TOWARDS AN AGRICULTURE SUPPORTIVE OF BIODIVERSITY

Synergies between biodiversity and soil organic matter
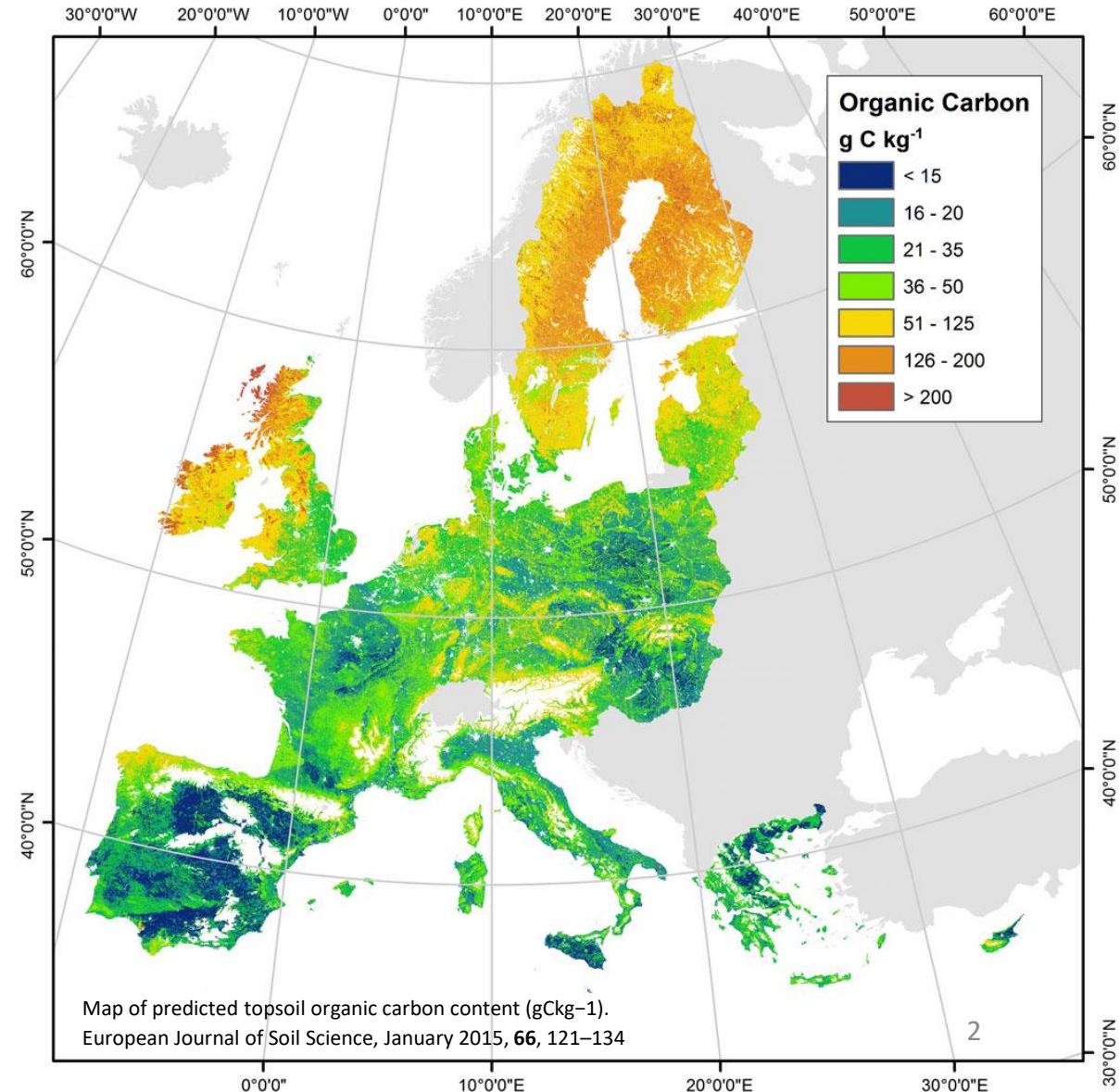
Vincent MANNEVILLE   IDELE

Sylvain FORAY   IDELE

10th ATF seminar (virtual meeting)   21st April (9:30-13:00 CET)

