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Using Functional Traits of Soil Organisms in Ecological Engineering to restore sustainable SUITMA: A Promising Approach?

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*Biological and Ecological Traits
for Soil Invertebrates*

CONTEXT: ecological engineering and soil biodiversity

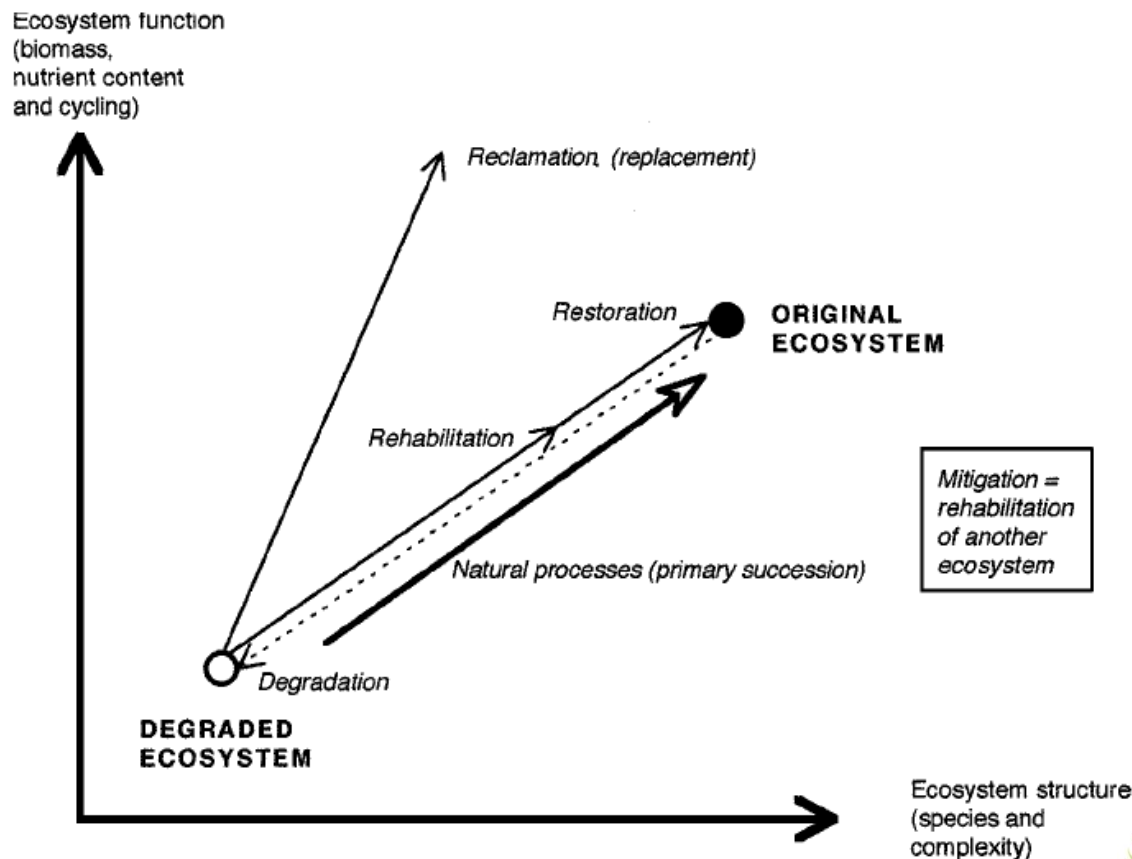
What is ecological engineering?

Ecological engineering has been originally defined as **the design of sustainable ecosystems** that integrates human society with its natural environment for the benefit of both (Mitsch and Jørgensen, 1989).

