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, 18th 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

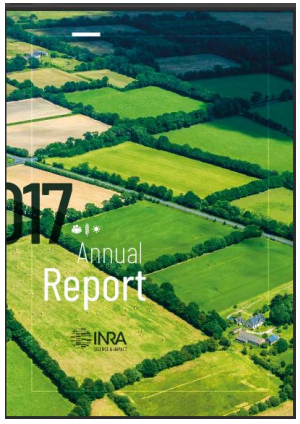
The INRA : short presentation

- Created in 1946

- From the scientific support to the modernization of agriculture (50-70s) …

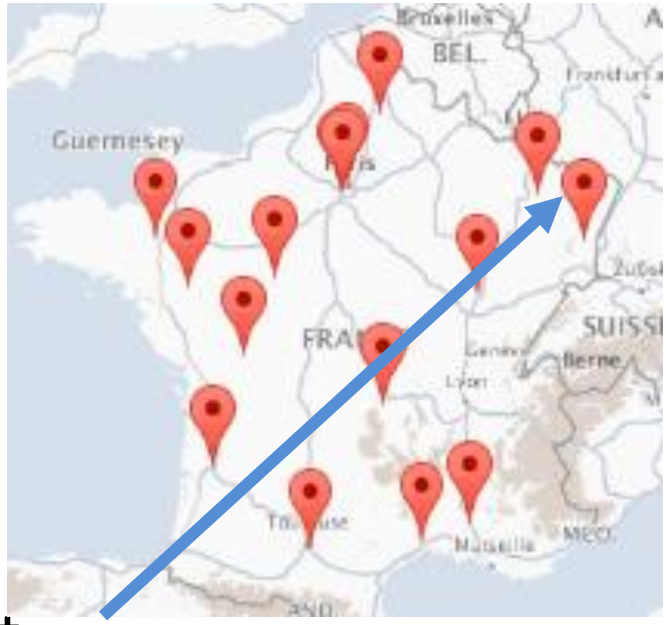
  to a research institute of high level (80s-90s)
  - Agriculture Environment and Food

- 2nd 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

2 research teams

Director: Dr. habil. Christophe Robin

Deputy director: Dr. habil. Olivier Therond

+ 5

AGriculture, b**I**odiversity, **E**cosystem **S**ervices, & Multicriterai Evaluation

AGISEM

Plant Secondary metabolism

Common service

Conference
Thünen Institute of Biodiversity

The AGISEM research team

February, 18th 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

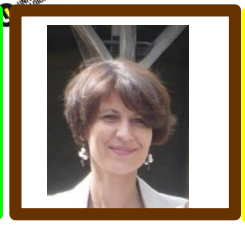
Frédéric PIERLOT
MAST - UL

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

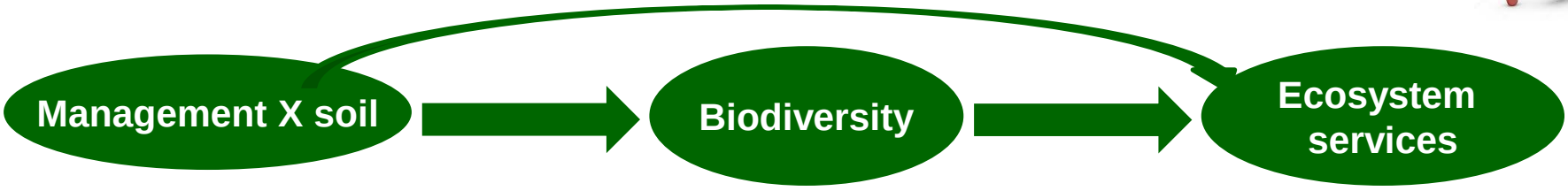
Production & resource conservation

Agroecology

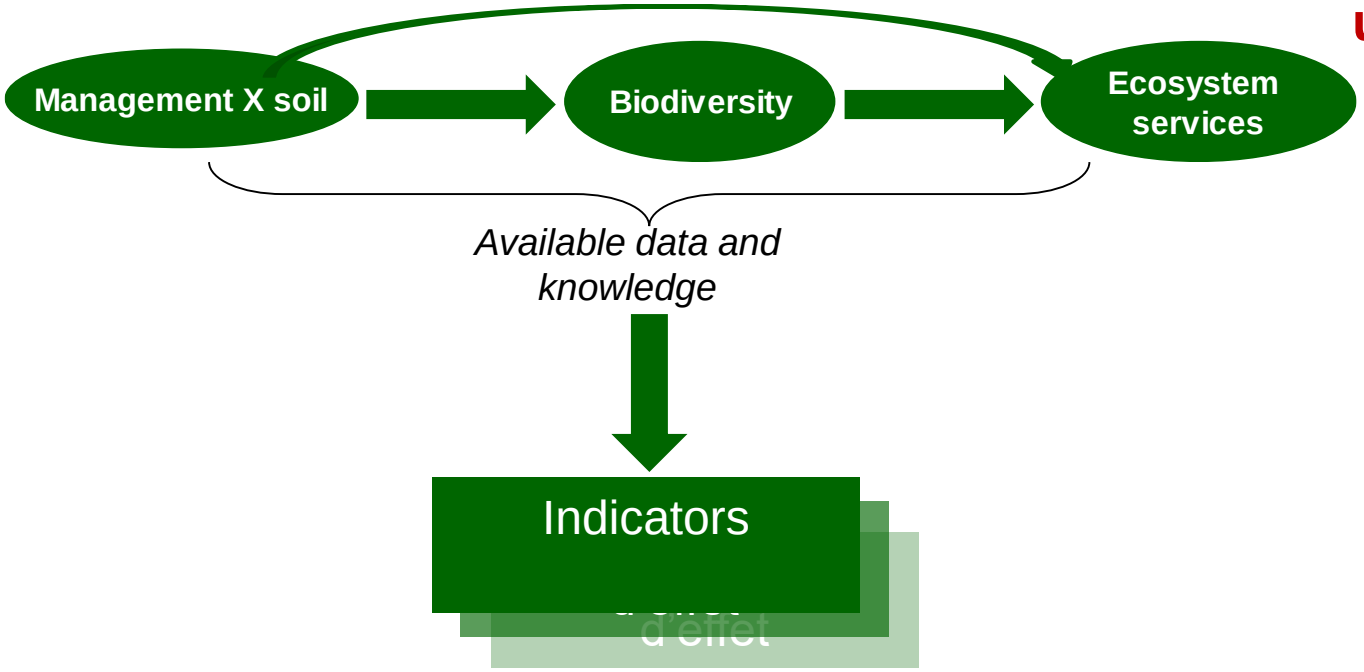
(A research priority, French agriculture project)

Maximisation of ecosystem services (ES)

Assessing ES & understanding their determinism



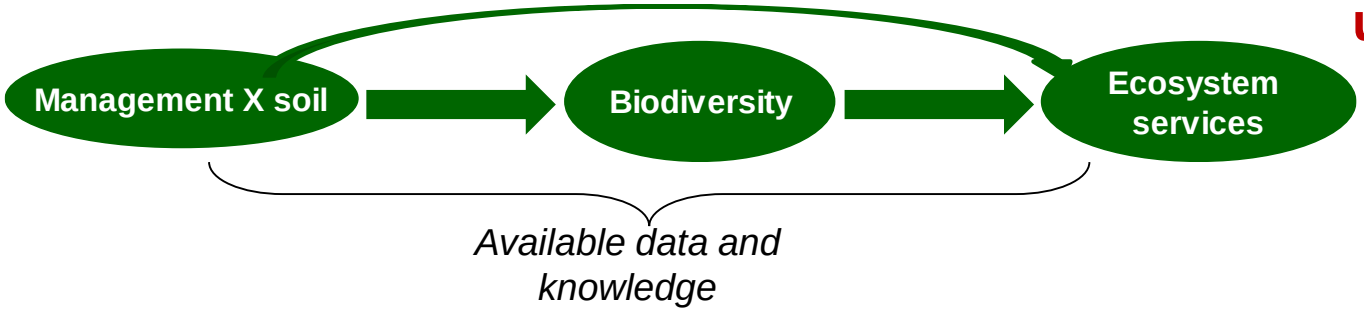
Structuration of the research project



Axis 1
Knowledge and understanding of process

Axis 2
Indicators
and multicriteria (integrated) assessment

Presentation of Axis 1



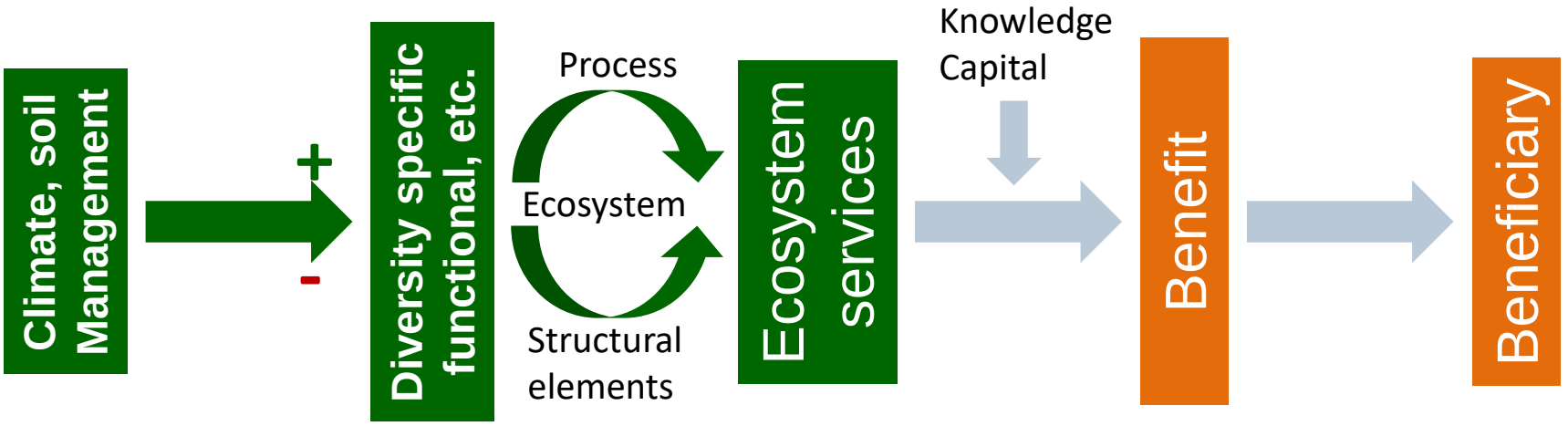
Axis 1
Knowledge and understanding of process

