Modelling the interaction between soil processes

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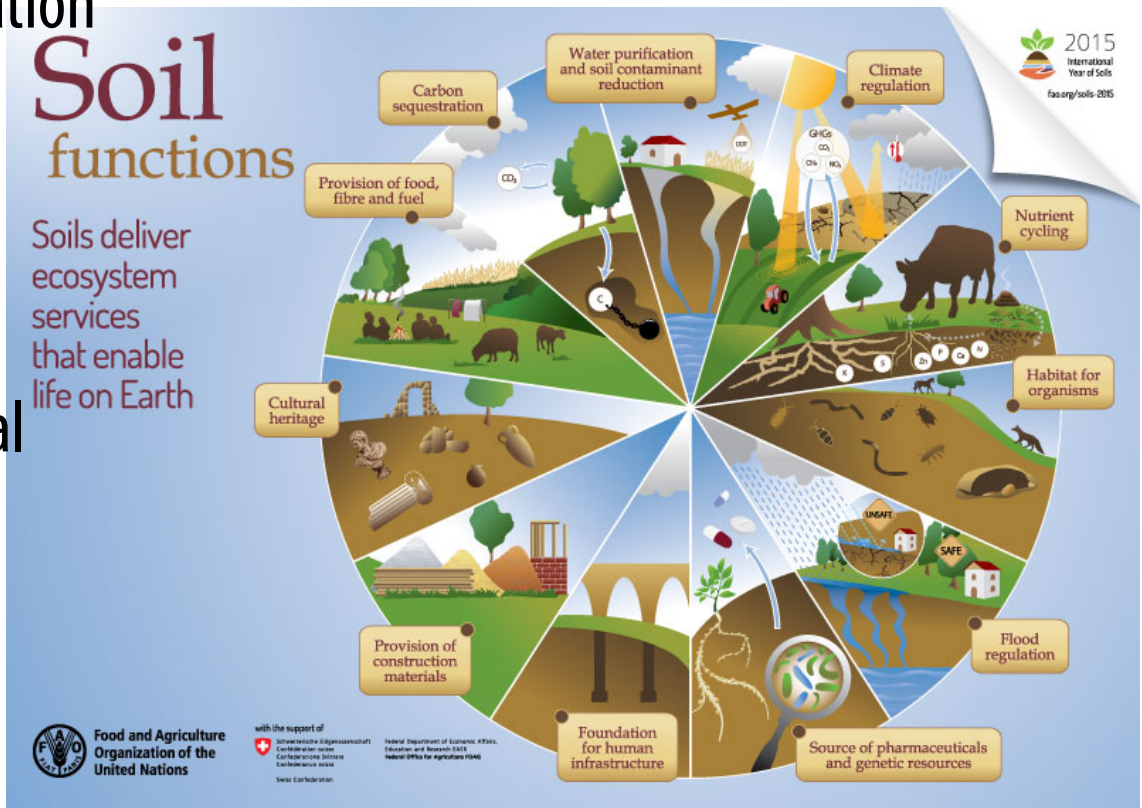
Why modelling the interaction between soil processes?

- For ecosystem services assessment
- To quantify the impact of global changes on soil and the role of soil on global changes
  - Climate change and C sequestration
  - Nitrogen cascade and denitrification
- To be able to represent soil along a gradient of anthropization
  - Physical, biological and chemical processes