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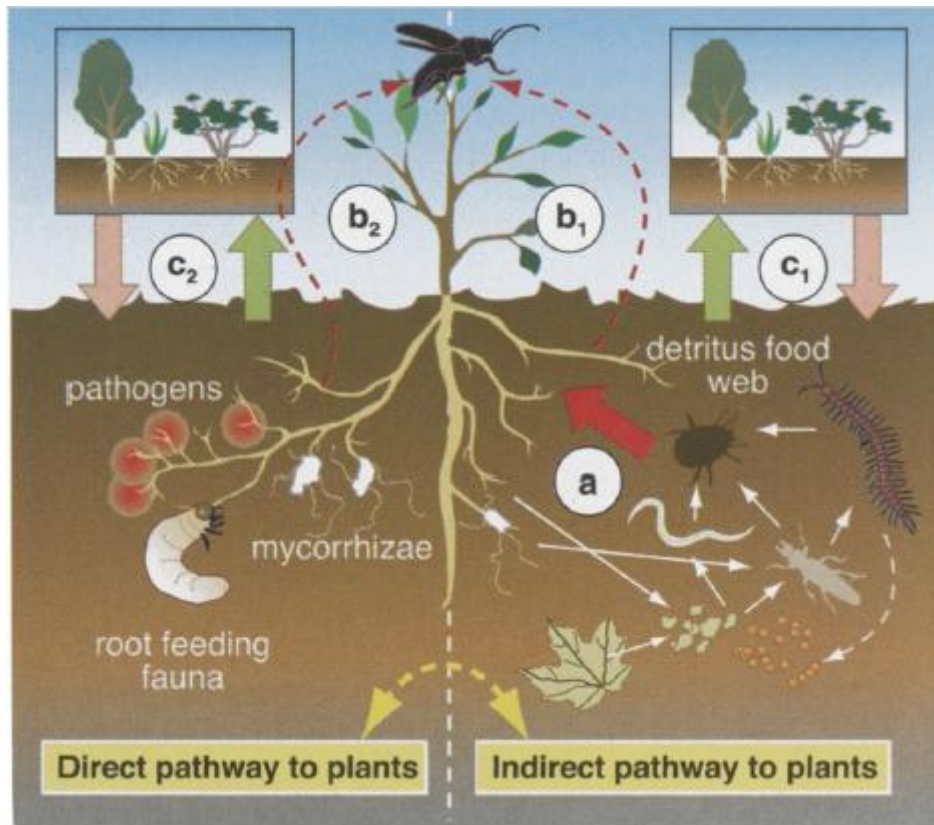
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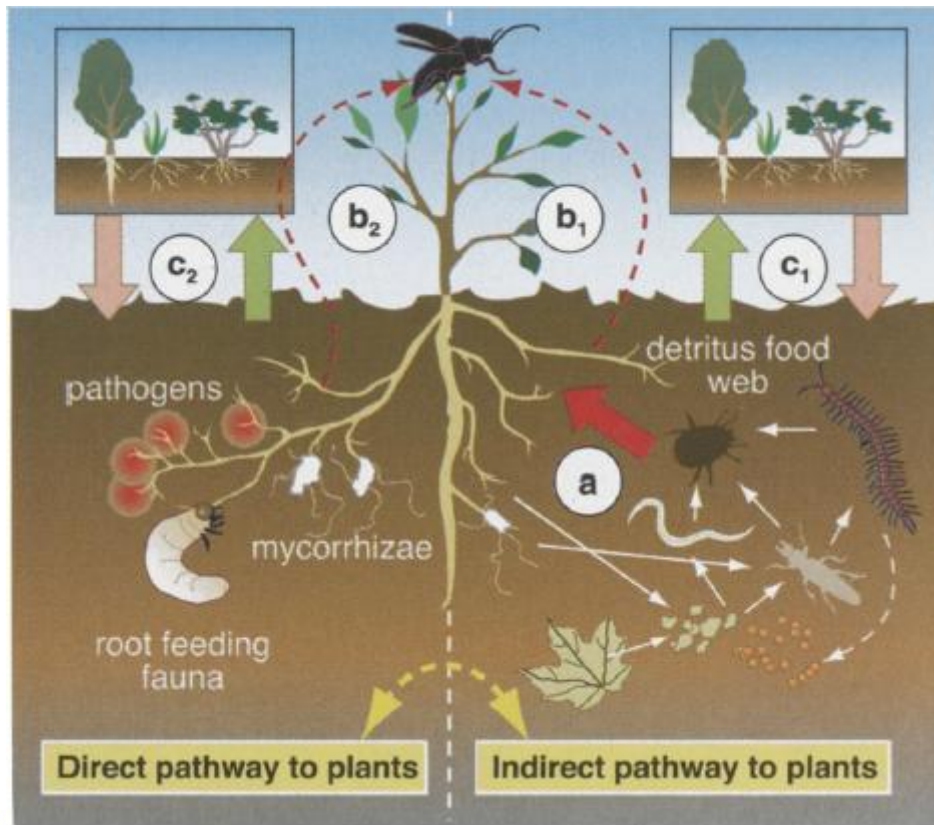


Several compartments
in an ecosystem: aboveground
– belowground linkages
multitrophic interactions