Indicators

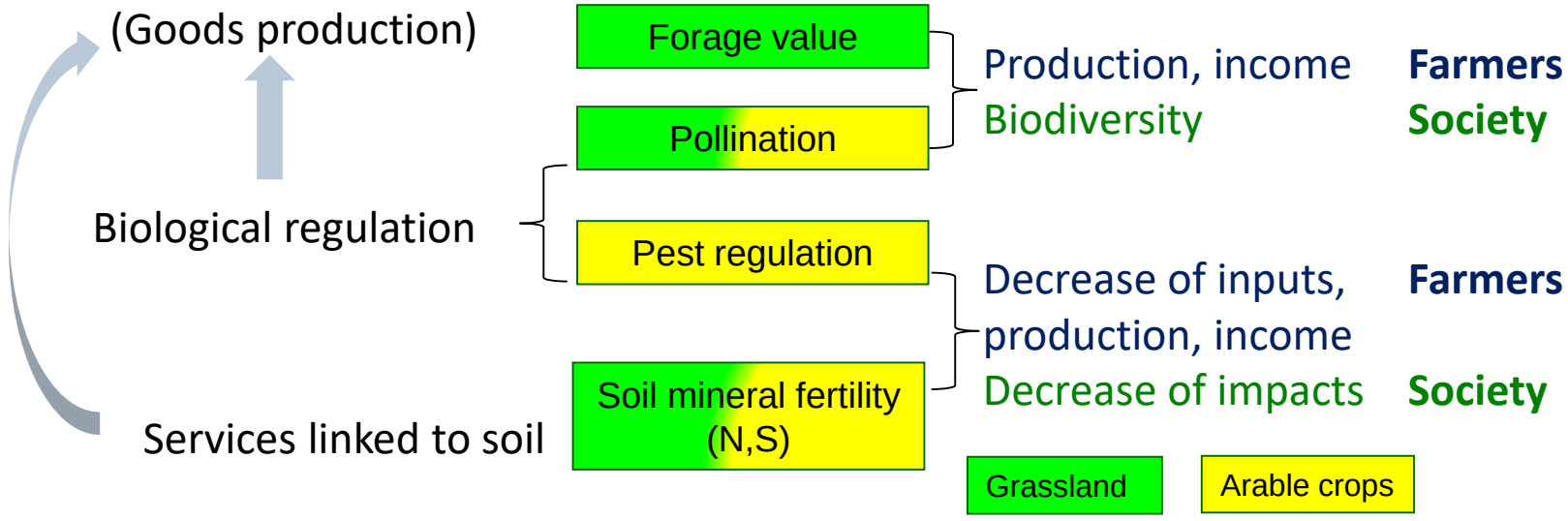
d'effet

Axis 2
Indicators
and multicriteria (integrateded) assessment

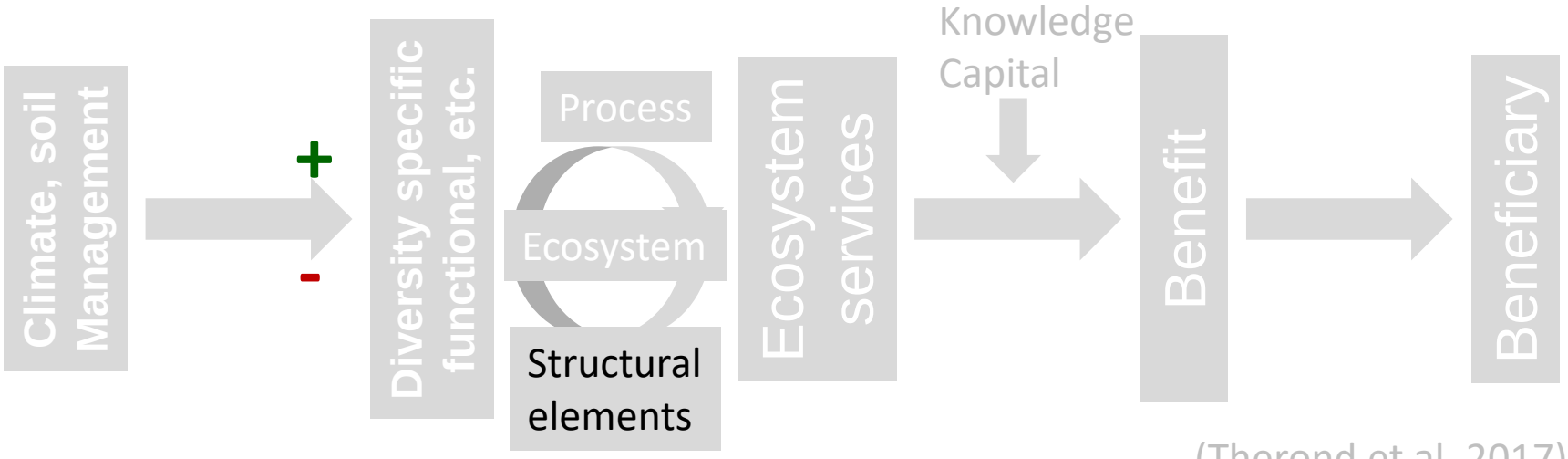
ES: conceptual framework and ES studied



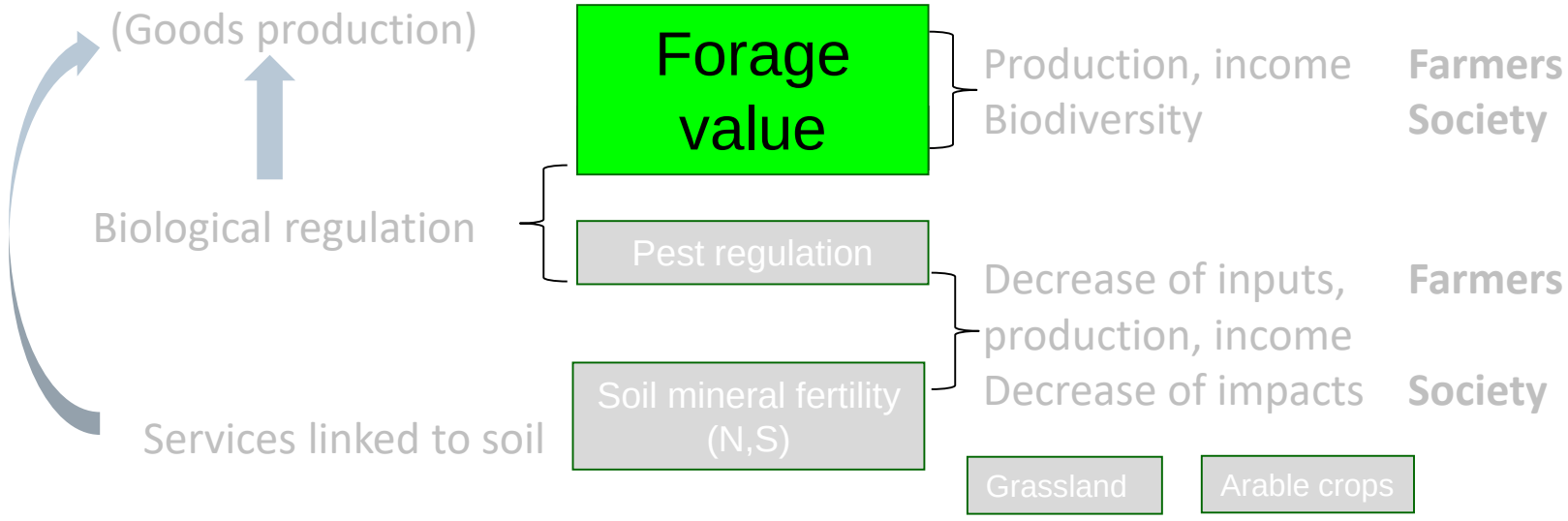
(EFESE study Therond et al. 2017)



Presentation of Axis 1



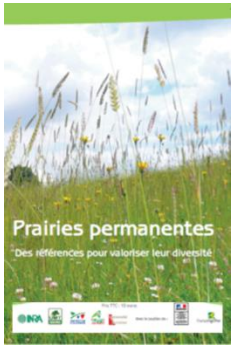
(Therond et al. 2017)



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

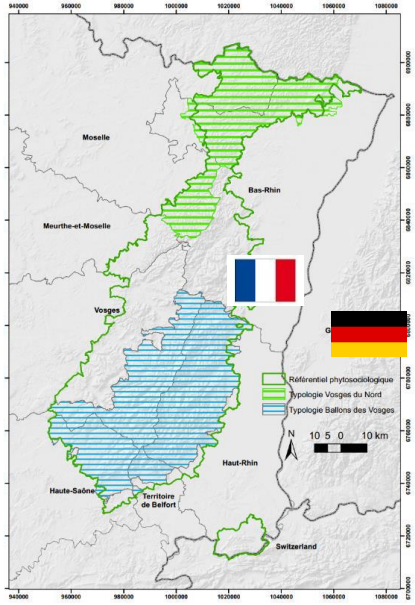
Decision aid tool

MultiSward

http://www.multisward.eu

EU FP7 2010-2014

(Plantureux et al. 2014 EGF)



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

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laboratoire agronomie et environnement

A new service studied: animal heath 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,*[,†] Alice Michelot-Antalik,[§] and Sylvain Plantureux[§]

[†]Laboratoire Agronomie et Environnement, INRA, UMR 1121, Colmar, 29 rue de Herrlisheim, F-68021 Colmar Cedex, France

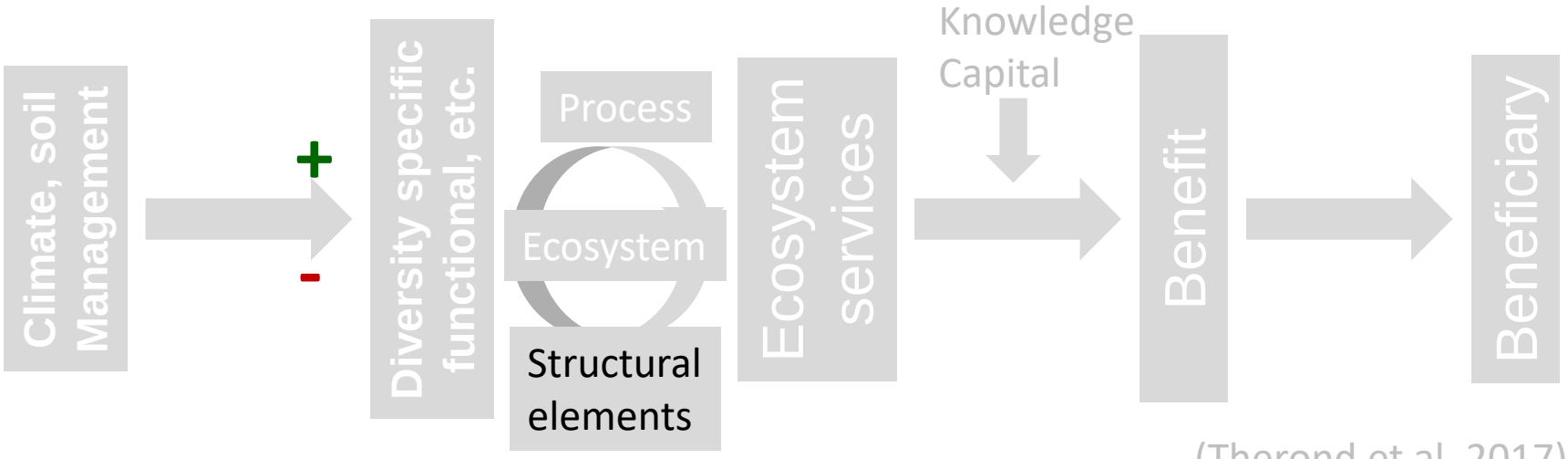
[§]Laboratoire Agronomie et Environnement, Université de Lorraine, UMR 1121, 2 Avenue de la forêt de Haye - TSA 40602, F-54518 Vandœuvre-lès-Nancy Cedex, France

