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# Activités de recherche à l'unité de recherche INRA LAE : pratiques agricoles, biodiversités, services écosystémiques et évaluation multicritère

Christian Bockstaller

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Conference  
Thünen Institute of Biodiversity

# Overview of research activities at the INRA research unit LAE on: management, biodiversity, ecosystemic services relationships & multicriteria assessment

Dr. habil. Christian Bockstaller



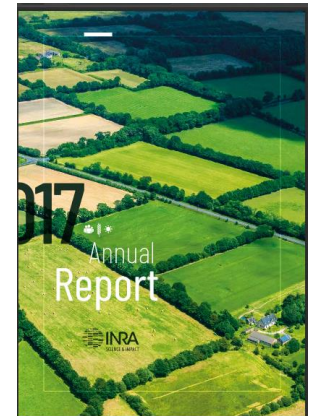
February, 18<sup>th</sup> 2019

# Presentation purpose and outline

- Purpose: overview on the research in the LAE unit
  - Future collaboration between Thuenen Institut und LAE?
- Outline
  - Short presentation of INRA
  - Short presentation of the LAE
  - Overviewe on the reseach in the LAE unit
    - Some zooms on topics

# The INRA : short presentation

- Created in 1946
- From the scientific support to the modernization of agriculture (50-70s) ...  
to a research institute of high level (80s-90s)
  - Agriculture Environment and Food
- 2<sup>nd</sup> institute in the world for publications in agriculture sector



# The INRA : some figures

- INRA = Institut National de la Recherche Agronomique
  - Depends on Research and Agriculture Ministries
  - **7903** permanent employers (1850 researchers)
  - **13** research divisions (e.g. Environment & Agronomy)
  - **17** research centres (e.g. Grand-Est Colmar)
  - **250** research units and **45** experiment units



# Some recent results and orientations

- Responses to climatic and pathogen threats differ in biodynamic and conventional vines (Soustre-Gacougnolle et al. 2019 Nature Scientific Report)
  - In the Alsace region
- Organic food and cancer (Baudry et al. 2018 JAMA)
  - -25 % cancer
- Zero pesticides Zero glyphosate
  - The Ca-Sys platform at the experimental farm of INRA Dijon

# The Agronomy & Environment Laboratory (LAE)

- 1975: Created by Pr. A. Guckert at ENSAIA Nancy
  - ENSAIA: one of five “Grandes Ecoles” in agriculture science
- 2001: Joint Research Unit (UMR) with INRA Colmar
  - 2018-2022: new five years project after evaluation by HCERES



Nancy



Colmar





# Stuff

45 people



## 29 permanents (20 full time)

17 UL – 12 INRA (57%/43%)  
9 EC, 1 PREM, 2 C, 6 Ing, 2 AI,  
6 techniciens et 2 GU  
5 HDR

## 9 Temporary

1 ATER  
6 Doctorants  
2 à 5 Post-Docs

+2



AGriculture, biodiversity, Ecosystem  
Services, & Multicriterai Evaluation

AGISEM



## 2 research teams

Director: Dr. habil. Christophe Robin



Deputy director: Dr. habil. Olivier Therond



+ 5

Plant  
Secondary  
metabolism

Common service





Conference  
Thünen Institute of Biodiversity

# The AGISEM research team



February, 18<sup>th</sup> 2019

# The team & scientific disciplines

## Permanents UL-INRA



Aimé BLATZ  
AI - INRA



Christian BOCKSTALLER  
IR - INRA



Gaël CARO  
MC - UL



Claude GALLOIS  
ADT - UL



Françoise LASSERRE-  
JOULIN  
MC - UL



Helmut MEISS  
MC - UL



Nadia MICHEL  
MC - UL



Alice MICHELOT  
MC - UL



Frédéric PIERLOT  
MAST - UL



Anne POUTARAUD  
IR - INRA



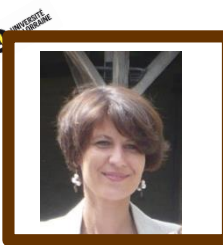
Sylvain PLANTUREUX  
PR - UL



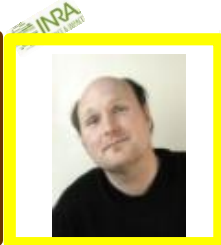
Séverine PIUTTI  
MC - UL



Chantal RABOLIN-  
MEINRAD  
AI - INRA



Sophie SLEZACK-  
DESCHAUMES  
MC - UL



Christophe SCHNEIDER  
TR - INRA



Jodie THENARD  
TR - INRA









Olivier THEROND  
IR - INRA



Jean VILLERD  
IR - INRA

PR: Professor  
MC: assistant prof  
IR: Research engineer  
AI, TR: Technical support

-  Agronomy
-  Agroecology
-  Community ecology
-  Microbial ecology
-  Landscape ecology
-  Computer science

# Context & research goal



Production & resource conservation



**Agroecology**

(A research priority, French agriculture project)



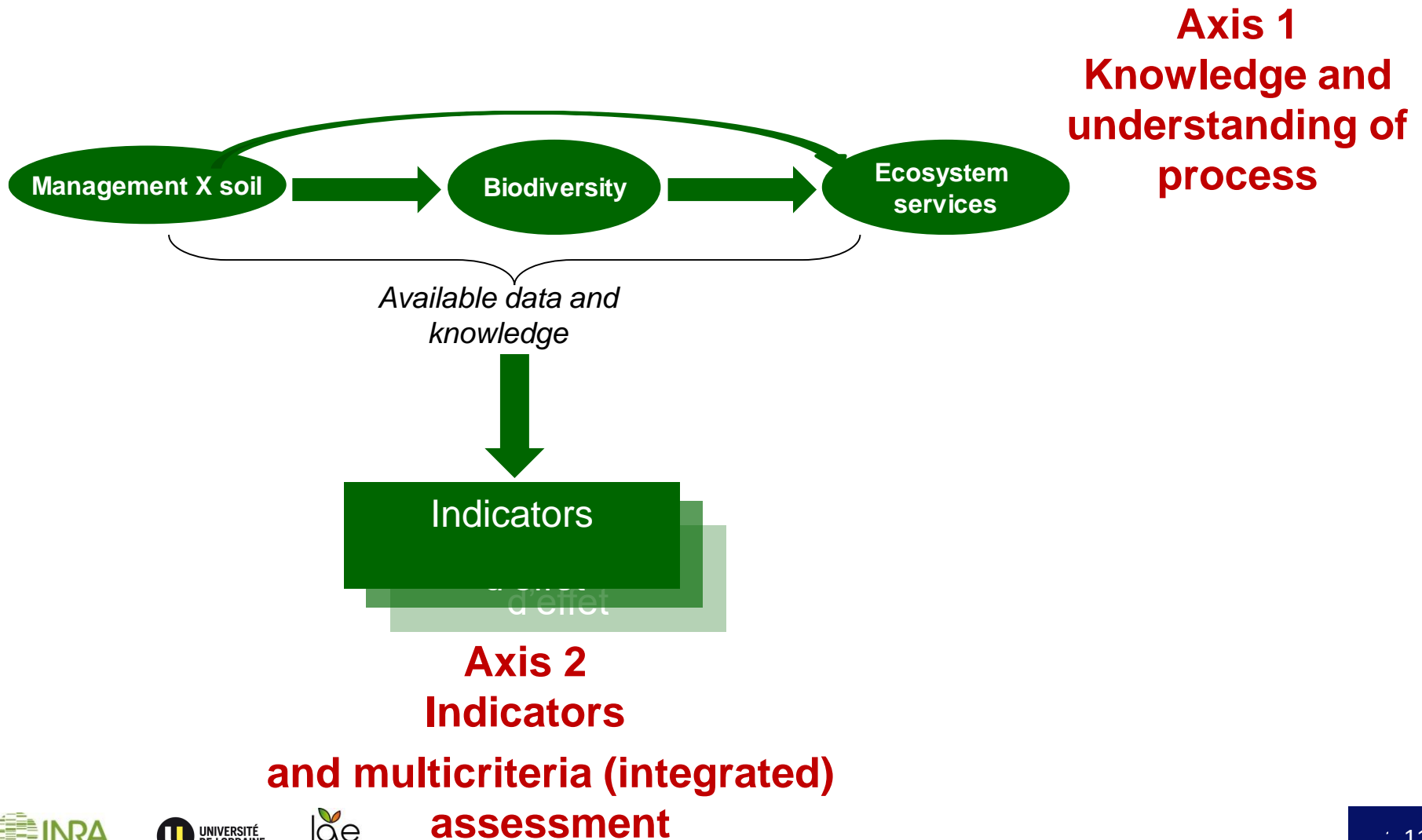
Maximisation of ecosystem services (ES)