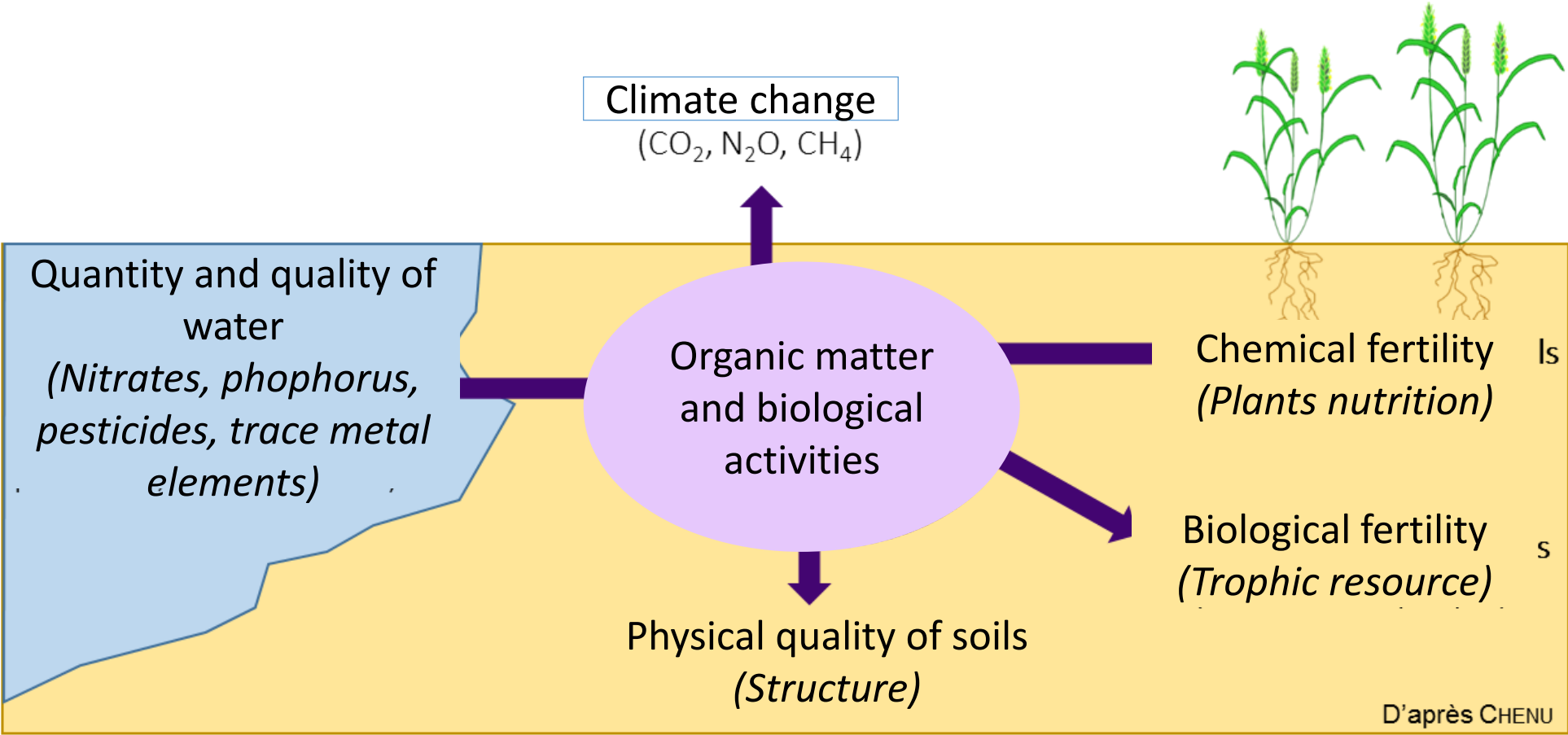# In Europe, around 45% mineral soils have low or very low C. content (0–2%) in the first horizon (0-30 cm)

The European Commission has identified 8 threats about European soils:

- Erosion
- **Decreasing organic matter (OM) content**
- Contamination
- Waterproofing
- Soil compaction
- **Biodiversity loss**
- Landslides

Map of predicted topsoil organic carbon content (gCkg−1).
European Journal of Soil Science, January 2015, **66**, 121–134

Soil performs essential functions...

The soil is an essential component of the ecosystem that regulates and controls many ecological processes ...