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-

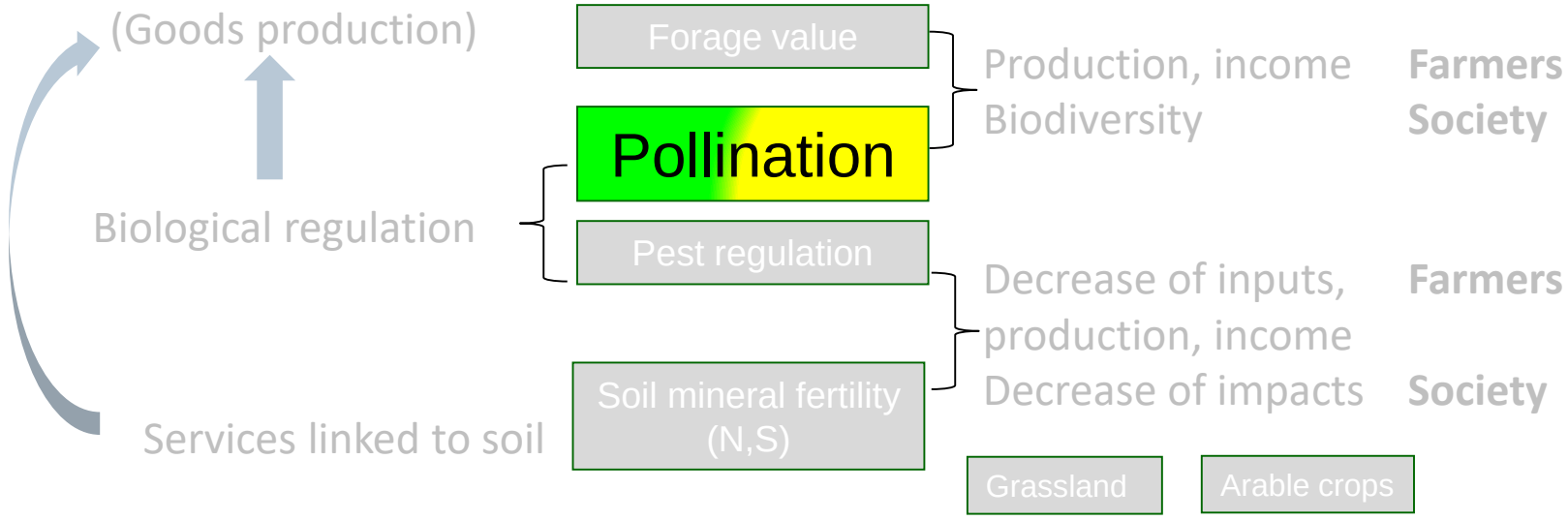
Just first results

Methodological work on analyse of anti-oxydants

Presentation of Axis 1



(Therond et al. 2017)

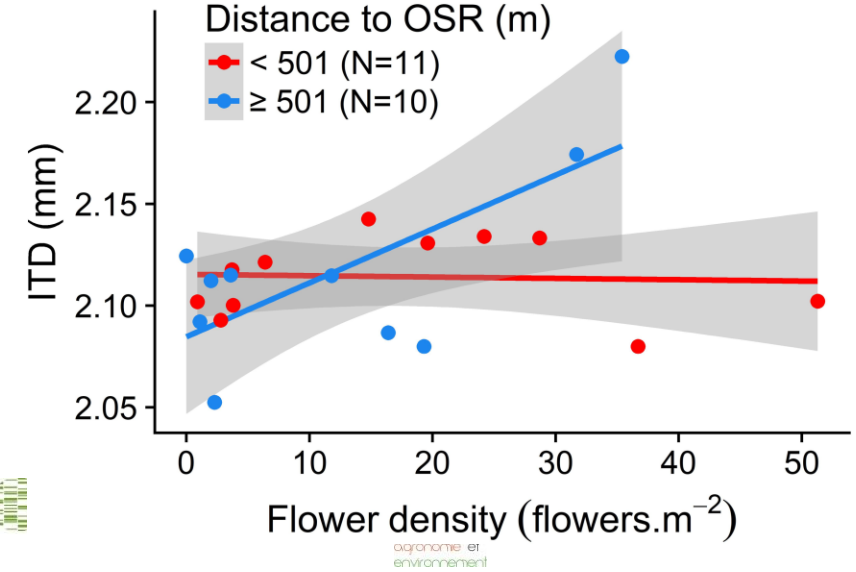


Pollination at landscape level

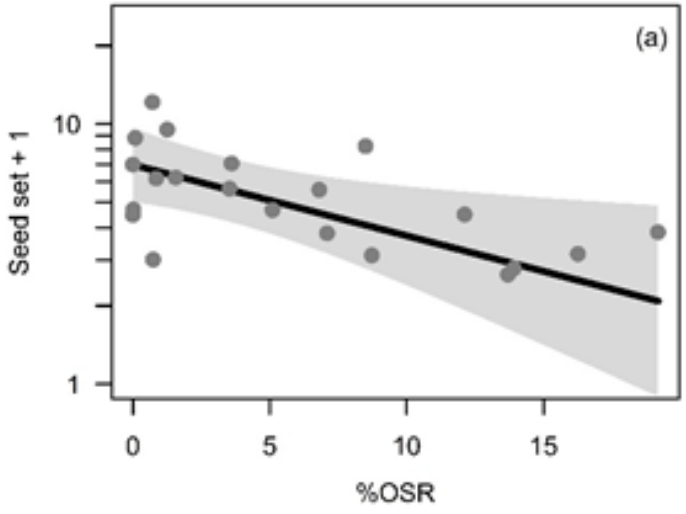
Interactions management X landscape on pollinators and pollination service?

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)*

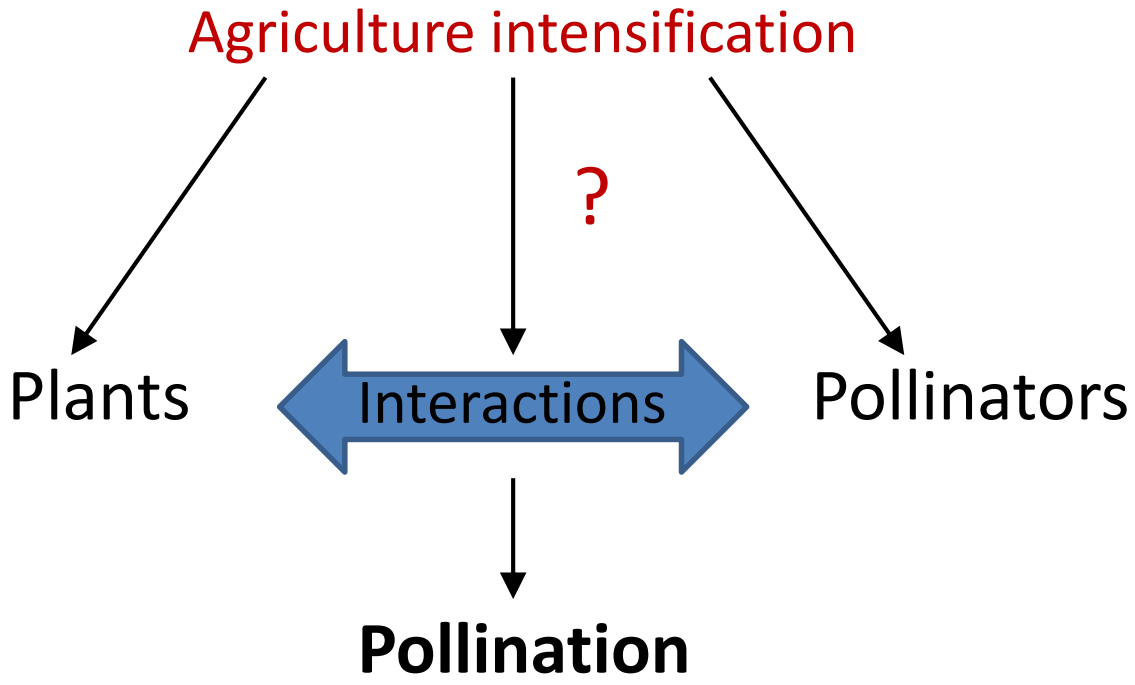


Effect on % OSR on seed set of *Cardamine pratensis* *(van Reeth et al; submitted AEE)*



Pollination at field level

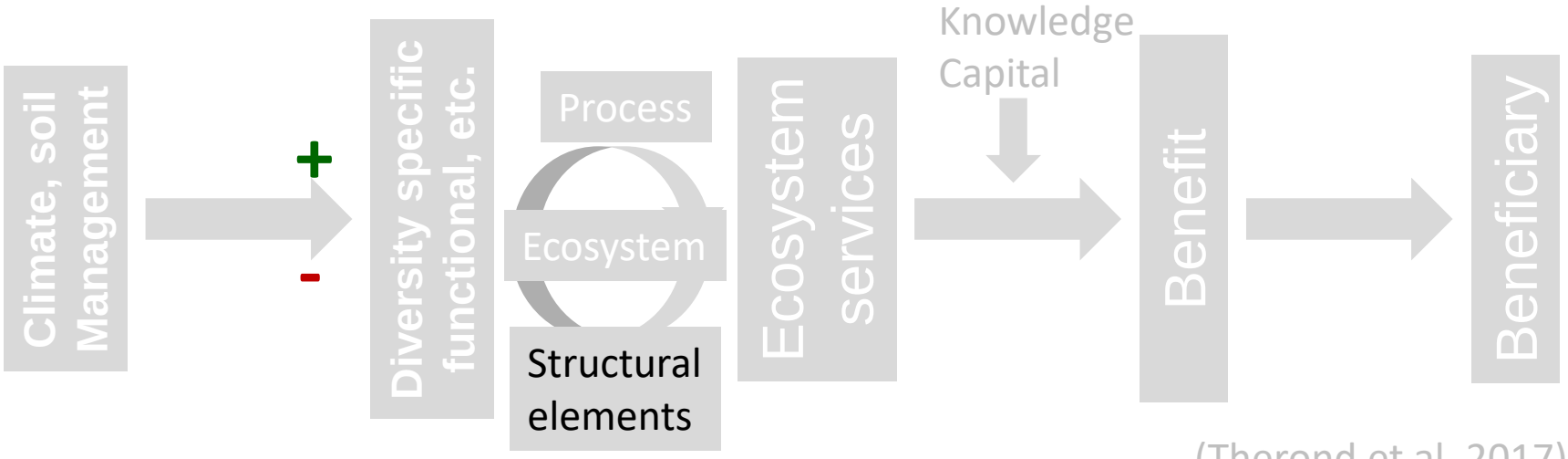
Which relation between agriculture intensification and “trait matching” mediating trophic interactions (Le Provost et al. 2017)?



