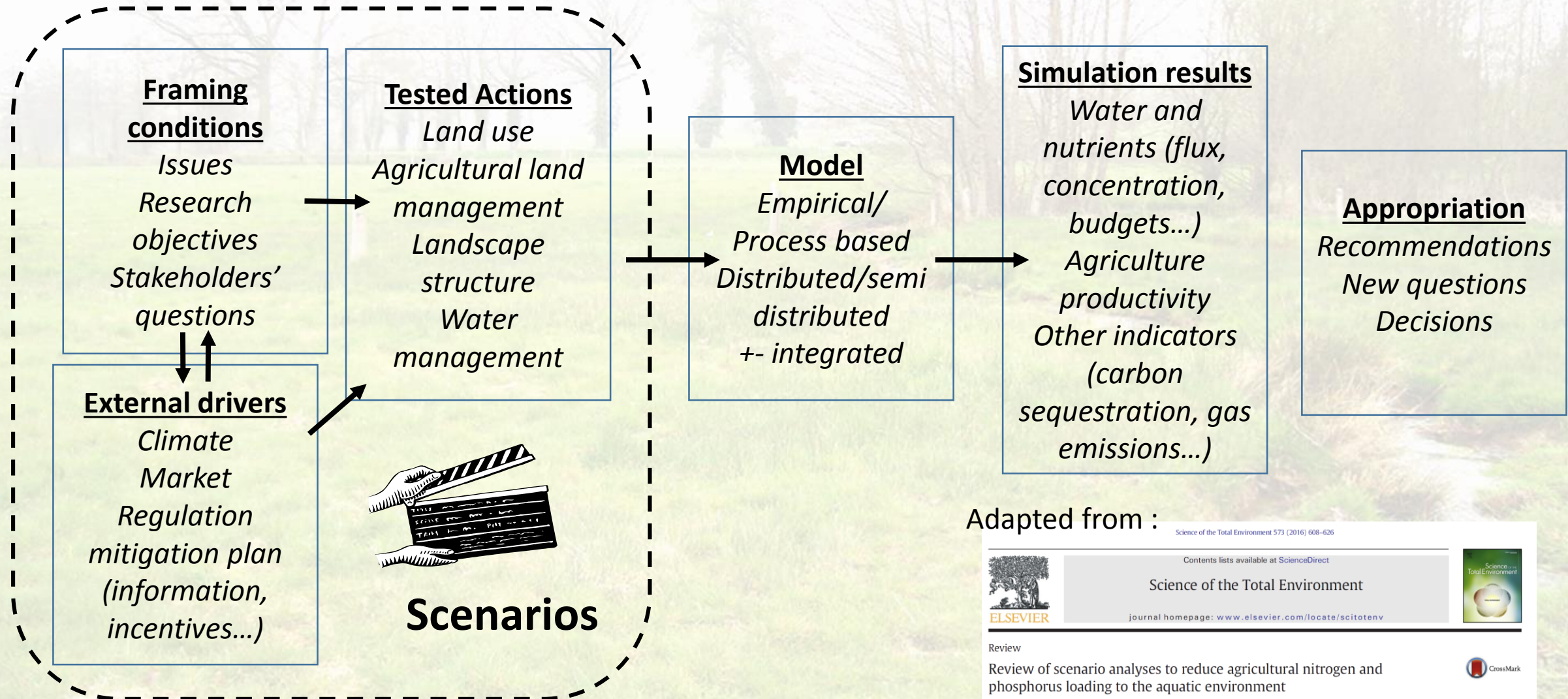


Land use scenarios and nutrient fluxes

Patrick Durand , UMR SAS INRA Rennes
With stolen illustrations from many co-workers.....



The approach



Adapted from :

Science of the Total Environment 573 (2016) 608–626

Contents lists available at ScienceDirect

Science of the Total Environment

ELSEVIER journal homepage: www.elsevier.com/locate/scitotenv

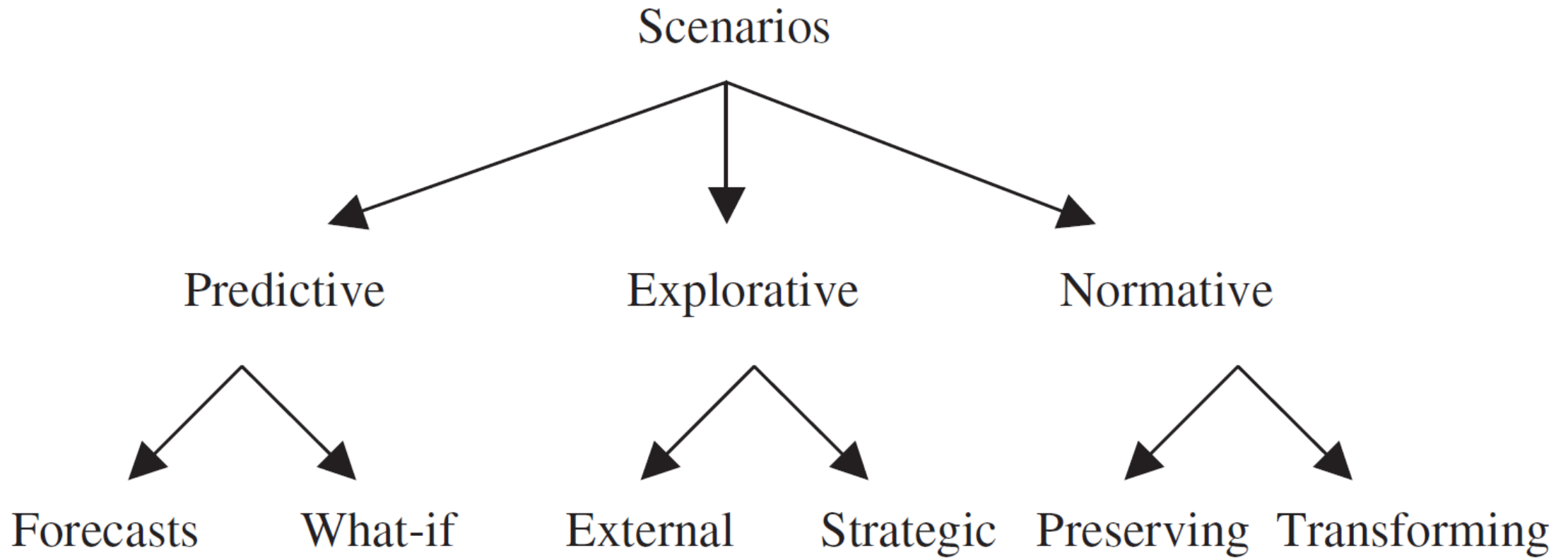
Review

Review of scenario analyses to reduce agricultural nitrogen and phosphorus loading to the aquatic environment

Fatemeh Hashemi *, Jørgen E. Olesen, Tommy Dalgaard, Christen D. Børgesen

Department of Agroecology, Aarhus University, Blichers Allé 20, 8830 Tjele, Denmark



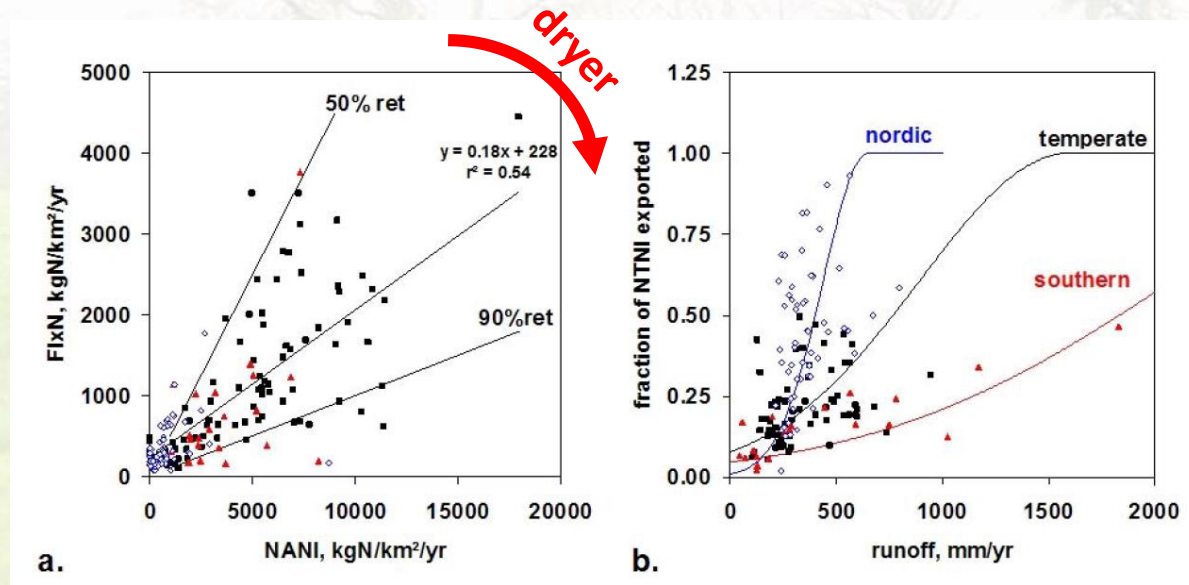


What will happen?

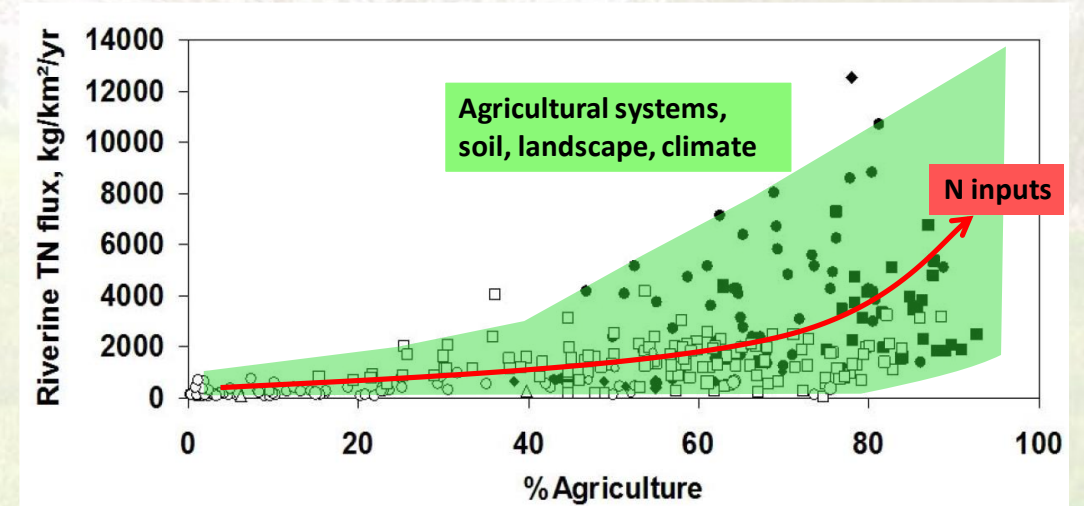
What can happen?