Climate change
(CO_2, N_2O, CH_4)

Quantity and quality of water
(Nitrates, phophorus, pesticides, trace metal elements)

Organic matter and biological activities

Chemical fertility
(Plants nutrition)

Biological fertility
(Trophic resource)

Physical quality of soils
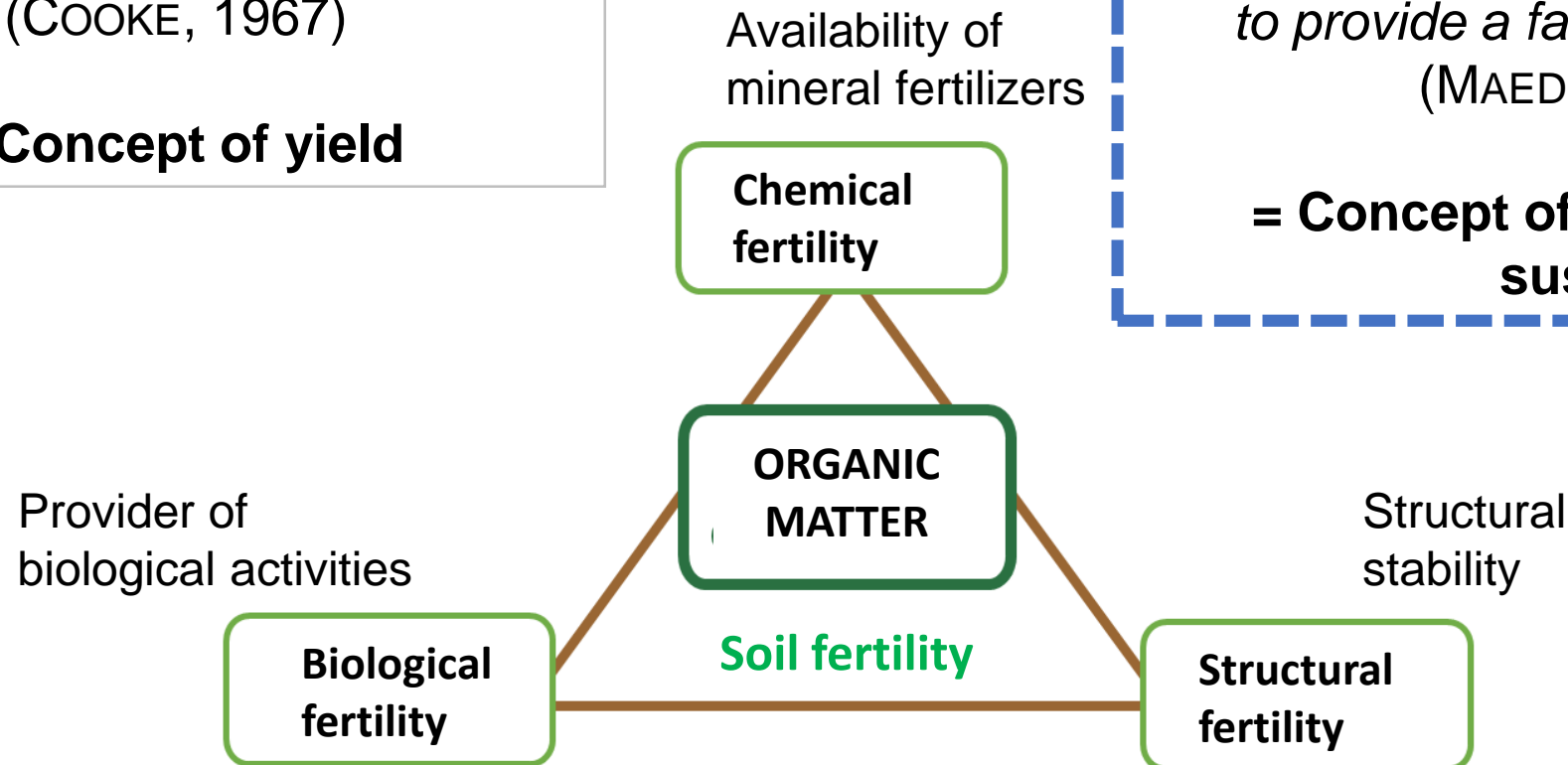*(Structure)*

D'après CHENU

Soil biodiversity: Organic matter is vital to soil healthy

"The capacity of the soil to produce the desired crops."
(COOKE, 1967)

