Land use scenarios and nutrient fluxes

Patrick Durand

Land use scenarios and nutrient fluxes

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

The approach

Framing conditions
Issues
Research objectives
Stakeholders' questions

External drivers
Climate
Market
Regulation
mitigation plan (information, incentives…)

Tested Actions
Land use
Agricultural land management
Landscape structure
Water management

Scenarios

Model
Empirical/ Process based
Distributed/semi distributed
+- integrated

Simulation results
Water and nutrients (flux, concentration, budgets…)
Agriculture productivity
Other indicators (carbon sequestration, gas emissions…)

Appropriation
Recommendations
New questions
Decisions

Adapted from :


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

Contents lists available at ScienceDirect

Science of the Total Environment

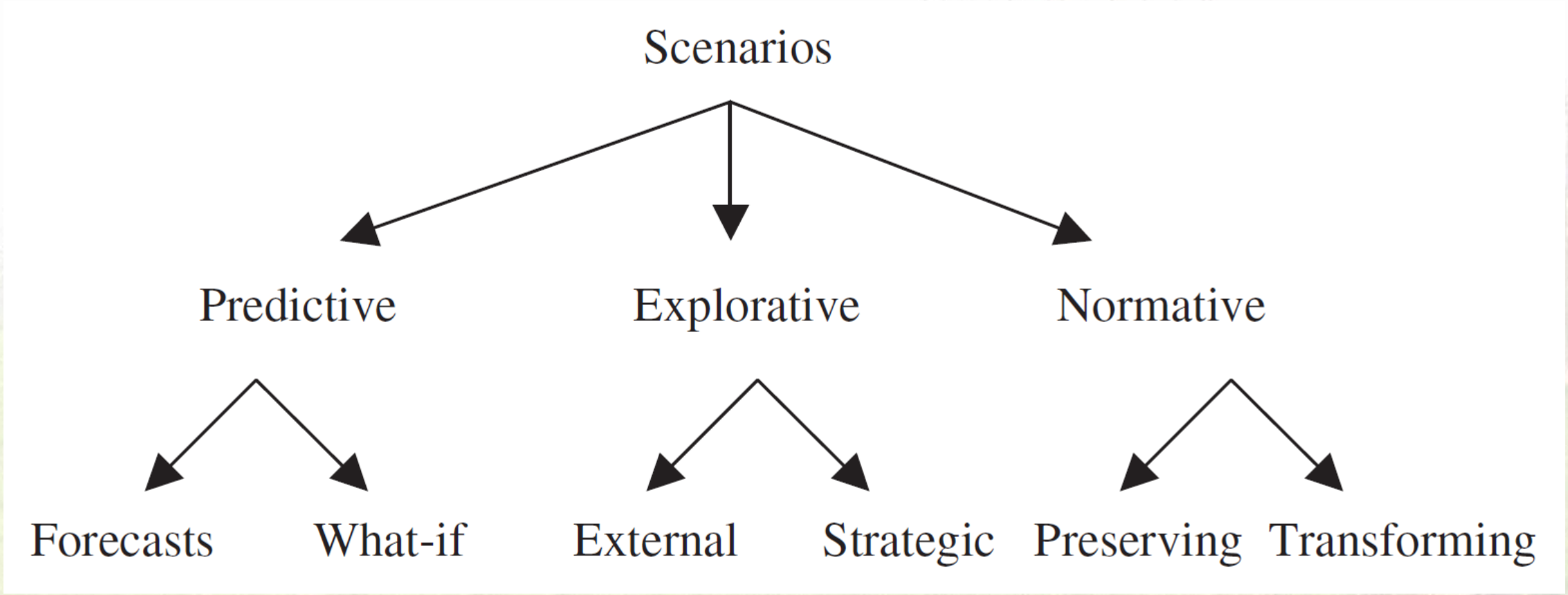
journal homepage: www.elsevier.com/locate/scitotenv

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

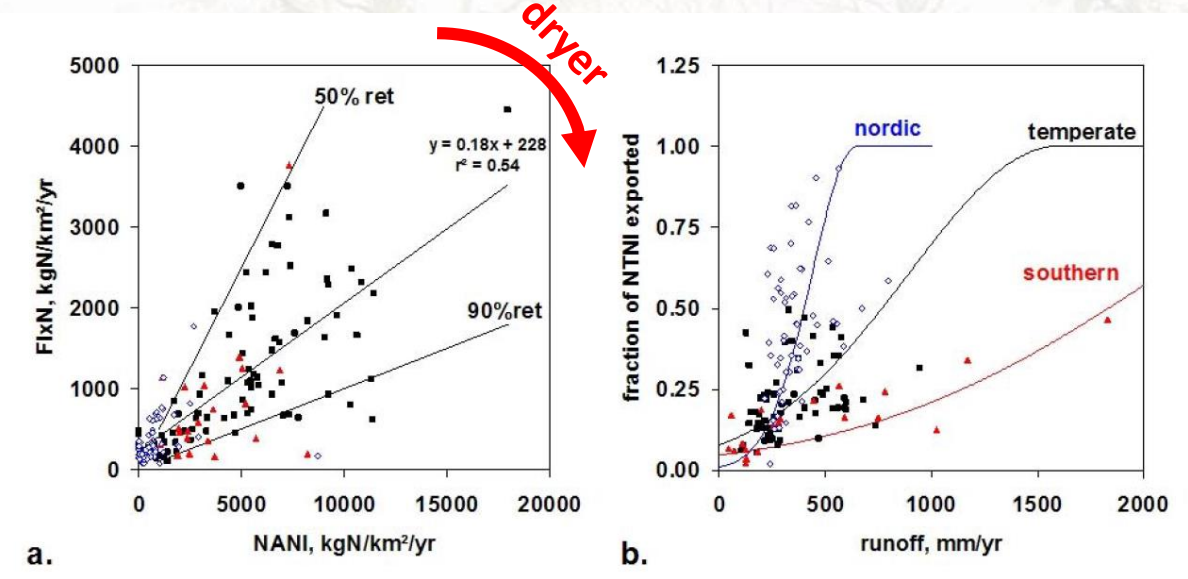
Department of Agroecology, Aarhus University, Blichers Allé 20, 8830 Tjele, Denmark

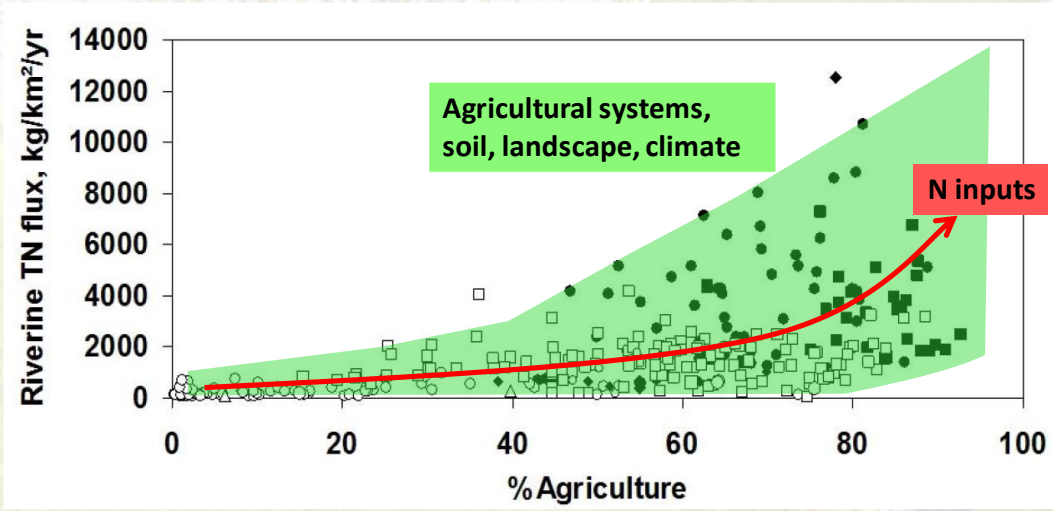


What will happen? *What can happen?* *How to reach the target?*

Börgeson et al., 2006. Futures

Main factors (1/2)



