UMR7618 « Institut d'Ecologie et des Sciences de l'Environnement- Paris»

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Modelling the impact of soil fauna on soil organic matter dynamics

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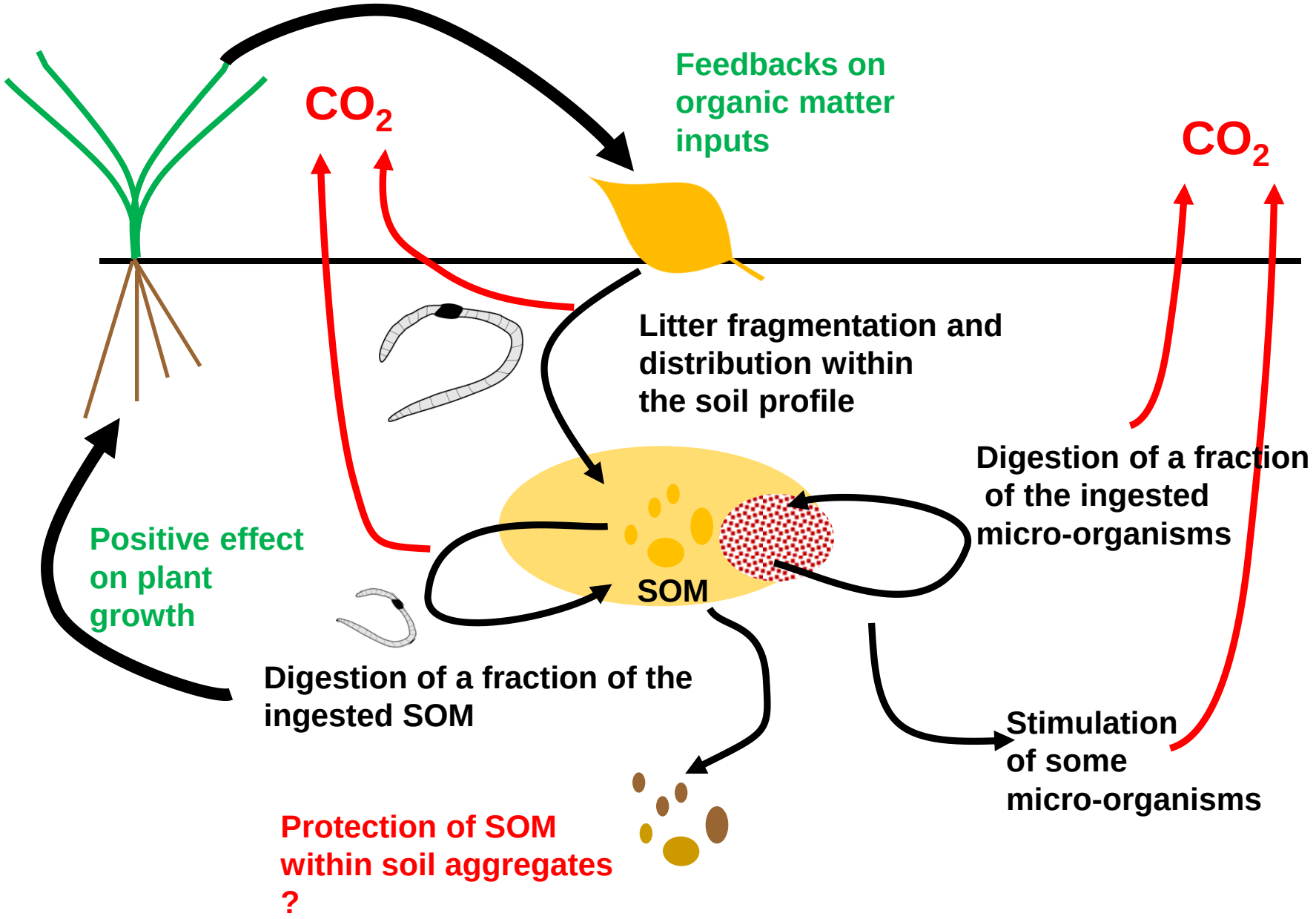
A huge quantity of empirical data

- The impact of soil fauna on the dynamics of dead organic matter has been studied for ages

Yes but …

- Many many mechanisms are involved
- Several spatial scales are involved
- Several temporal scales are involved
- Many organisms are involved
- Many compartments of organic matter are involved

Example of earthworms



Probably many open questions

- What is the net impact of earthworms on SOM dynamics through their influence on micro-organisms (stimulation + consumption)?

- What is the net impact of earthworms on SOM dynamics through the distribution of litter fragments and SOM within the whole soil profile?

- Earthworms increase mineralization on the short term, which releases mineral nutrients, which increases plant growth… what is the net effect on the stock of organic matter?

- Short term increase in mineralization but is there stabilization on a longer term?

How can we answer these questions?

- New clever experiments
- Models

Why do we need models?

- We often think first about making quantitative predictions!