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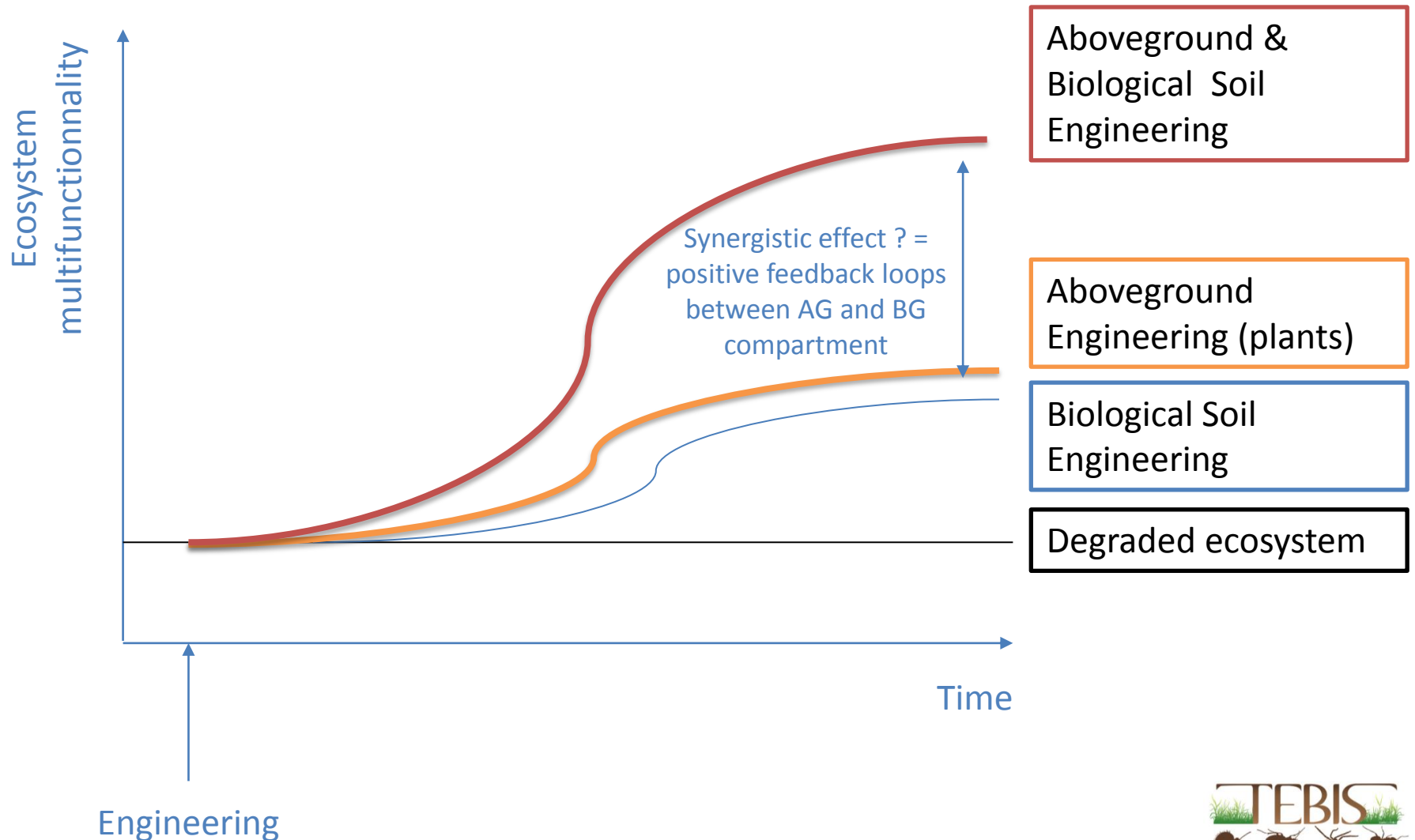
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