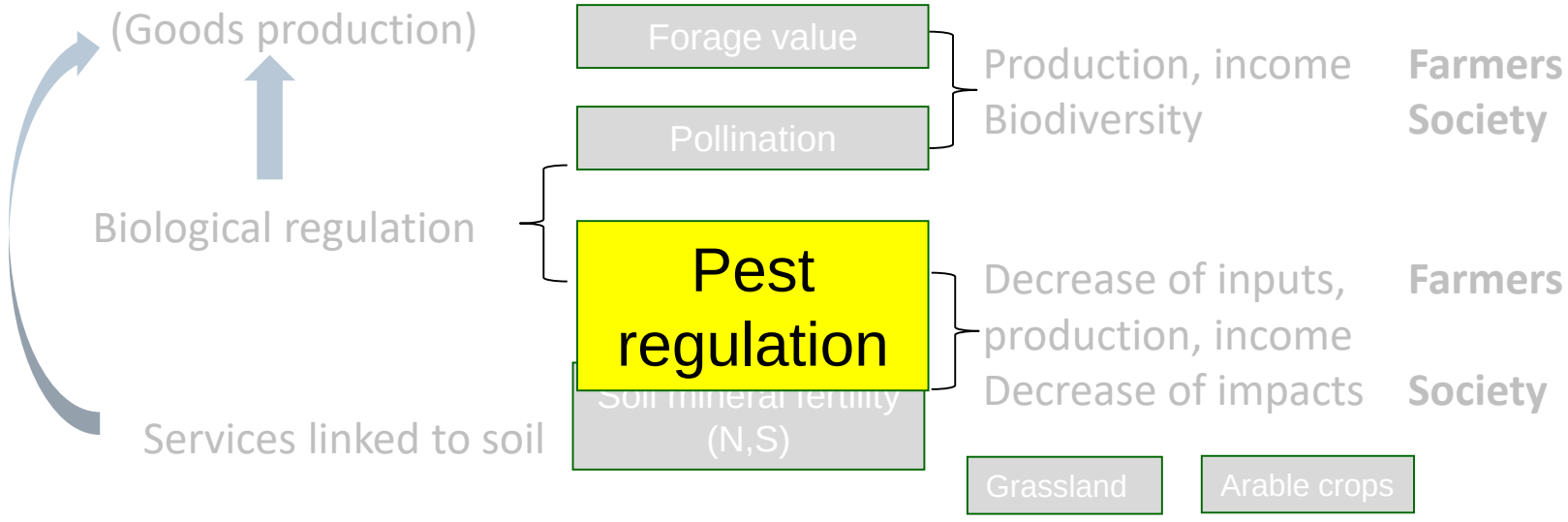
PhD Jérémie Goulnik (2017-2019):

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

Presentation of Axis 1

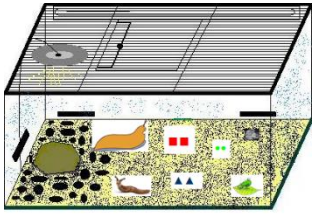


(Therond et al. 2017)



Pest regulation

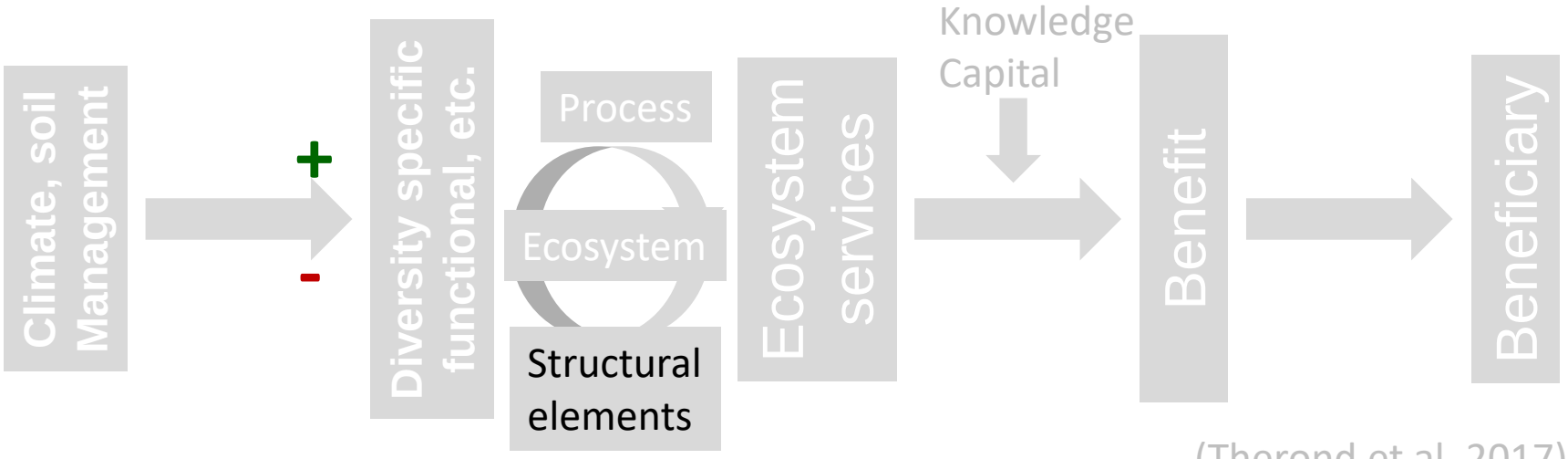
- Effect of large beetles and not of size diversity on predation *(Rouhaba et al. 2014 EE)*



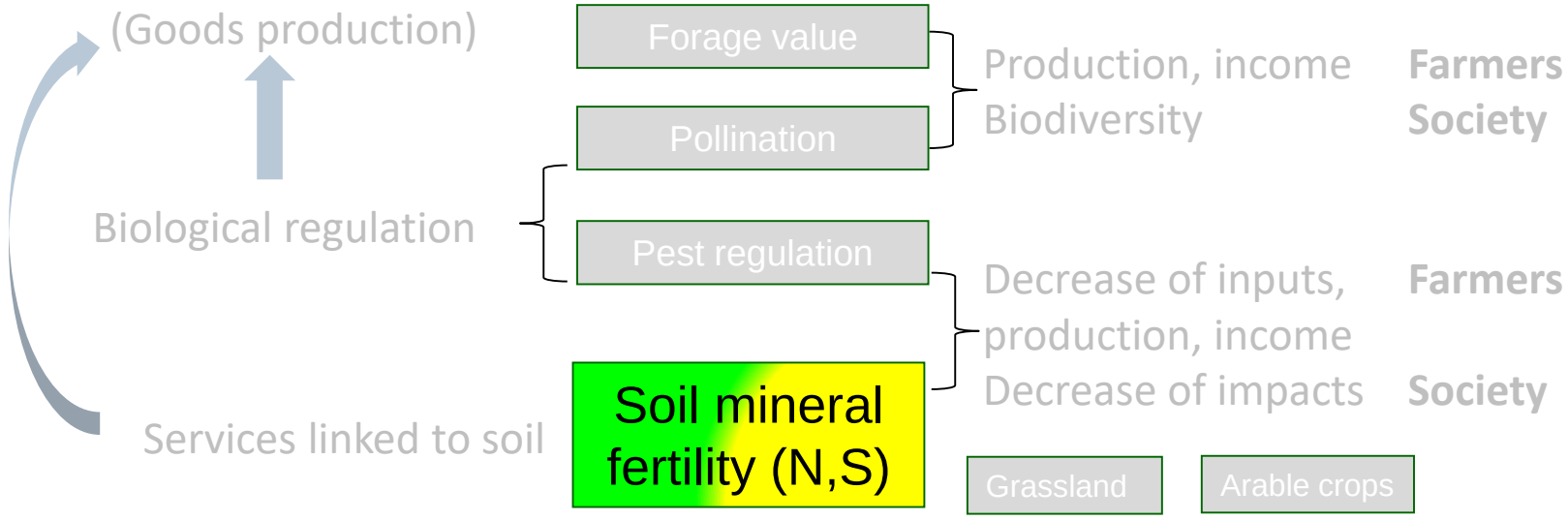
- Effect of field margin vegetation *(Rouhaba et al. 2015 AEE)*
  - Vegetation homogeneity and bare soil → Large species favoured
  - Vegetation heterogeneity → Small species

- 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



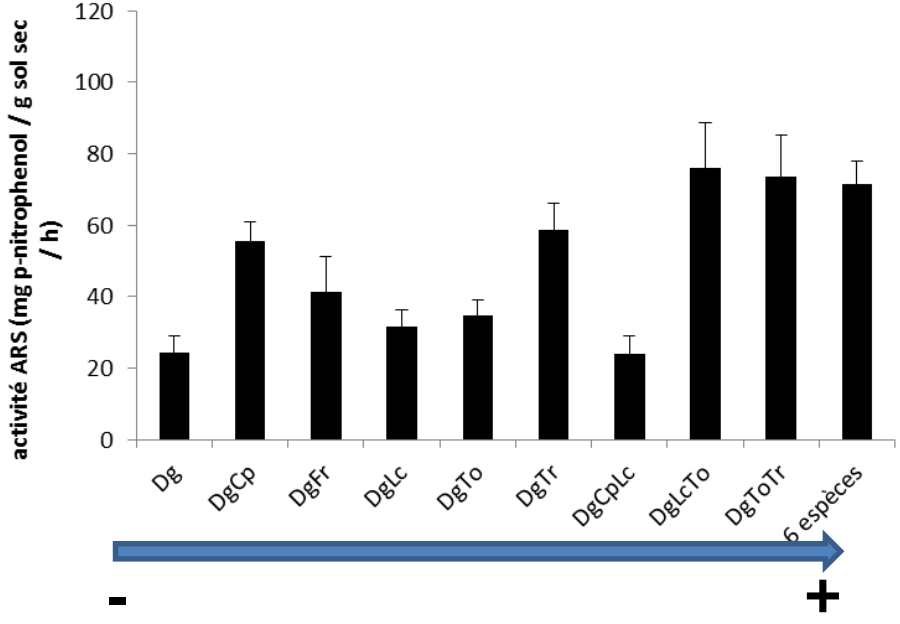
(Therond et al. 2017)



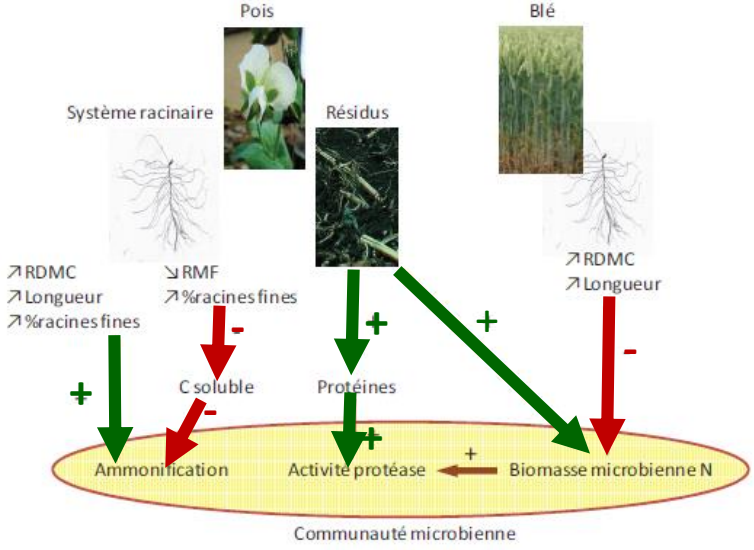
Interactions plant and microbilal communites

Interactions plant traits and microbial traits on N/S fertility

Effect of plant diversity on S mineralization (ARS activty)