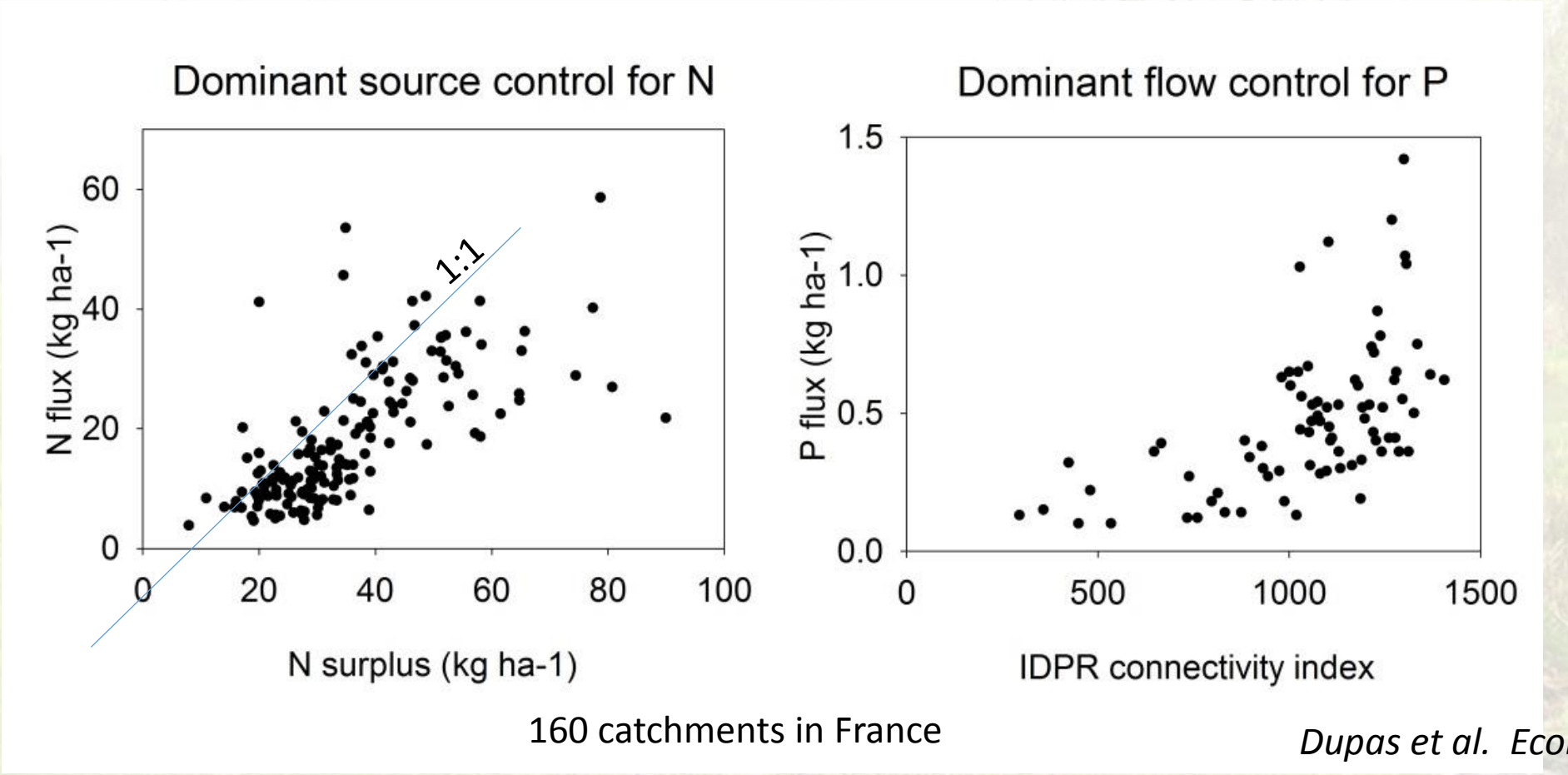


European Nitrogen Assessment, Chap. 13

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

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**

Source

Storage

Annual input

Transfert

Surface flow

Subsurf. flow Infiltration

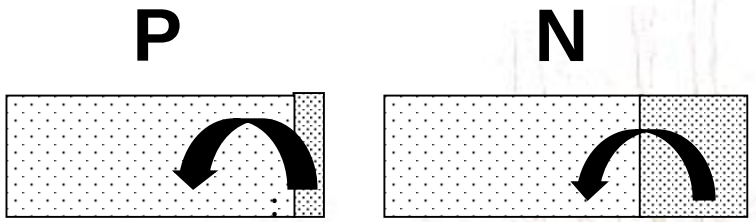
Retention processes

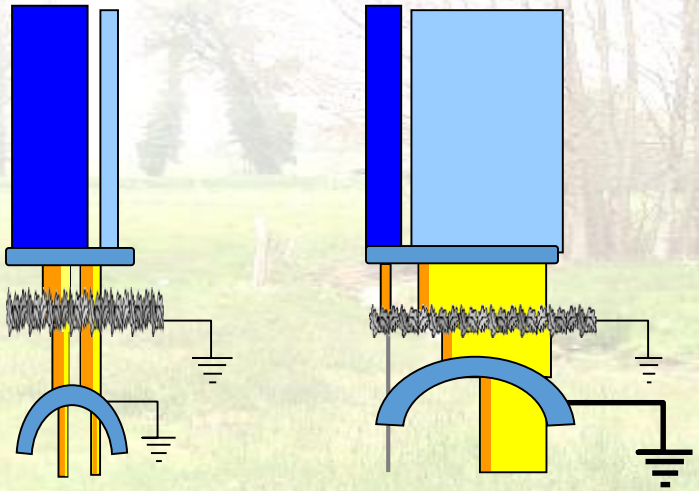
Physical + Biogeoch. biological

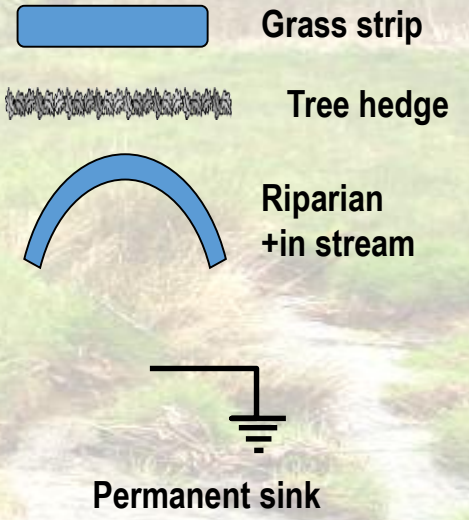
Annual budgets

Landscape features

limits





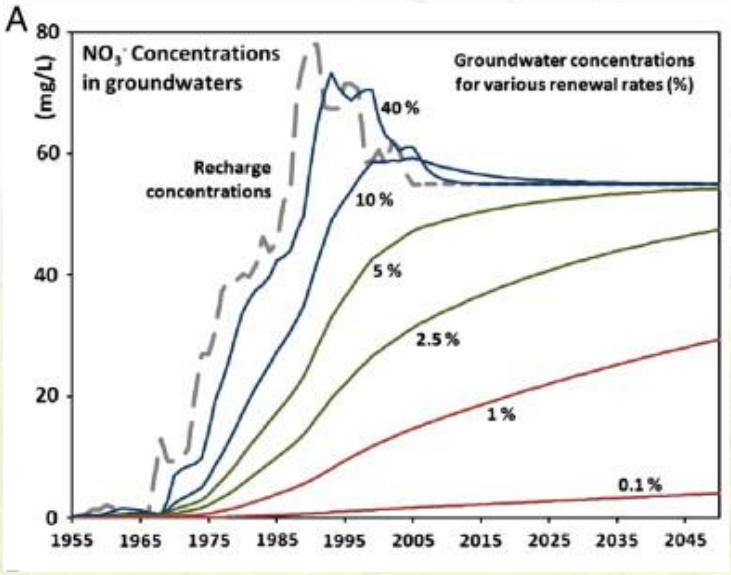


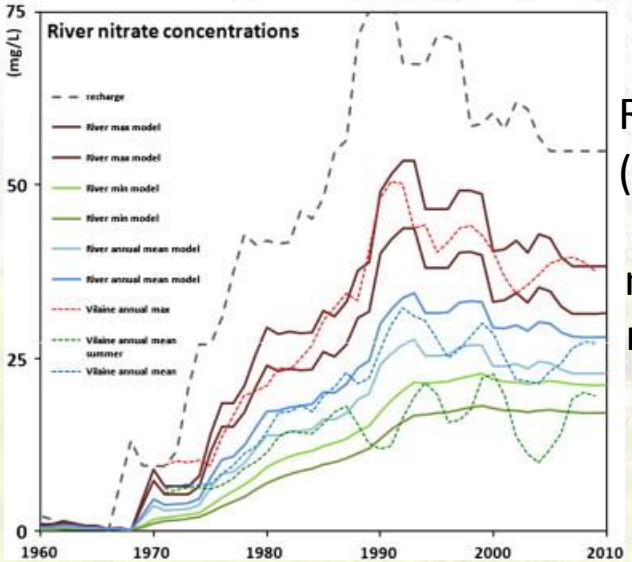
emissions/input	<5%	>10%
σ(emissions)	>100%	~ 100%
Flux	≠ f(stock)	= f(stock)

erodibility
connectivity
Sustainability ?

hydrological setting
biological activity
Variability ? Air ?