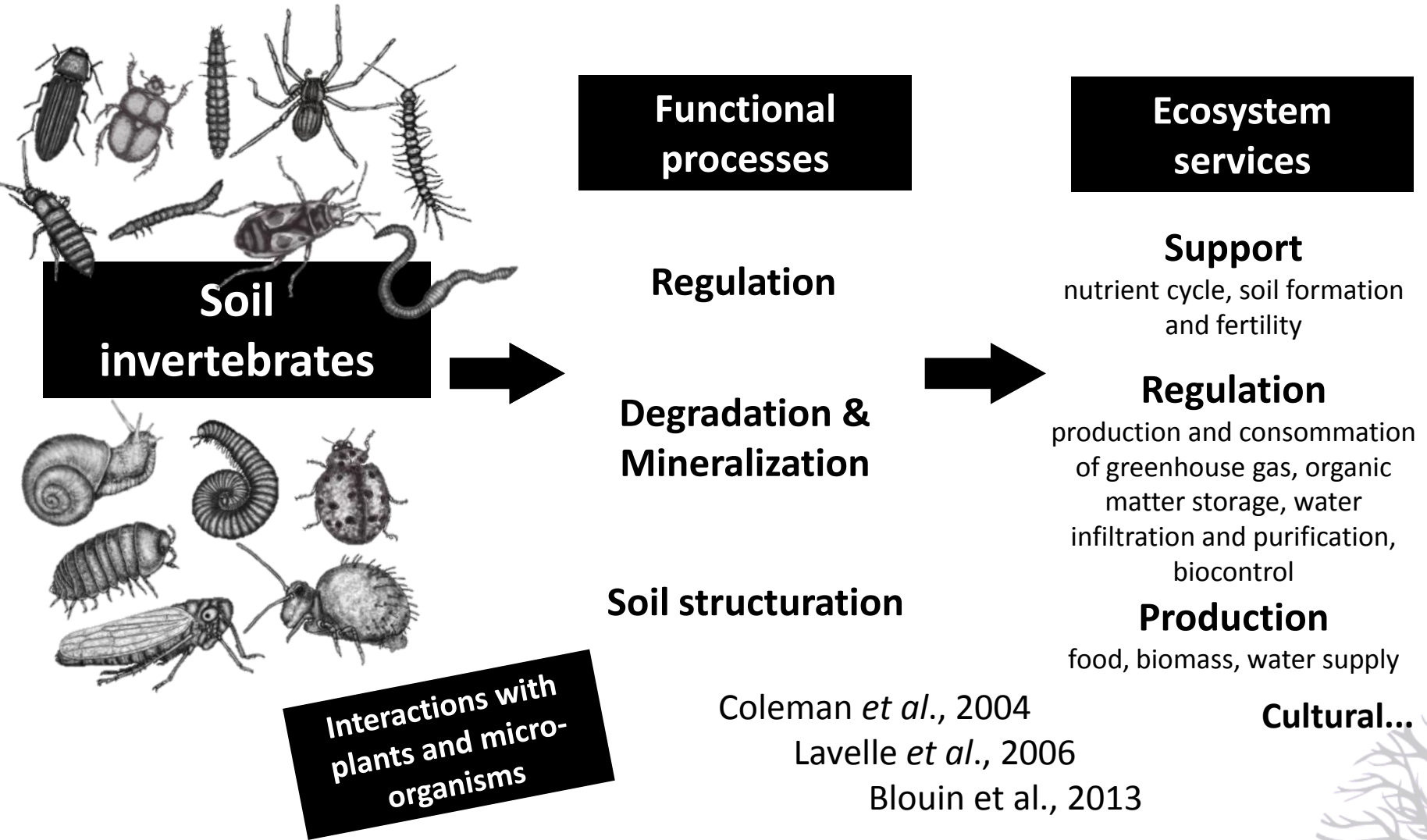
*Our goal: find a way to improve
feedbacks between plants and
soil communities by taking soil
organisms in account
in restoration plan*