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



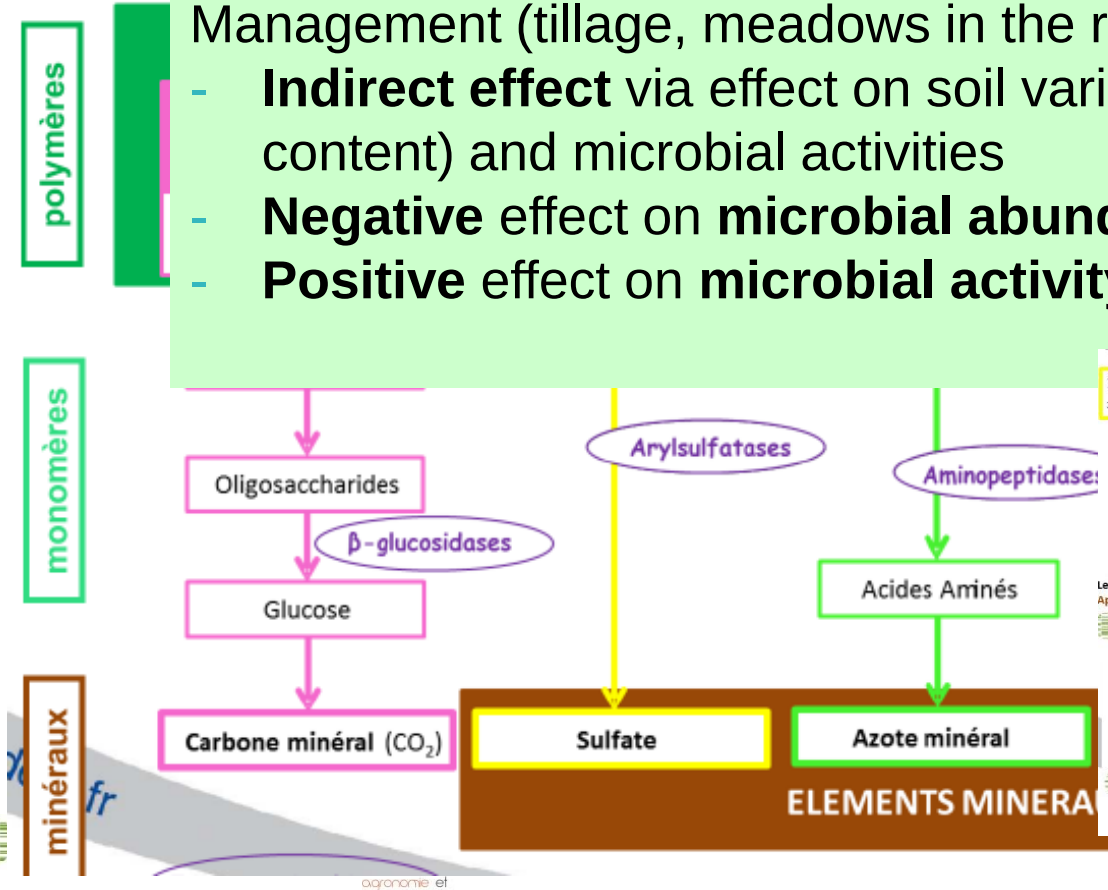
Potential N mineralization of soil

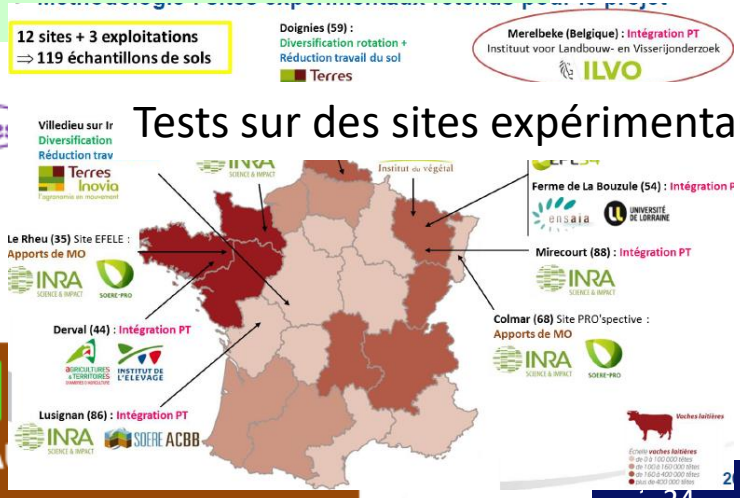
Effect of management on potential mineralization of soil

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

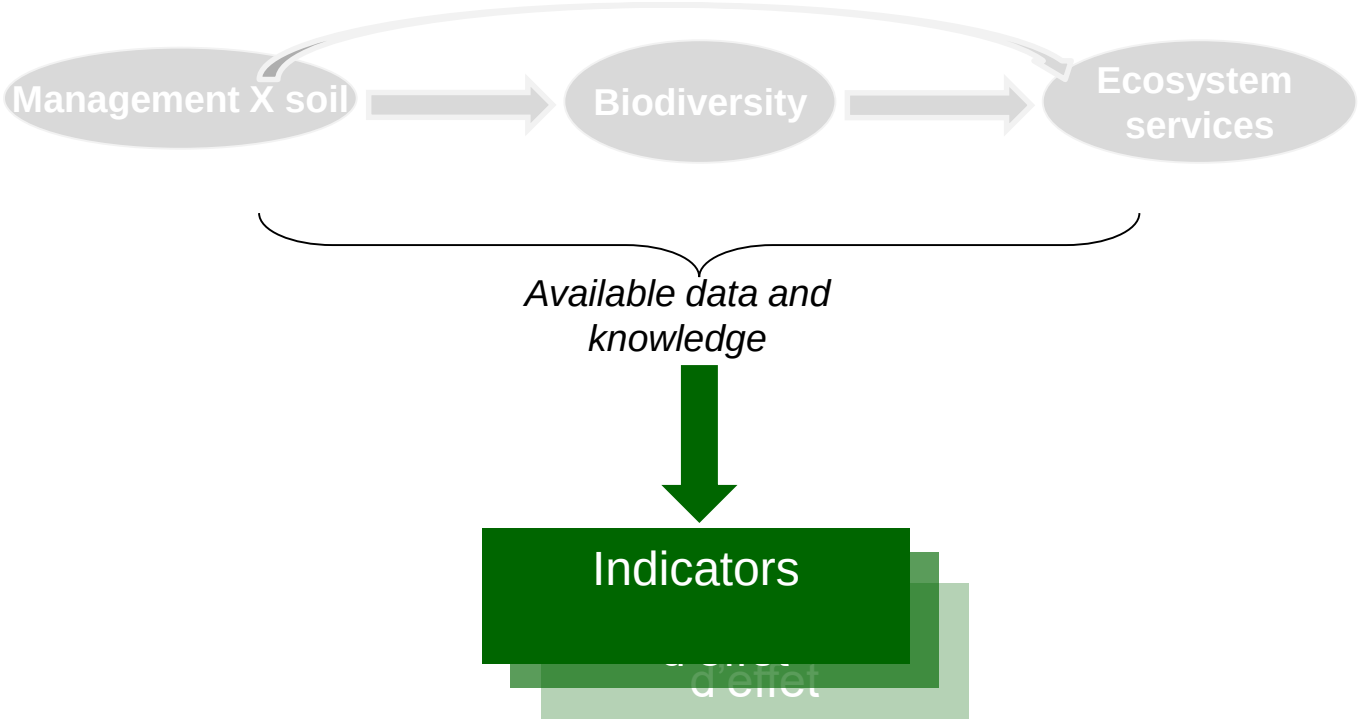
Management (tillage, meadows in the rotation, mineral N):

- **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



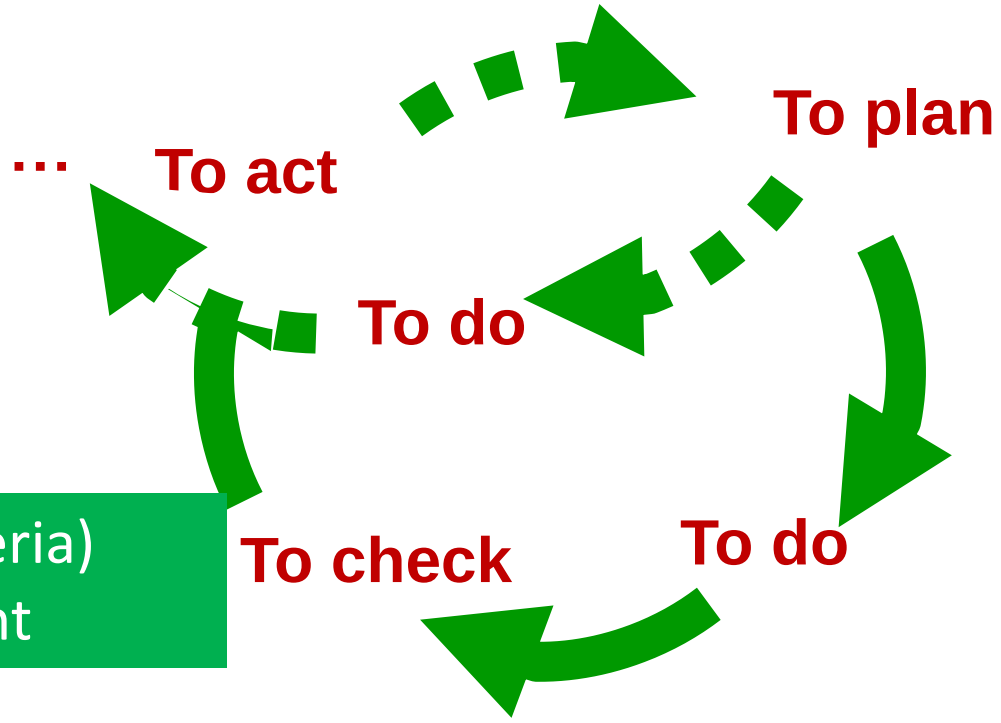
Axis 1
Knowledge and understanding of process

Axis 2
Indicators
and multicriteria (integrated) assessment

The need of assessment/evaluation

The sustainability issue:
A "driving illusion?"