How to reach the target?

Main factors (1/2)



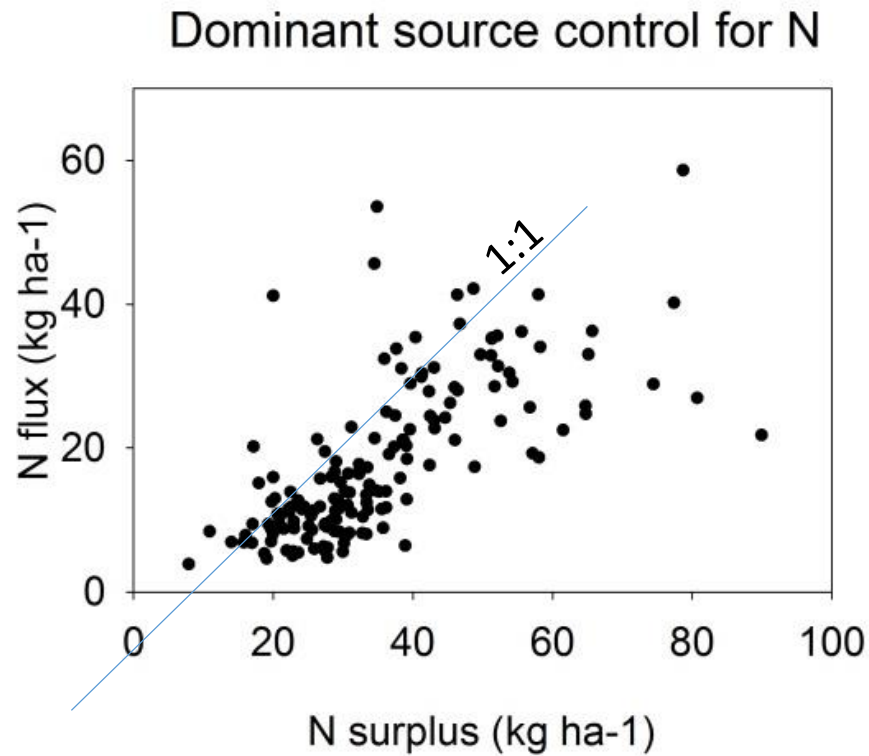
N losses are related to N budgets of the catchments, but the relationship is strongly dependent on climate



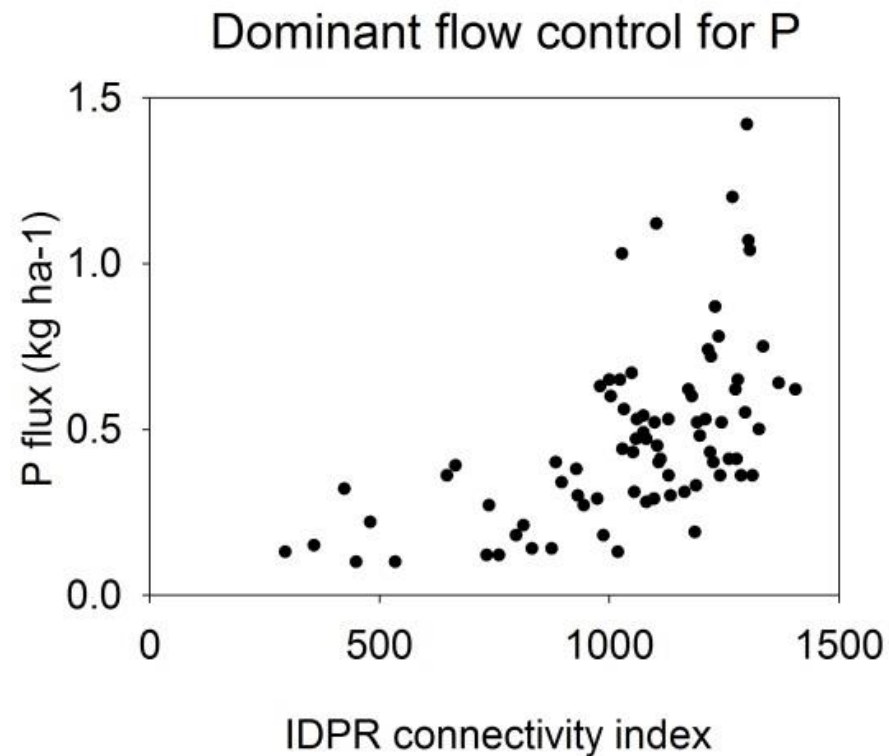
European Nitrogen Assessment, Chap. 13

N losses is related to proportion of agriculture in the catchments, but the relationship is complex

Main factors (2/2)

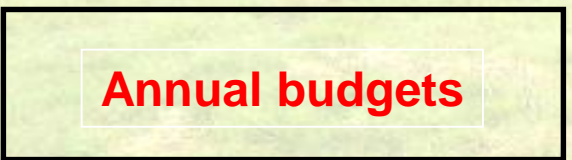
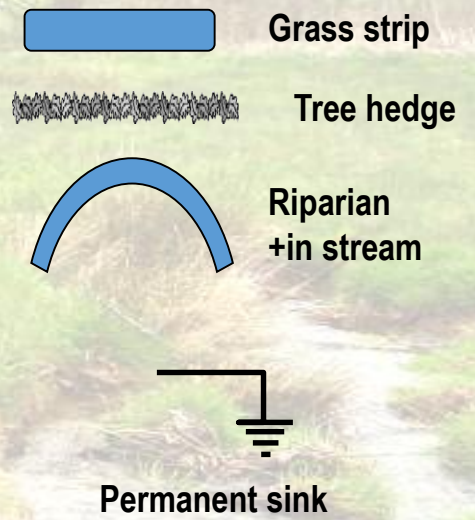
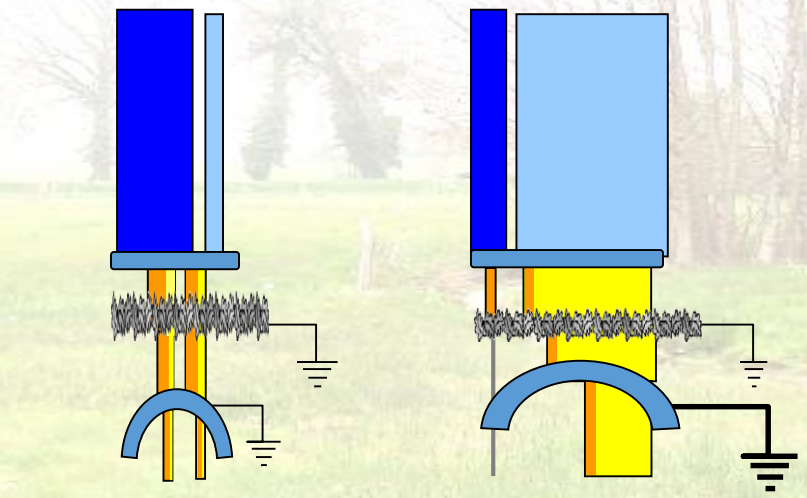
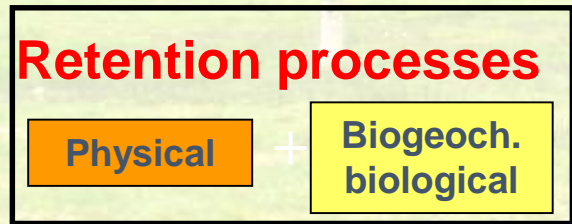
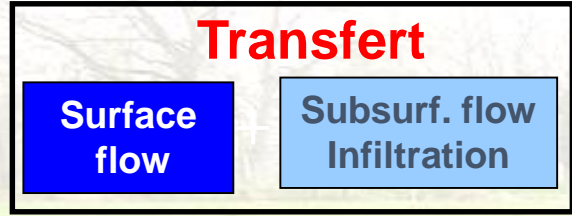
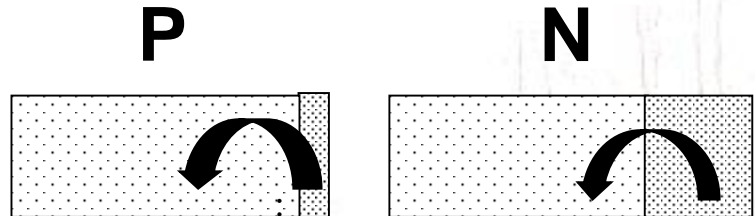
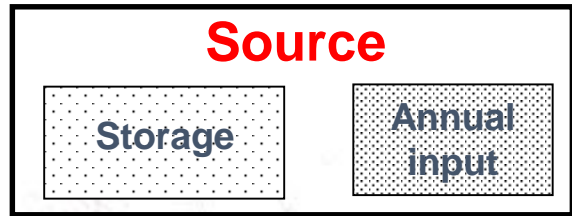