Legacy…



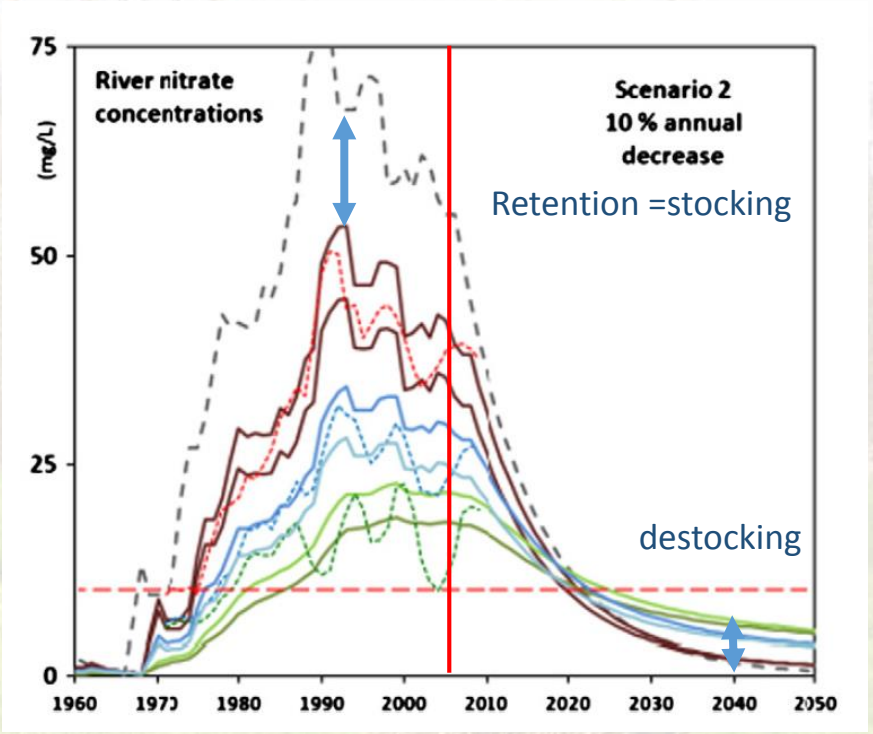


Recharge (N input)

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, preverving 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

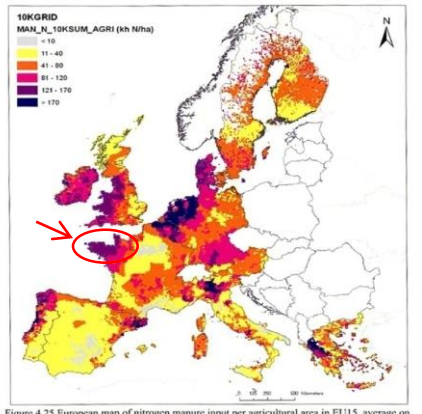


Figure 4.25 European map of nitrogen manure input per agricultural area in EU15, average on 10 km² area. (In Sweden and Finland the white colour indicates the absence of agricultural land within the 10 km² area).

P manure input

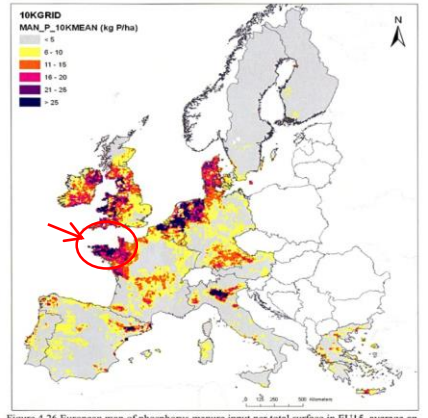
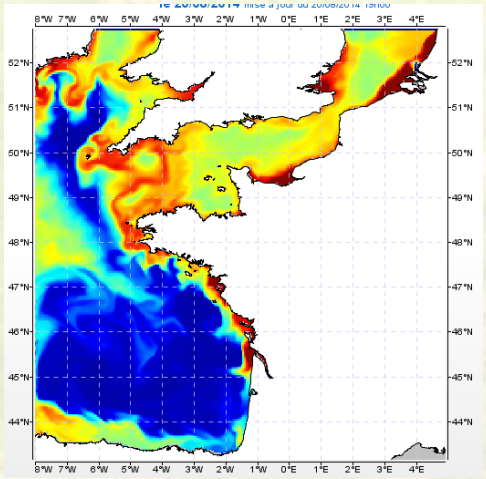


Figure 4.26 European map of phosphorus manure input per total surface in EU15, average on 10 km² area.

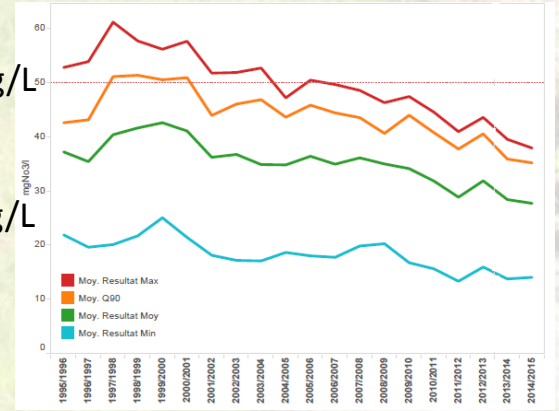
Chlorophyl a simulation 20/8/2014



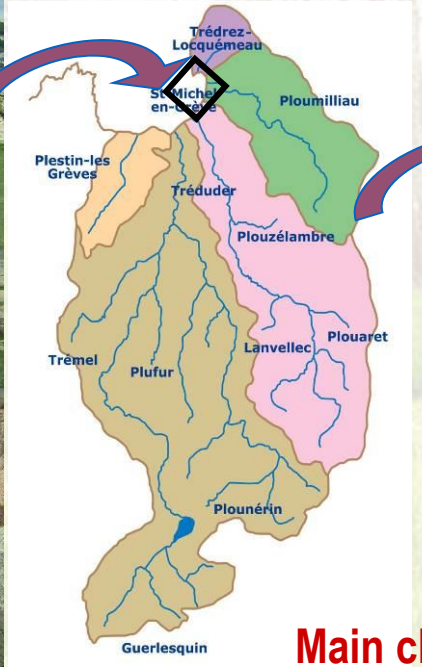
Decrease of N03 concentration by 30%

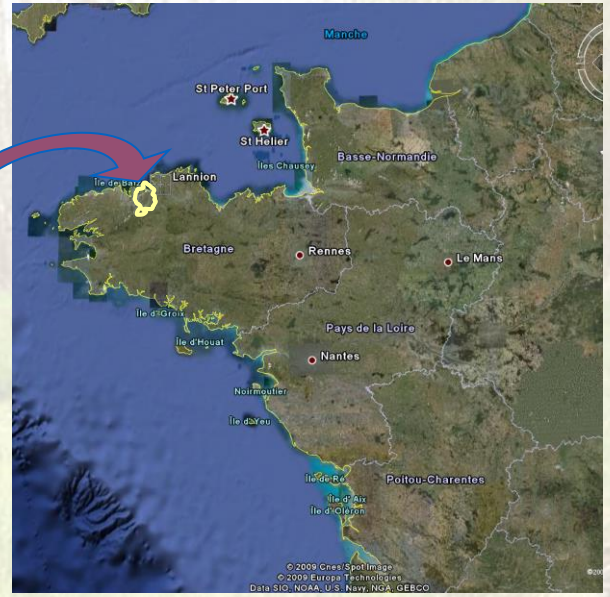
50 mg/L

25 mg/L



Lieue de Grève : an emblematic site in Brittany





↘50% algae if < 8 mg NO_3 /l *(Menesguen, 1999)*
(1.8 N-NO_3)

Mean current concentration : 30 mg/l NO_3
(6.8 N-NO_3)

Main characteristics Lieue de Grève

- 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)

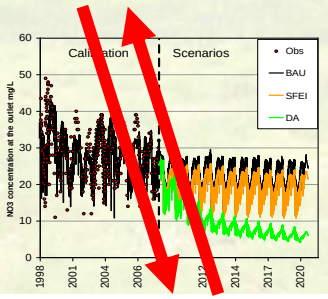
+ stakeholder partners : **LTA, CPA Lieue de Grève, CA22, CRAB**, IE, Cedapa