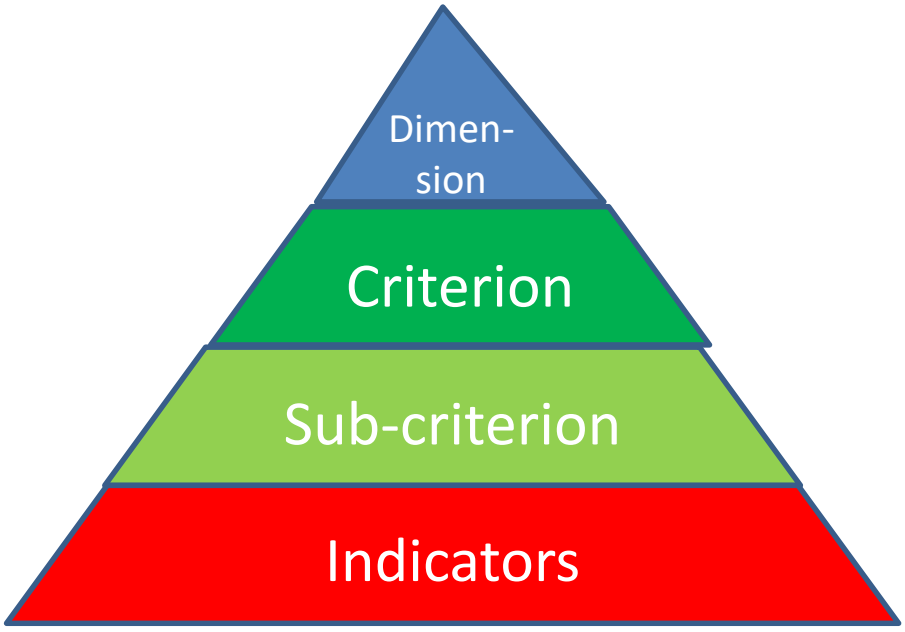
(Lascoumes, 2005)



(Multicriteria) assessment

(Meynard et al. 2002)

The conceptual framework

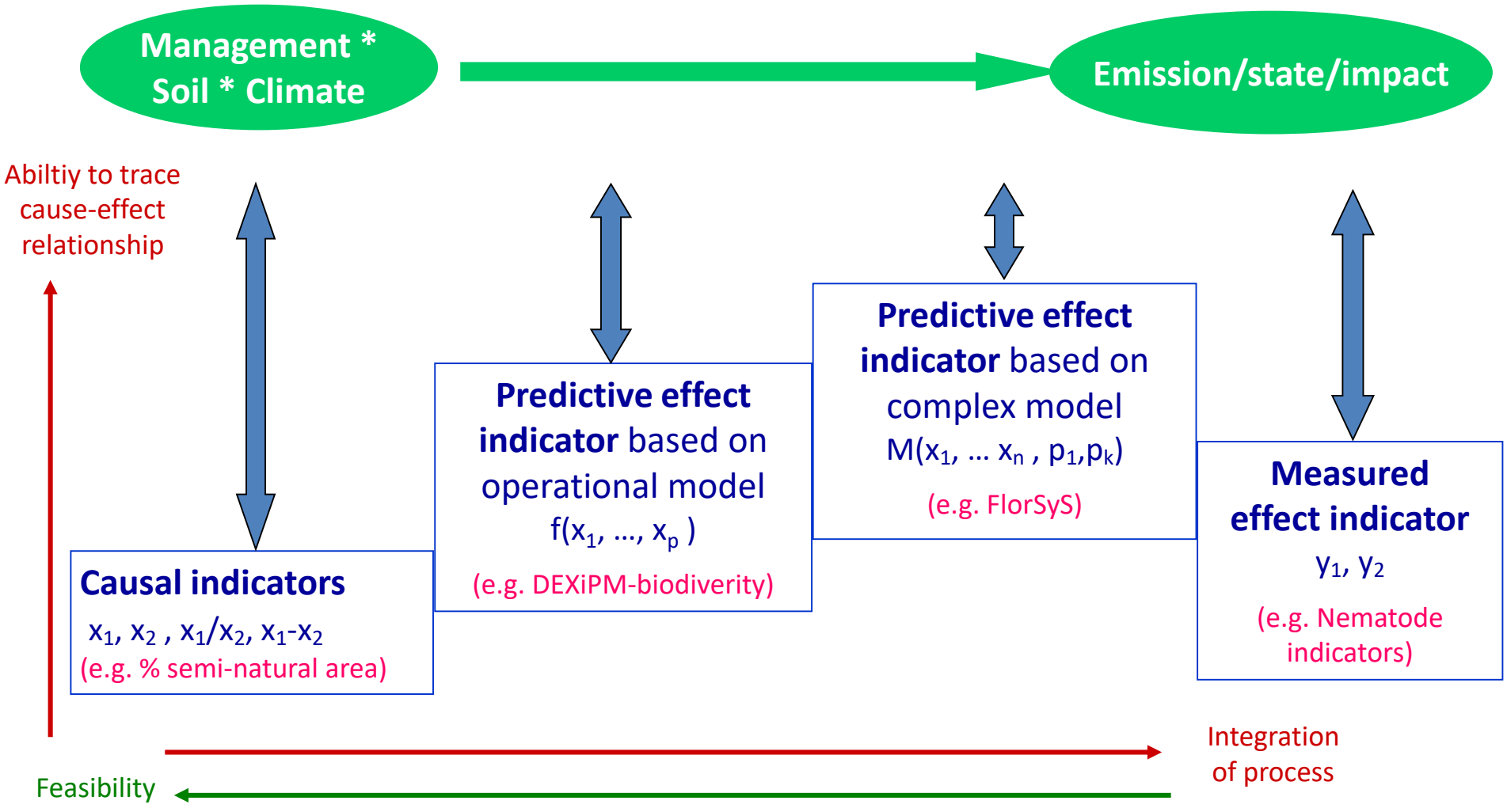


Examples	Synonyms
Environment	Aspects, domain, pillar
Biodiversity	Attribute, component, impact category, issue, principle, theme
Floristic	
Vascular plant species richness	Parameter, metric, proxy

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

A typology of indicators

(Bockstaller et al., 2015; Larrez, Reschet et al. 2015)



Each type for a given purpose

(Bockstaller et al. 2015 OCL)

Example 1: pollination value of field margin

Weed predicted by FlorSys model (COSAC project ANR)

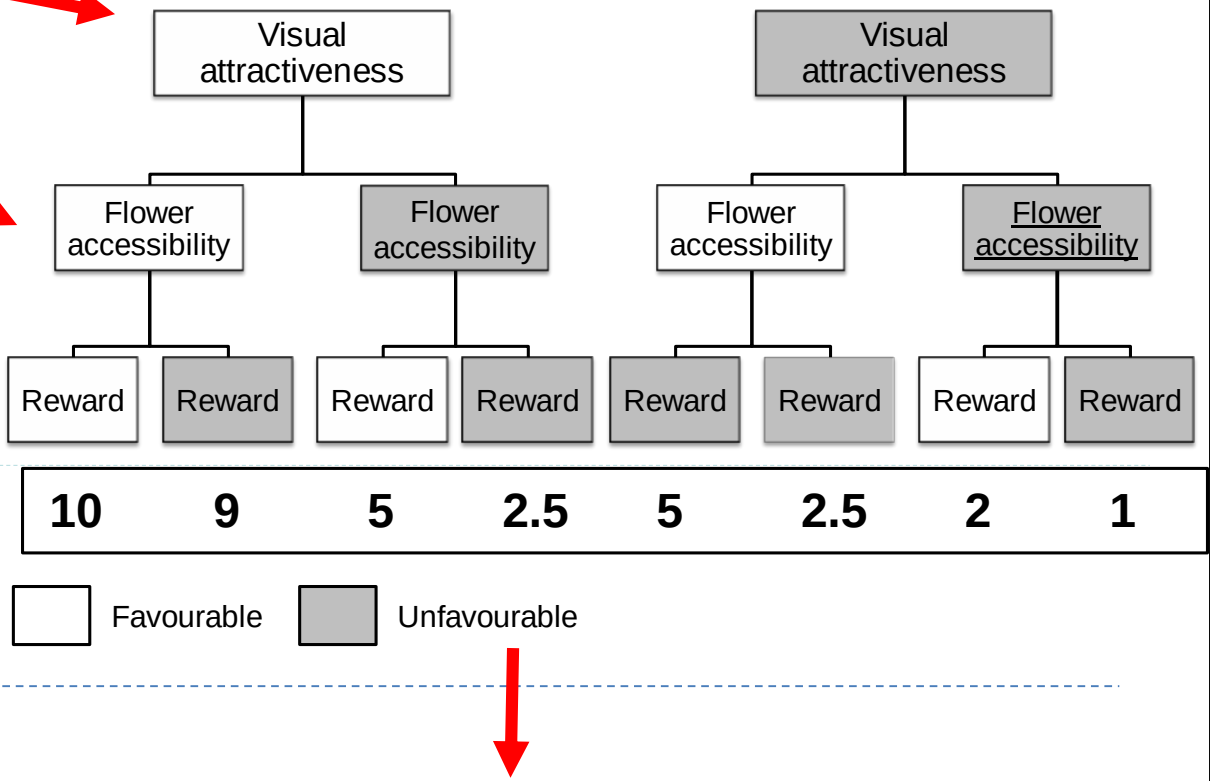
Database on flower traits of species

Flower size, colour and UV reflect

Botanical family, symetry and shape

Quantity and q… of nectar a…

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



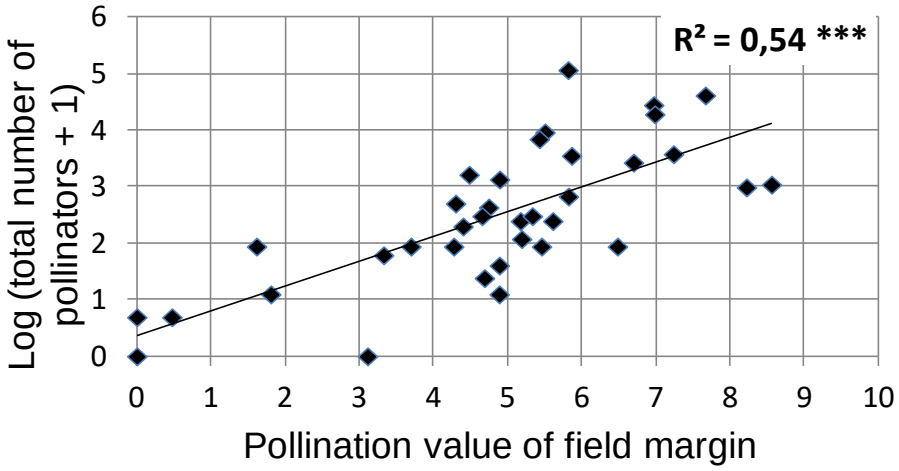
(Ricou et al. 2014, EI)

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

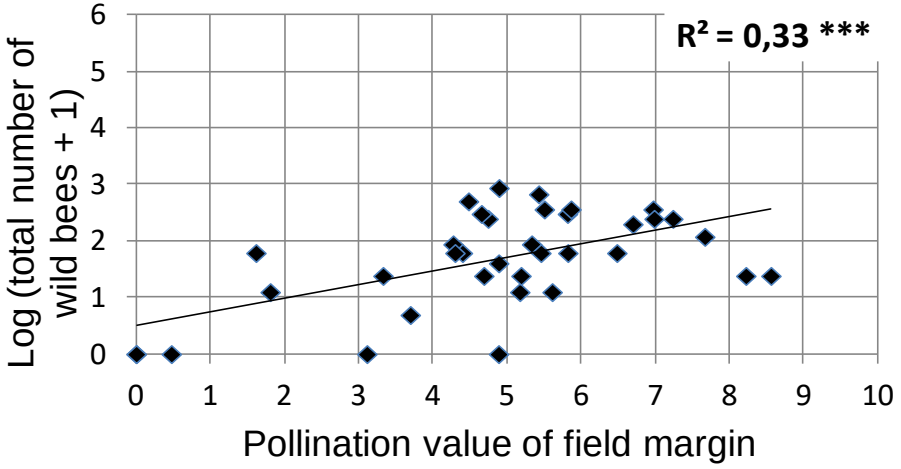
INRA SCIENCE & IMPACT — UNIVERSITÉ DE LORRAINE — lae laboratoire agronomie et environnement