160 catchments in France

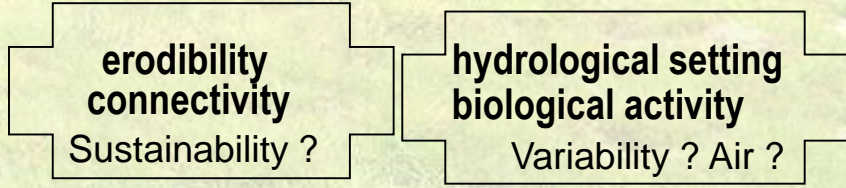


Dupas et al. Ecol. Ind., 2015

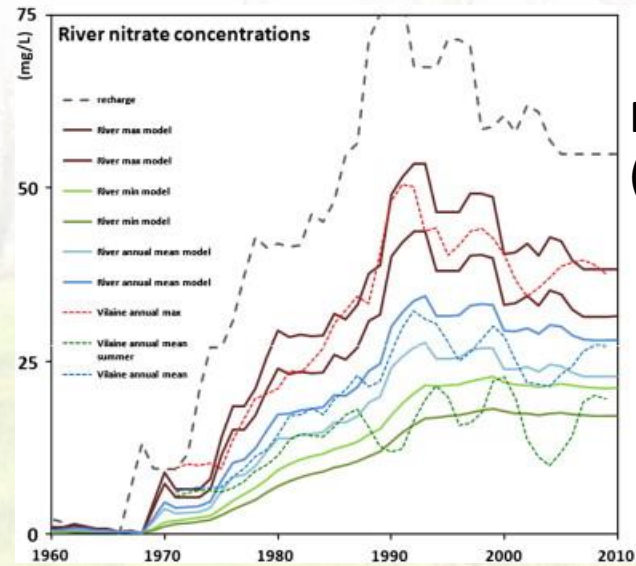
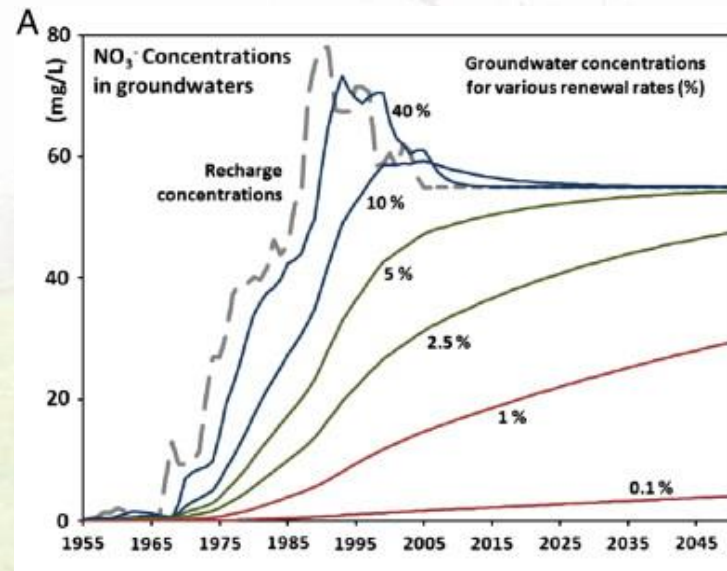
- **N : Land use > climate > nutrient budgets > nutrient inputs > landscape structure**
- **P : Land use > climate > landscape structure > nutrient inputs > nutrient budget**



emissions/input < 5%	> 10%
$\sigma(\text{emissions}) > 100\%$	$\sim 100\%$
Flux \neq f(stock)	= f(stock)

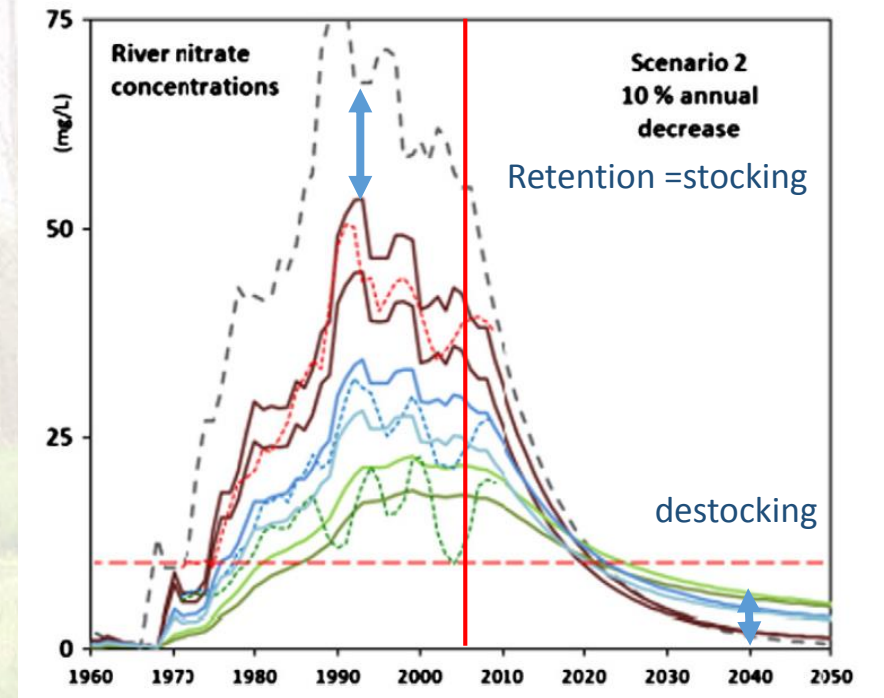


Legacy...



Recharge
(N input)

maximum
mean
minimum



L. Aquilina, et al., Sci. Tot. Envir. 2012

Review of results *(from Hashemi et al. 2016)*

The most frequently tested : decrease fertilisers

- For P : usually little or no effects on the short term (need first to decrease P legacy in soil by soil mining)
- For N : for 10 kg/ha less, the decrease in emissions at the catchment scale varies from almost 0 to ~ 5 kg/ha

Land use changes

arable -> forest , arable -> set aside, arable ->grassland : not surprisingly, decline of nutrient emissions, BUT the ratio between the magnitude of reduction and the proportion of conversion is widely variable...
Spatially targeted changes are more efficient

Other agricultural practices

Optimizing nutrient use efficiency in livestock systems

No till or conservation tillage (although at the field scale it is not that clear : suspicion on models?)

Catch crops, cover crops

Buffer strips, riparian zones...

Tested alone or combined, always beneficial, but also with very variable results

In most cases, as far as eutrophication limitation is concerned, preventing scenarios are not sufficient to reach the objectives and transforming scenarios were mostly built as an academic exercise

A case study from Brittany...



N manure input

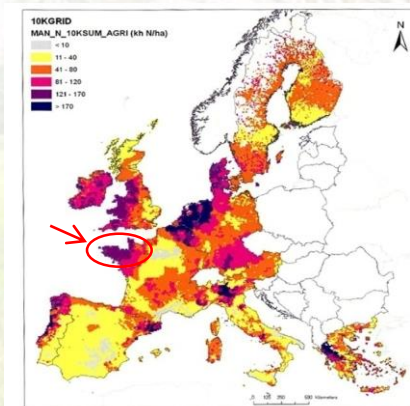


Figure 4.25 European map of nitrogen manure input per agricultural area in EU15, average on 10 km² area. (In Sweden and Finland the white colour indicates the absence of agricultural land within the 10 km² area).

P manure input

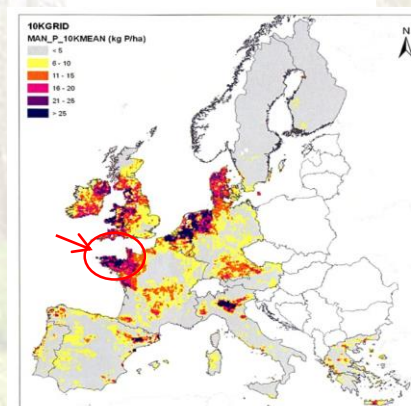
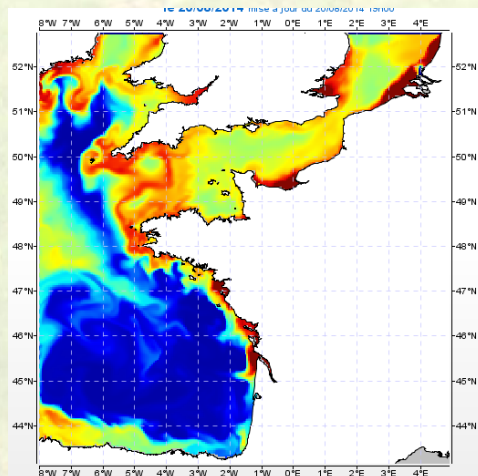
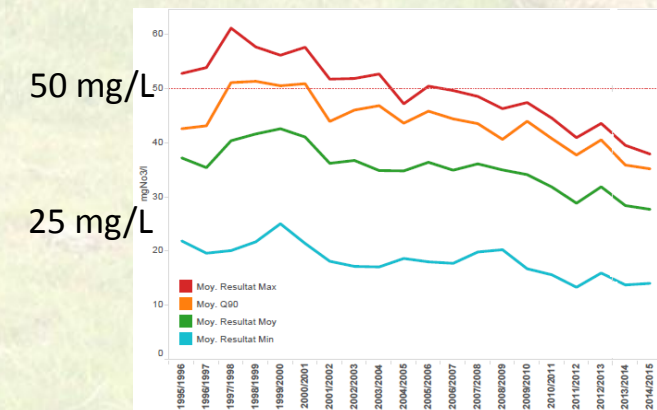


Figure 4.26 European map of phosphorus manure input per total surface in EU15, average on 10 km² area.