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

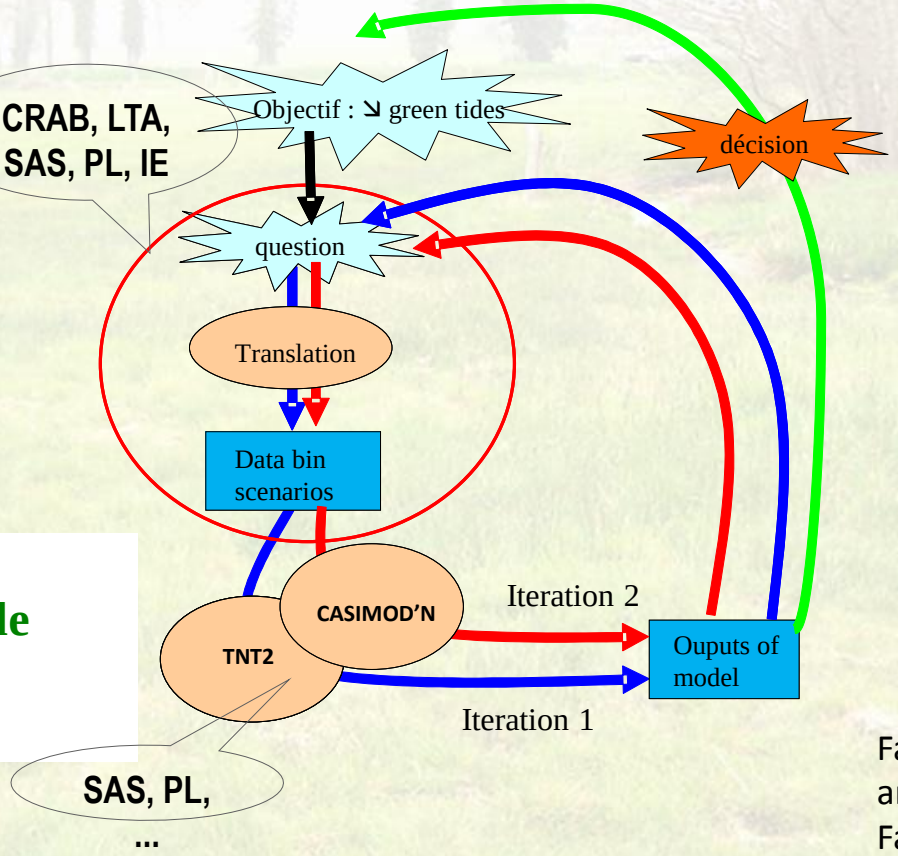
Method, partners

- 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



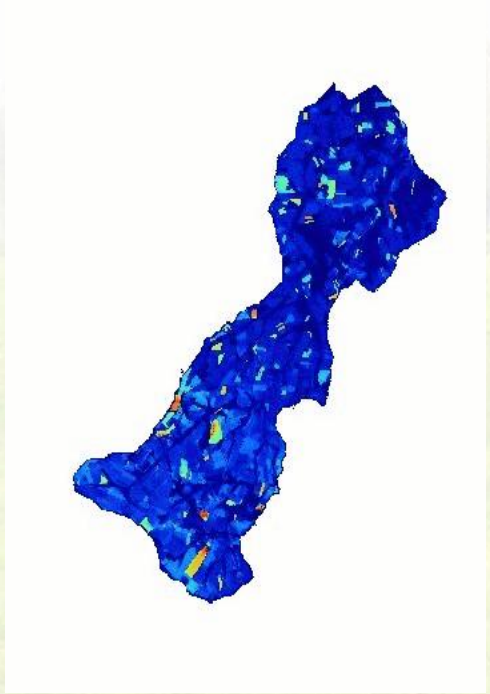
Coupling models :
- AH catchment scale
- farm functionning

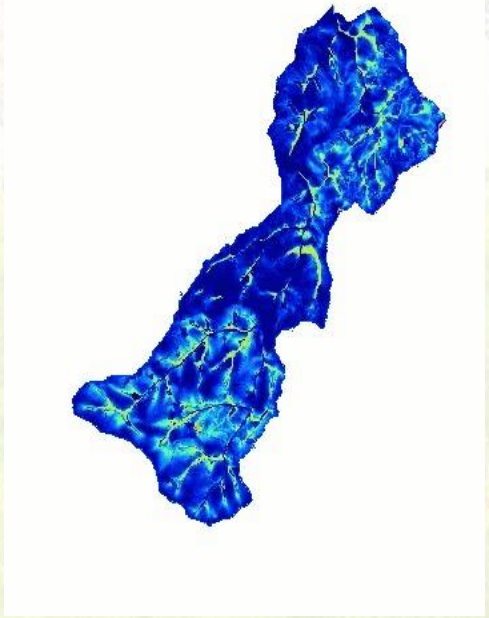


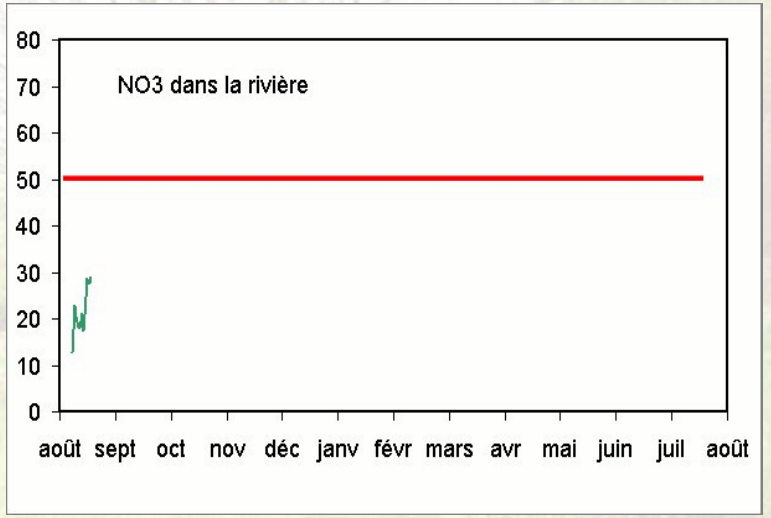
Farms varying by structure, production and objectives, physical conditions, …
Farmers dynamics and motivation

Adapted from Lehenhardt et al., EMS, 2012

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)

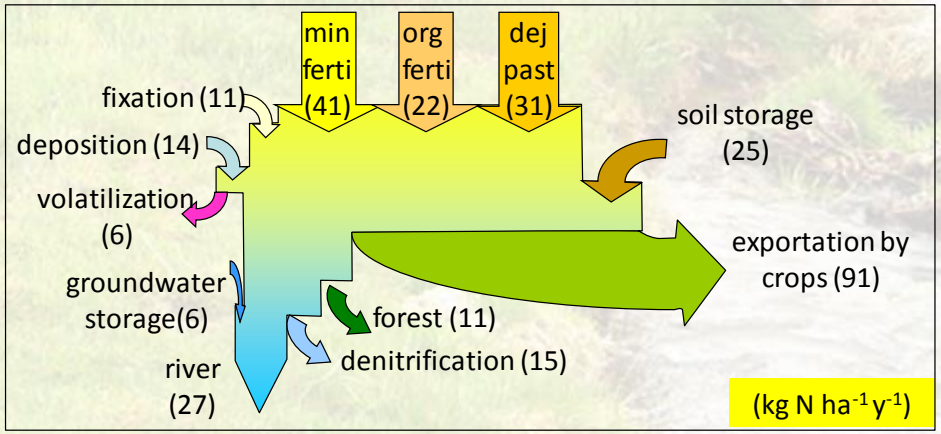




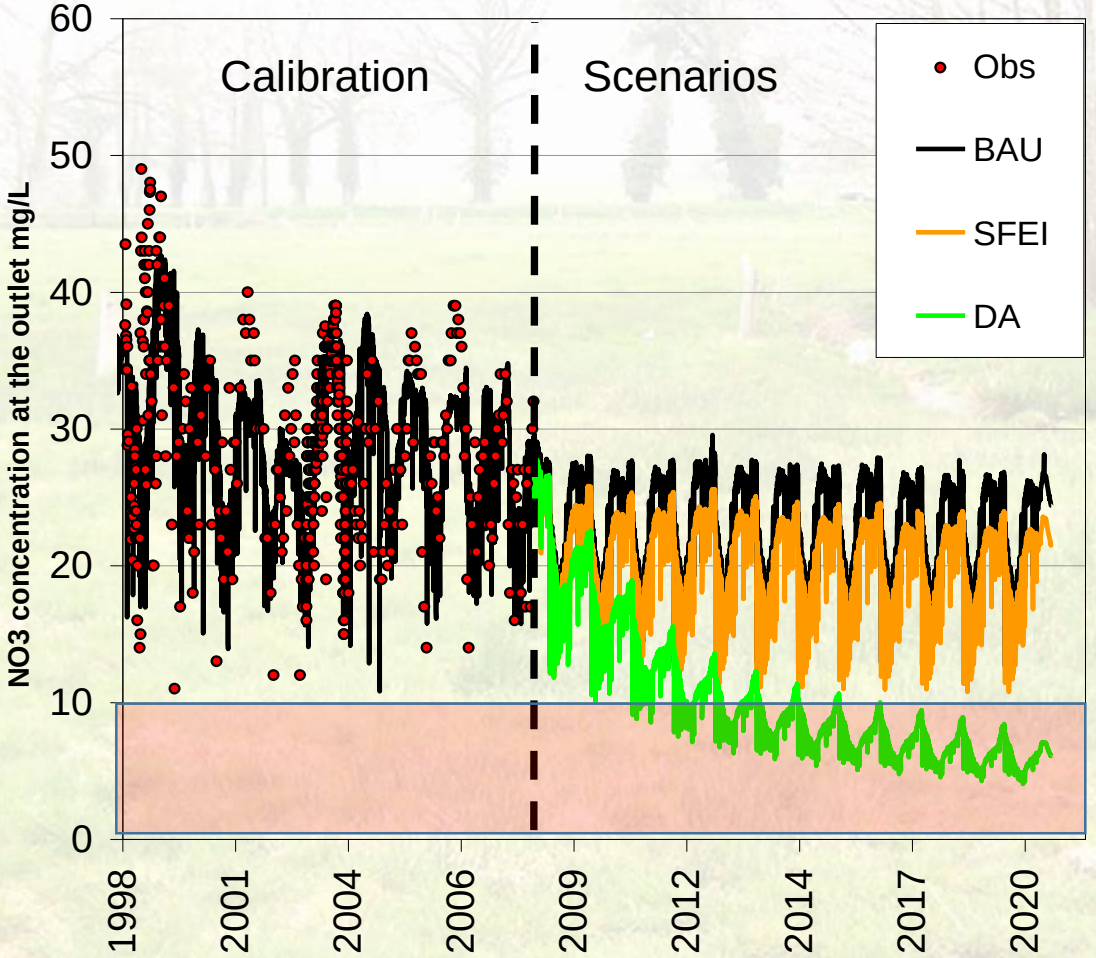


…to nitrate concentrations in streams and detailed N budgets of the catchments.