Evaluation of predictive quality of the indicator

Total number of pollinators vs. Indicator (bee)



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

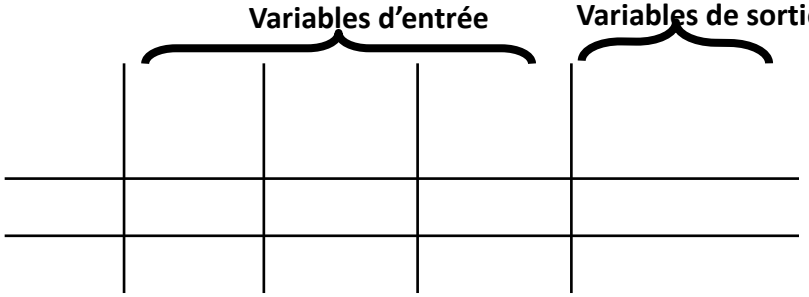


- Similar results for bumblebees and hoverflies

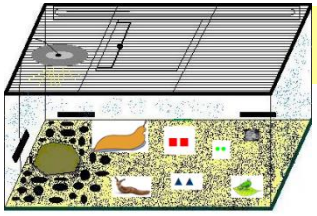
Example 2: Icarab assessing the predation potential by beetles

Development steps:

Field data — Entomophages project

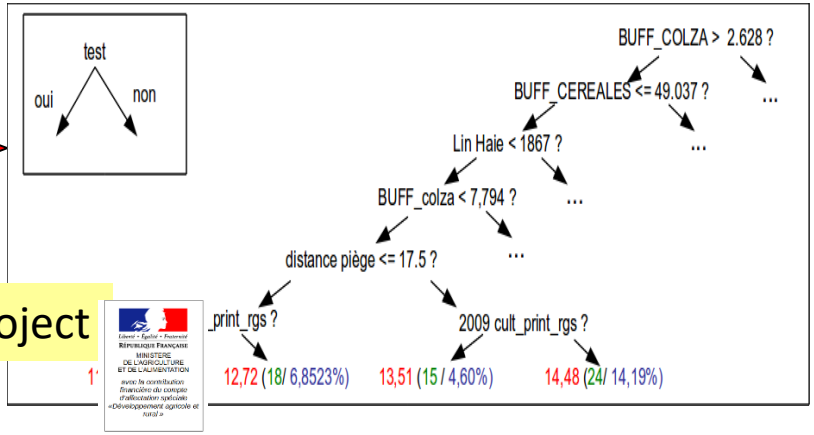


New knowledge and data



Rouhaba et al. (2015)

Auximore project



ARENA project

Production of decision tree

Indicateur I_{carab} prototype 0.1

Transformation in indicators

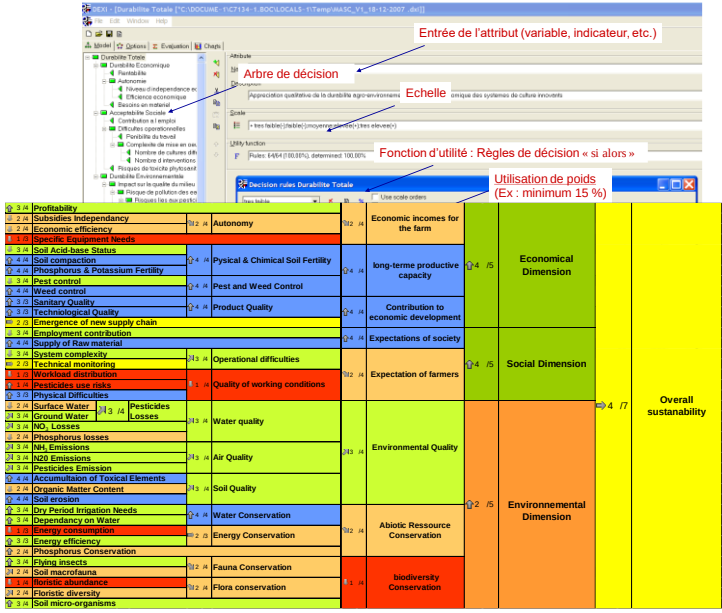
Assessement by target users (agric CIVAM, ACTA….)

To aggregate or not ?

- Composite agregation 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



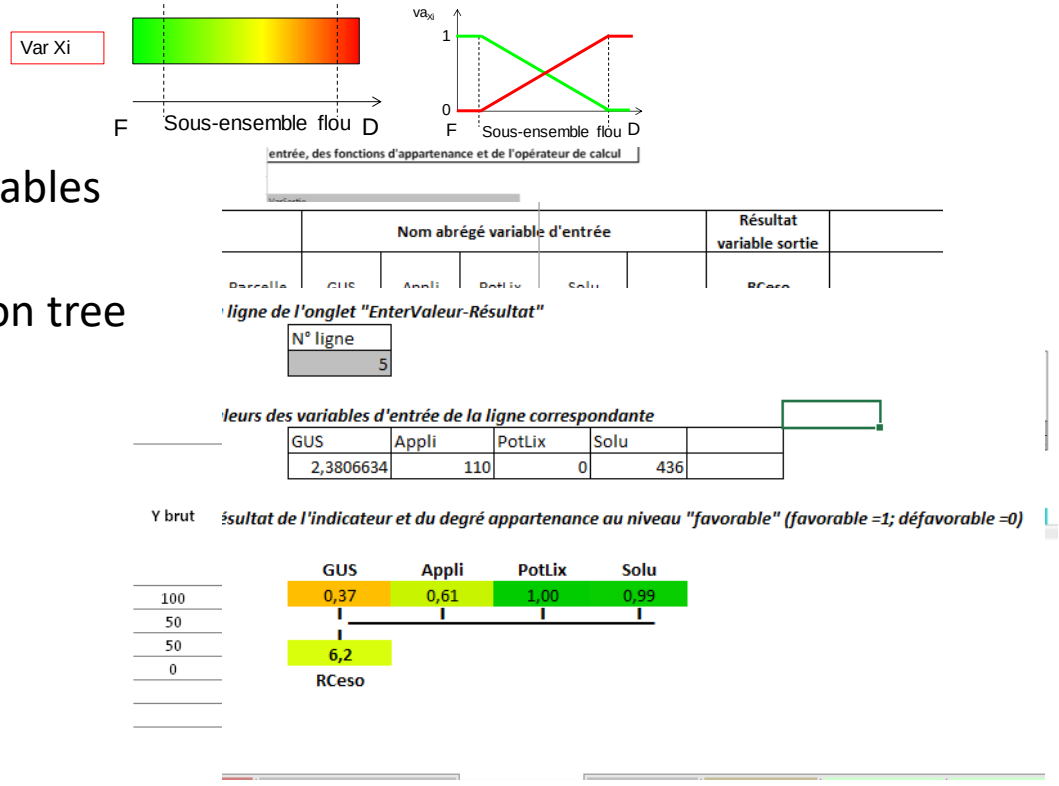
(Sadok et al. 2008, 2009 ASD; Bockstaller et al. 2017 EMS)

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

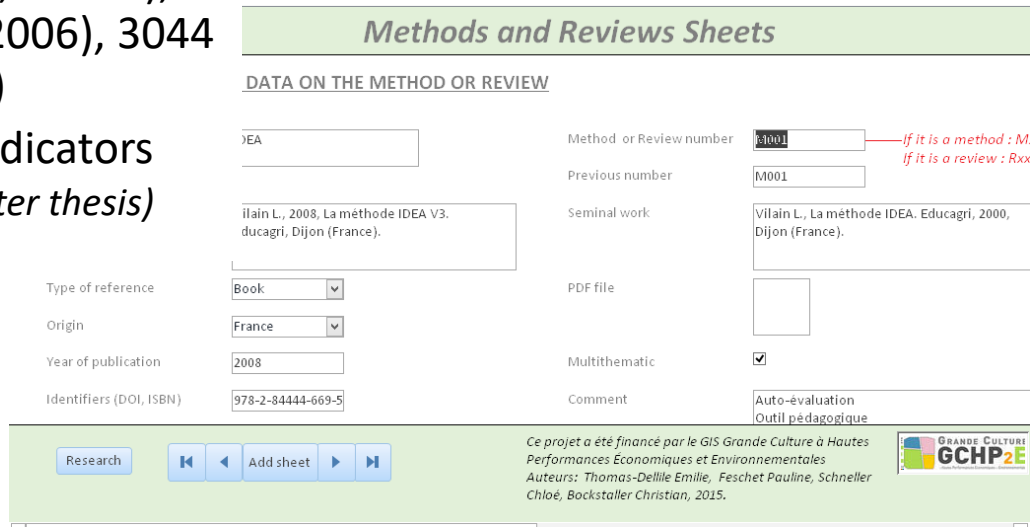


(Bockstaller et al. 2017 EMS)