Assessing ES & understanding their determinism

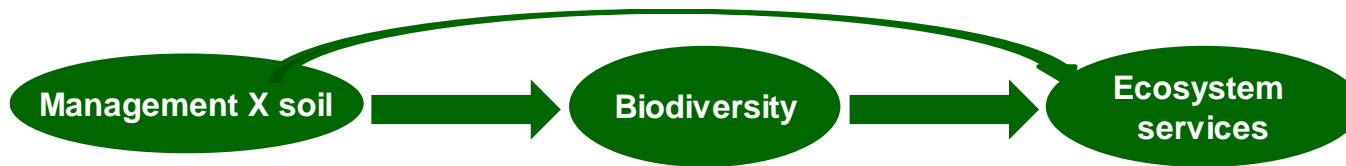


# Structuration of the research project



# Presentation of Axis 1

**Axis 1**  
**Knowledge and understanding of process**



*Available data and knowledge*



Indicators

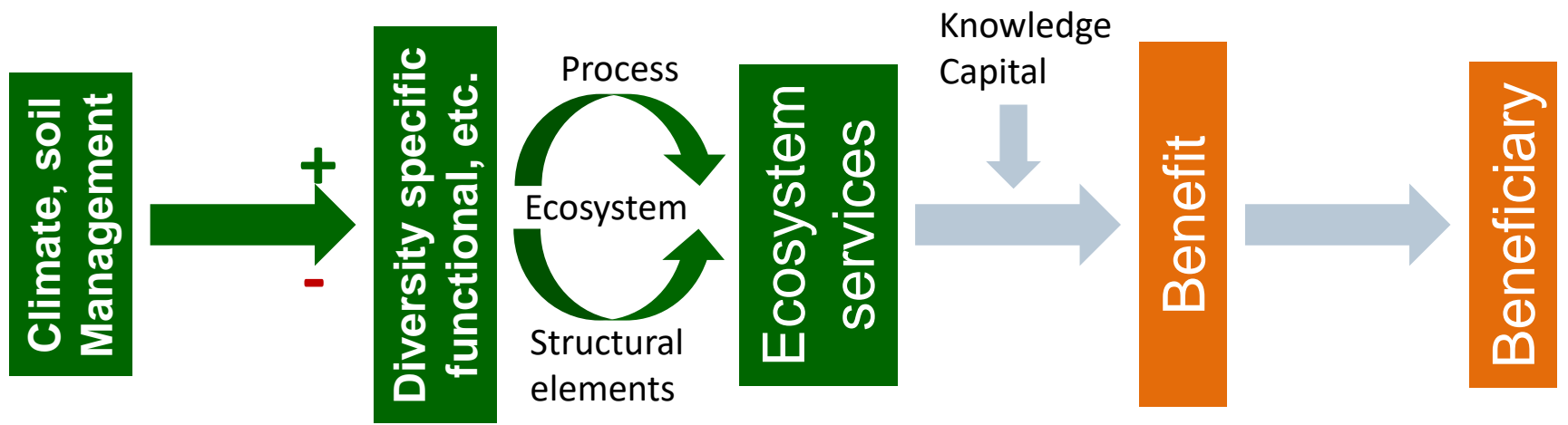
Axis 2

Indicators

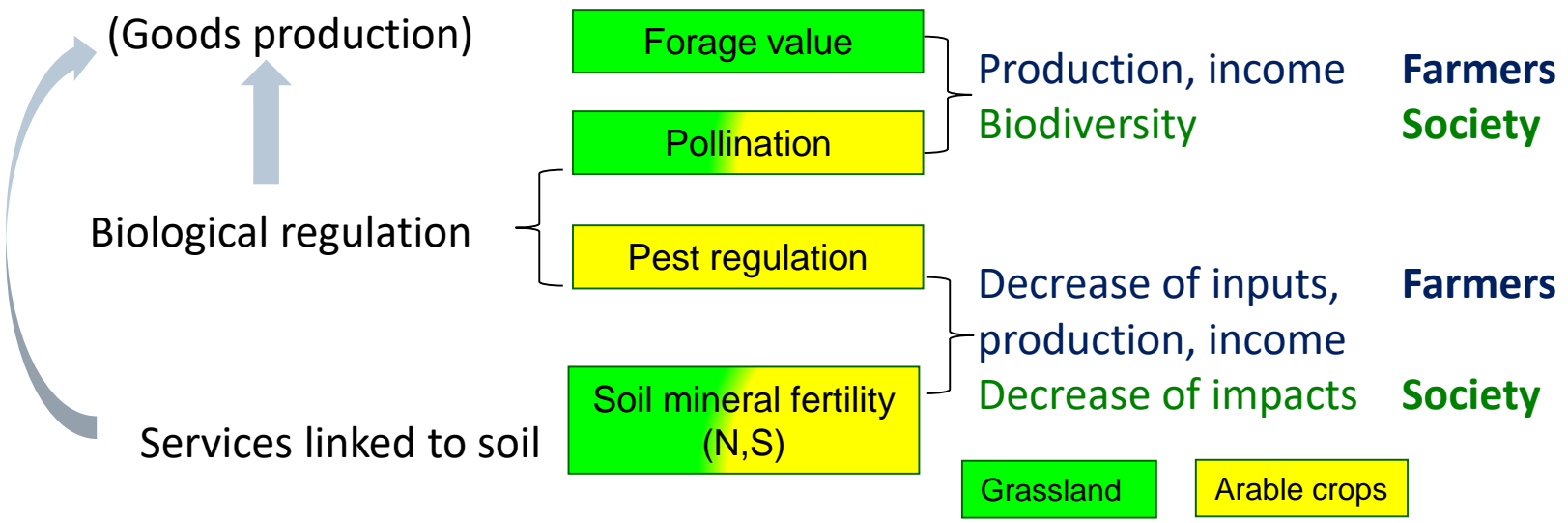
and multicriteria (integrated)

assessment

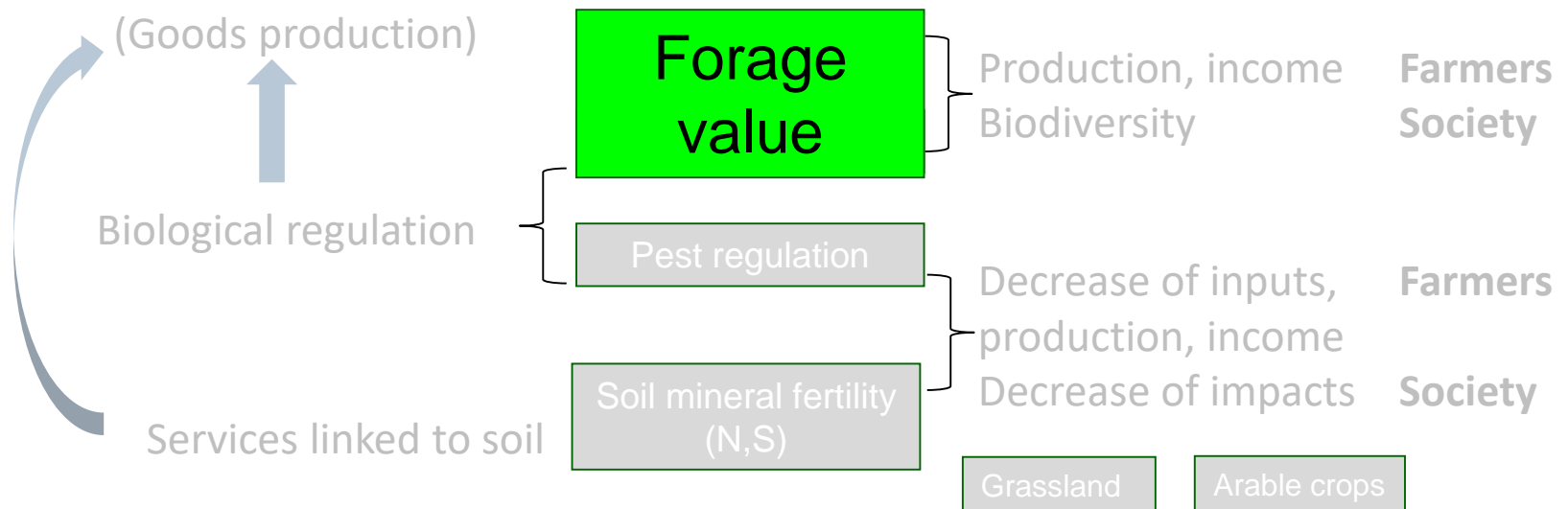
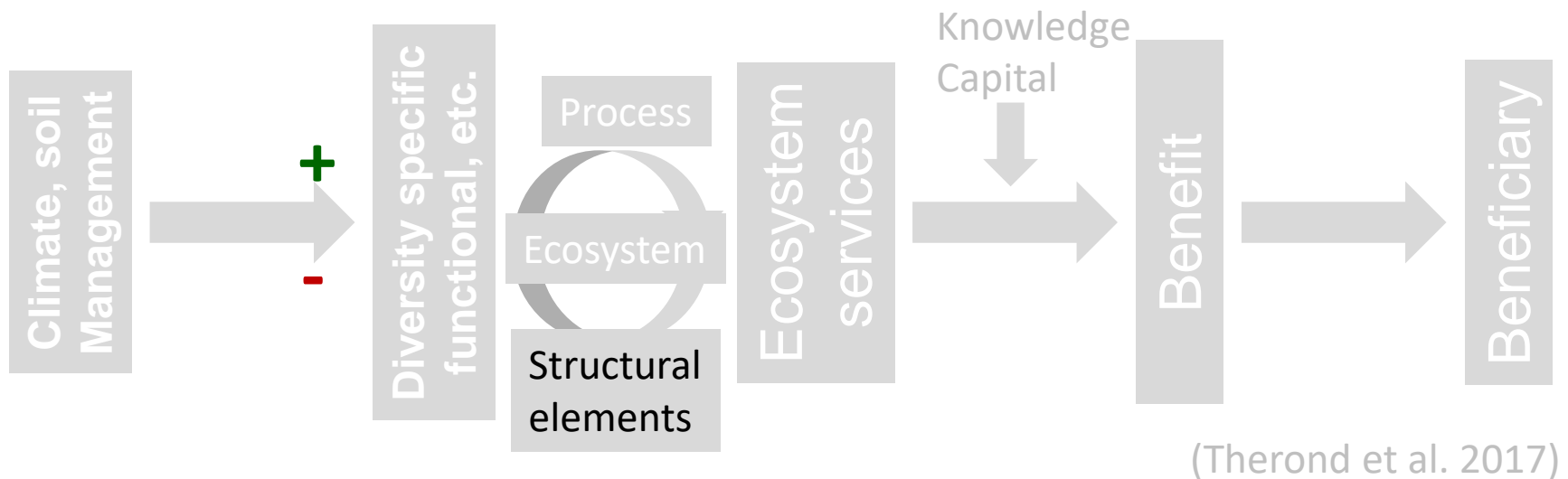
# ES: conceptual framework and ES studied



(EFESE study Therond et al. 2017)



# Presentation of Axis 1





# Management and value of permanent grassland

Understanding of grassland functioning  
(management-soil-climate-plants) + impact assessment



National typology (2012)



Regional (Vosges)  
PhD of Geoffrey Mesbahi

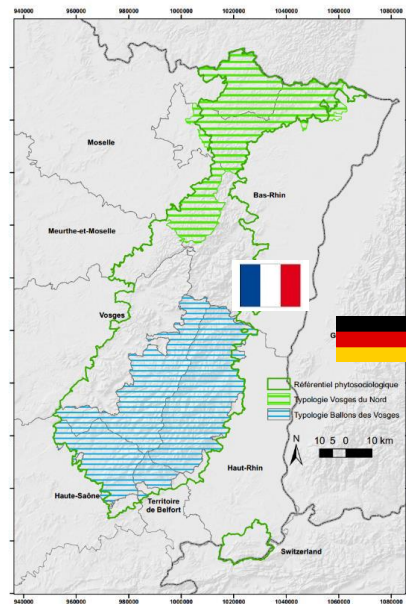


Decision aid tool

**MultiSward** (Plantureux et al. 2014 EGF)

<http://www.multisward.eu>

EU FP7 2010-2014



2 years monitoring  
of 60 grasslands  
Grass production  
Feed value  
Animal health value  
Production costs  
Plant biodiversity

+ Survey of famers  
expectations

**eFLORAsys**: <http://eflorasys.univ-lorraine.fr>

# A new service studied: animal health value

Animal health value: a way to valuing low productive grassland with high biodiversity?



State of art (*Poutaraud et al. 2017 JAFC*)

JOURNAL OF  
AGRICULTURAL AND  
FOOD CHEMISTRY

Review  
pubs.acs.org/JAFC

## Grasslands: A Source of Secondary Metabolites for Livestock Health

Anne Poutaraud,<sup>\*,†</sup> Alice Michelot-Antalik,<sup>§</sup> and Sylvain Plantureux<sup>§</sup>

<sup>†</sup>Laboratoire Agronomie et Environnement, INRA, UMR 1121, Colmar, 29 rue de Herrlisheim, F-68021 Colmar Cedex, France

<sup>§</sup>Laboratoire Agronomie et Environnement, Université de Lorraine, UMR 1121, 2 Avenue de la forêt de Haye - TSA 40602, F-54518 Vandœuvre-lès-Nancy Cedex, France