TNT2 : from agriculture management at the field scale…



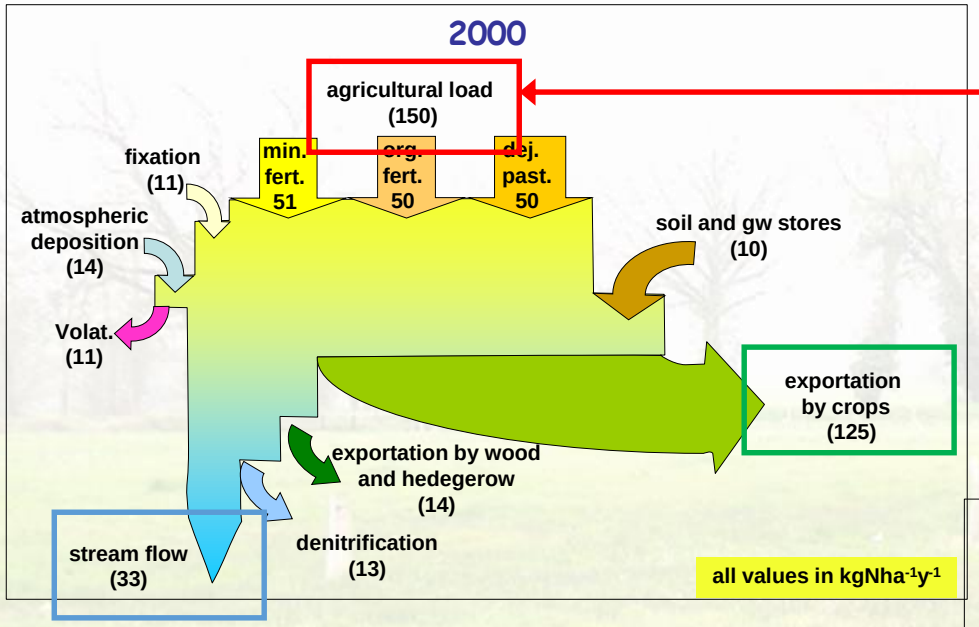
First iteration : preserving scenarios… *and a destructive one!*



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

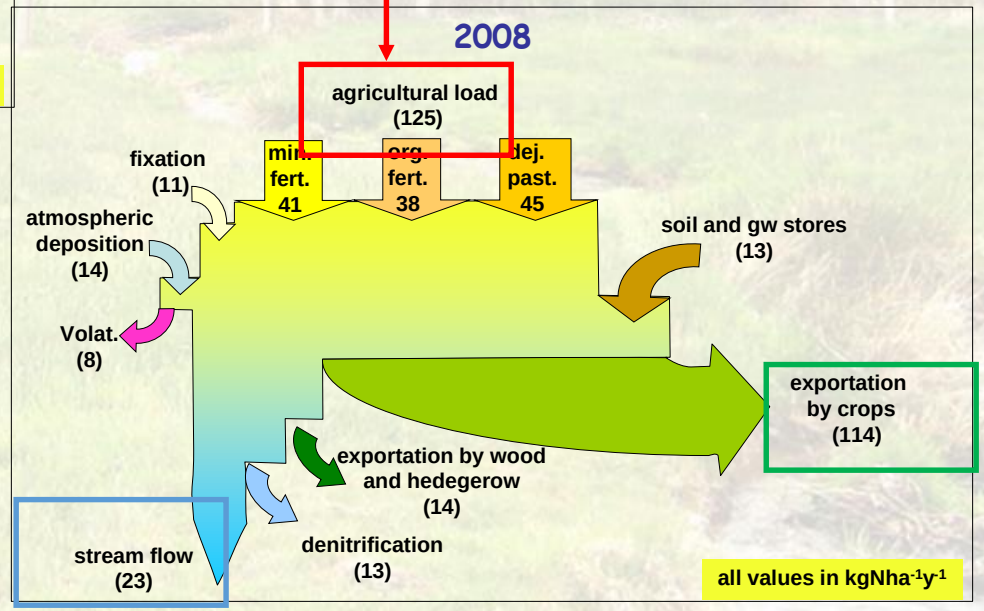


Ag. load: - 25 kgN/ha/y

Ag. balance: - 14 kgN/ha/y

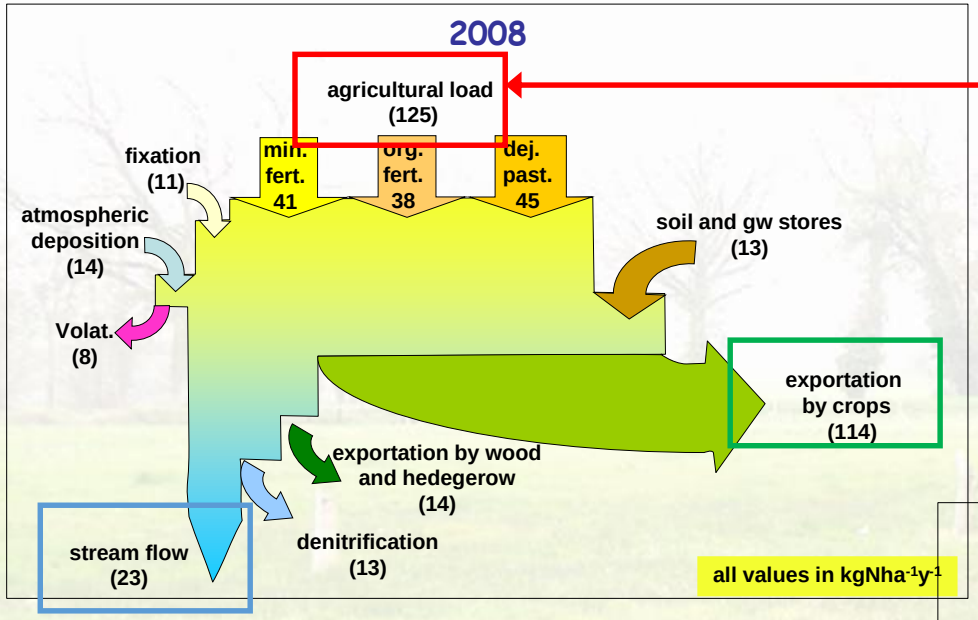
N in the river: -10 kgN/ha/y

Efficiency: 40 %



From N excess to balanced fertilisation

N budget: going on decreasing N inputs

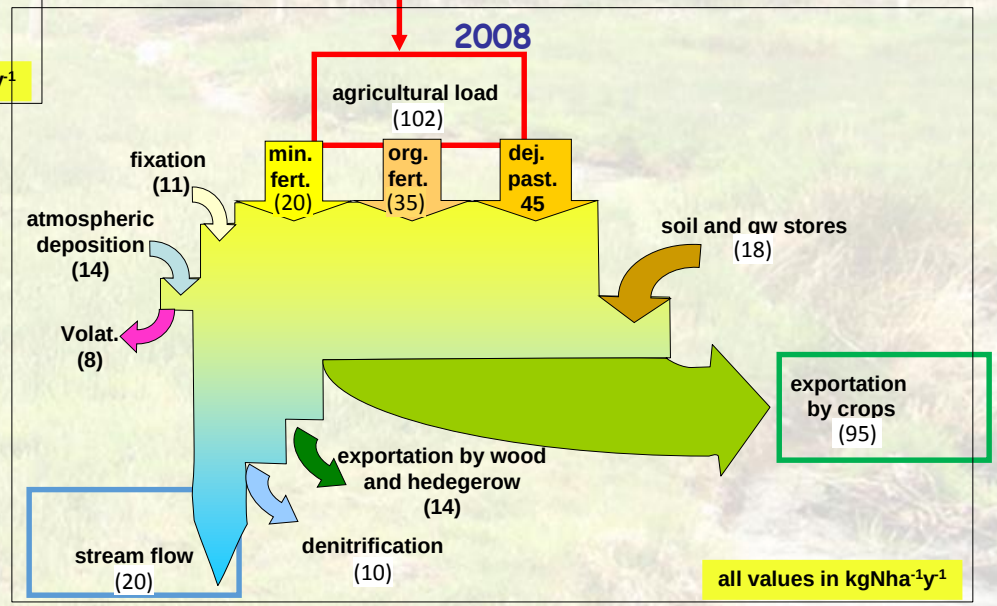


Ag. load: - 23 kgN/ha/y

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

?