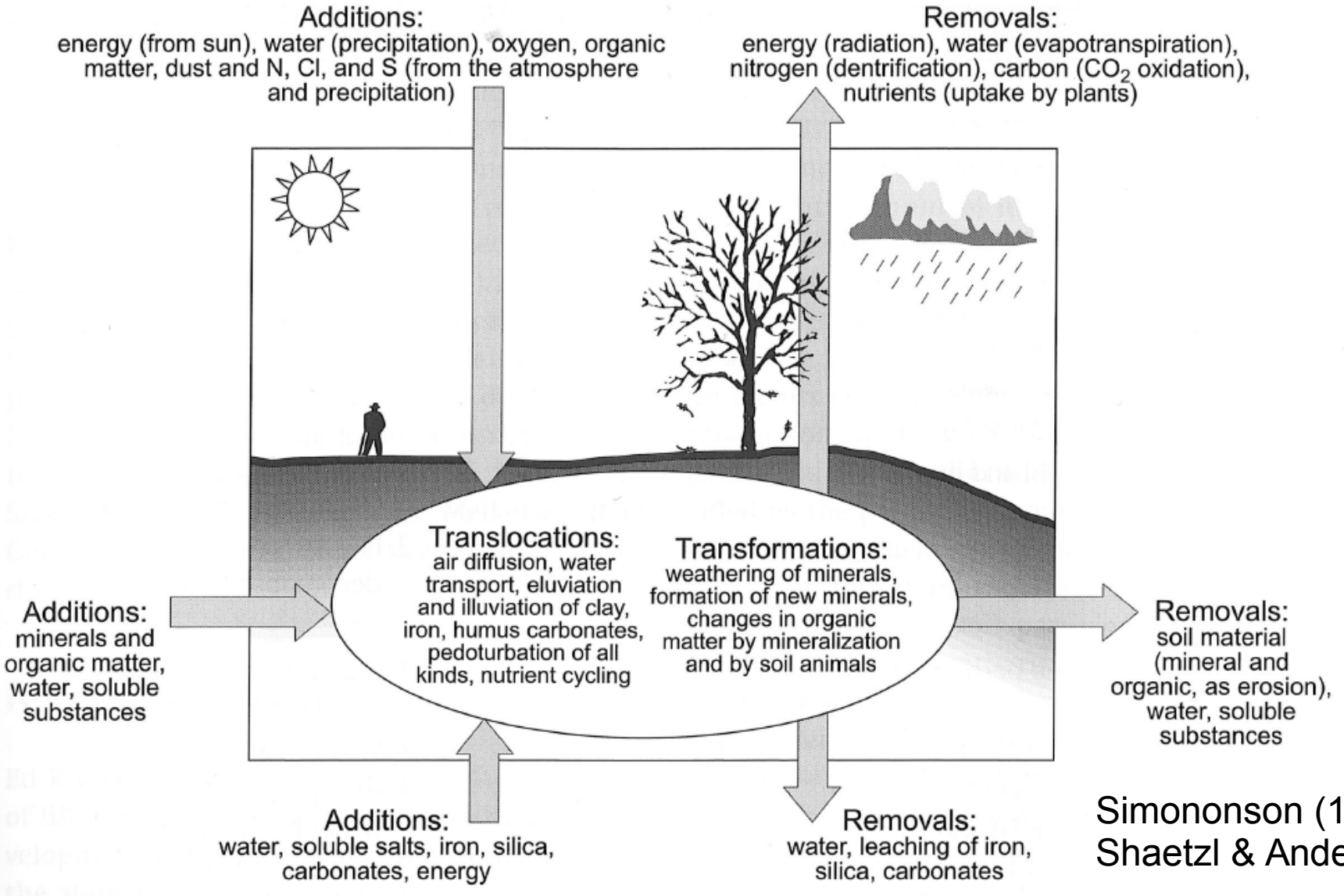


Are processes the same in soils along a gradient of anthropization?

- What are your thoughts after those 4 days of summer school?