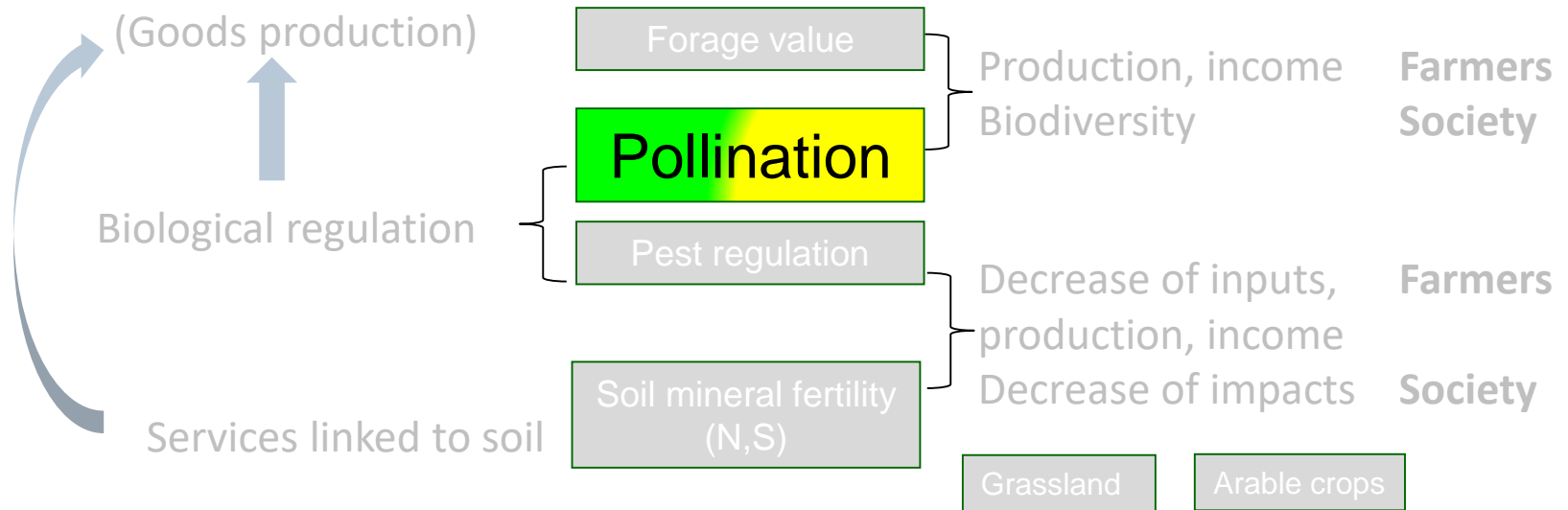
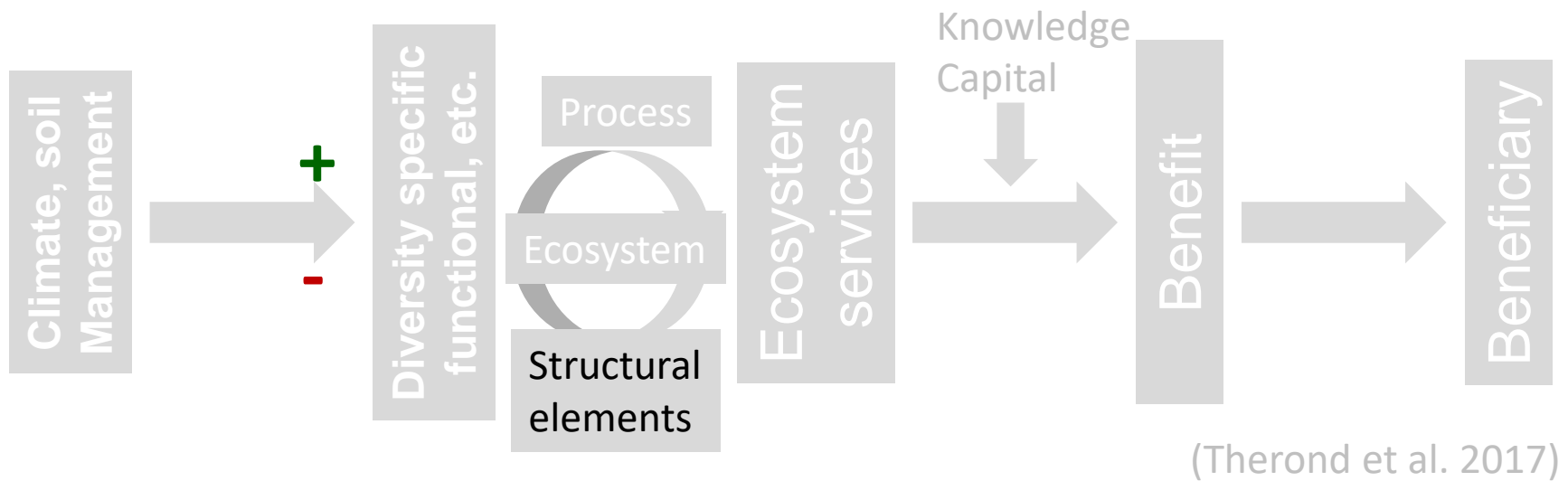
**ABSTRACT:** The need for environmentally friendly practices in animal husbandry, in conjunction with the reduction of the use of synthetic chemicals, leads us to reconsider our agricultural production systems. In that context, grassland secondary metabolites (GSMs) could offer an alternative way to support to livestock health. In fact, grasslands, especially those with high dicotyledonous plant species, present a large, pharmacologically active reservoir of secondary metabolites (e.g., phenolic compounds, alkaloids, saponins, terpenoids, carotenoids, and quinones). These molecules have activities that could improve or deteriorate health and production. This Review presents the main families of GSMs and uses examples to describe their known impact on animal health in husbandry. Techniques involved for their study are also described. A particular focus is put on anti-

Methodological work on analyse of anti-oxydants



Just first results

# Presentation of Axis 1



# Pollination at landscape level

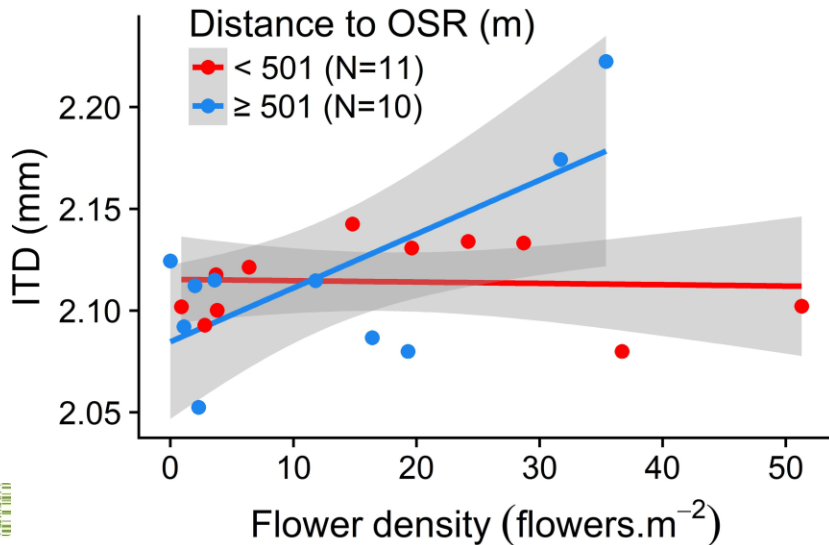
Interactions management X landscape on pollinators and pollination service?



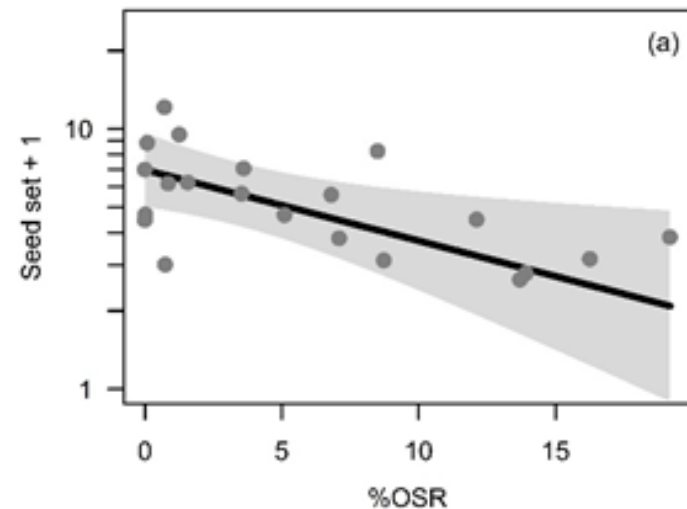
PhD. Colin van Reeth (2017) study on 21 grasslands  
- Complex effects of winter oilseed rape  
- No data on management



Effect on the body size of a solitary wild bee, *Andrena cineraria* (van Reeth et al. 2018 PlosOne)

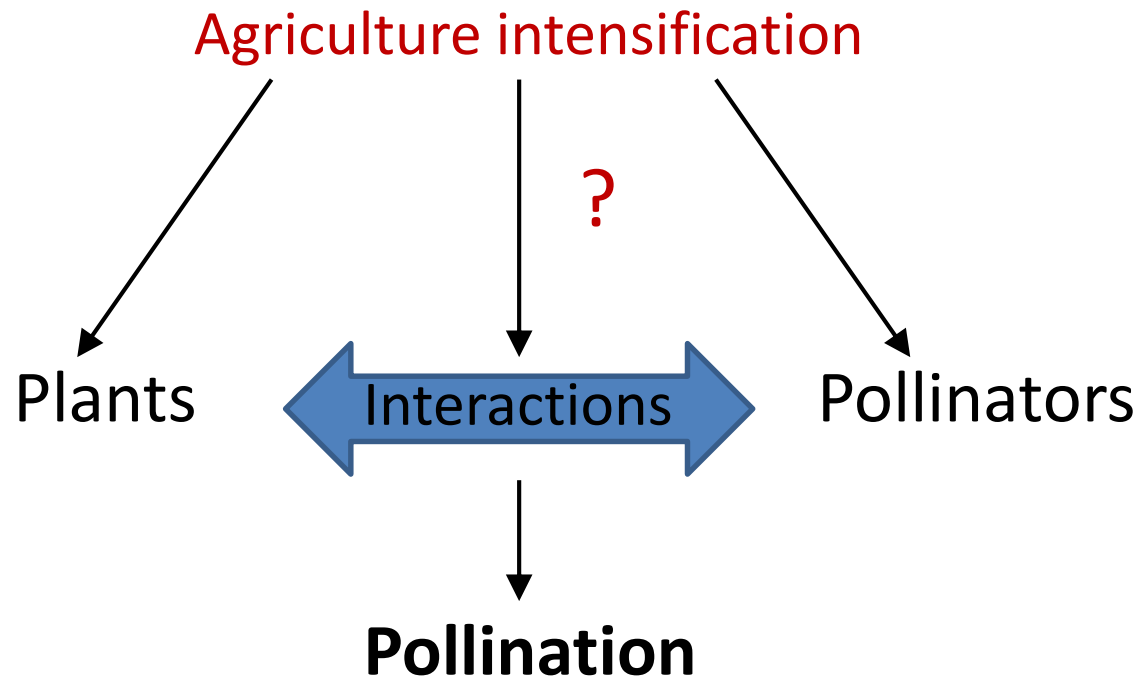


Effect on % OSR on seed set of *Cardamine pratensis* (van Reeth et al; submitted AEE)



# Pollination at field level

Which relation between agriculture intensification and “trait matching” mediating trophic interactions (Le Provost et al. 2017)?