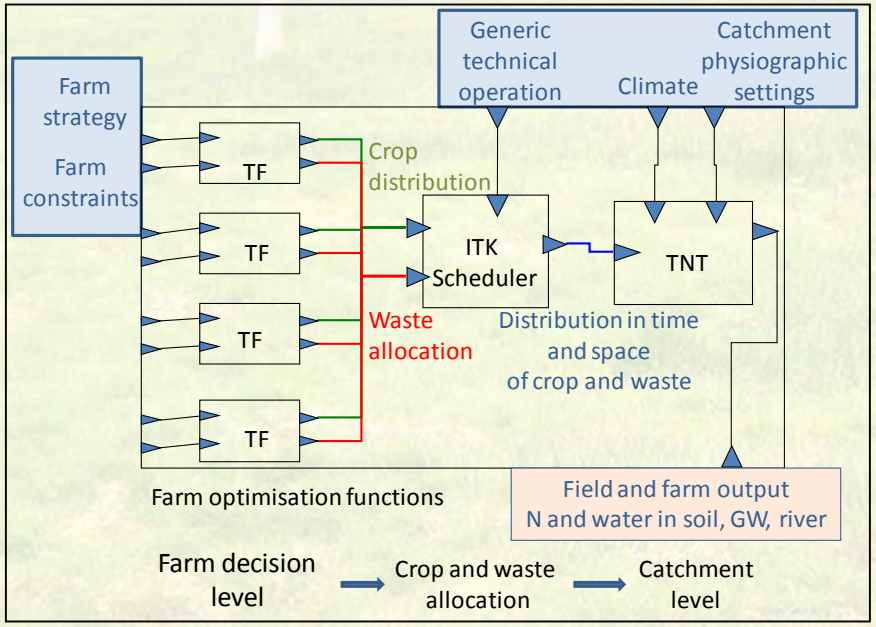
Moreau et al., AGEE, 2012

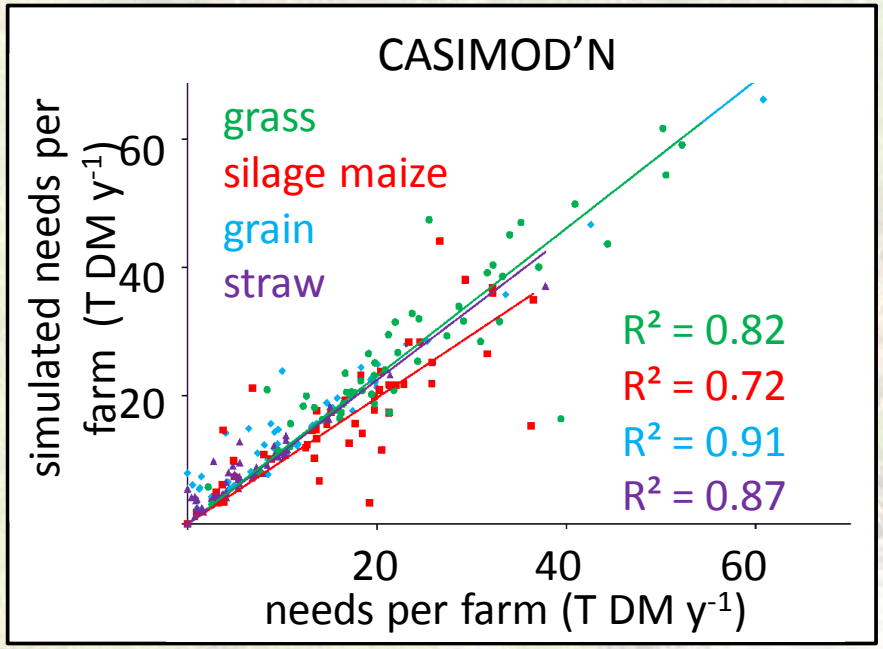
system consistency?

-Feeding the cows to sustain milk production (main income)

-Being able to manage animal waste according to the regulations

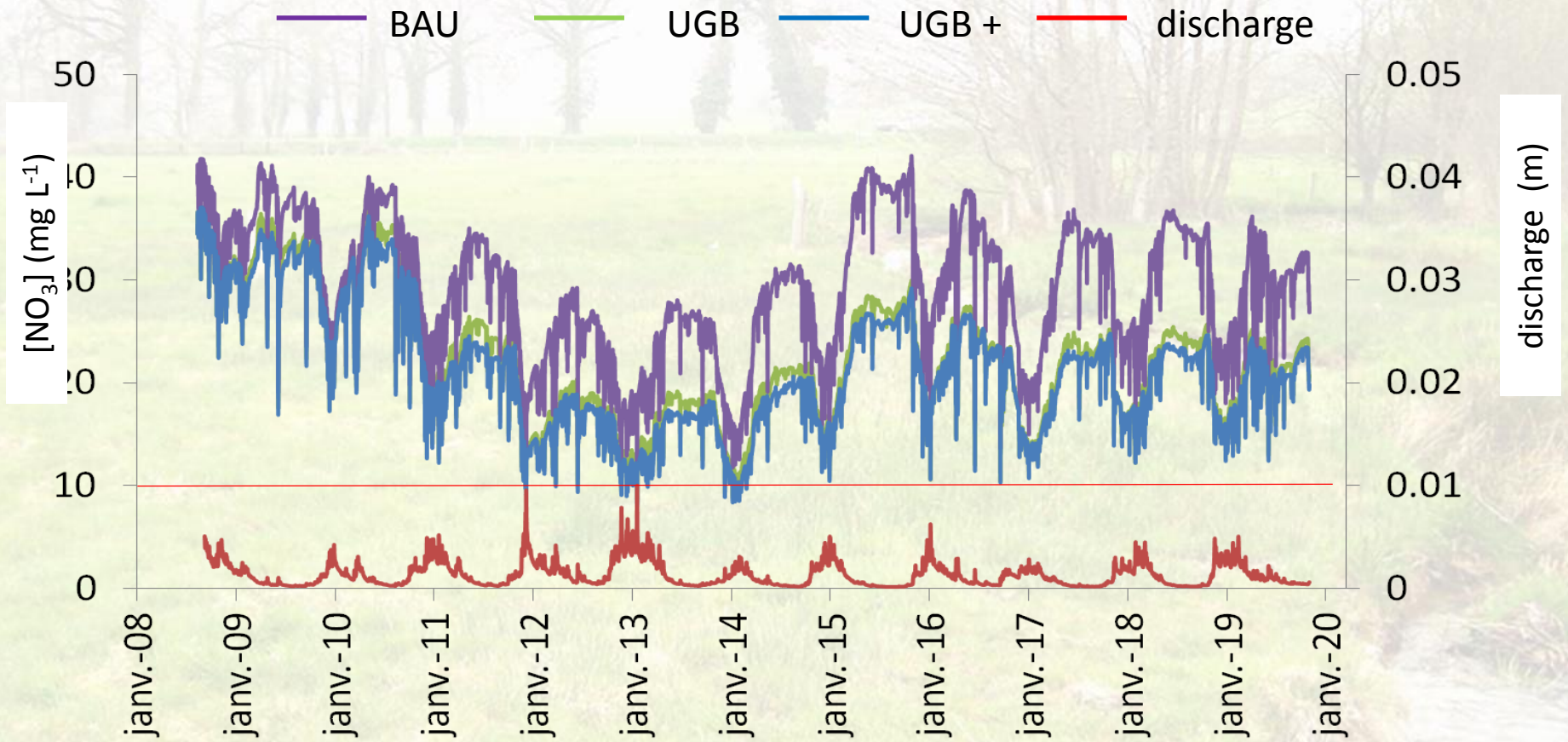
-Sustain the economic margin by compensating every loss of income (e.g. decrease of cash crop area) by a decrease in charges