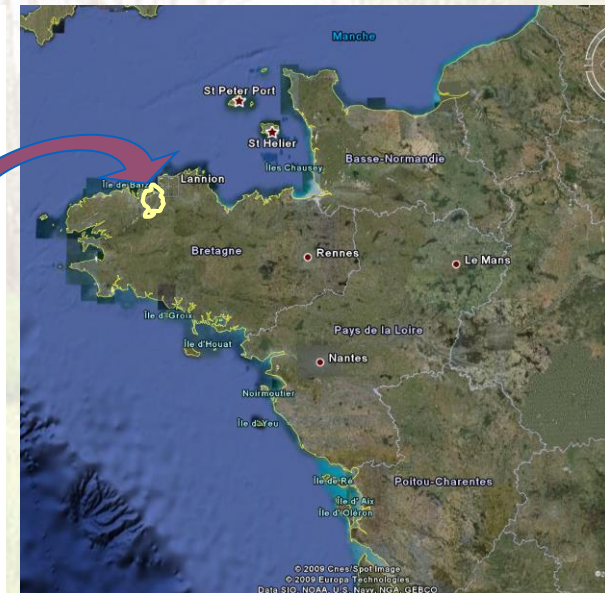
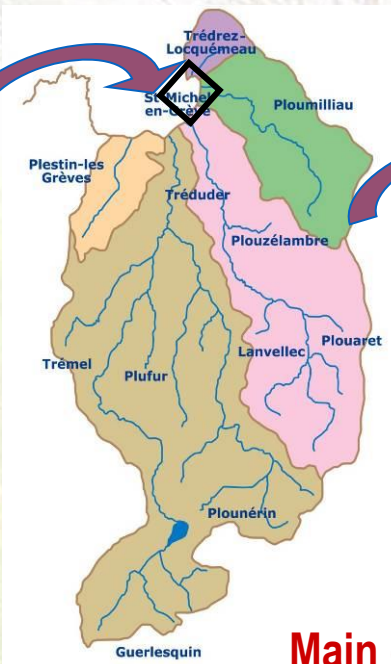
Chlorophyll a simulation 20/8/2014



Decrease of N03 concentration by 30%



Lieue de Grève : an emblematic site in Brittany



Main characteristics Lieue de Grève

≥50% algae if $< 8 \text{ mg NO}_3 / \text{l}$ (Menesguen, 1999)
(1.8 N-NO₃)
Mean current concentration : 30 mg/l NO_3
(6.8 N-NO₃)

- total area **12 km²**, **5 streams**
- **12 villages**, **13 500 inhabitants**
- Agricultural area **8 500 ha**,
- **170 farmers**, **85% dairy farms** (east and west: intensive pig/veget)



ACASSYA Project

C. Gascuel-Odoux, L. Ruiz, L. Aquilina, M.O. Cordier, L. Delaby, P. Durand,
L. Hubert-Moy, J.L. Peyraud, E. Ramat, M. Sebilo, Z. Thomas, F. Vertes.

Supporting the agro-ecological evolution of animal production systems in coastal catchments

(ACcompagner l'évolution Agro-écologique deS SYstèmes d'élevAge dans les bassins versants côtiers)

	<ul style="list-style-type: none">• UMR 1069 SAS, INRA 65 rue de St Brieuc 35042 RENNES Cedex, France		<ul style="list-style-type: none">• Biogéochimie et écologie des milieux continentaux CNRS Unité mixte de recherche 7618 UPMC - CNRS - INRA - IRD - ENS - AgroParisTech Université Paris-Est
	<ul style="list-style-type: none">• UMR Production du Lait INRA Domaine de la Prise 35590 SAINT-GILLES, France		<ul style="list-style-type: none">• Géosciences Rennes (UMR CNRS 6118) CNRS Université de Rennes1 Bâtiment 15, Campus de Beaulieu, CS 74205 F-35042 Rennes Cedex
	<ul style="list-style-type: none">• Laboratoire COSTEL CNRS Climat et Occupation du Sol par TELédétection LETG UMR 6554 CNRS Pôle de Rennes		<ul style="list-style-type: none">• IRISA Rennes I Campus de Beaulieu 35 042 Rennes Cedex

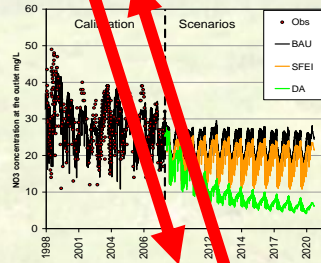
+ stakeholder partners : **LTA, CPA Lieue de Grève, CA22, CRAB, IE, Cedapa**

Main question : is it possible to reconcile agriculture and good ecological status of the bay?

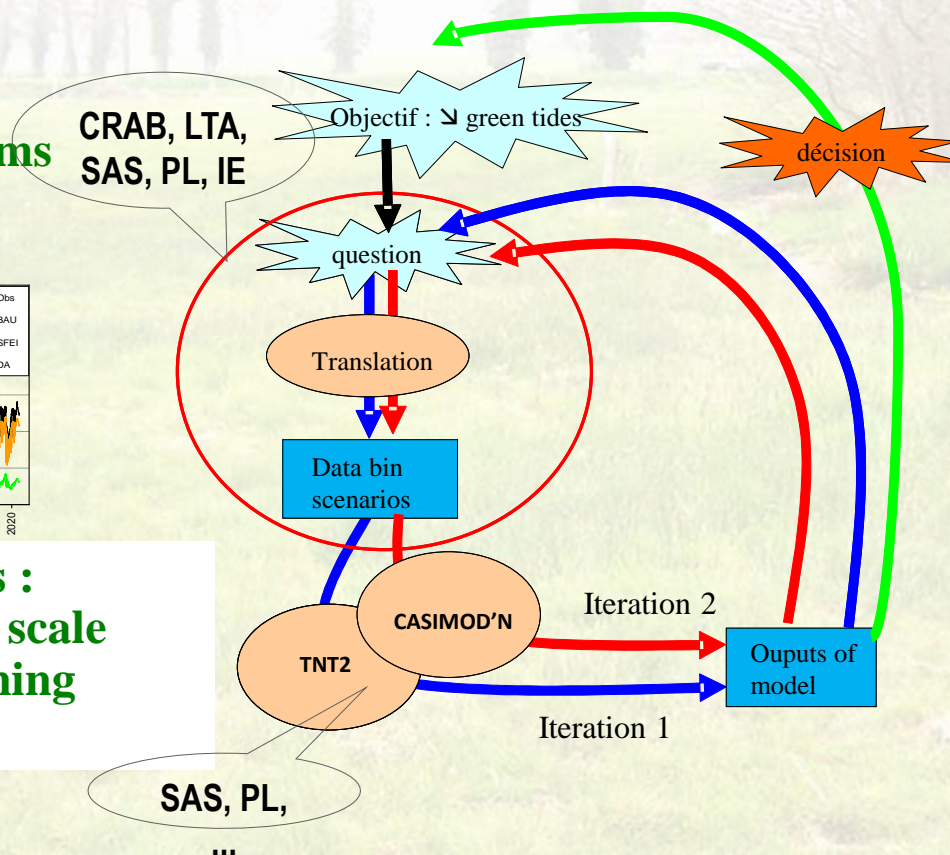
Method, partners

- combining the use of coupled models with a participatory approach in which 10 pilot farmers engage themselves to change their production system

Co-building of scenarios with actors : pilot farms in evolution

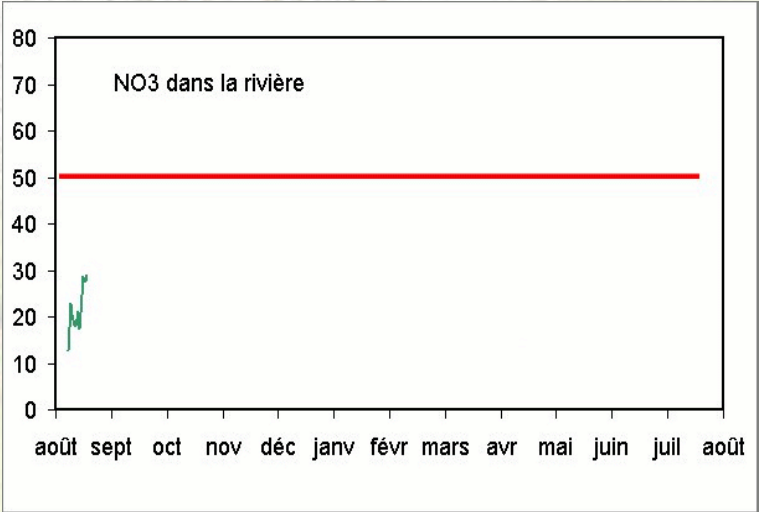
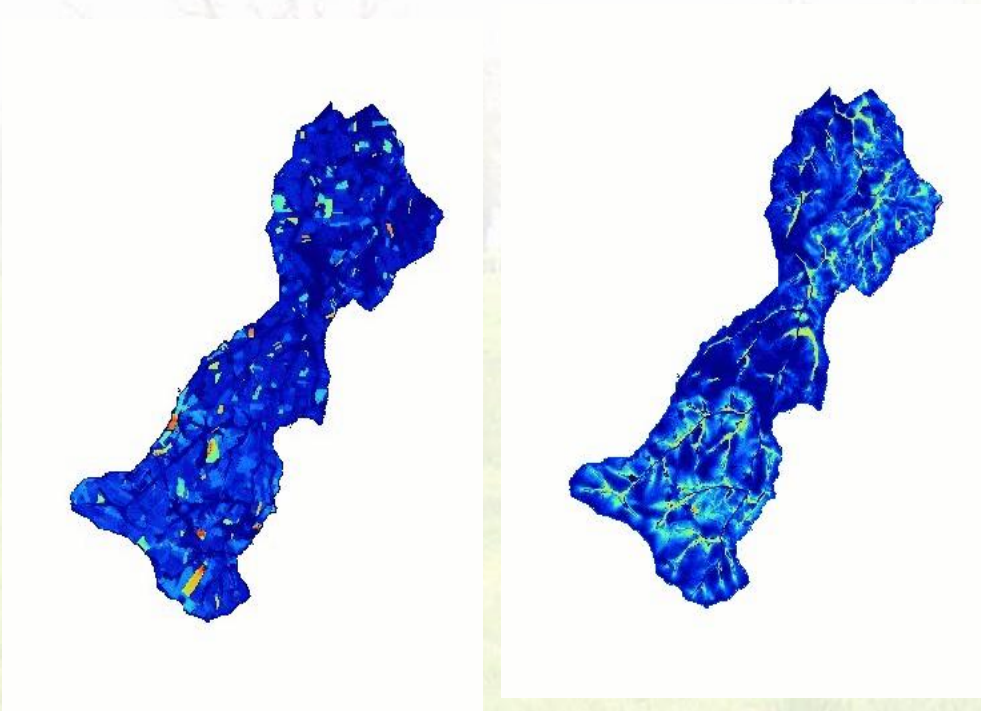