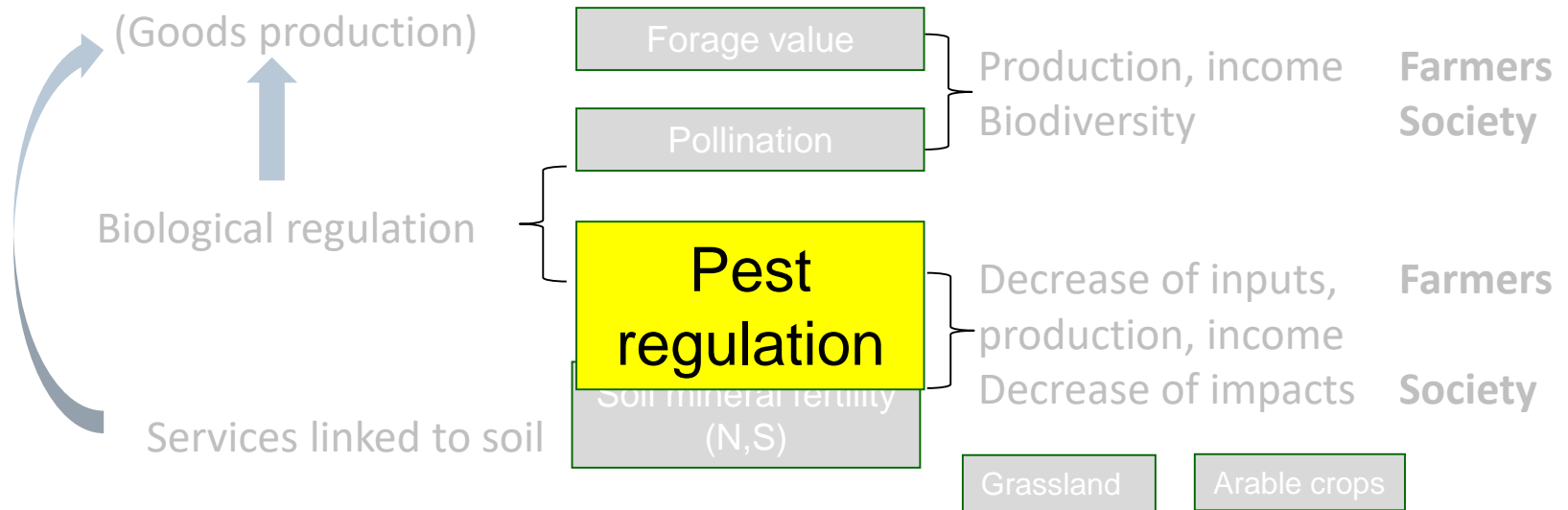
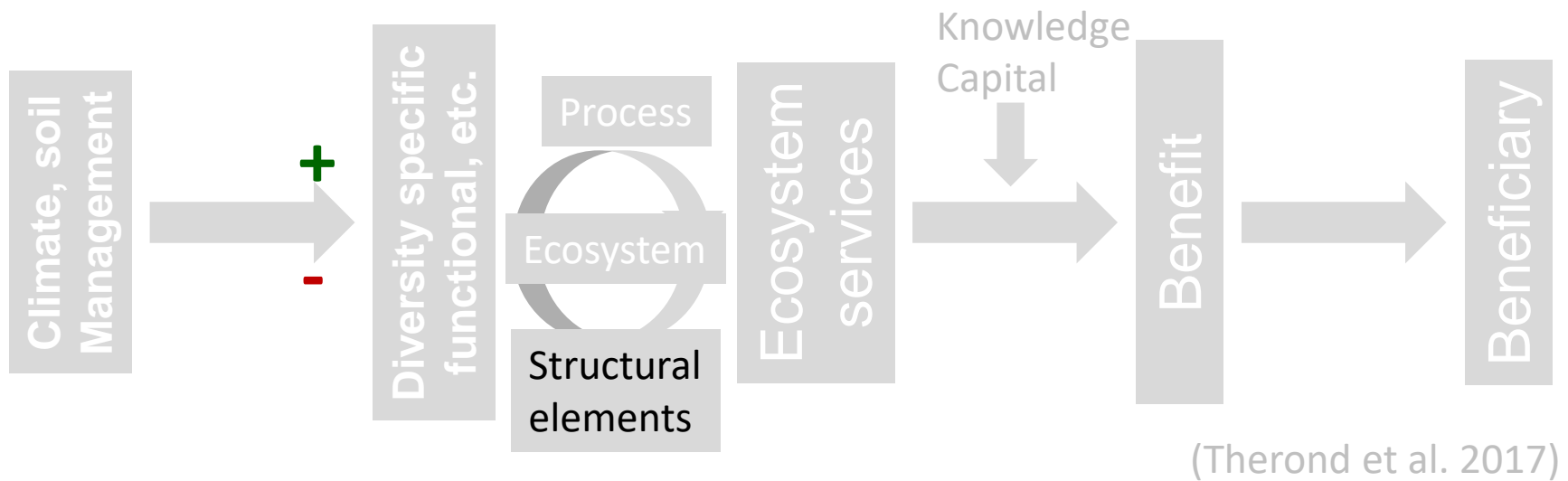


PhD Jérémie Goulnik (2017-2019):

- Study on 16 grasslands with a intensification gradient
- On all pollinator (dipterae included)



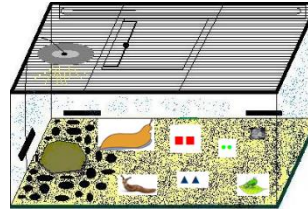
# Presentation of Axis 1



# Pest regulation



- Effect of large beetles and not of size diversity on predation (*Rouhaba et al. 2014 EE*)



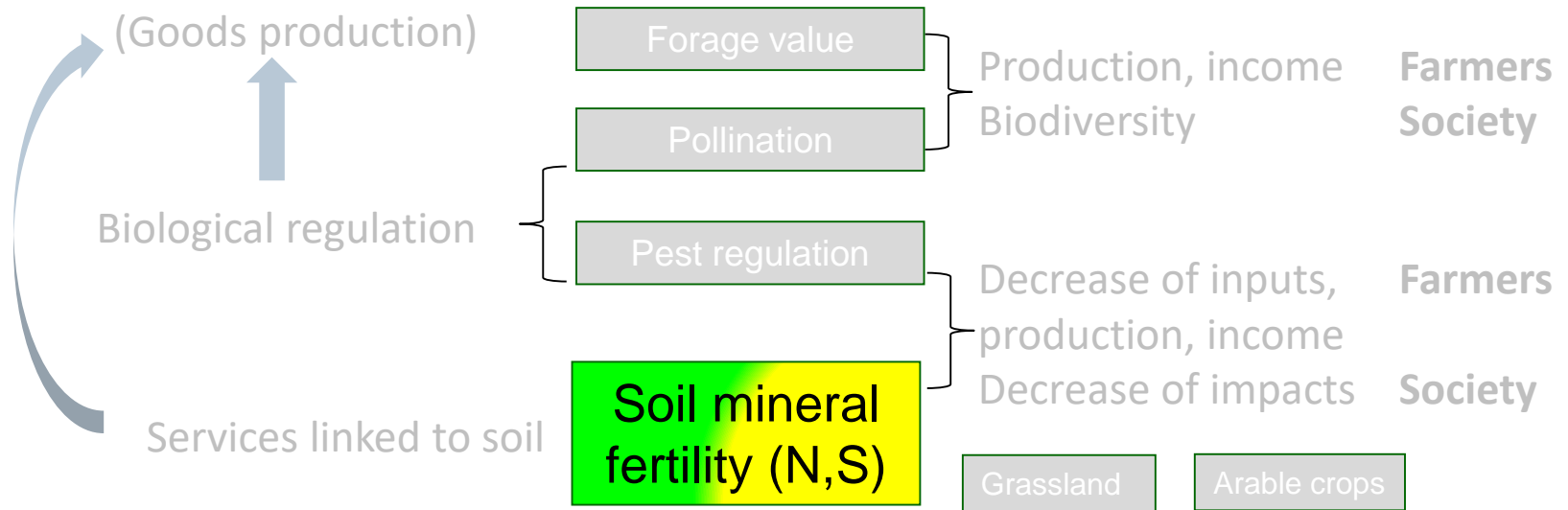
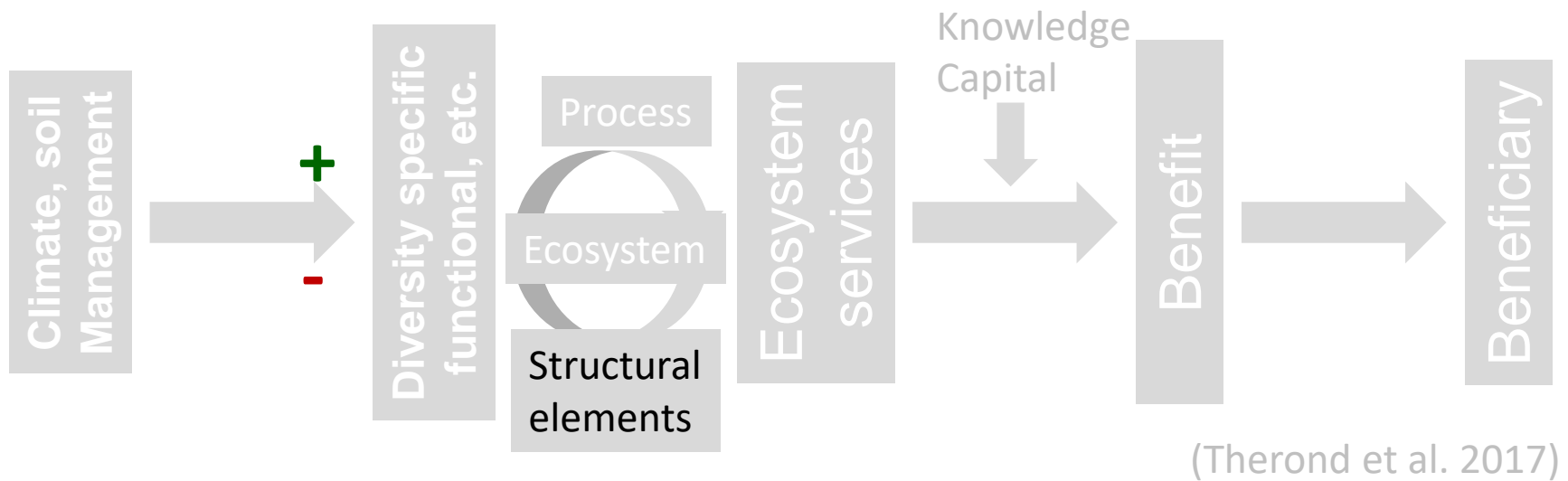
- Effect of field margin vegetation (*Rouhaba et al. 2015 AEE*)
  - Vegetation homogeneity and bare soil → Large species favoured
  - Vegetation heterogeneity → Small species



- Ongoing experiment: effect of crop mixture on natural enemies (ground beetles, hoverflies, etc.) in organic farming
  - SEMIX project on the experimental farm (organic) of INRA at Mirecourt



# Presentation of Axis 1

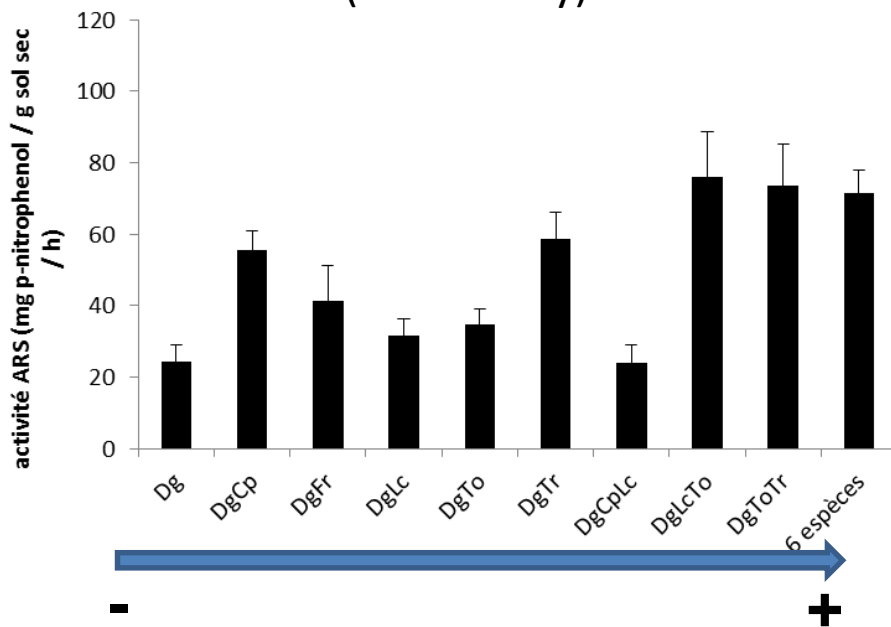


# Interactions plant and microbial communities

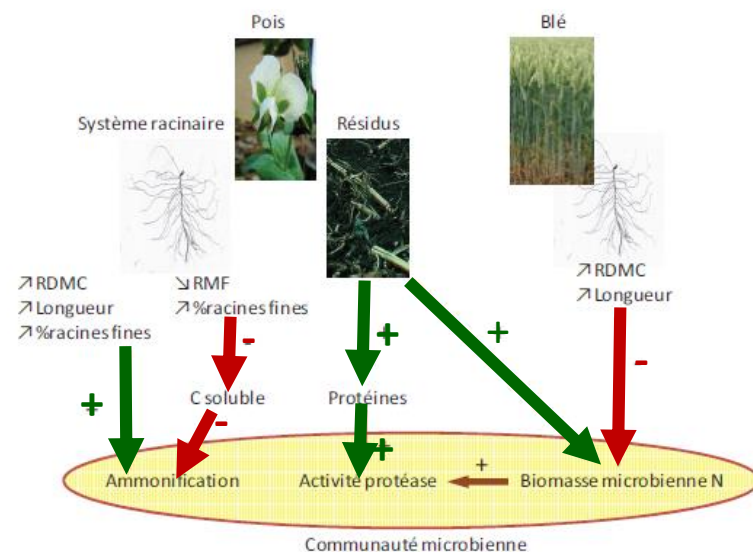
## Interactions plant traits and microbial traits on N/S fertility