Moreau et al., Agr. Syst, 2013

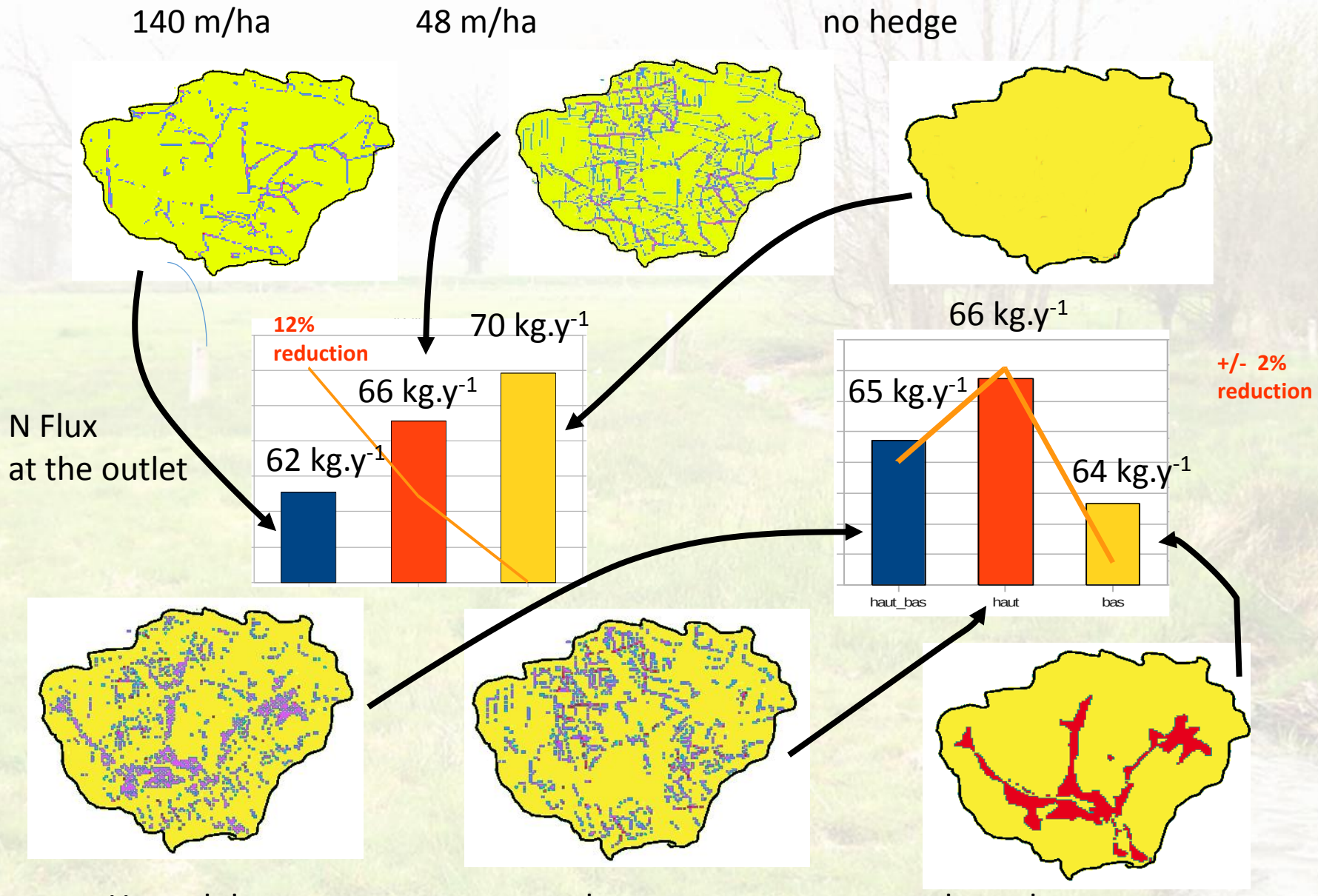
Results : significant decrease of N fluxes without decrease of milk production… but still not enough to reach N limitation concentrations!



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

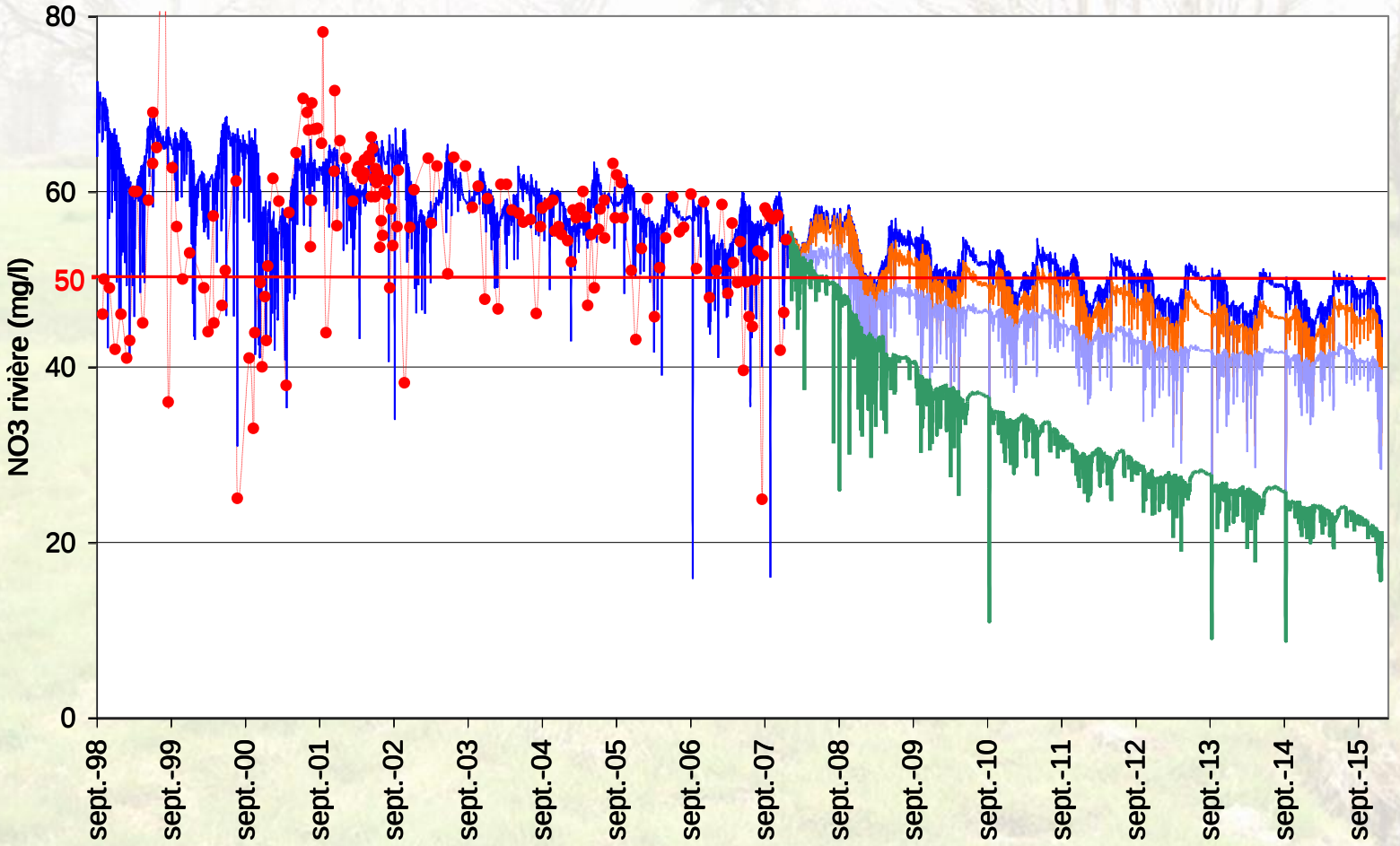
Testing landscape management scenarios

Effects of hedgerow networks on N fluxes



Benhamou et al., 2013, Agr. Wat. Manag.