- But ecology, as a science, also aims at understanding, interpreting, finding general laws…

- But models also help disentangling complex interactions, assessing the sensitivity towards different processes

- Precise quantitative predictions are often only “local” : only valid in a precise and limited context

Idea to build a generic, rather theoretical, model integrating the most important mechanisms to study their interactions

So far such a model has never been developed

Towards a generic model

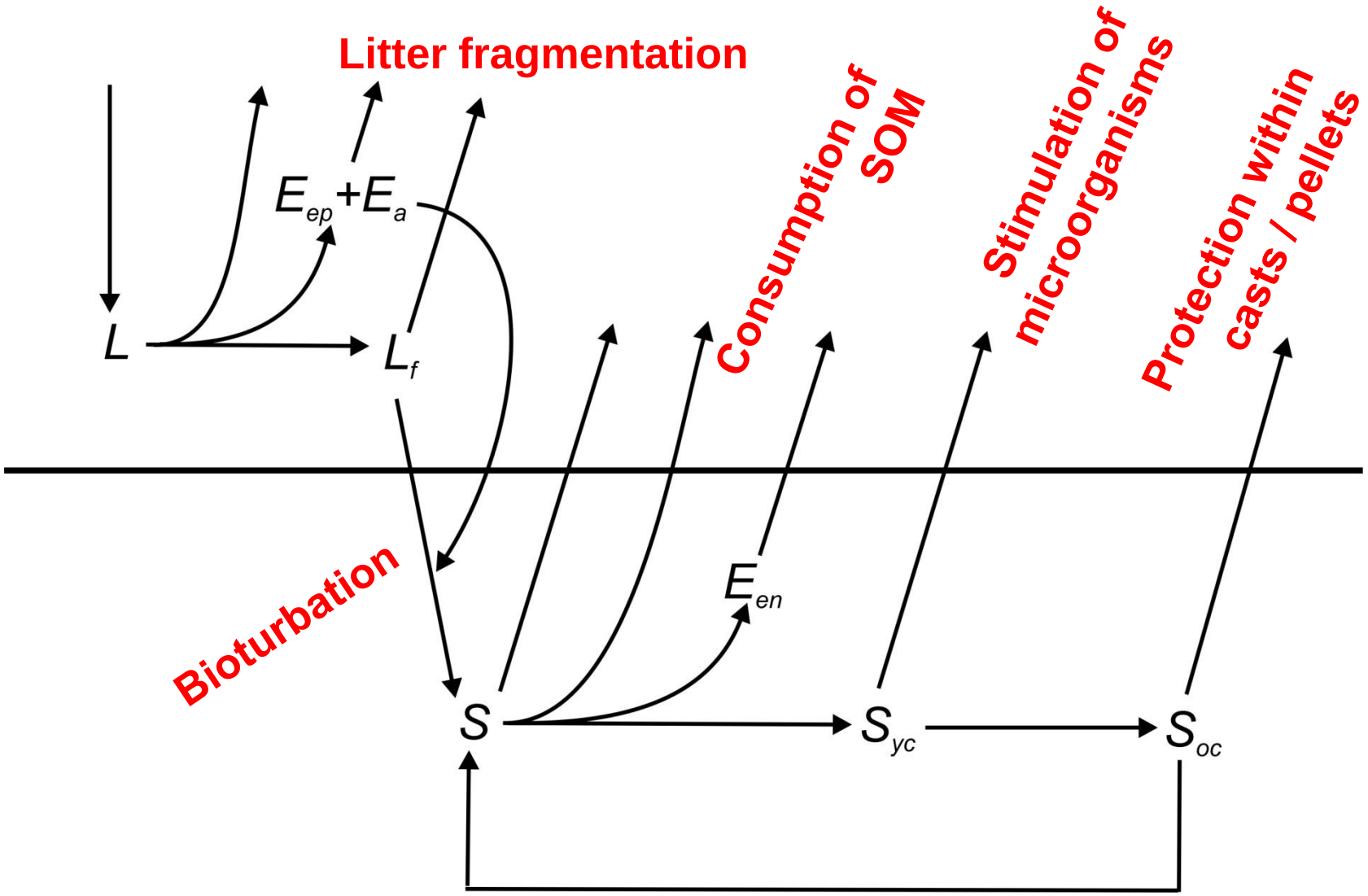
- The model must incorporate the most important processes controlled by soil fauna

  Litter fragmentation
  Bioturbation
  Consumption of SOM and stimulation of microorganisms
  Protection of SOM in casts / pellets

- The model must be kept relatively simple to allow mathematical analyses

- It should be possible to use the model for any group of soil fauna or combination of groups of soil fauna

Towards a generic model



Preliminary results

- **Total stock of C without fauna**

$$S_{tot} = \left[\frac{1}{\delta_f} + \frac{1-\sigma_f}{m_f + \delta_b} \left(1 + \frac{\delta_b}{m_S} \right) \right] R$$

- **Total stock of C with fauna achieving all functions**

$$S_{tot} = R \frac{1}{f_{ep} E_{ep} + f_{an} E_{an} + \delta_f} \frac{1}{m_f + bE_{an} + \delta_b} \left[\begin{array}{l} \left(m_f + bE_{an} + \delta_b + f_{ep}\left(1-\sigma_{ep}\right)E_{ep} + f_{an}\left(1-\sigma_{an}\right)E_{an} + \delta_f\left(1-\sigma_f\right)\right) + \\ \left(\frac{m_{yc} + a}{c\left(1-\sigma_{en}\right)E_{en}} + 1 + \frac{a}{m_{oc} + w} \right) \\ \frac{\left(bE_{an} + \delta_b\right)\left(f_{ep}\left(1-\sigma_{ep}\right)E_{ep} + f_{an}\left(1-\sigma_{an}\right)E_{an} + \delta_f\left(1-\sigma_f\right)\right)}{\left(m_S + cE_{en}\right)\frac{m_{yc} + a}{c\left(1-\sigma_{en}\right)E_{en}} - \frac{wa}{m_{oc} + w}} \end{array} \right]$$

Simple model

Next steps

- Mathematical analysis of the results
  E.g.
  Derivatives relatively to biomasses of soil fauna
  Mathematical conditions for soil fauna to increase the total C stock

- Parameterization, probably for earthworms, probably using "mean standard parameters"

- Inclusion of new mechanisms
  Feedbacks between soil fauna dynamics and SOM dynamics
  Explicit inclusion of microorganisms
  Possibility of concentration of organic matter within casts/ pellets