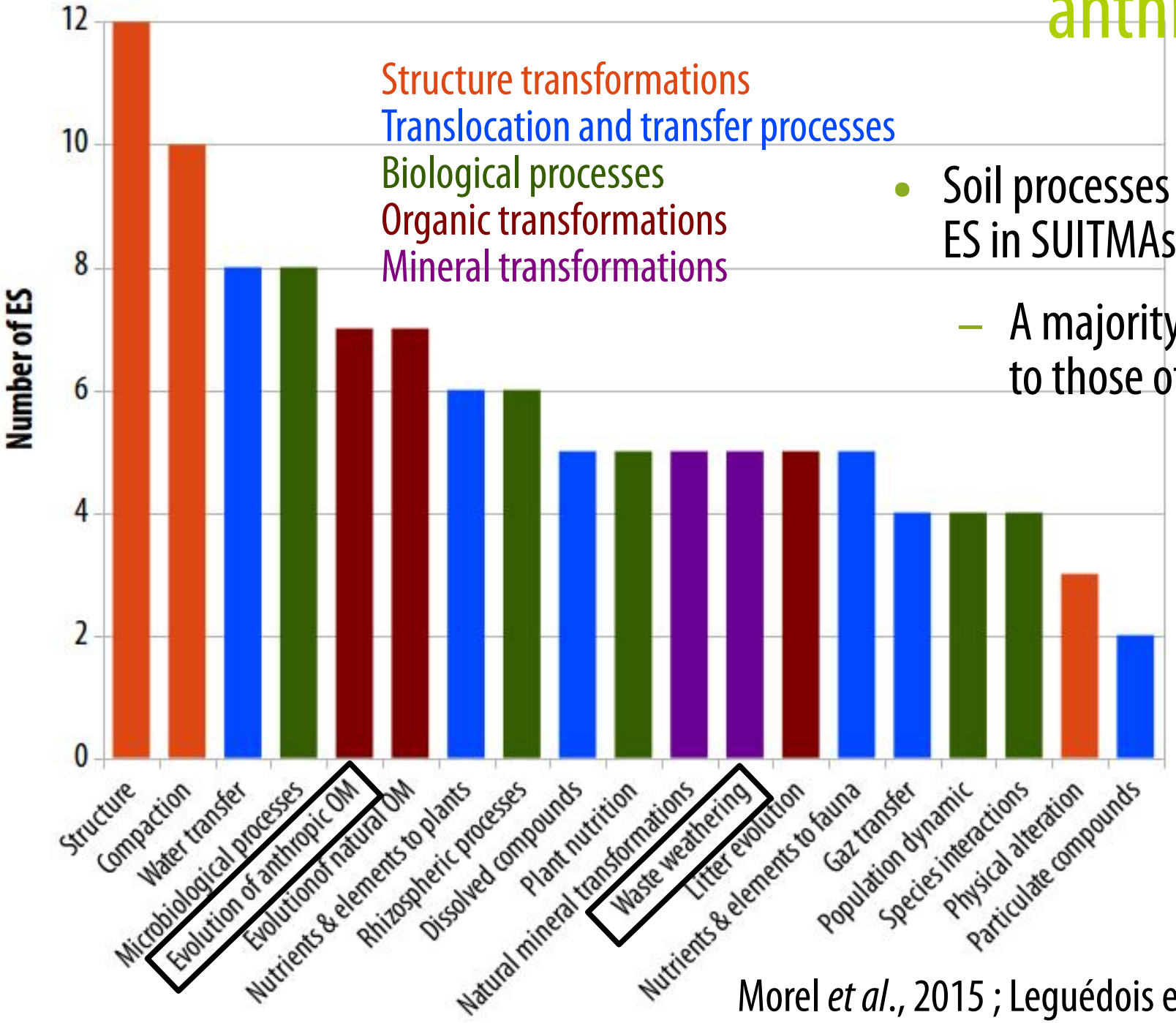
Are processes the same in soils along a gradient of anthropization?

- Processes in "natural" soils



Simononson (1978)
Shaetzl & Anderson (2005)

Are processes the same in soils along a gradient of anthropization?



- Soil processes needed to represent ES in SUITMAs
  - A majority of processes similar to those of more natural soils

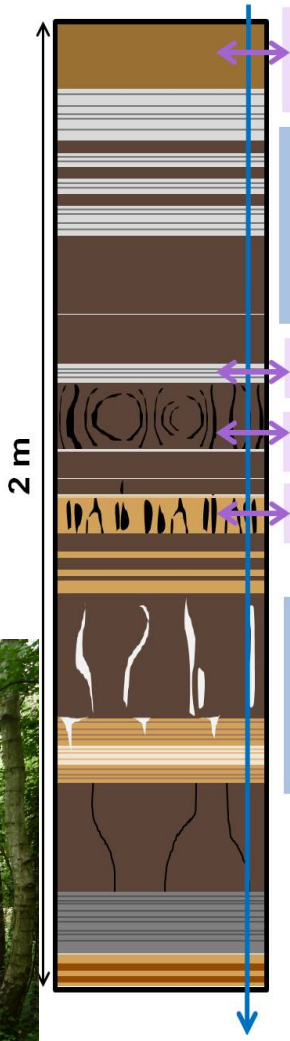
Morel *et al.*, 2015 ; Leguédois et al., 2016

Are processes the same in soils along a gradient of anthropization?