= Concept of yield

Availability of mineral fertilizers

" The capacity of soils to provide essential nutrients for crop growth, to support biological activity and to provide a favourable soil structure"
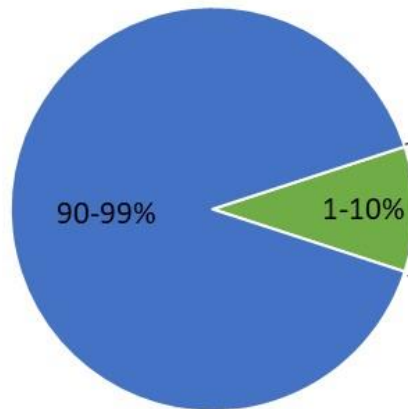(MAEDER *et al.,* 2002)

= Concept of biological activity & sustainability

Chemical fertility

ORGANIC MATTER

Soil fertility

Provider of biological activities

Structural stability

Biological fertility

Structural fertility

What about Soil Organic Matter (SOM)

All organic constituents, dead or live, of plant, animal or microbial origin, processed or not, present in the soil. The weight of micro-organism for a soil with 2,5% of OM is higher 4 t per ha
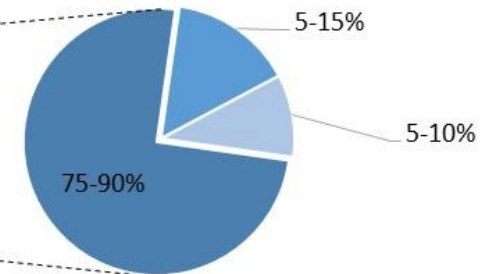
SOIL = Minerals + Organic matter   SOIL ORGANIC MATTER = (live + dead) Organic matter   LIVE ORGANIC MATTER = Micro-organisms + Roots + Macro-fauna

90-99%   1-10%

85%   15%

5-15%
5-10%
75-90%

- Organic matter
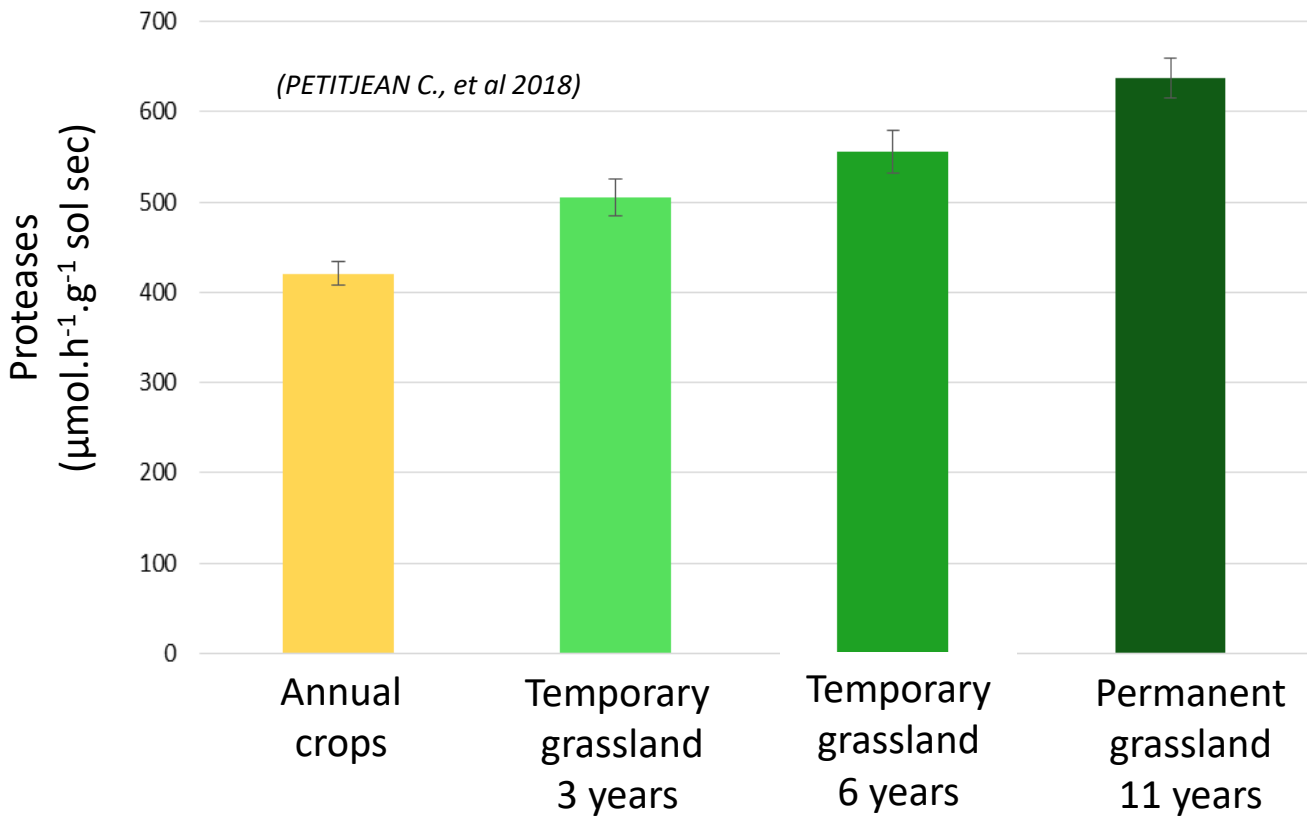- Minerals
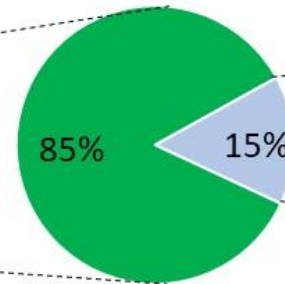
- Live organic matter
- Dead organic matter