Coupling models :
 - AH catchment scale
 - farm functioning



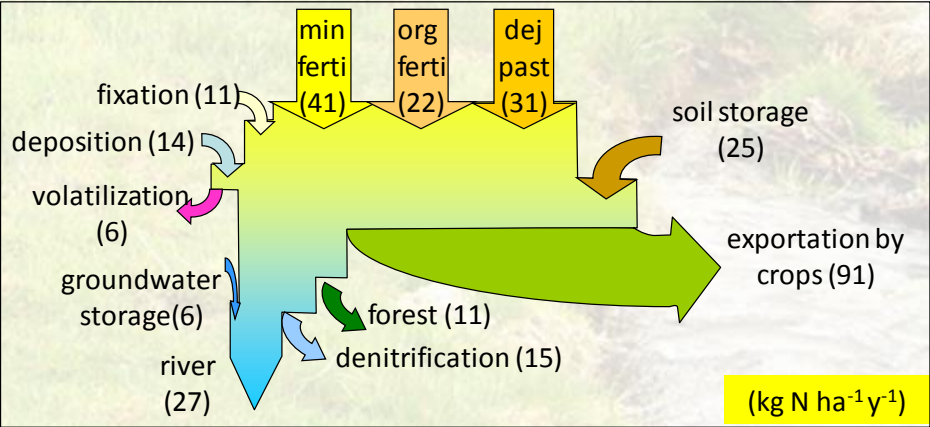
Farms varying by structure, production and objectives, physical conditions, ...
 Farmers dynamics and motivation

TNT2 : a model designed to analyse scenarios of changing cultivation practices and landscape management : fully distributed, coupling a detailed crop model and a hydrological model accounting for soil-groundwater interactions (->riparian buffers)

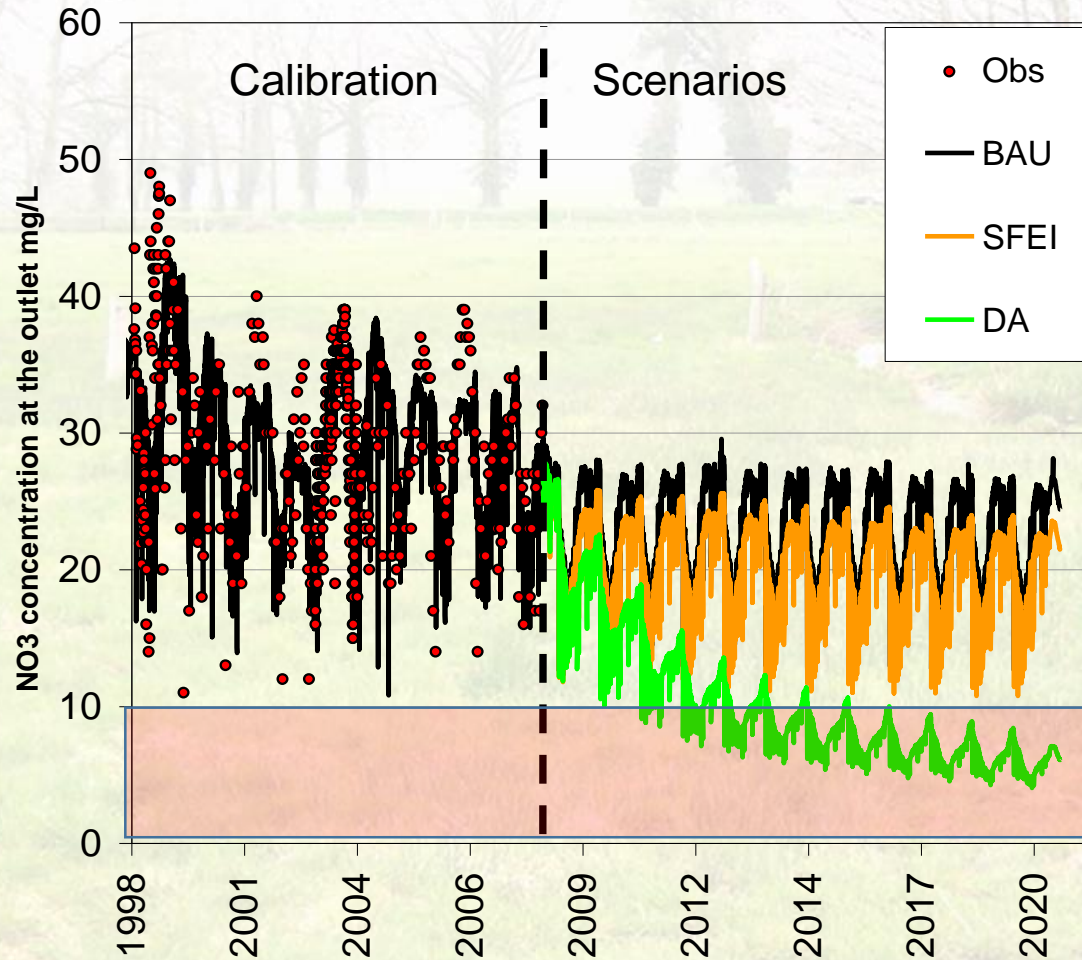


...to nitrate concentrations in streams and detailed N budgets of the catchments.

TNT2 : from agriculture management at the field scale...



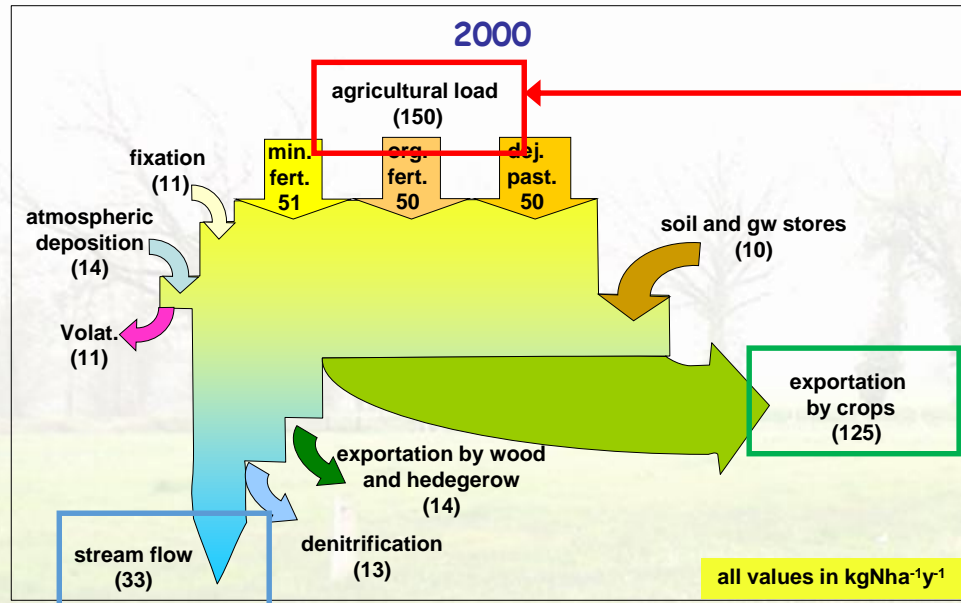
First iteration : preserving scenarios... *and a destructive one!*



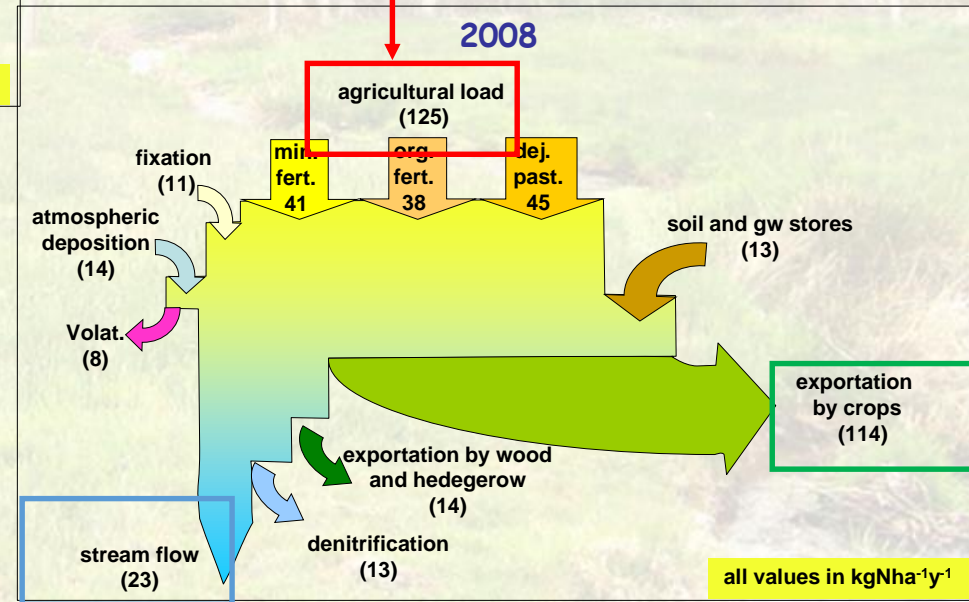
The most efficient N directive incentive for the area
All agriculture land converted in unmanaged grassland

N limiting conditions for algae

N budget: reconstruction of past evolution

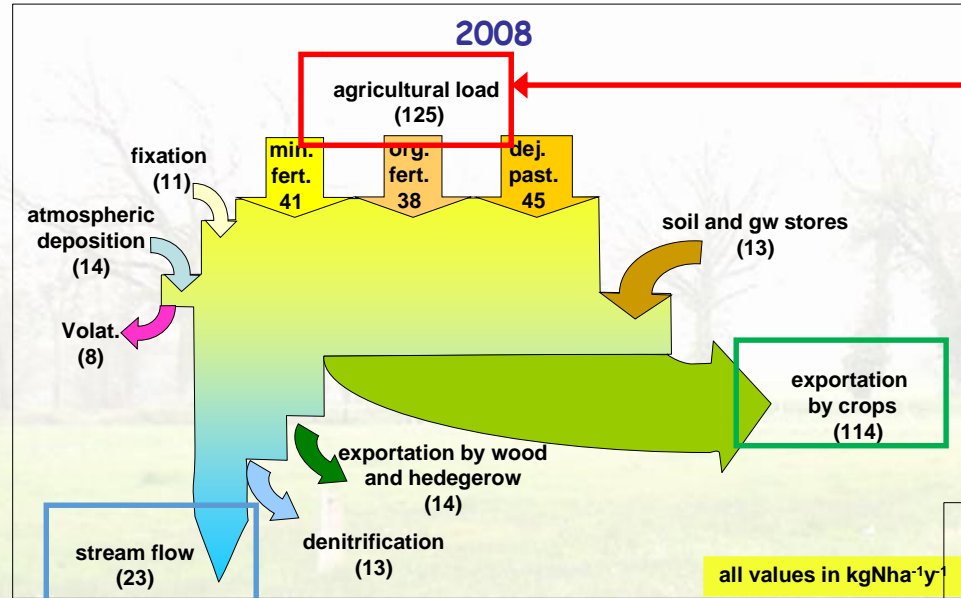


Ag. load: - 25 kgN/ha/y
 Ag. balance: - 14 kgN/ha/y
 N in the river: -10 kgN/ha/y
 Efficiency: 40 %



