970: cap
implementation

2005: cross-
compliance

?



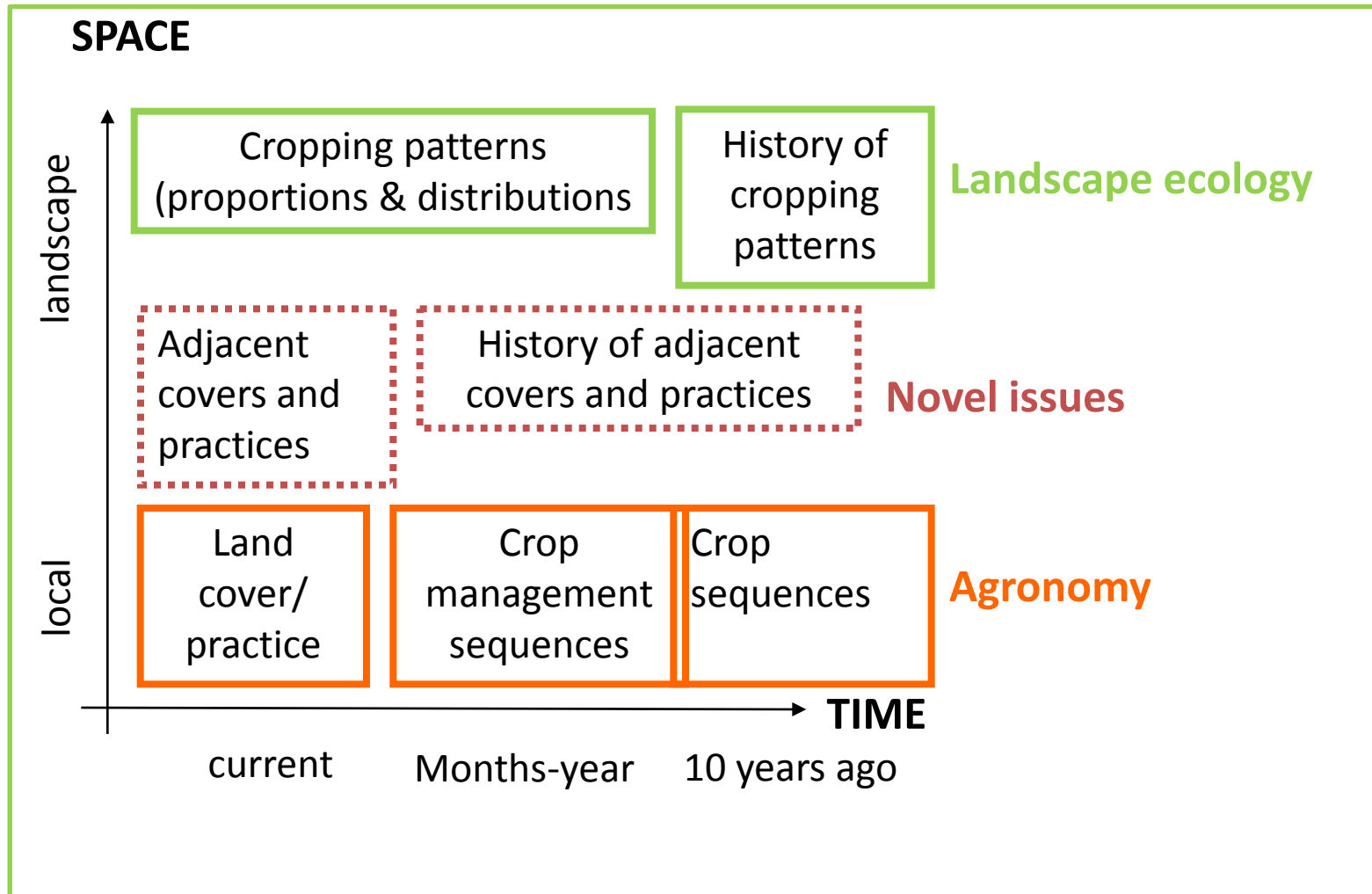
Hedgerows have a profound effect on fluxes, those fluxes change landscape patterns

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





Thank you for your attention