Soil Biodiversity

DECLINE IN SOIL BIODIVERSITY is the reduction of forms of life living in soils, both in terms of quantity and in variety.

Soil biodiversity is a term used to describe the variety of life below-ground. The concept is conventionally used in a genetic sense and denotes the number of distinct species (richness) and their proportional abundance (evenness) present in a system, but may be extended to encompass phenotypic (expressed), functional, structural or trophic diversity. The total biomass below-ground generally equals or exceeds that above-ground, whilst the biodiversity in the soil always exceeds that on the associated surface by orders of magnitude, particularly at the microbial scale. A handful of grassland soil will typically support tens of thousands of genetically distinct prokaryotes (bacteria, archaea) and hundreds of eukaryotic species across many taxonomic groups. The soil biota plays many fundamental roles in delivering key ecosystem goods and services, and is both directly and indirectly responsible for carrying out many important functions.

Ecosystems **goods** provided by soil biota:

- food production
- fibre production
- provision of secondary compounds (e.g. pharmaceuticals / agrochemicals)

Ecosystems **services** provided by soil biota:

- driving nutrient cycling and regulation of water flow and storage
- regulation of soil and sediment movement and regulation of other biota (including pests and diseases)
- detoxification of xenobiotics and pollutants and regulation of atmospheric composition

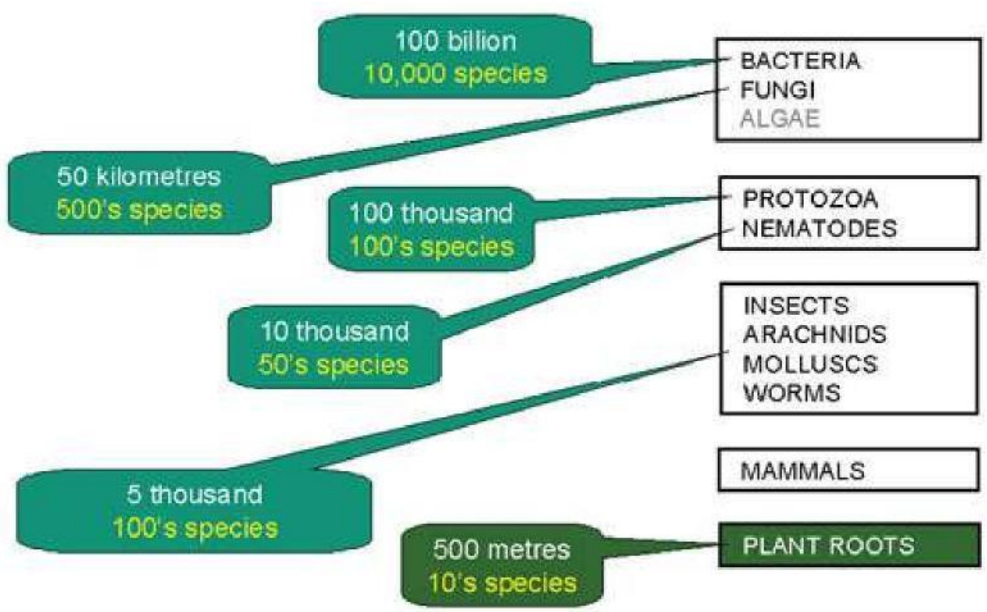
The value of soil biodiversity

Soil biodiversity carries a range of values that depend on the perspective from which they are being considered. These include:

- **Functional value**, relating to the natural services that the soil biota provides, the associated preservation of ecosystem structure and integrity, and ultimately the functioning of the planetary system via connections with the atmosphere and hydrosphere.
- **Utilitarian** (“direct use”) value, which covers the commercial and subsistence benefits of soil organisms to humankind.
- **Intrinsic** (“non-use”) value, which comprises social, aesthetic, cultural and ethical benefits
- **Bequest** (“serependic”) value, relating to future but as yet unknown value of biodiversity to future planetary function or generations of humankind.