From N excess to balanced fertilisation

N budget: going on decreasing N inputs

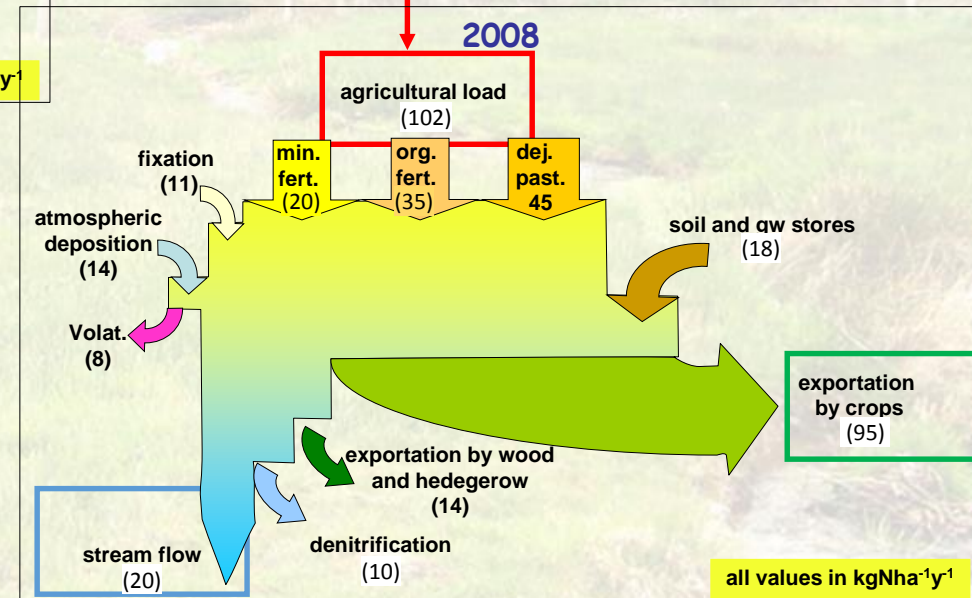


Ag. load: - 23 kgN/ha/y

Ag. balance: - 4 kgN/ha/y

N in the river: -3 kgN/ha/y

Efficiency: 12 %



The N use efficiency of the agricultural system being limited, the yield is the most impacted

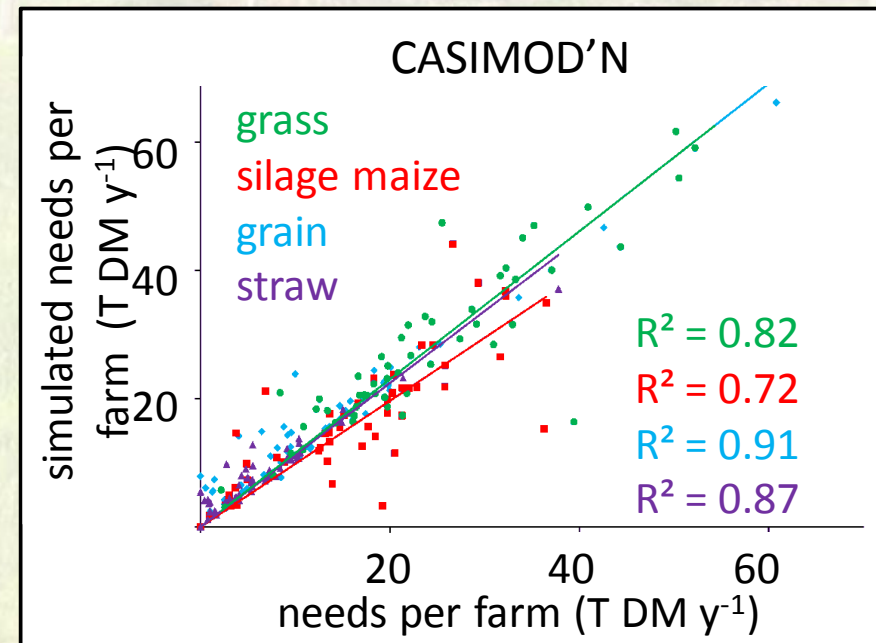
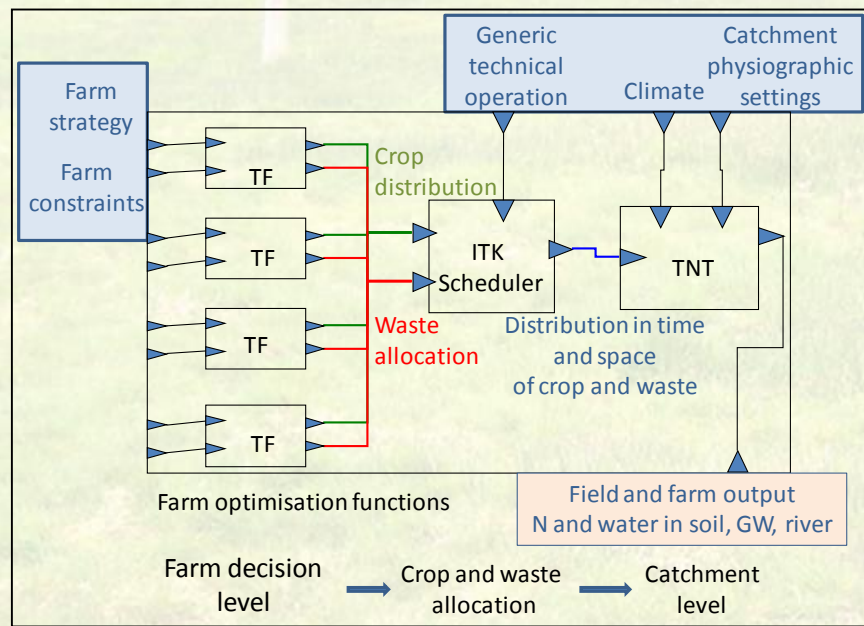
Increase N use efficiency of the systems while keeping them profitable:

- replace annual crops by grassland
- decrease the high-protein complementation of milking cows
- >decreasing grazing pressure and enhanced N recycling

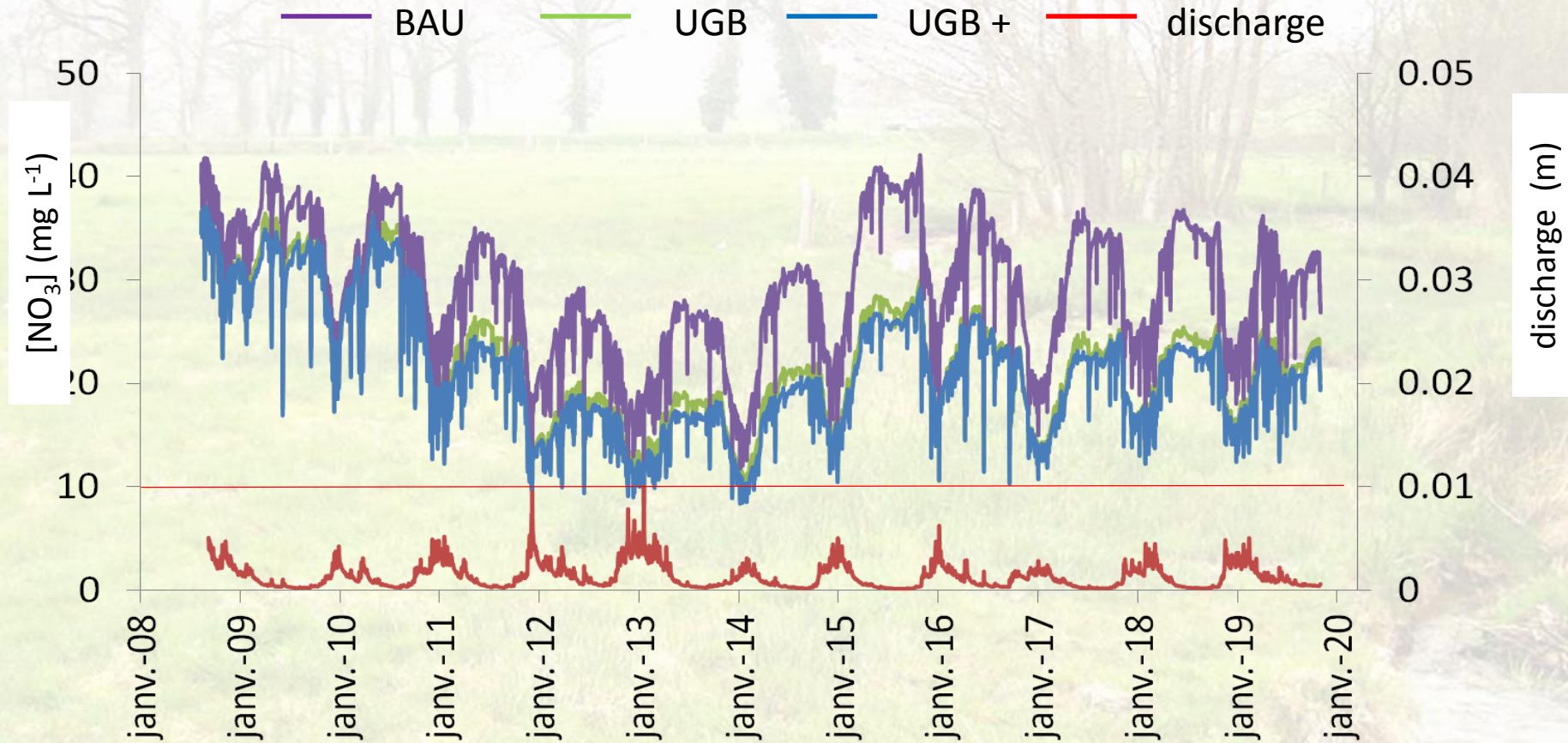


system consistency?