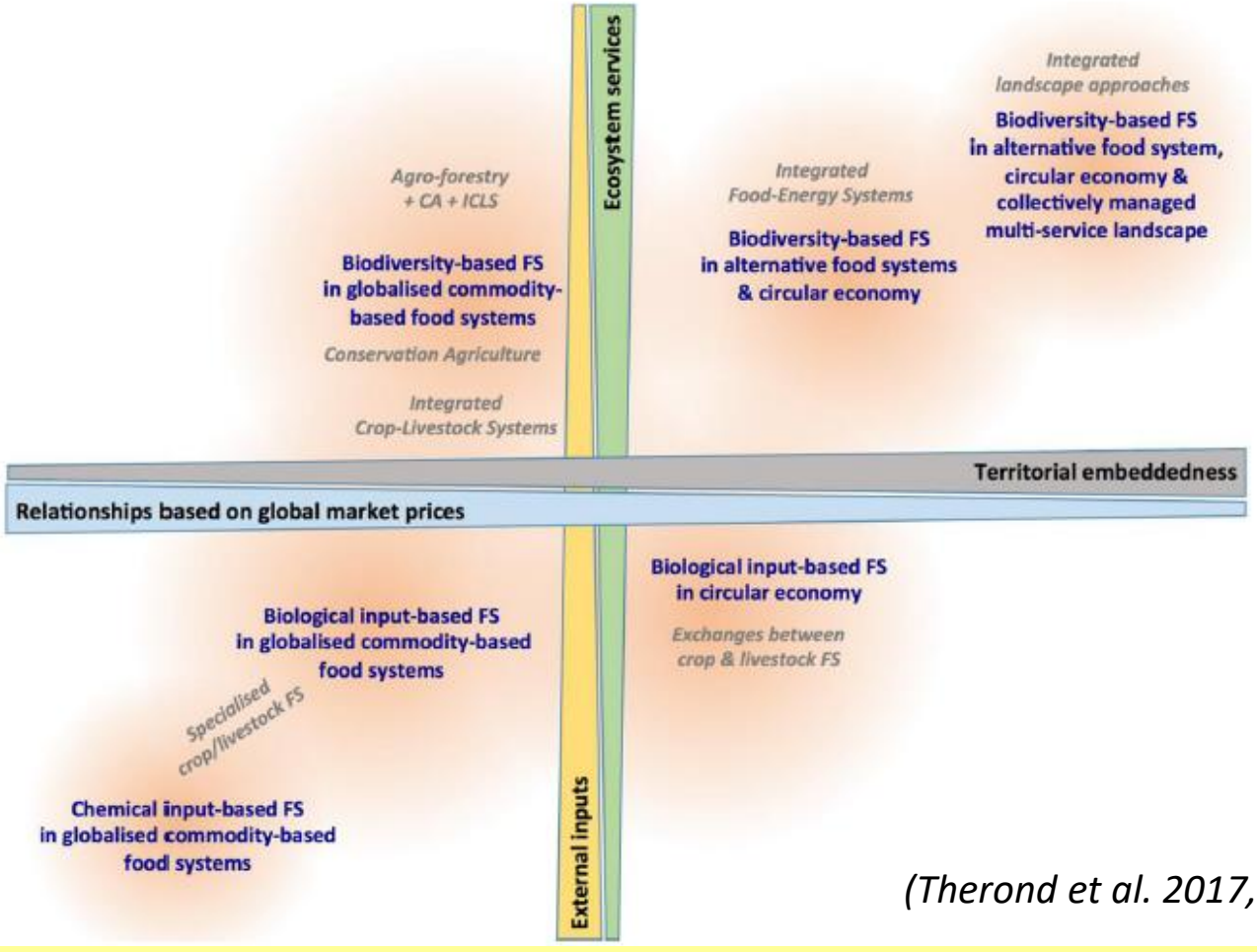
Indicators and methods reviews

- 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)*



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 ths framework

The MAELIA platform

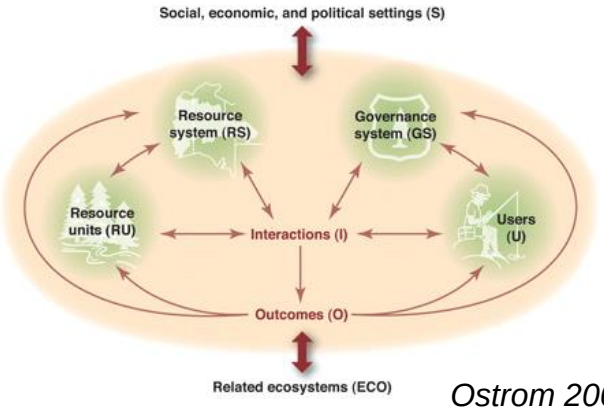
- **Generic platform** for integrated assessment and modelling (IAM) of **social-ecological systems at territorial level** (local to regional) for **landscape design**/planning and management

- Representation of **dynamics and interactions between the 4 sub-systems of social-ecological systems**

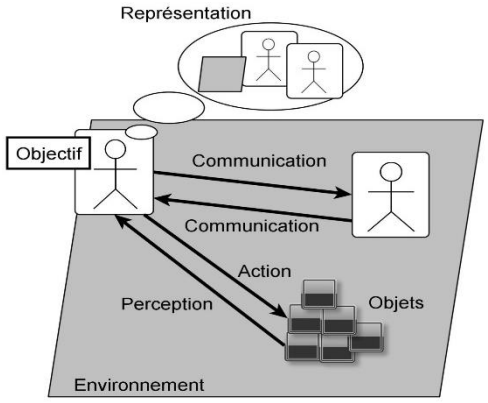
- Agent-based architecture: **autonomous human agents** with a representation of their biophysical and social environment that drives their **actions**

→ Representation of **specific individual situations** (e.g. farmer, dam manager) with **parsimonious modelling** (AqYield, SWAT, etc.)

→ Bottom-up model of emerging properties/processes



Ostrom 2009



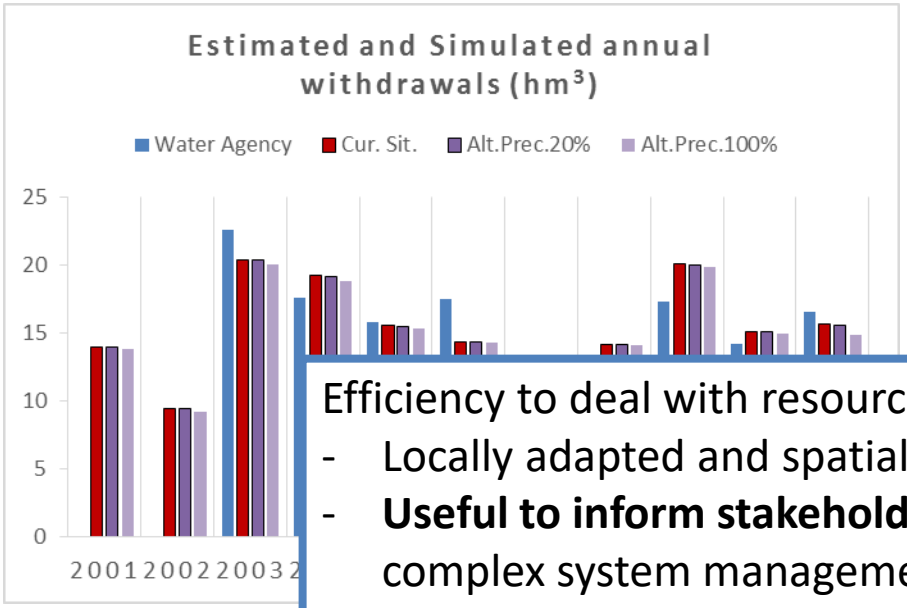
Ferber, 1995

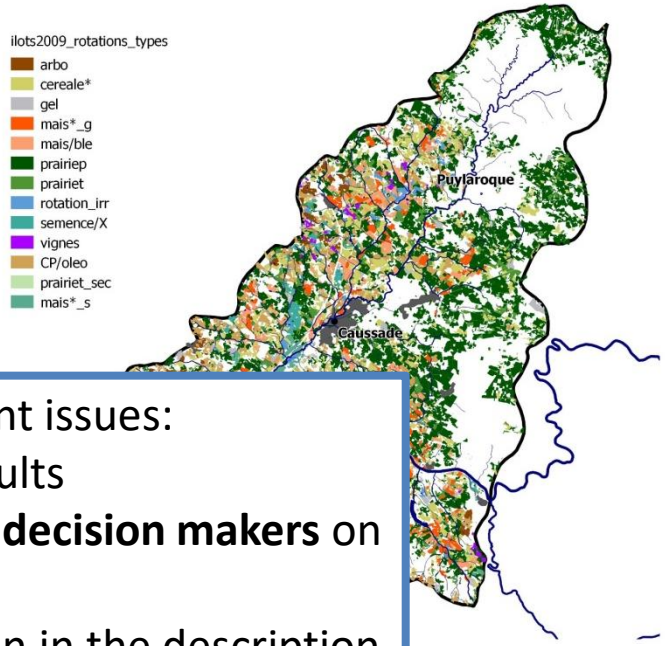
Description of decision rules for cropping systems

NOM_ITK_AFFICHAGE	*	maist_g_ter
IDS_SDCS	[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]	O
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]	O
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]	O
RECOLTE_TEMPS	[Ha/h]	3
RECOLTE_TEMPS_INTERNE	NA	O
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]	O

The MAELIA plateform: example of application

- Example of application of MAELIA to deal with **quantitative water resource management**: « Aveyron aval » territory, 800 km^2:
  - 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





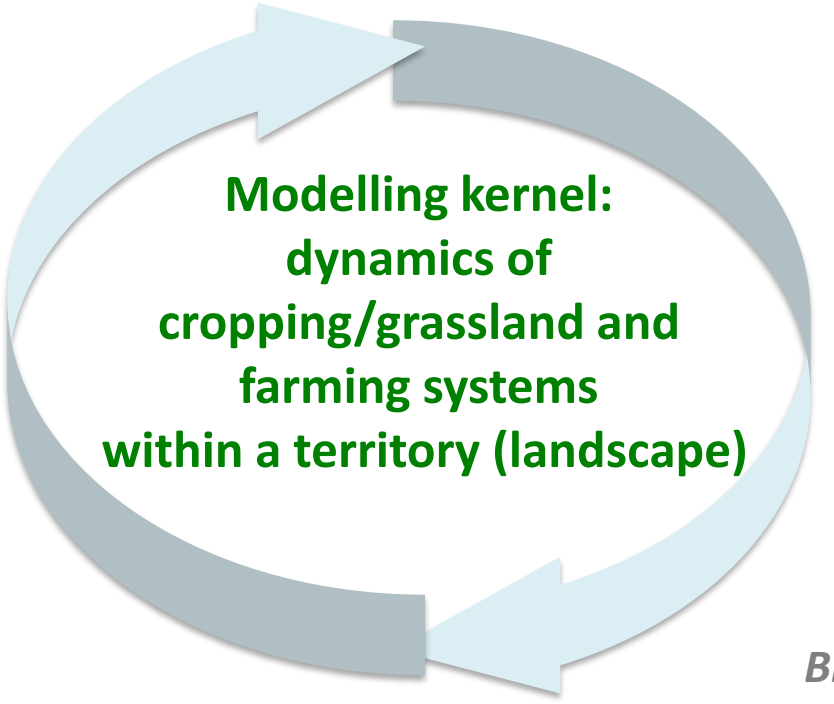
Efficiency to deal with resource management issues:

- 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)



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)

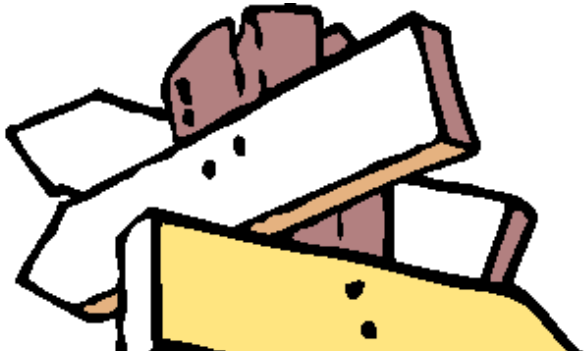
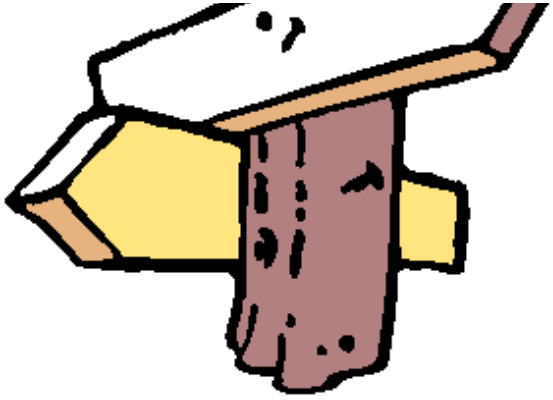
- Involved in WP4 T 4.1
  - Contribution to the indicator list (n=29)

Proposal of criteria	Dimension	Principle for the choicie of indicators	Proposal of indicator (with increasing complexity			
Water quality (nitrate)	En	For nitrate: either a predicive (from model) or measured one, or two indicators assessing nitrogen surplus and soil cover in winter. Can be completed by one for P (one compoent on	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. (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, 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 assesing impact (or use) of pestcide)?	TFI	Pesticide risk indicator		
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
	Feasability					
		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