Effect of plant diversity on S mineralization (ARS activity)



Effect of crop type in the rotation and its root traits on microbial activity in soil (Romillac et al., 2015 SBB)



# Potential N mineralization of soil

Effect of management on potential mineralization of soil

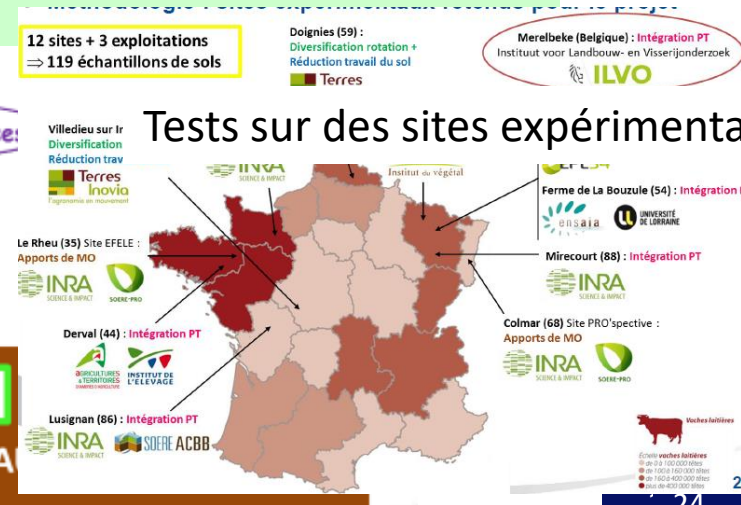
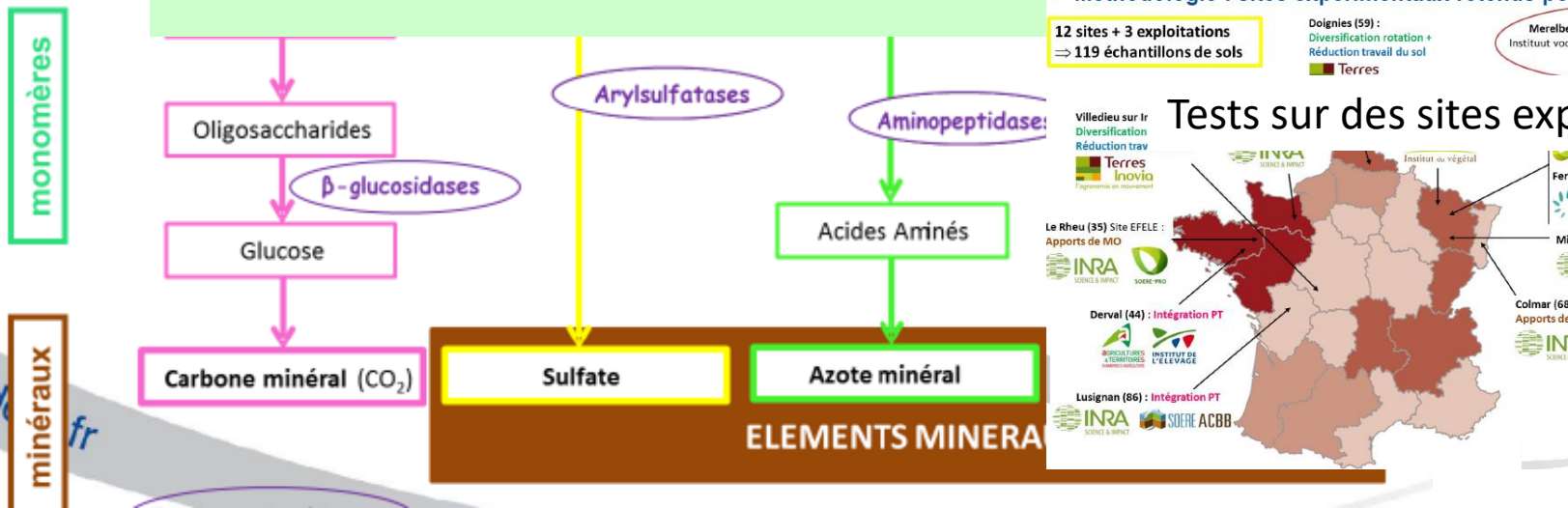


Postdoctoral work of Caroline Petitjean (2015-2017) CNIEL-IDELE

**polymères**

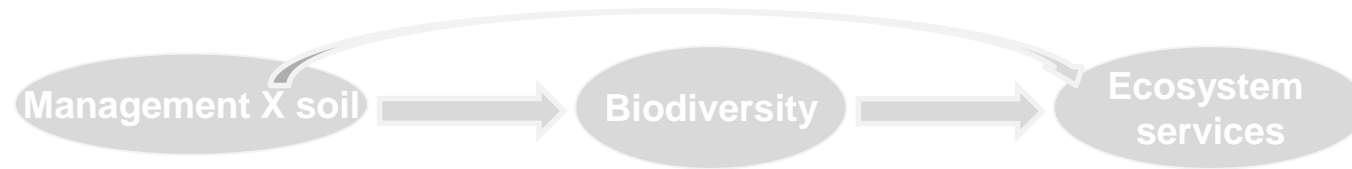
Management (tillage, meadows in the rotation, mineral N):

- **Indirect effect** via effect on soil variables (e.g. C & N content) and microbial activities
- **Negative effect on microbial abundance**
- **Positive effect on microbial activity:**



# Presentation of Axis 2

Axis 1  
Knowledge and  
understanding of  
process



Available data and  
knowledge

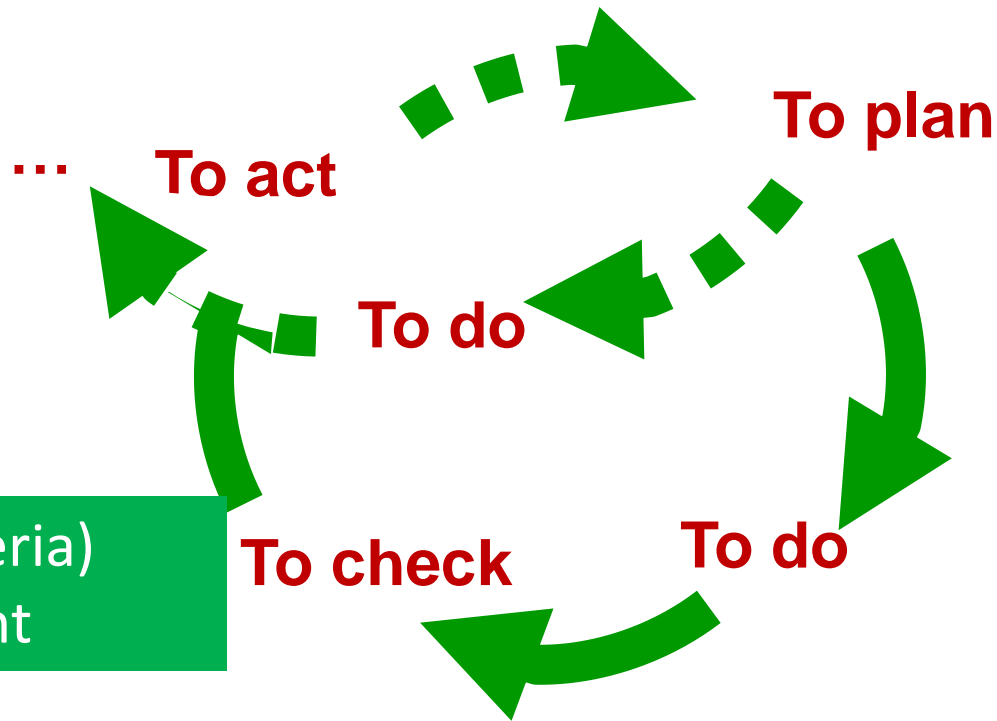
Indicators

**Axis 2**  
**Indicators**  
**and multicriteria (integrated)**  
**assessment**

# The need of assessment/evaluation

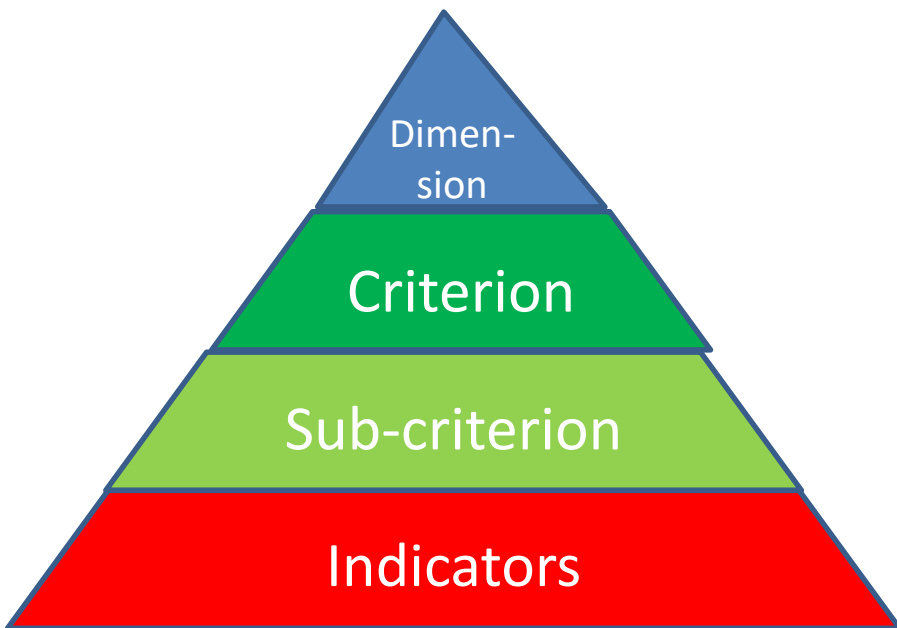
The sustainability issue:  
A "driving illusion?"