- Micro organisms
- Roots
- Macro fauna

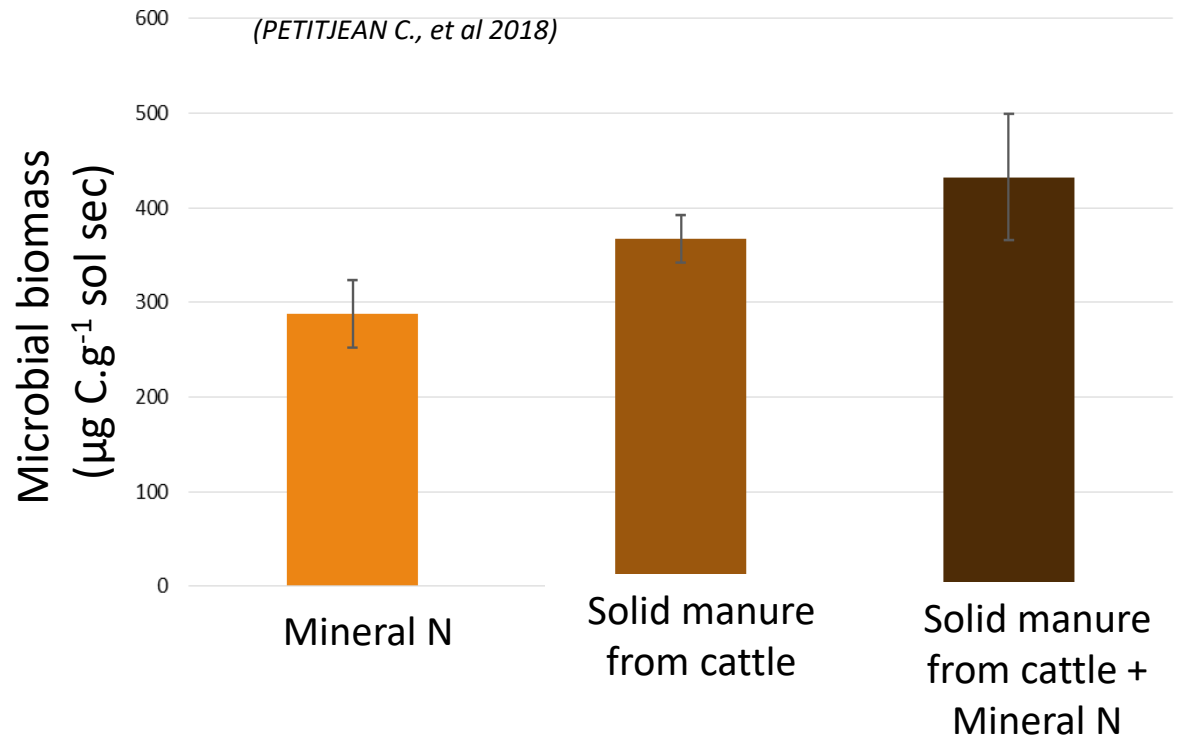*Distribution of organic constituents in soils according to CALVET et al. (2011).*

It's on live organic matter that our studies focused = Biodiversity of soil

Integrating temporary grasslands in crop rotation and spreading organic matter is key to preserve biological activities and ecological services provided by soils

Biological activity under permanent grassland is a reference in term of soil fertility !