CONTEXT: ecological engineering and soil biodiversity

Conceptual trajectories of degraded ecosystems
subject or not to engineering



CONTEXT : What are the services provided by soil invertebrates to human?



CONTEXT: ecological engineering and soil biodiversity

What is a functional trait of a soil invertebrate?

Functional trait: a characteristic of an organism, which has demonstrable links to the organism's function

→ a functional trait determines the organism's response to pressures (response trait), and its effects on ecosystem processes or services (effect trait)

DeBello *et al.*, 2010

CONTEXT: ecological engineering and soil biodiversity

What is a functional trait of a soil invertebrate?

Soil invertebrate traits = “morphological, physiological, phenological or behavioral features, measurable at the individual level, from the cell to the whole-organism level, without reference to the environment or any other level of organization”.



<http://betsi.cesab.org/>



GfÖ

GfÖ Ecological Society of Germany,
Austria and Switzerland

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Applied Ecology**

www.elsevier.com/locate/baae

PERSPECTIVES

Current use of and future needs for soil invertebrate functional traits in community ecology



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Daniel Cluzeau^f, Jérôme Cortet^g, Thibaud Decaëns^h, Louis Deharvengⁱ,
Florence Dubs^j, Sophie Joimel^k, Charlène Briard^f, Fabien Grumiaux^l,
Marie-Angélique Laporte^m, Alain Pasquetⁿ, Céline Pelosi^a, Céline Pernin^l,
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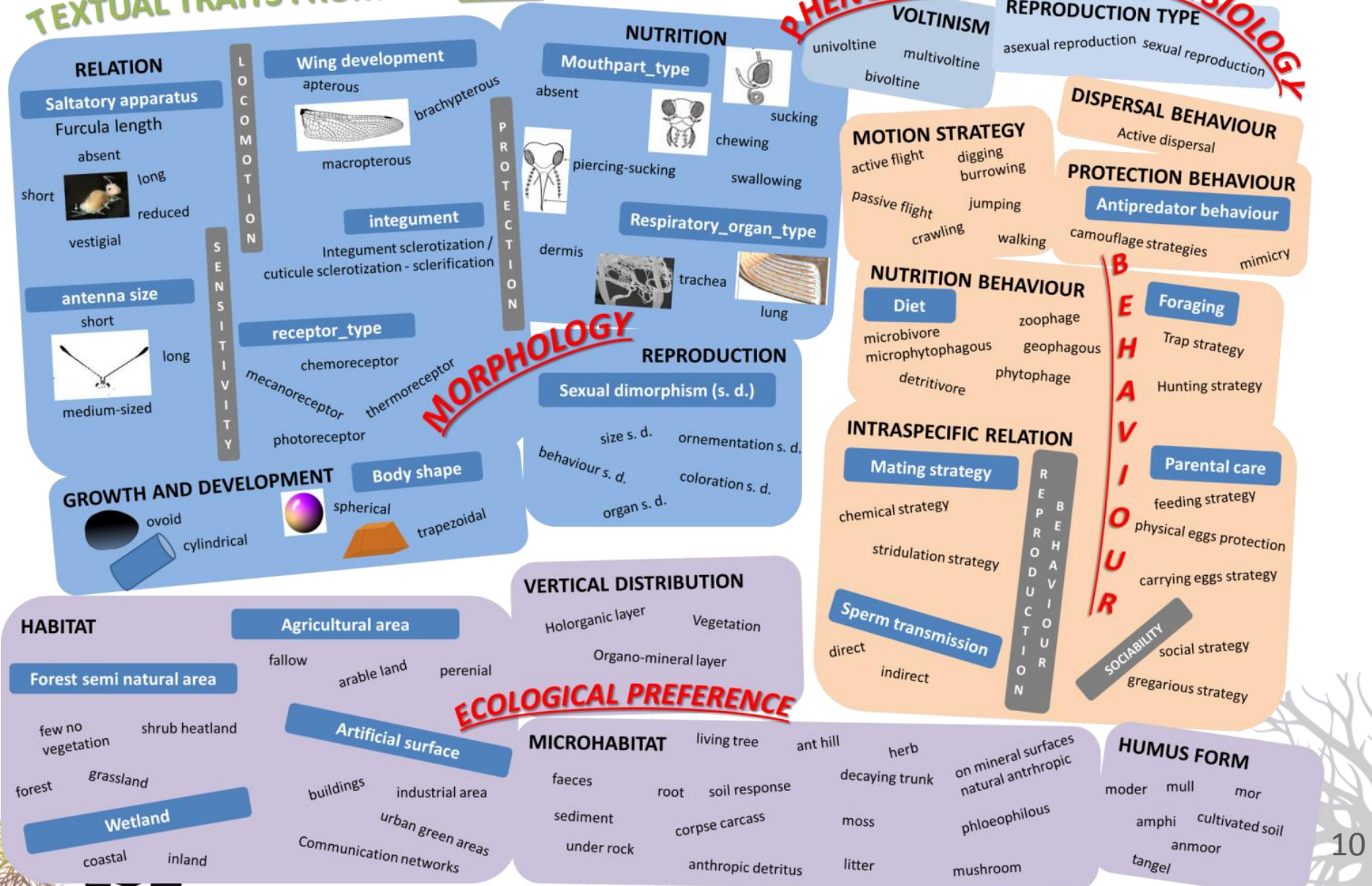


CONTEXT: examples of traits

<http://betsi.cesab.org/>



TEXTUAL TRAITS FROM THE BETSI DATABASE



Example for « **recycling function (nutrients)** »

Example of application of our approach on a soil with low fertility level: the goal would be to increase the chemical fertility of this soil/ecosystem,

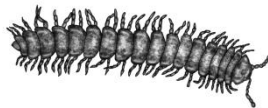
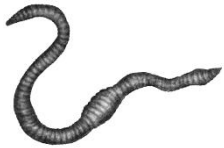
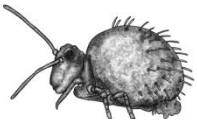
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Selection of one functional trait « **diet** »: *detritivores*

detritivores : fragmenting & digesting the organic matter
and indirectly altering the structure and functions
of microbial communities