- Feeding the cows to sustain milk production (main income)
- Being able to manage animal waste according to the regulations
- Sustain the economic margin by compensating every loss of income (e.g. decrease of cash crop area) by a decrease in charges



Results : significant decrease of N fluxes without decrease of milk production...
but still not enough to reach N limitation concentrations!

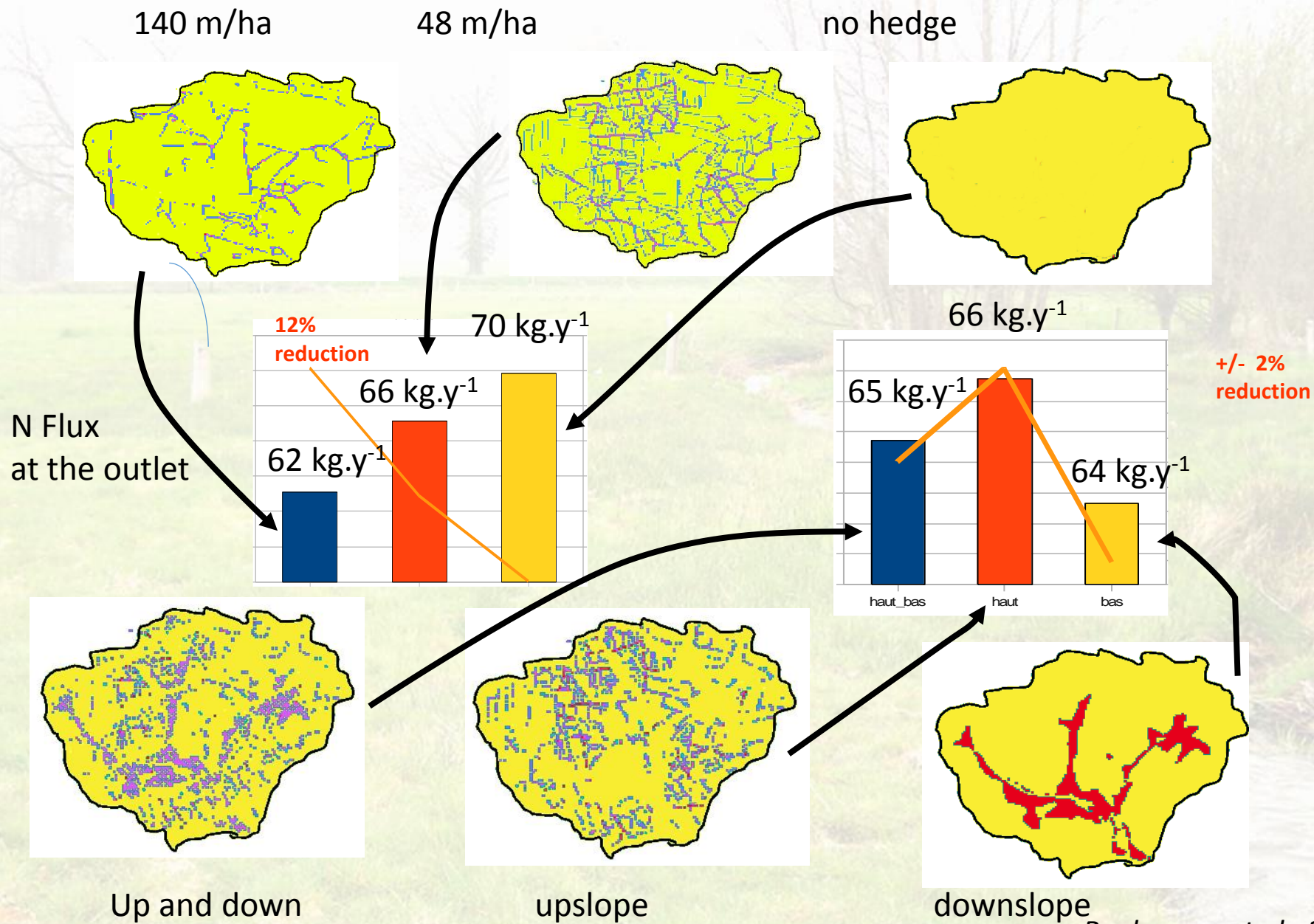


...Need to act on landuse proportion and landscape structure?