(PETITJEAN C., et al 2018)

Proteases ($\mu mol.h^{-1}.g^{-1}$ sol sec)

Annual crops | Temporary grassland 3 years | Temporary grassland 6 years | Permanent grassland 11 years

Solid manure spreading increases the abundance of soil bacteria & microscopic fungi

(PETITJEAN C., et al 2018)

Microbial biomass (μg C.g^{-1} sol sec)

Mineral N | Solid manure from cattle | Solid manure from cattle + Mineral N

Is it possible to sustain soil fertility without livestock production?

The balance of Soil Organic Matter is calculated from the difference between INPUTS of Organic Matter (OM) and OUTPUTS of Soil OM
Results indicate the humic balance at farm level

BALANCE		OM INPUTS				Soil OM OUTPUTS (mineralization)		
Variation of SOM content	=	Inputs of gross organic matter	x	K1	−	Storage stable Soil OM	x	K2
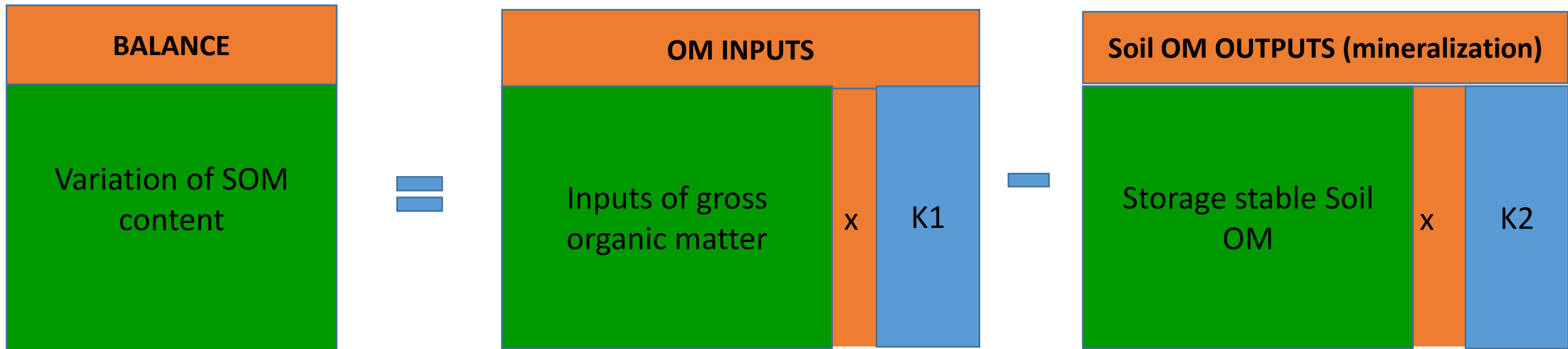
Equation – Entretien du stock de matières organiques évoluées de la couche arable.

Modèle monocompartimental de Hénin-Dupuis (1945)

Application on two types of farms

FCD = mixed farming combining annual crops & dairy cows

- UAA = 100 ha including:
  - Permanent grassland : 25 ha
  - Temporary grassland : 25 ha
  - Silage maize : 10 ha
  - Cereals : 40 ha

  either 75 ha of crops

- 80 LSU - 6 months in pasture

FSC = specialized farm: annual crop production

- UAA = 100 ha including:
  - Rapeseed : 33 ha
  - Wheat : 33 ha
  - Barley 33 ha

  either 100 ha of crops

Results of global humic balance: Balance measure between FCD$_{airy}$ et FSC$_{rops}$

Farm system/Oms resources	Livestock manure OMs	Temporary grassland	Buried straw	Stubble & roots	Inter. crop	INPUTS of OMs	OUTPUTS of OMs	Balance of SOM content
FCD = mixed farm annual crops & dairy cows	55	31	14	7	8	114	61,9	52,4
FSC = specialized farm annual crops	0	0	45	14	15	74	124	-50,3

FSC = specialized farm annual crops is structurally in deficit ! 25 years later, soil will be lost 0,5% content organic matter.