(Lascoumes, 2005)



(Meynard et al. 2002)

# The conceptual framework



## Examples

Environment

Biodiversity

Floristic

Vascular  
plant  
species  
richness

## Synonyms

Aspects, domain, pillar

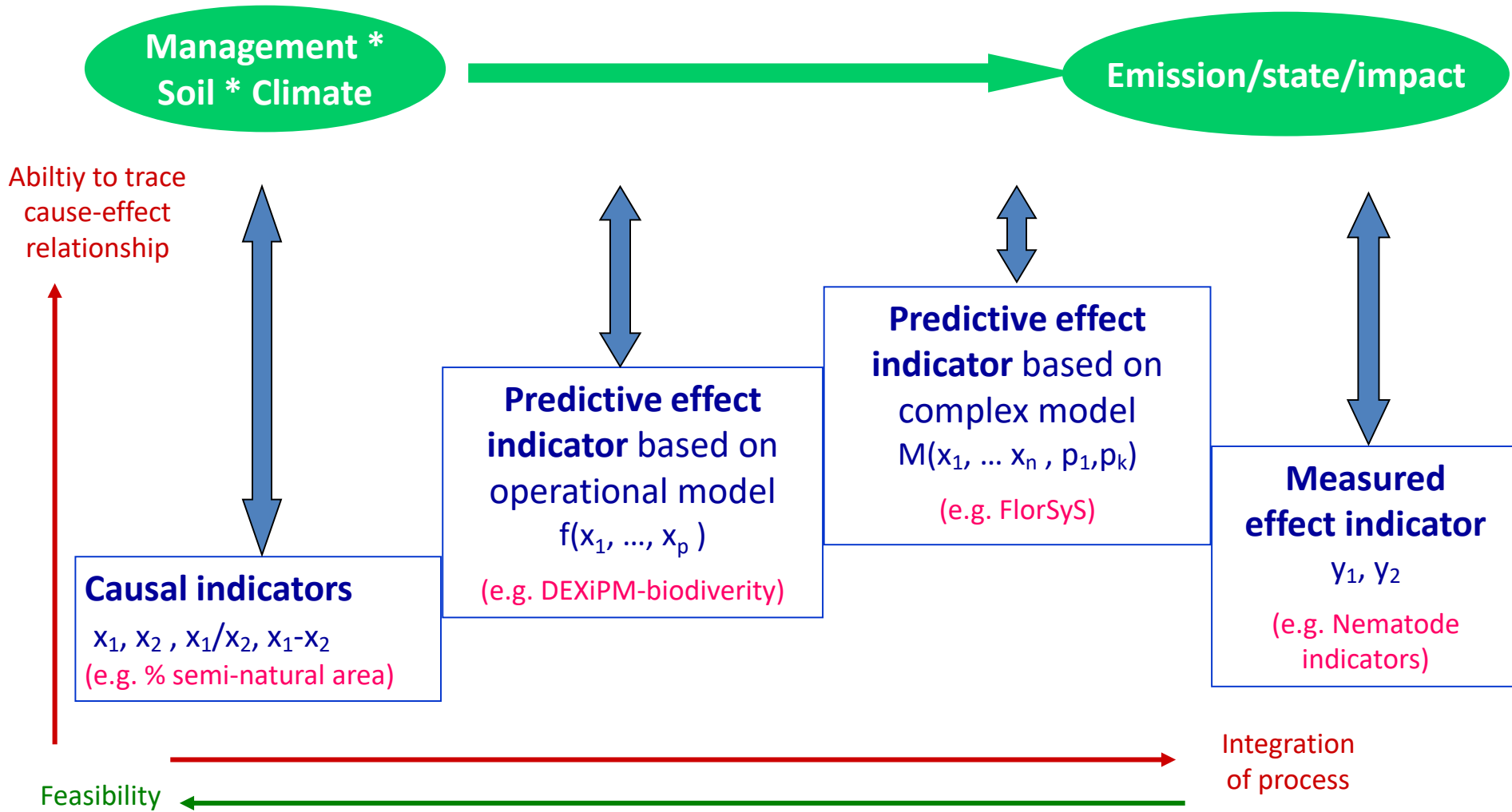
Attribute, component,  
impact category, issue,  
principle, theme

Parameter, metric, proxy

*Lairez & Feschet et al.,(2015), de Olde et al. (2016)*

# A typology of indicators

(Bockstaller et al., 2015;  
Laluet, Peschet et al. 2015)



Each type for a given purpose



# Example 1: pollination value of field margin

Weed predicted by FlorSys model (COSAC project)



Species diversity + Flower unit number

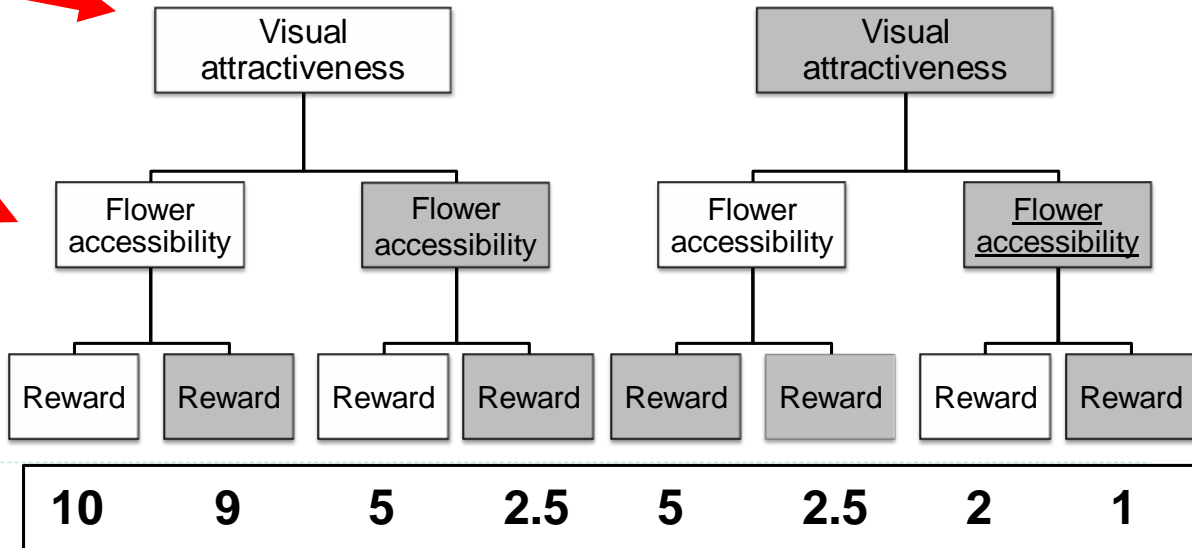


Database on flower traits of species

Flower size, colour and UV reflect

Botanical family, symmetry and shape  
Quantity and quality of nectar

Indicator for bees, wild bees, bumblebee and hoverflies (syrphidae)



□ Favourable    ■ Unfavourable

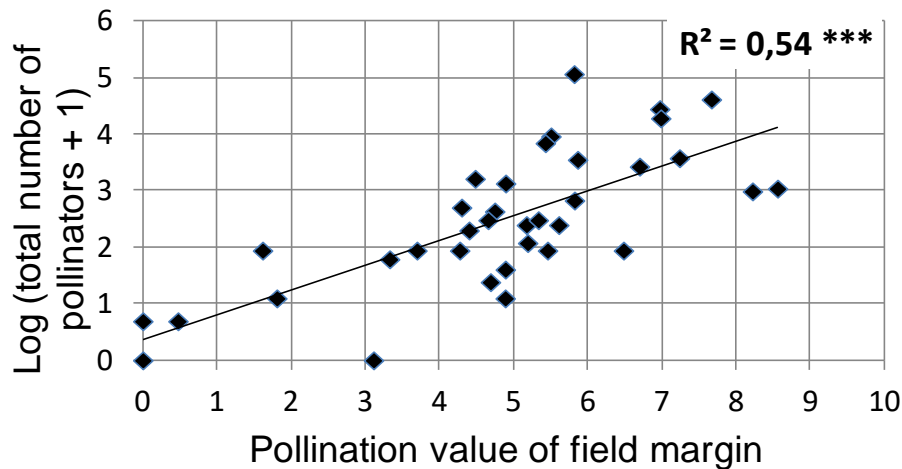
(Ricou et al. 2014, EI)

Aggregation of monthly species results on a field margin: weighted mean by flower abundance, presence of pollinator, flowering period and flower size

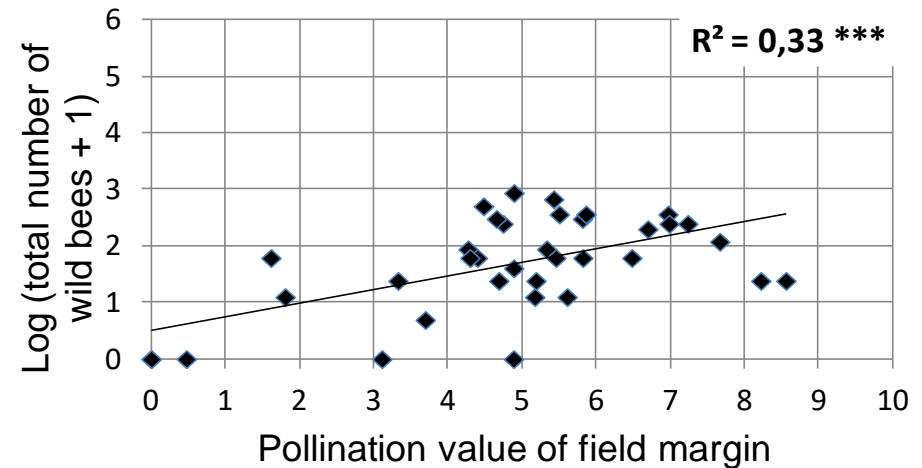


# Evaluation of predictive quality of the indicator

Total number of pollinators vs. Indicator (bee)



Total number of wild bees vs. Indicator (wild bee)



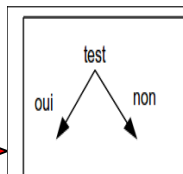
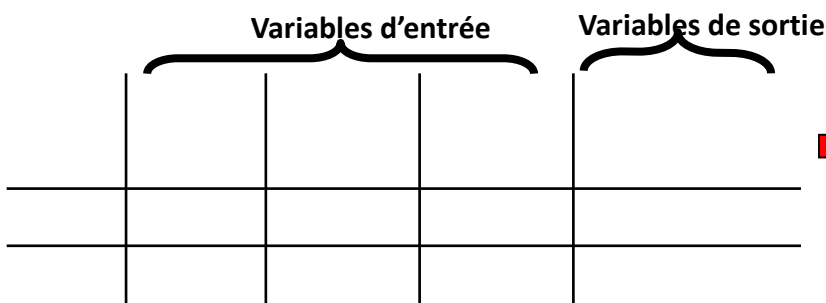
- Similar results for bumblebees and hoverflies

# Example 2: Icarab assessing the predation potential by beetles

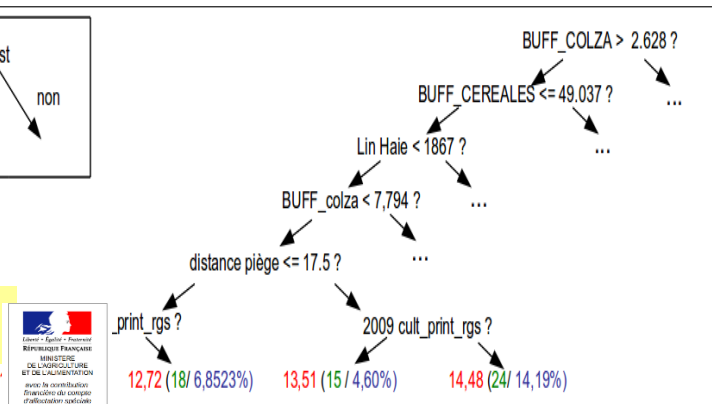


## Development steps:

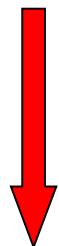
Field data Entomophages project



ARENA project



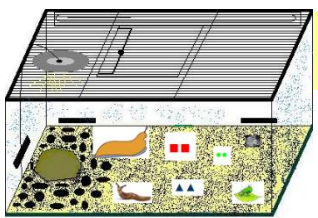
Production of decision tree



Transformation in indicators

New knowledge and data

Rouhaba et al. (2015)



Indicateur  $I_{carab}$  prototype 0.1

Auximore project



Assesment by target users (agric CIVAM, ACTA....)