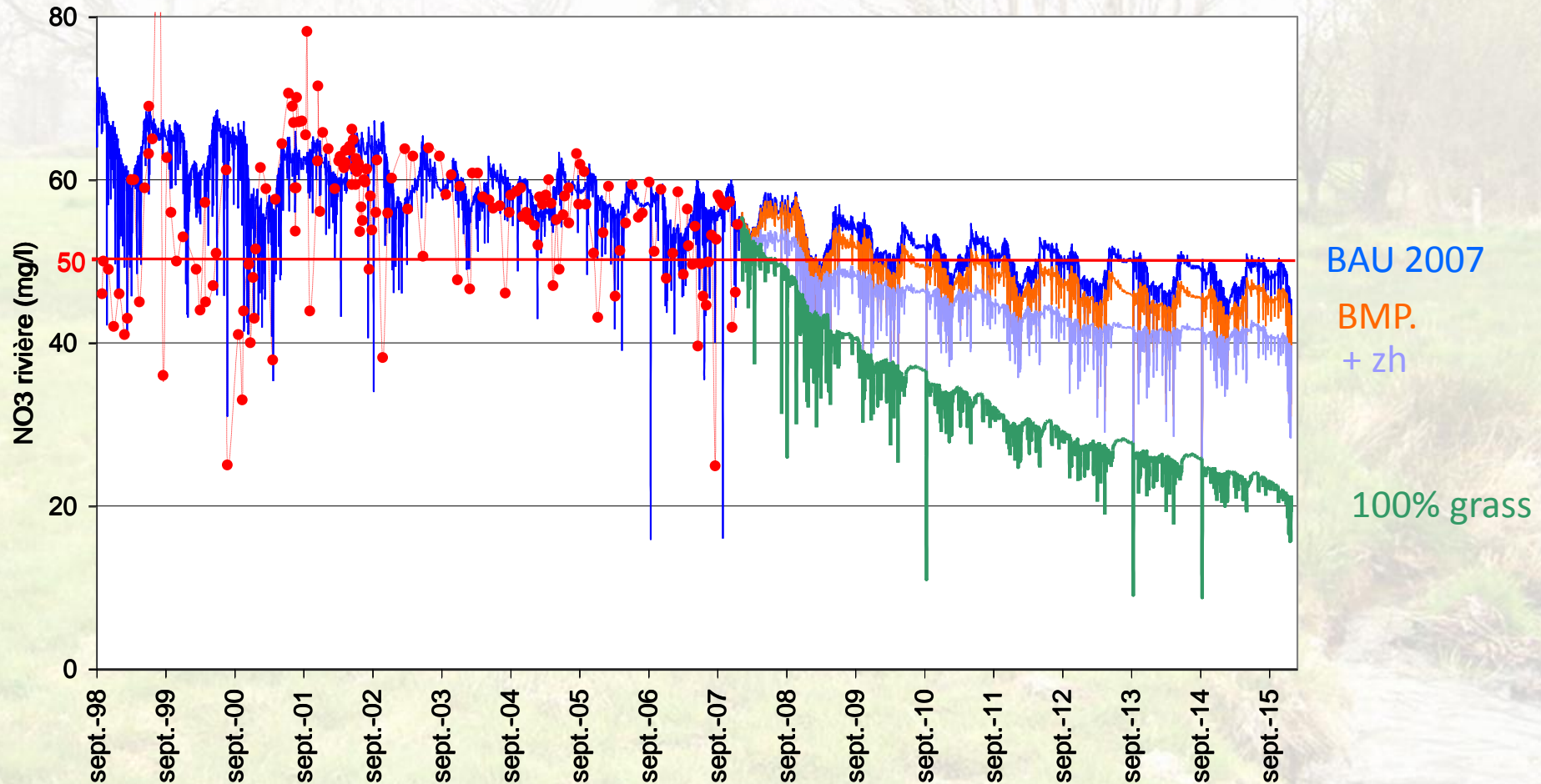
Testing landscape management scenarios



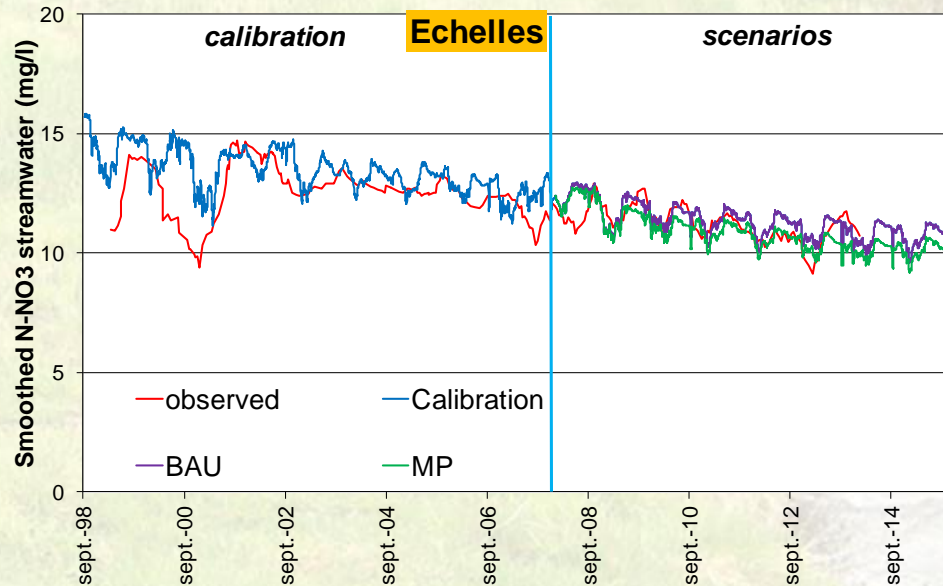
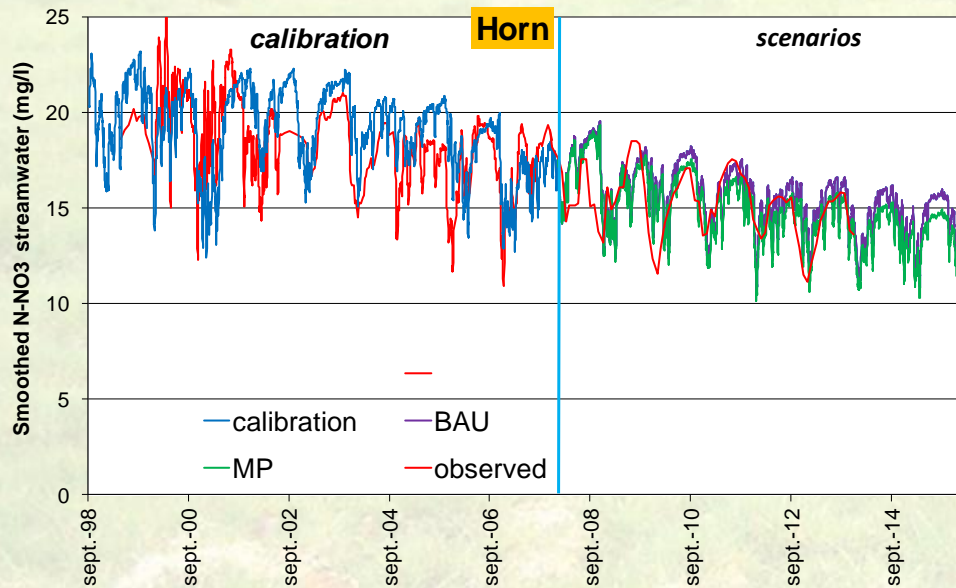
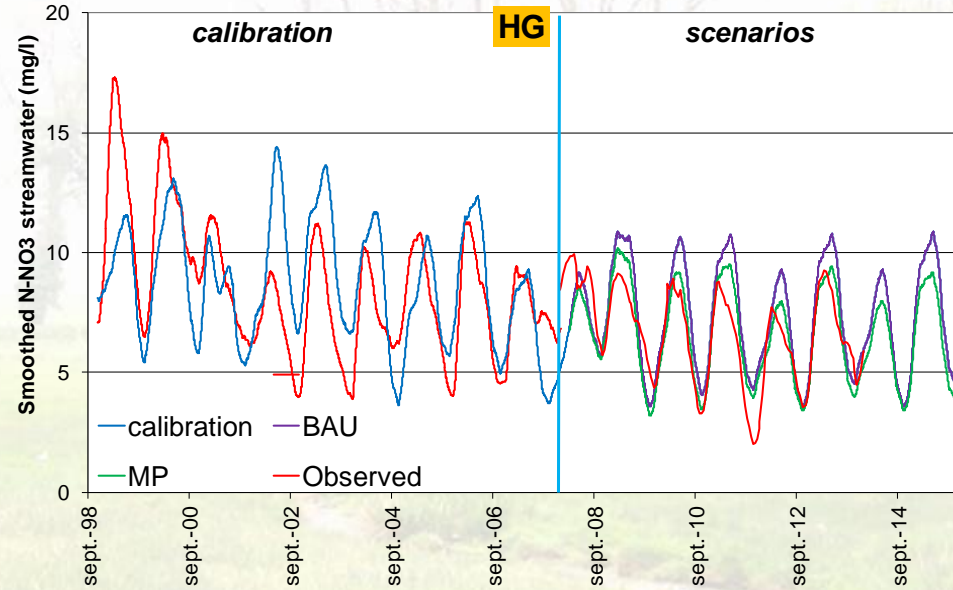
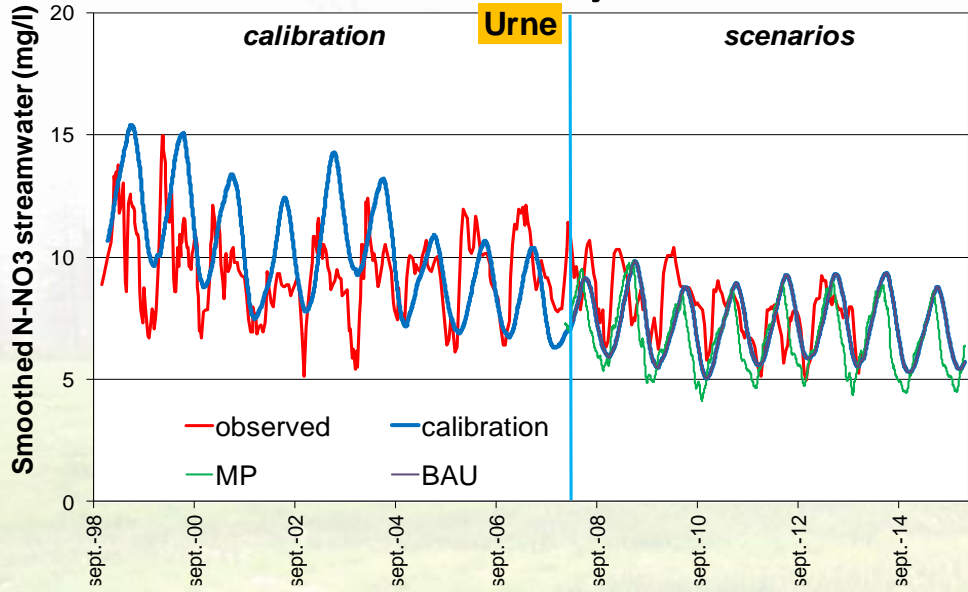
Effects of hedgerow networks on N fluxes



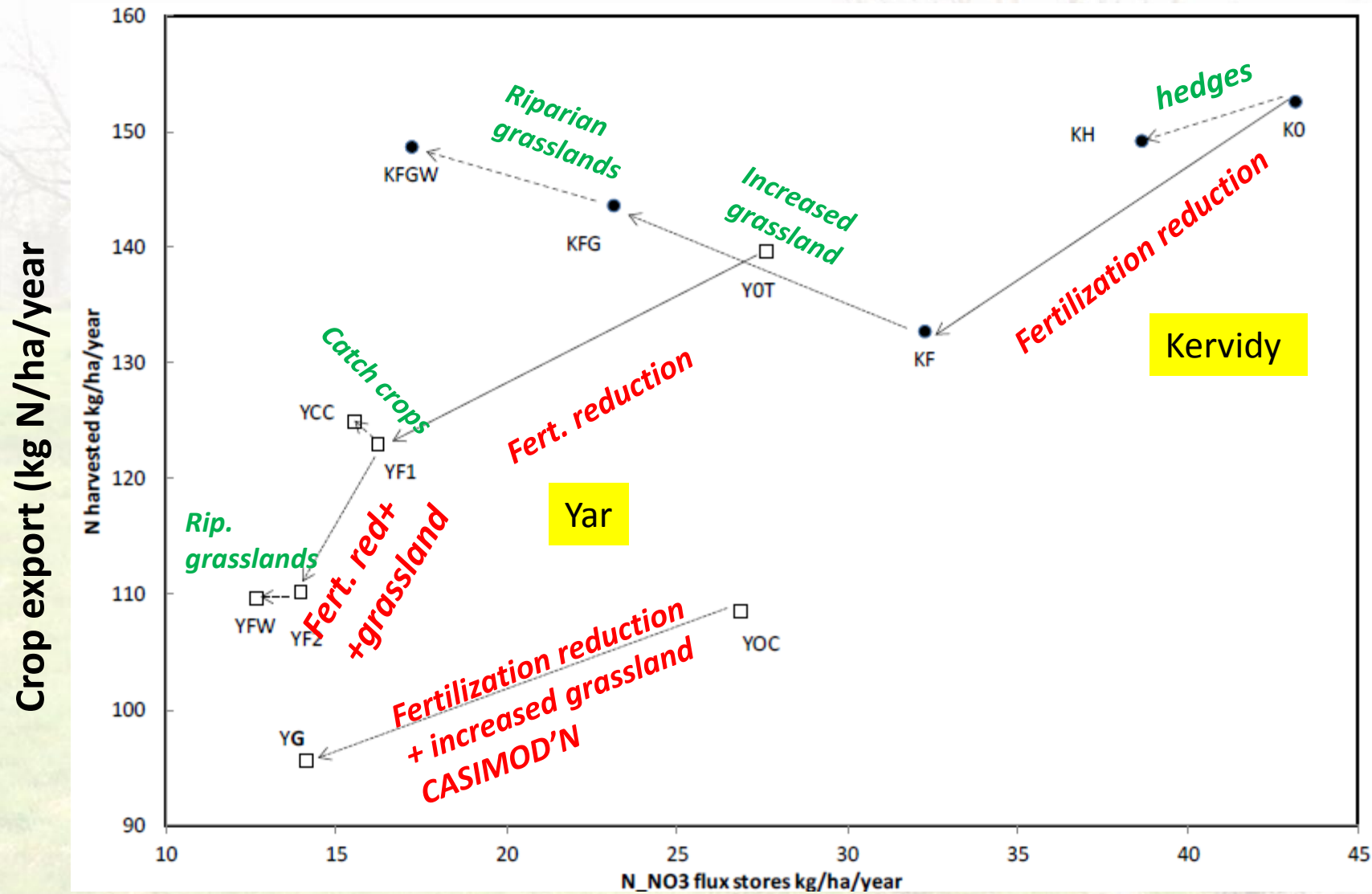
Riparian zone set aside: fast and efficient...but no miracle




Predictability....



Conclusion



NO3 fluxes + storage variation kg N/ha/year

A photograph of a herd of black and white cows in a lush green field. In the background, there is a blue ocean with white waves and a blue sky with scattered white clouds. A large number of birds are flying in the sky. A blue speech bubble is overlaid on the image, containing the text "Thank you for your attention!".

Thank you
for your
attention!