- Example: pedogenic processes observed in a Technosol
  - Occurrence of a wide variety of processes in SUITMAs
  - Unexpected combinations of processes

Spolic Technosol

Analogous processes in



organo-mineral horizon development

decarbonatation → **carbonated soils**

sulphate downward migration

glass weathering → **volcanic soils**

Mn oxide weathering

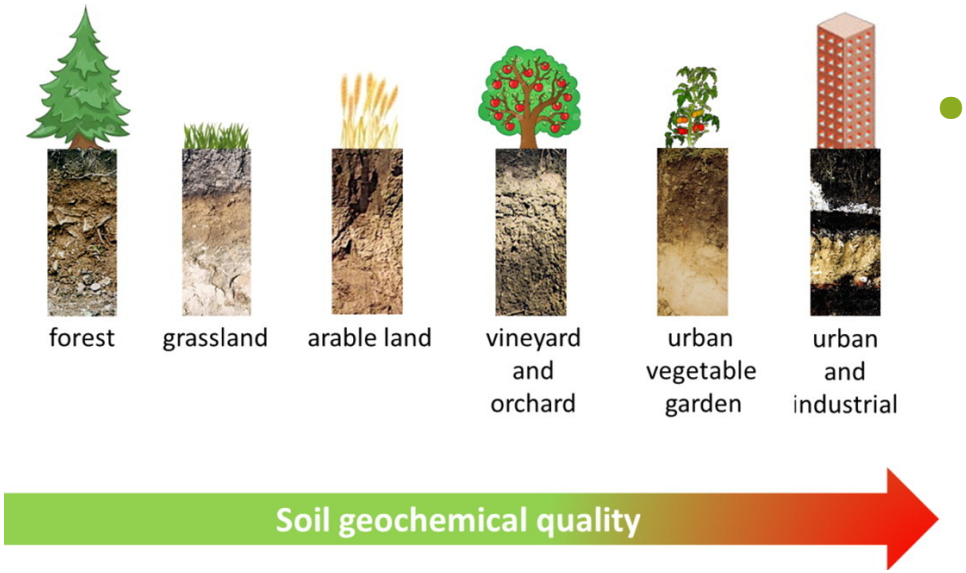
Mn segregation → **hydromorphic soils**

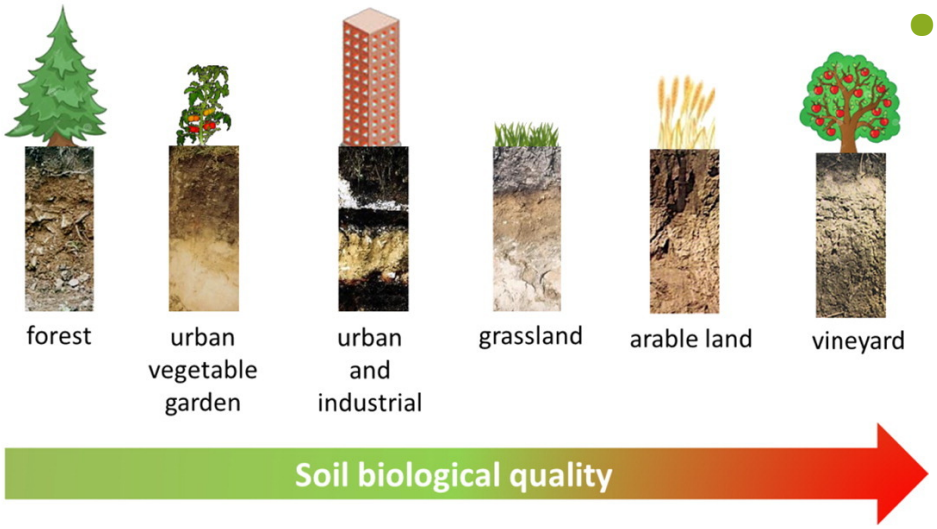
deeply precipitation of calcite → **carbonated soils**

Leguédois *et al.*, 2016, Geoderma

Huot *et al.*, 2015, Soil Science

Do processes act the same in soils along a gradient of anthropization?