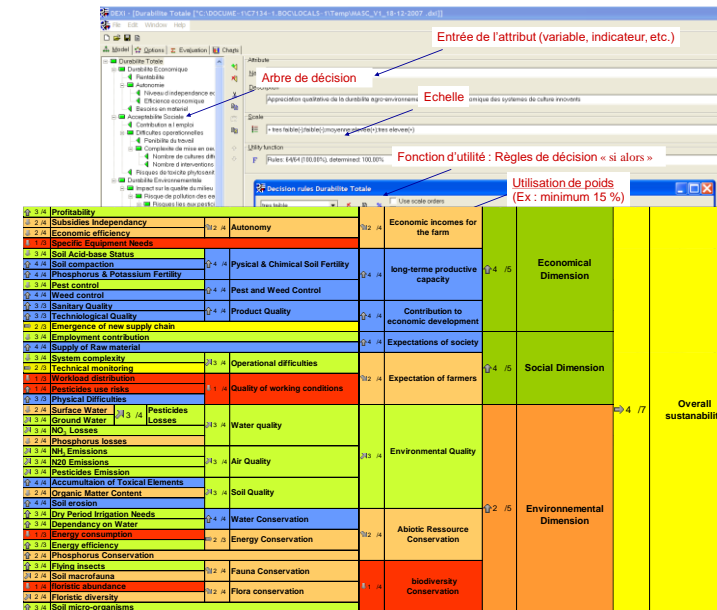


# To aggregate or not ?



- ❖ Composite aggregation discussed a lot
- ❖ Pitfalls but also solutions
  - Outranking (e.g. Electre)
  - Decision tree (e.g. DEXi tool)
  - Fuzzy decision trees (CONTRA)

👉 We need both, non aggregated indicators to analyse  
👉 Aggregated indicators to compare, decide

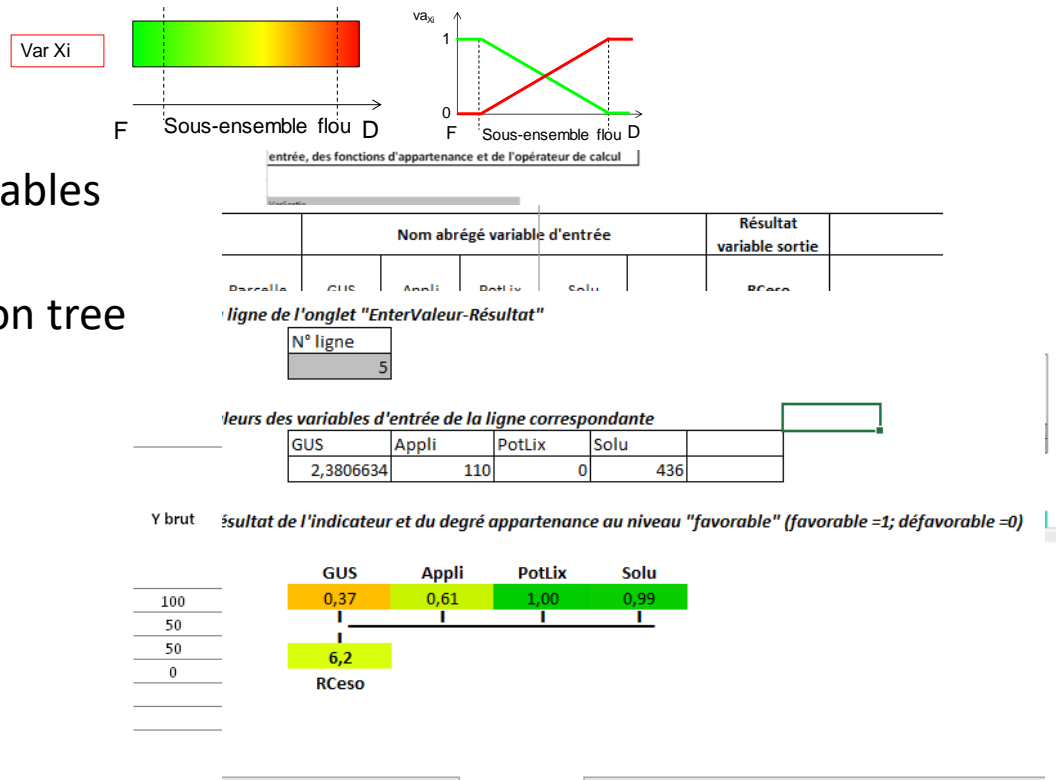


# The CONTRA method

## CONTRA®

Construction Transparente d'arbre de décision

- Based on **fuzzy decision tree**
- **Definition** of input/output variables
- Automatic **creation** of a decision tree
- **Transparent modification** of the decision rules
- **Calculation** for options
- **Analyse** of results/simulation



# Indicators and methods reviews

- Pesticide and Nitrogen indicators (*Bockstaller et al. 2009, 2014*)
- Biodiversity indicators (*Bockstaller et al. 2011*)
- INDIC database
- Access database
- 116 methods (e.g. INDIGO, RISE, SALCA), 6 reviews (e.g. Indic. N CORPEN 2006), 3044 indicators (1786 environmental)
- Description of environmental indicators achieved (*Thomas Delille, 2015 master thesis*)


**Methods and Reviews Sheets**

DATA ON THE METHOD OR REVIEW

IDEA	Method or Review number	M1001 <small>— If it is a method : M. If it is a review : Rxx</small>
	Previous number	M001
Vilain L., 2008, La méthode IDEA V3. ducagri, Dijon (France).	Seminal work	Vilain L., La méthode IDEA. Educagri, 2000, Dijon (France).
Type of reference	Book	PDF file
Origin	France	
Year of publication	2008	Multithematic <input checked="" type="checkbox"/>
Identifiers (DOI, ISBN)	978-2-84444-669-5	Comment
		Auto-évaluation Outil pédagogique

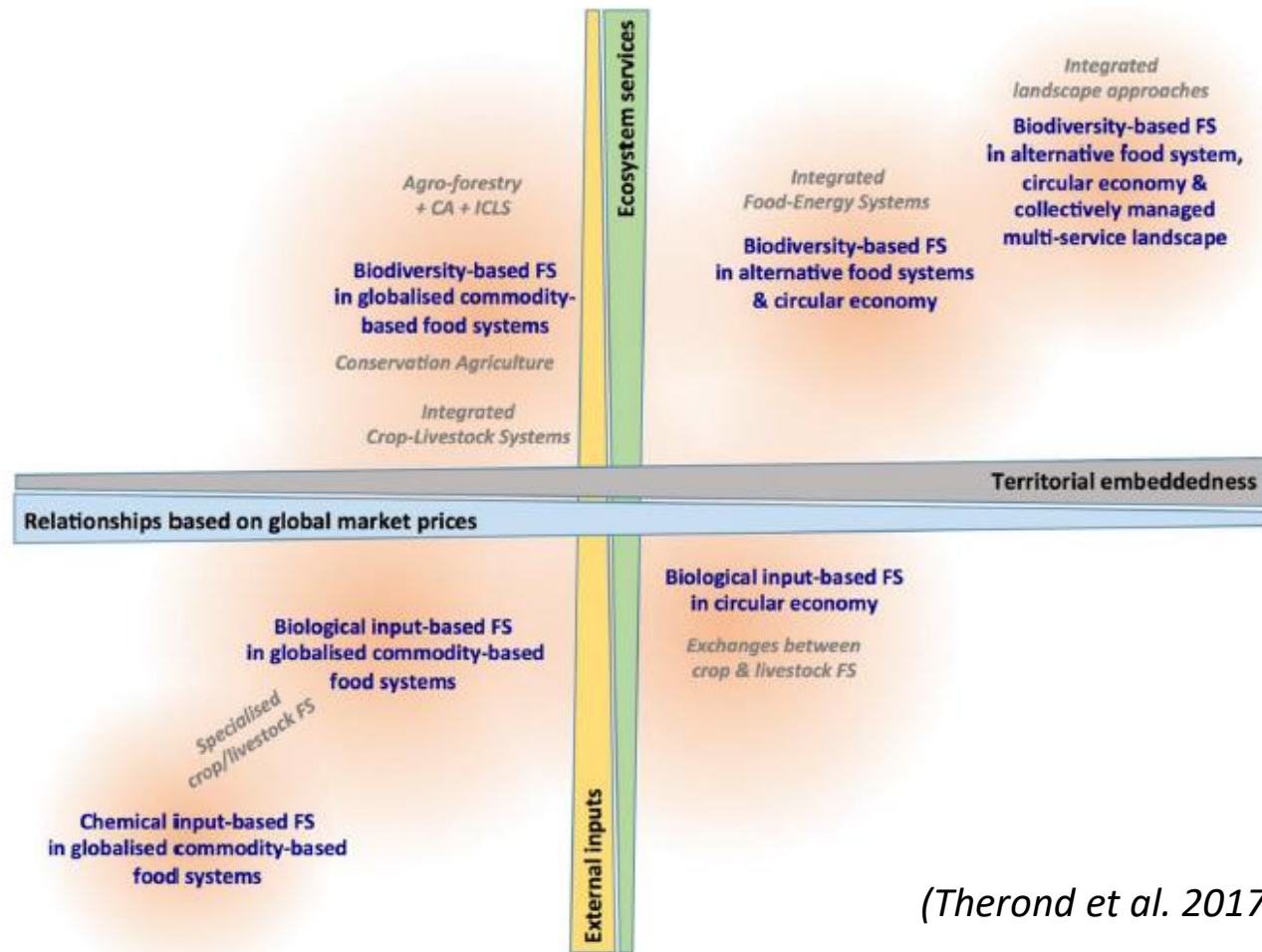
Research    Add sheet

Ce projet a été financé par le GIS Grande Culture à Hautes Performances Economiques et Environnementales  
Auteurs: Thomas-Delille Emilie, Feschet Pauline, Schneller Chloé, Bockstaller Christian, 2015.





# A new analytical framework of farming system and agriculture model diversities



(Therond et al. 2017, ASD)

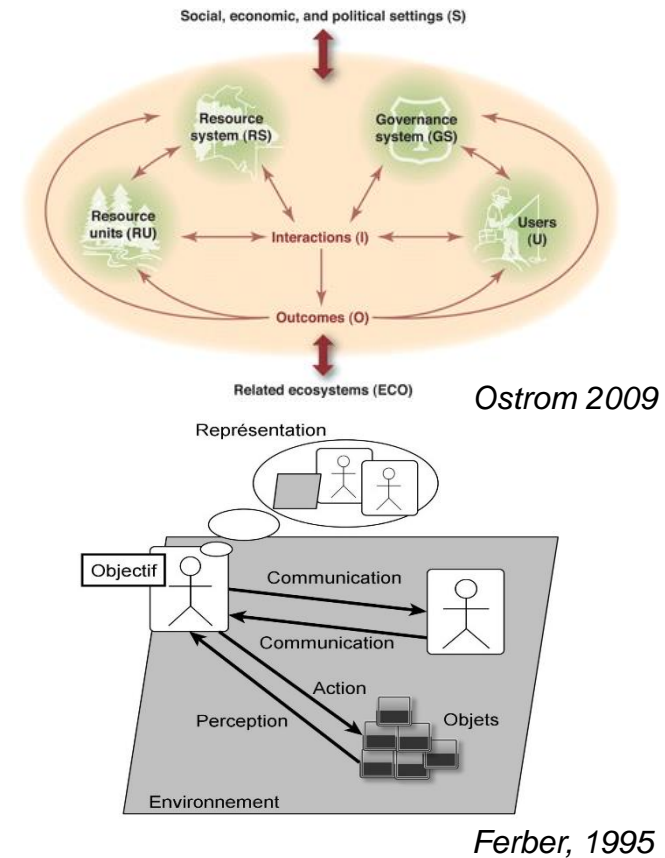
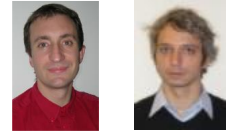
Ongoing PhD work of Manon Dardonville on the **vulnerability/resilience** of agriculture models according the framework