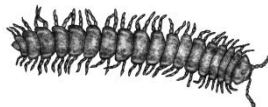
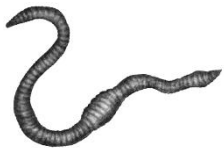
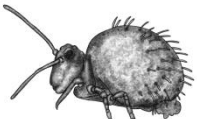


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↳ Selection of one functional trait « **diet** »: *detritivores*

↳ But also: « **body size** »: *the larger animals have generally the strongest effects, direct or indirect, on decomposition while the impact of smaller organisms is more likely to be indirect through their selective grazing of the microbial biomass (e.g. Bradford et al. 2002)*



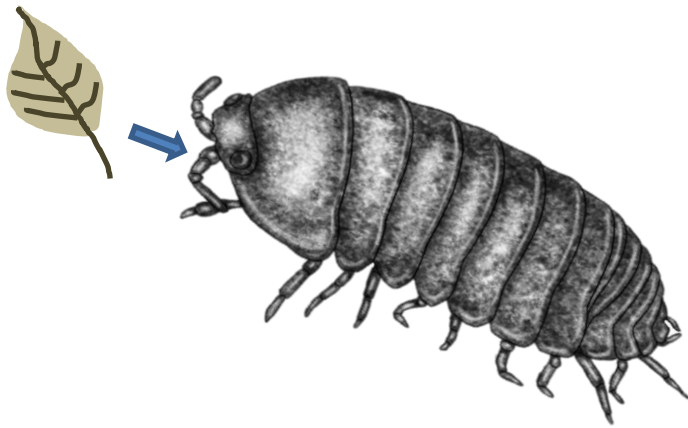
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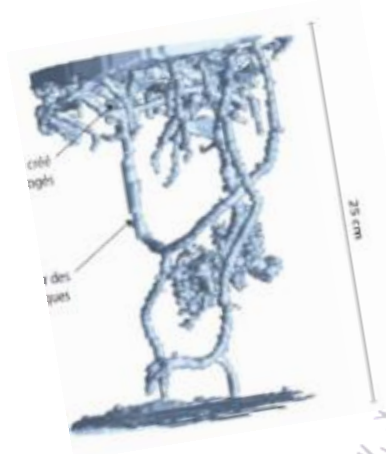
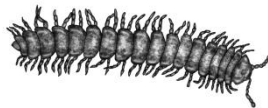
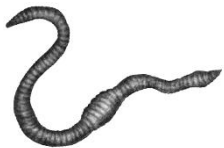
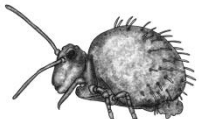
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↳ But also: **ability to fragment the litter** and **create burrow**
(*effect on distribution of organic matter in the soil profile*)



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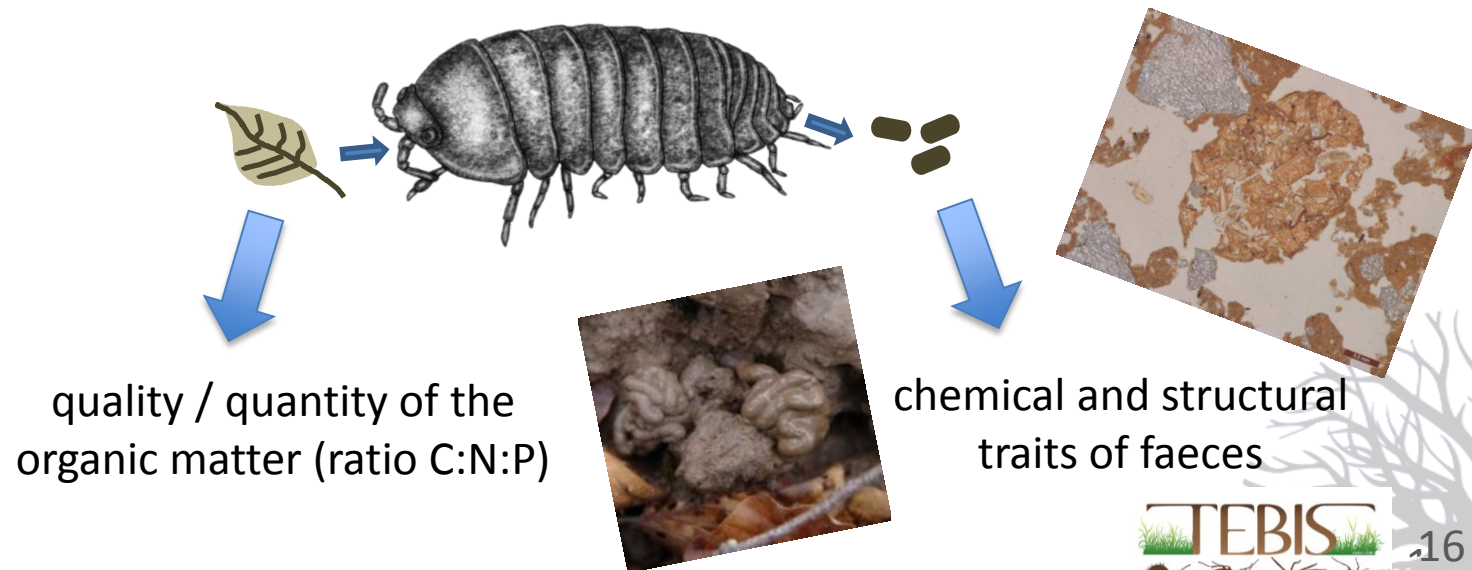
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Example for « **recycling function (nutrients)** »