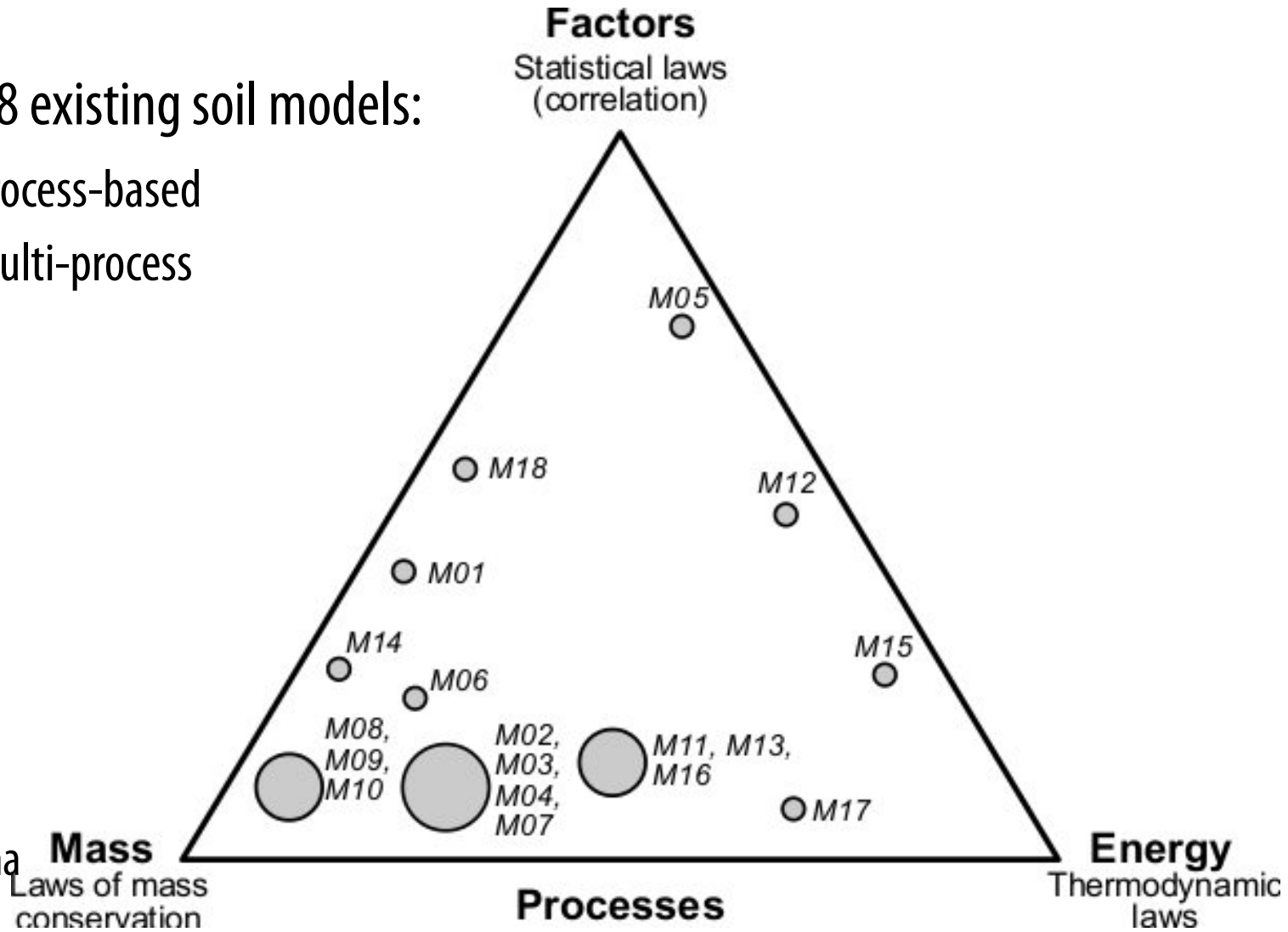


Joimel *et al* (2017)

- The gradient of quality identified for geochemical and biological parameters highlights the difference of intensity in the processes along the gradient of antrhopization
- Strong interactions between processes

How to model the processes?

- Most of the existing models of soil are process-based and multi-process
  - Analysis on 18 existing soil models:
    - 83% are process-based
    - 67% are multi-process

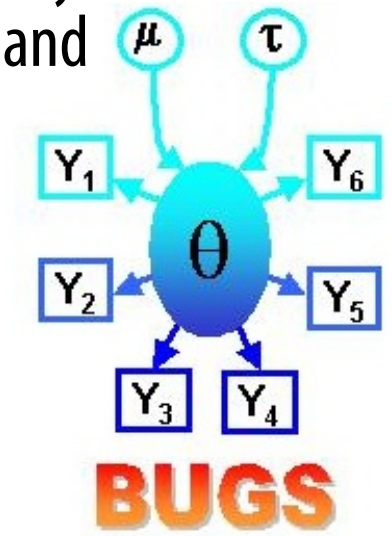


Leguédois *et al.*, 2016, Geoderma

How to model the processes?