# The MAELIA platform

- **Generic platform** for integrated assessment and modelling (IAM) of **social-ecological systems** at **territorial level** (local to regional) for **landscape design/planning** and management
  - Representation of **dynamics and interactions** between the 4 sub-systems of social-ecological systems
  - Agent-based architecture: **autonomous human agents** with a representation of their biophysical and social environment that drives their **actions**
- Representation of **specific individual situations** (e.g. farmer, dam manager) with **parsimonious modelling** (AqYield, SWAT, etc.)
- Bottom-up model of emerging properties/processes

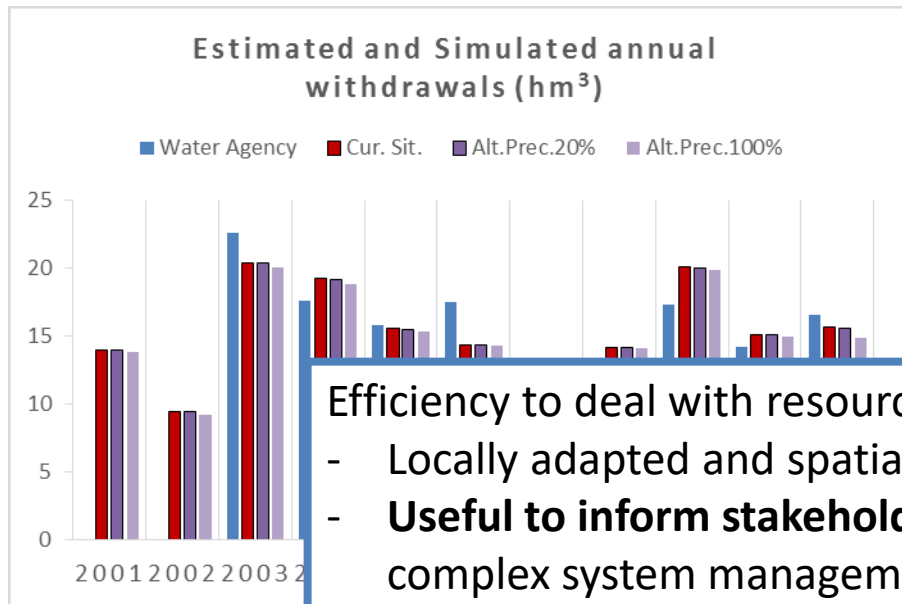


# Description of decision rules for cropping systems

NOM_ITK_AFFICHAGE	*	maist_g_ter
IDS_SDACS	[NA]	mais*_g_ter mais/ble_ter mais*_s CP/oleo_ter rotation_irr_ter prairiet_ter semence/X_ter prairiet
ID_ESPECE	[NA]	maisTardif
IS_SEMIS	[NA]	0
SEMIS_TEMPS	[Ha/h]	1.8
SEMIS_NB_SOUS_PERIODES	[NA]	3
SEMIS_DEBUT	[jour]	79 100 141
SEMIS_FIN	[jour]	99 140 161
SEMIS_JOURS_TMIN	[jour]	7 3 3
SEMIS_TMIN_MIN	[degresC]	3 3 3
SEMIS_JOURS_PLUIE	[jour]	5 3 2
SEMIS_HAUTEURS_PLUIE_MAX	[mm]	5 10 10
SEMIS_HUMIDITE_SOL_MAX	[%]	0.9 1 1
SEMIS_EFFET_RUs	[?]	W1 W1 W1
SEMIS_OPERATEUR	[NA]	NA
IS_BINAGE_SOL	[NA]	0
BINAGE_TEMPS	[Ha/h]	2
BINAGE_NB_SOUS_PERIODES	[NA]	1
BINAGE_DEBUT	[jour]	152
BINAGE_FIN	[jour]	181
BINAGE_EchV_MIN	[%]	0.6
BINAGE_HUMIDITE_SOL_MAX	[%]	1
BINAGE_EFFET_RUs	[NA]	W1
BINAGE_COMMENTAIRE	[NA]	NA
IS_RECOLTE	[NA]	0
RECOLTE_TEMPS	[Ha/h]	3
RECOLTE_TEMPS_INTERNE	NA	0
RECOLTE_NB_SOUS_PERIODES	[NA]	2
RECOLTE_DEBUT	[jour]	275 305
RECOLTE_FIN	[jour]	304 324
RECOLTE_ECHV_MIN	[mm]	2.6 2.2
RECOLTE_JOURS_PLUIE	[jour]	3 2
RECOLTE_HAUTEURS_PLUIE_MAX	[mm]	20 25
RECOLTE_HUMIDITE_SOL_MAX	[%]	1 1.1
RECOLTE_EFFET_RUs	[?]	W1 W1
RECOLTE_OPERATEUR	[NA]	NA
IS_IRRIGATION	[NA]	0

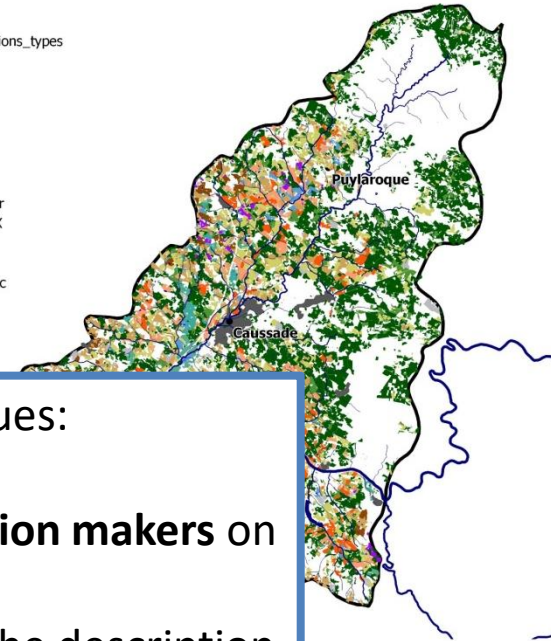
# The MAELIA platform: example of application

- Example of application of MAELIA to deal with **quantitative water resource management**: « Aveyron aval » territory, 800 km<sup>2</sup>:
  - 1100 farmers, 20 000 fields (20 000 instances of AqYield)
  - Agricultural land-use management scenarios were tested regarding water withdrawals
  - Spatially explicit results – global conclusion on scenarios



ilots2009\_rotations\_types

- arbo
- cereale\*
- gel
- mais\*\_g
- mais/ble
- prairiep
- prairiec
- rotation\_irr
- semence/X
- vignes
- CP/oleo
- prairiec\_sec
- mais\*\_s



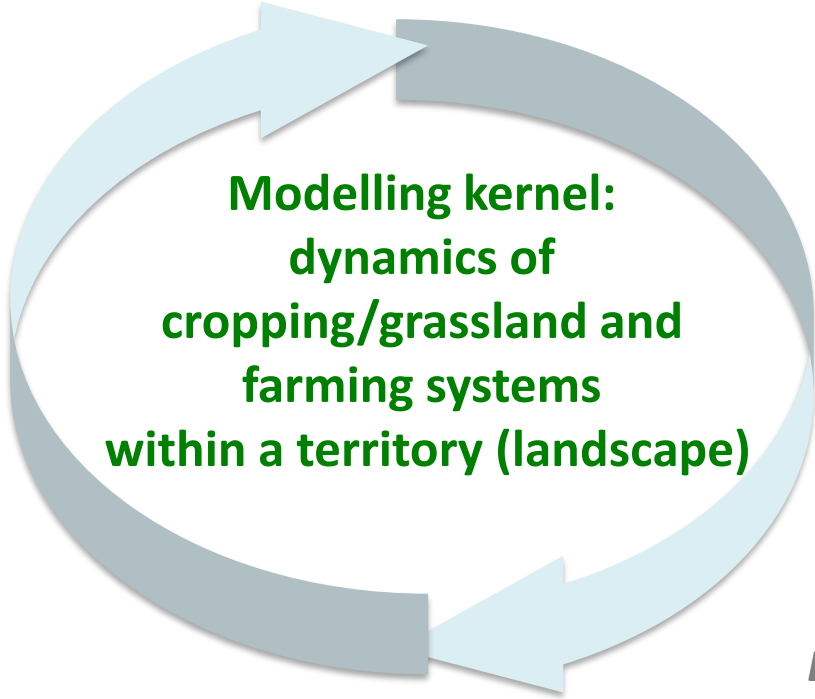
Efficiency to deal with resource management issues:

- Locally adapted and spatially explicit results
- **Useful to inform stakeholders and local decision makers on complex system management**
- **Adhesion of farmers** because of precision in the description of management and soils (*Murgue et al. 2015 LUP*)

# MAELIA developments at a glance

**Agroforestry systems**

**Agroecological systems  
(diversified systems)**



**Modelling kernel:  
dynamics of  
cropping/grassland and  
farming systems  
within a territory (landscape)**

**Organic products  
(chain management of  
organic wastes)**

**Crop-livestock interactions**

**Biological regulations**

*Biodiversity and pesticide  
contamination risk indicators*

*Territorial bioeconomic  
systems*

# The DiverImpacts project (H2020)

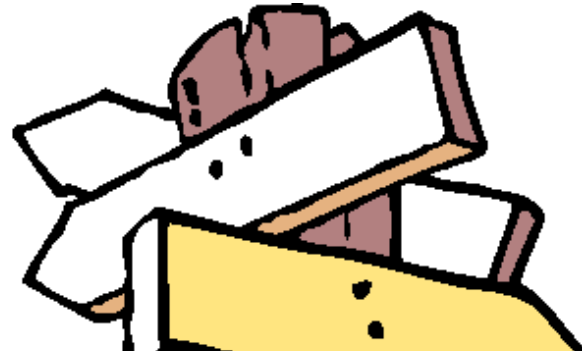
- Involved in WP4 T 4.1
  - Contribution to the indicator list (n=29)

Proposal of criteria	Dimension	Principle for the choice of indicators	Proposal of indicator (with increasing complexity)			
Water quality (nitrate)	En	For nitrate: either a predictive (from model) or measured one, or two indicators assessing nitrogen surplus and soil cover in winter. Can be completed by one for P (one component on model)	Nitrogen use	Nitrogen balance (farm gate)	Bare soil during drainage period (winter)	Soil mineral content before drainage
Water quality (pesticide)	En	For pesticide risk: TFI (poor predictor), amount of a.i., amount of leachable a.i., pesticide risk	amount of a.i.	TFI	amount of leachable a.i.	Pesticide risk (e.g. i-Phy, EYP, EPRIP, etc.)
Air quality	En	For pesticide risk: TFI (poor predictor), amount of a.i., amount of volatile a.i. (to define with a pesticide risk indicator), pesticide risk	amount of a.i.	TFI	amount of leachable a.i.	Pesticide risk (e.g. i-Phy, EPRIP, etc.)
Access / Rediscovery of "new" knowledge	So	by interview				
Famer and public health	So	by assessing impact (or use) of pesticide?				
Farmers' quality of life	So	by interview, or calculation of average work load or day number with work peak	Assessment by interview	average work load	average work load	Number of days with peak
	Feasibility					
	high					
	medium					
	low					

- Involved in WP4 T 4.4
  - Implementation of MAELIA to assess territorial scenario of diversification for three case studies
  - 1 case study in Lower Saxony (#3 Hauke Ahnemann, Chamber of Agriculture Lower Saxony) :
    - 25 farmers with a common goal of improve water quality in catchment basin trough new viable, valuable and sustainable farming strategies, as well as to increase the cooperation and trade between farmers. To be updated

# Conclusions

- Studies in agroecology on the relation agriculture-biodiversity-ecosystem services
  - Grassland and arable crops
- Multicriteria assessment and integrated assessment modelling
  - Indicators
  - MAELIA platform
- Ongoing and future works (examples):
  - Integrating ES in MAELIA
  - Vulnerability, resilience
  - Trade-off between production, impacts and ES



**Thank you for your attention**