Tool for choosing interesting multitrait attributes (*values*) in restoration plan

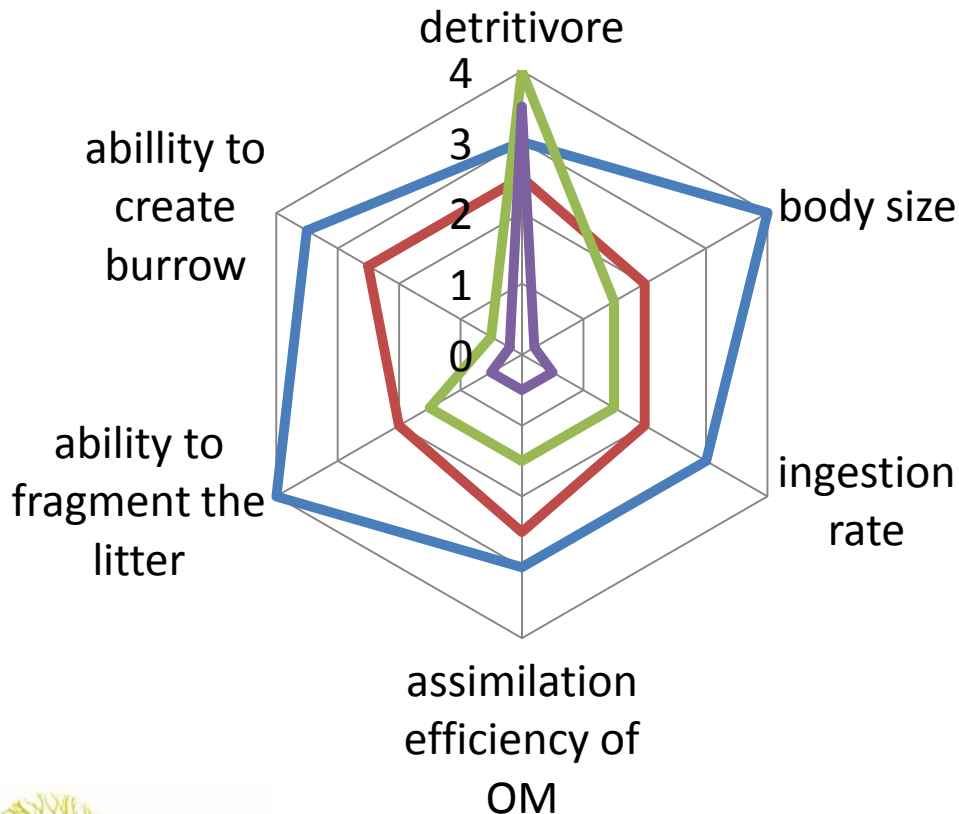
Scores could be created thanks to traits databases that combine a large amounts of data such as