- Existing tools to couple process-based models able to cope with the diversity of formalisms (e.g. differential equations, agent-based)
  - Coupling platforms like Sol Virtuel, Record
    - Bergez et al, 2010
  - VLE modelling environment/ DEVS
    - Quesnel et al., 2009; Zeigler et al., 2000
  - Link with computing and numerical calculus domains
- Methods to handle complex codes with potential instability, difficulty in parametrisation and inverse modelling, high computing demand, and uncertainties on output data
  - uncertainty and sensitivity analyses
    - Saltelli et al. (2004)
  - Bayesian modelling

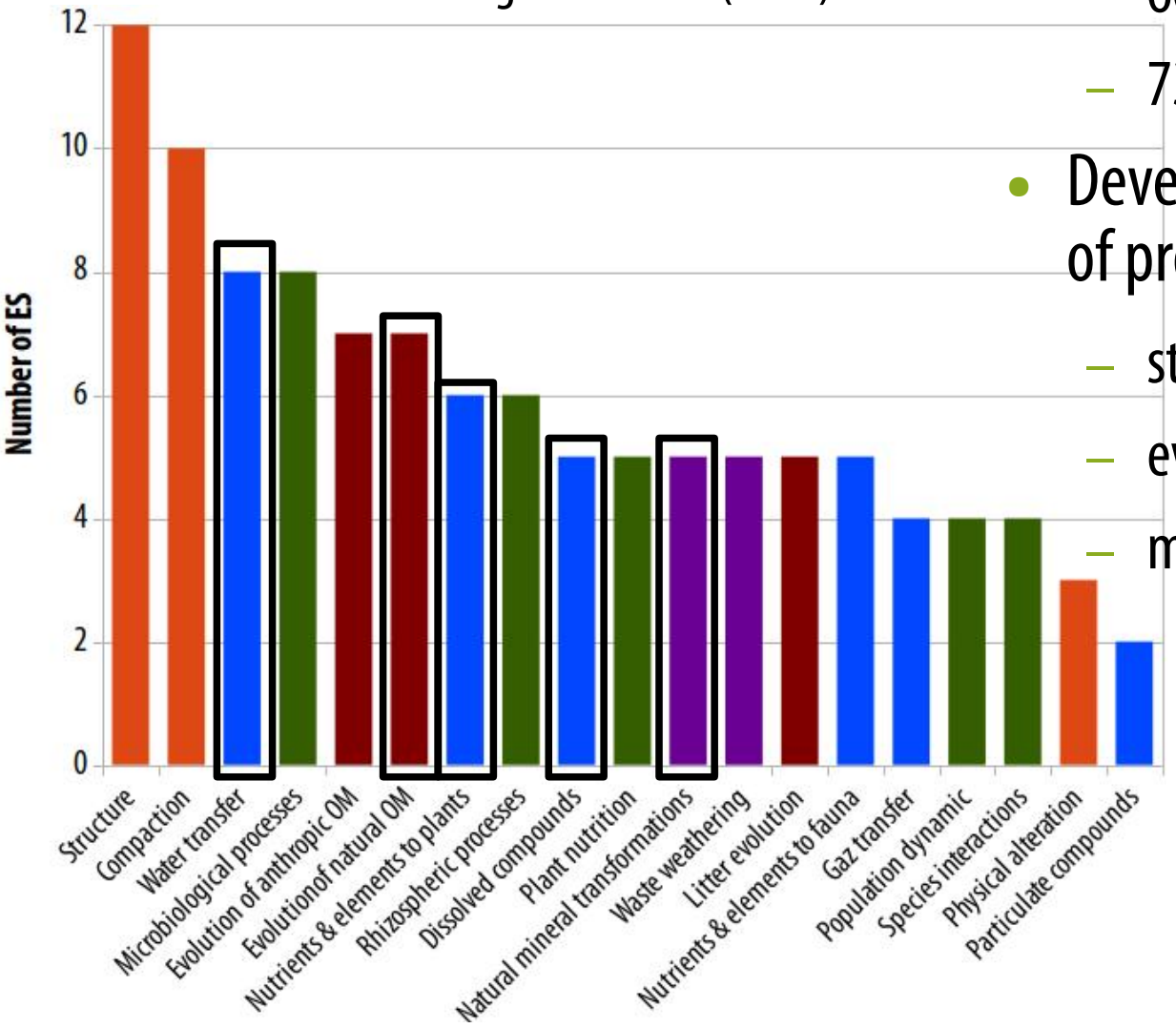
RECORD



Which processes to model?