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

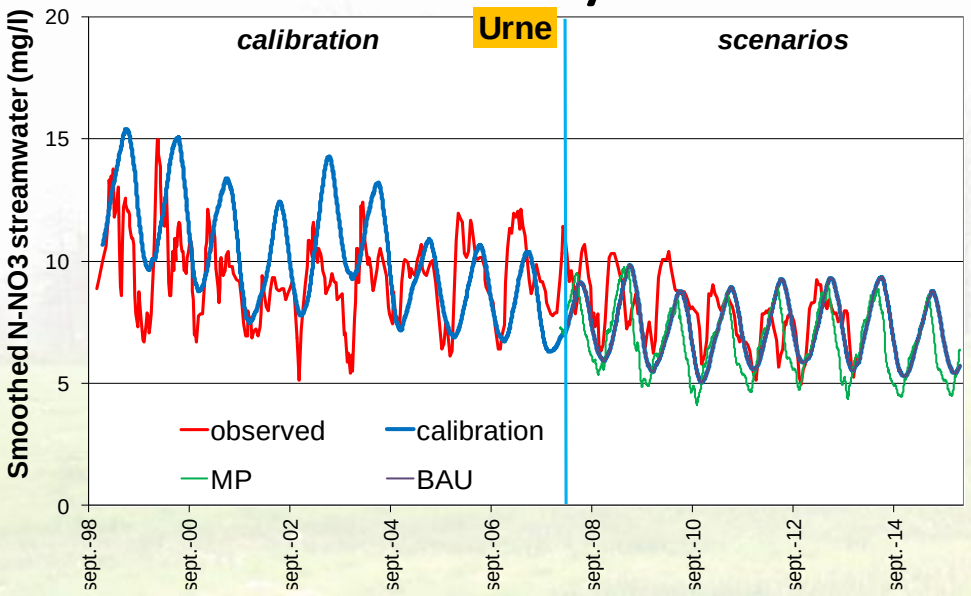


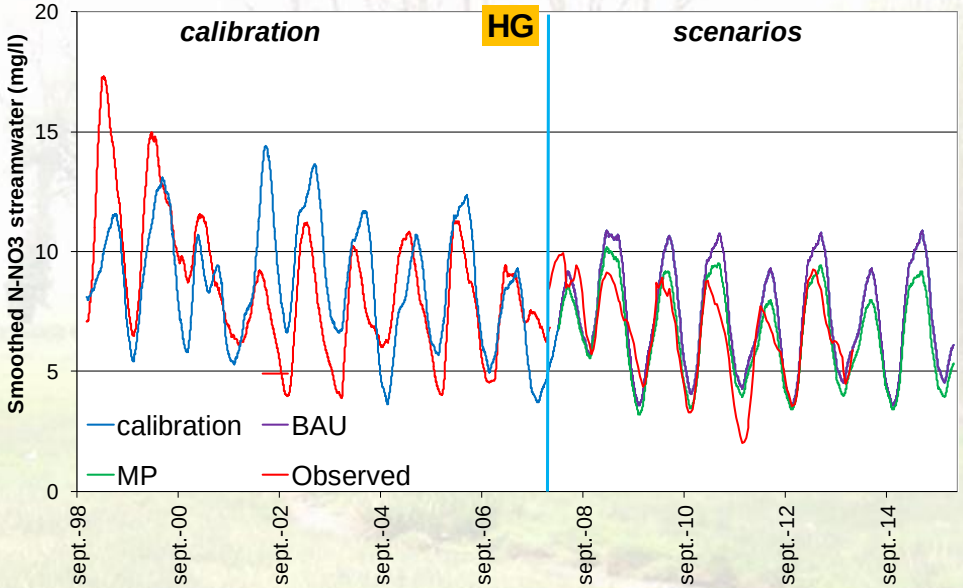
BAU 2007

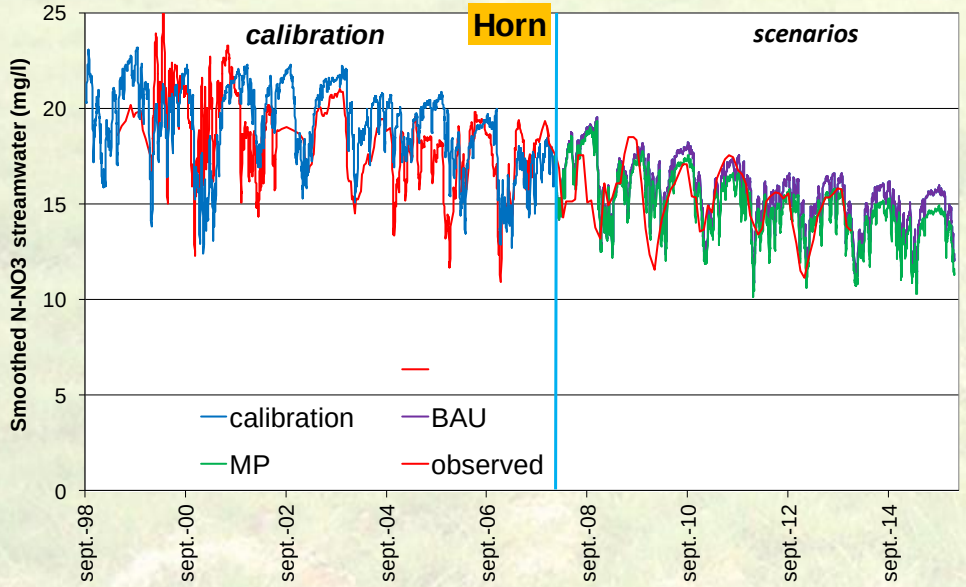
BMP.
+ zh

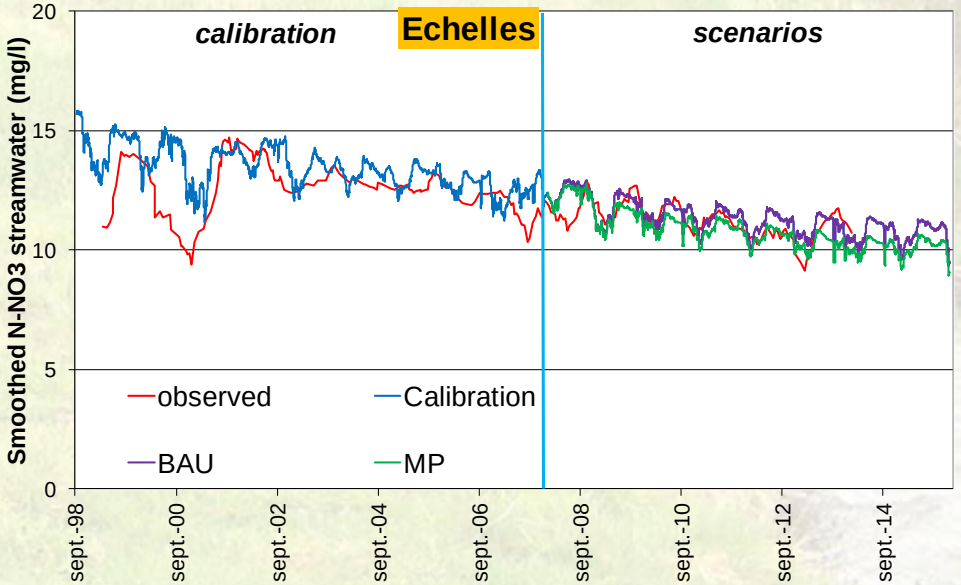
100% grass

Predictability….



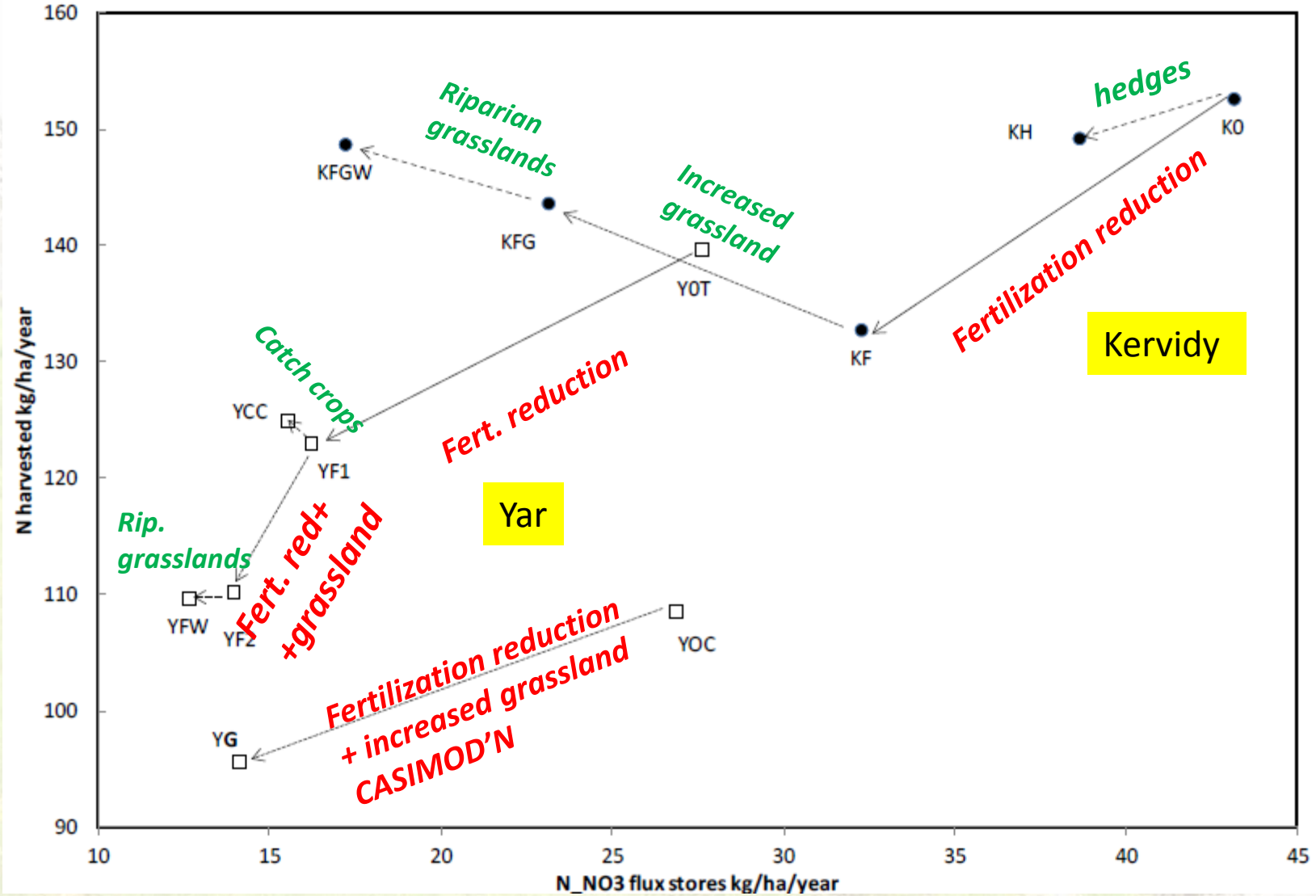






Durand et al.
18th N workshop, 2014

Conclusion



NO3 fluxes + storage variation kg N/ha/year

Durand et al., J.A.S., 2015


Thank you for your attention!