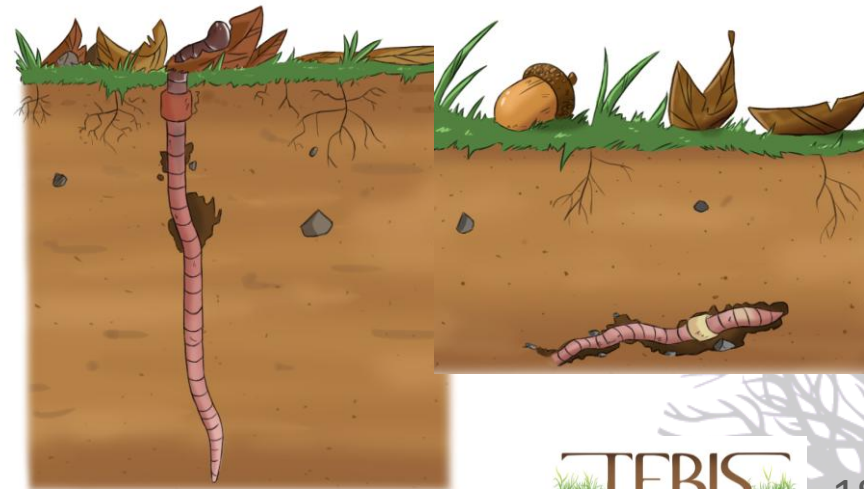
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Tool for choosing interesting multitrait attributes (*values*) in restoration plan

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- *Lumbricus terrestris (anecic)*
- *Aporrectodea caliginosa (endogeic)*
- *Porcellio scaber* 
- *Lepidocyrtus lanuginosus* 



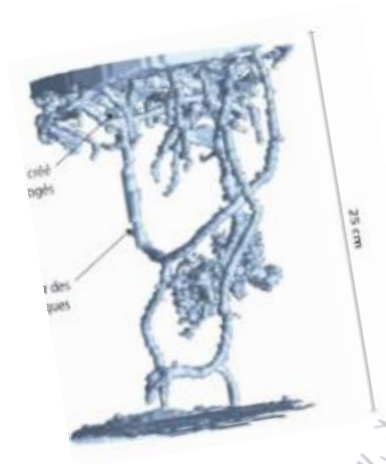
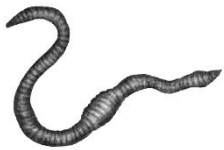
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↳ Selection of one functional trait: **body size**: *the bigger the individuals the bigger the effects (Lee & Foster 1991; Lehmann et al 2017). Large earthworms produce large burrows that increase soil porosity and water infiltration (Lee & Foster 1991).*

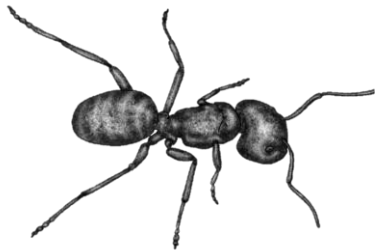


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↳ But also: **mandible size**: *the size of ant workers' mandibles determines the size of aggregates they are able to move (Dostal et al 2005)*



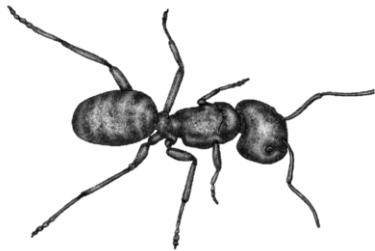
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↳ But also: **activity**: *sedentary ant species can be expected to have higher and long-term impacts on soil structure than nomad species*



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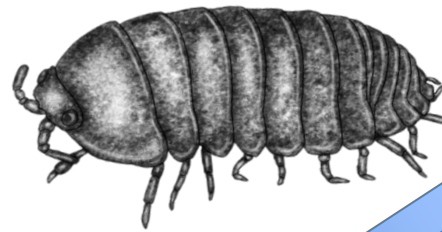
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↳ But also: **activity**

↳ - size of the **colony** (superorganism?)
↳ - **sociability** (gregarious – social species)
...




nature and structure of the faecal pellets.

Casts produced by earthworms modify aggregates in soils (Shipitalo & Protz 1989; Lee & Foster 1991). Large species produce large and compact casts that increase the proportion of large aggregates in soil and the bulk density (Blanchart et al 1999).



Quantity of faecal pellets

Etc...




CONCLUSION & PERSPECTIVES

-  Promoting the use of soil invertebrates within a restoration project by considering explicitly their effects on element cycling should help to improve soil quality rehabilitation / ecosystem sustainability.

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-  Promoting the use of soil invertebrates within a restoration project by considering explicitly their effects on element cycling should help to improve soil quality rehabilitation / ecosystem sustainability.
-  Experts can help the stakeholders to design sustainable ecosystem by proposing integrative decision support tool (considering above- belowground compartments; plants and soil traits).
-  There is a need of indicators to follow the success of a management method across time (*e.g.* network complexity indices / functional redundancy / direct and indirect effects of traits / ranking and correlation between traits...)

THANKS FOR YOUR ATTENTION

Questions?

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