Soil processes needed to represent ES in SUITMAS

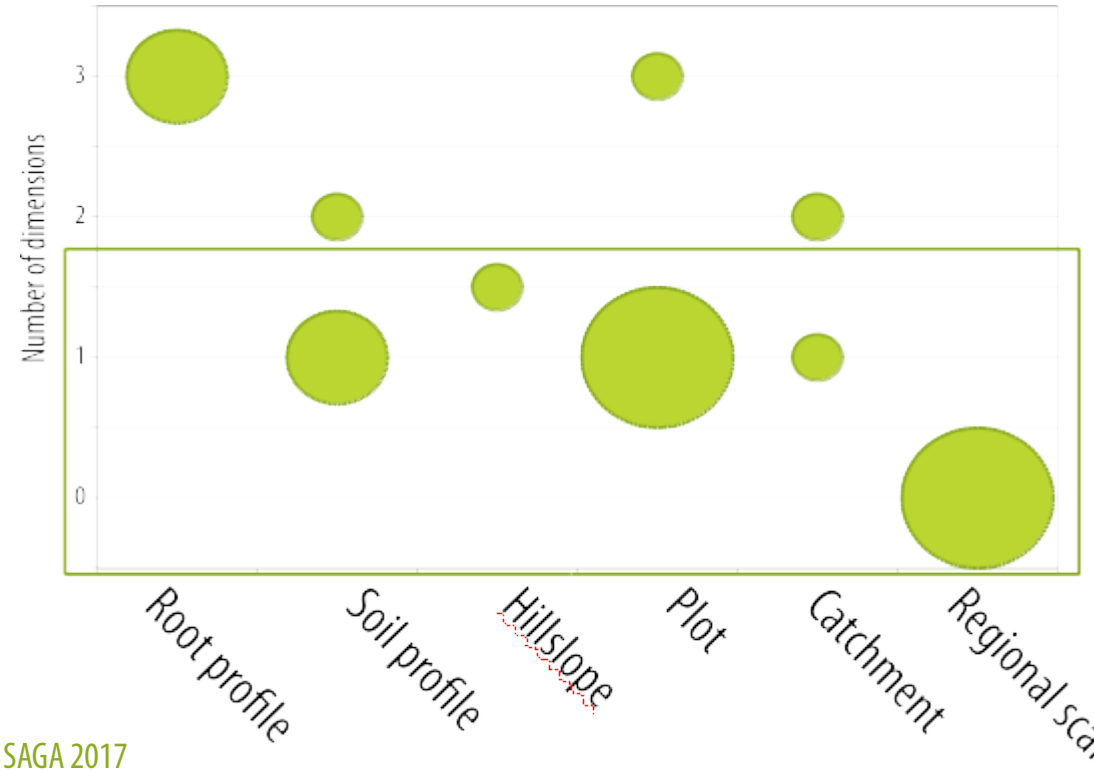
Leguédois *et al* (2016)



- Analysis on 18 existing soil models:
  - 60 % represent water transfer
  - 73 % represent chemical reactivity
- Developments needed in the modeling of processes fro SUITMAS related to:
  - structure
  - evolution of anthropic OM
  - microbiological activities

Modelling challenge: heterogeneous spatial representation

- Generally poor spatial description of the existing models
- Importance of spatial heterogeneity
  - ⇔ ecological intensification, lower fertiliser inputs, and no-tillage
    - Doré et al. (2011), Hinsinger et al., (2011)
  - ⇔ highly heterogeneous spatial organisations observed in SUITMAs and forested soils
    - De Kimpe and Morel (2000), Huot et al. (2013), Monseriée et al. (2009)



Conclusion

- Soil models have mainly been developed for agricultural or contminated pollutions
  - Main modelled processes related to water transfer and chemical reactivity
  - Soil homogeneity due to tillage
- Development needed
  - Soil heterogeneity / structure evolution
  - Soil biological processes
- Existing technical tool to support complex coupled models
  - Coupling platform
  - UA and SA