Results: a positive humic balance for the livestock system

- **FCD = 75 ha of crop rotation**
- **FSC = 100 ha of crop rotation**
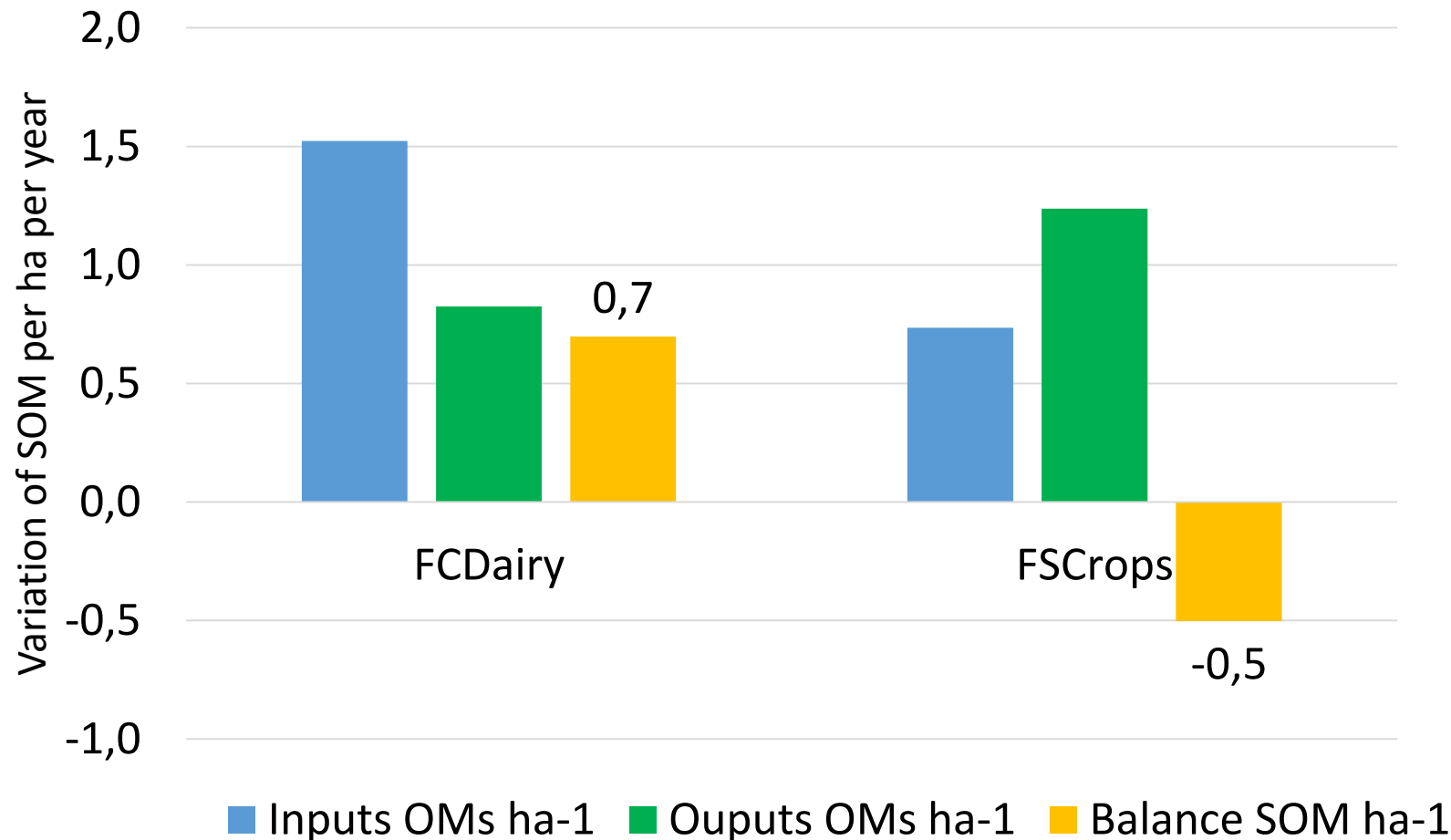
Discussion points

FCD *(annual crops & dairy cows)* **livestock system** do preserve regulating ecological services as climate change, quality of water and also the food production

FSC *(annual crops)* as they are managed today are not able to preserve or restore soil functions nor associated services

Livestock farming, mixed farming systems and complementarities between crops and livestock will be offering opportunities to restore the loss of biodiversity in European agricultural landscape, improve soil fertility, health and stability and may support climate change mitigation strategies