The ecological value of soil biodiversity is increasingly appreciated as we understand more about its origins and consequences. The monetary value of ecosystem goods and services provided by soils and their associated terrestrial systems, an entirely human construct which assists putting their significance into an economic context, was estimated in 1997 to be thirteen trillion US dollars ($13 x 1012). The soil biota underwrites much of this value.

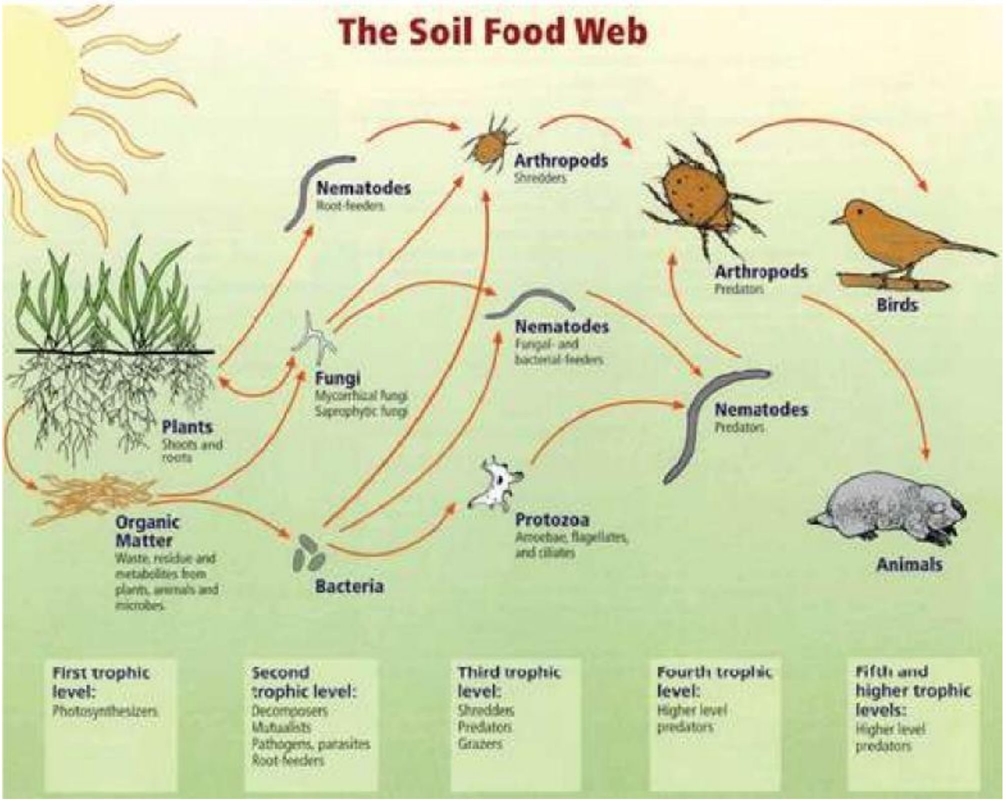
In the image, you can view an **approximate number and diversity** of organisms typically found in a handful of temperate grassland soil (KR & JJIM).



Threats to soil biodiversity

A healthy soil biota needs an appropriate habitat. In soil, this is essentially the space denoted by the complex architecture of the pore network, and the associated supply and dynamics of gases, water, solutes and substrates that this framework supports. Hence threats to soil such as erosion, contamination, salinisation and sealing all serve to threaten soil biodiversity by compromising or destroying the habitat of the soil biota. Management practices that reduce the deposition or persistence of organic matter in soils, or bypass biologically-mediated nutrient cycling also tend to reduce the size and complexity of soil communities. It is however notable that even polluted or severely disturbed soils still support relatively high levels of microbial diversity at least. Specific groups may be more susceptible to certain pollutants or stresses than others, for example nitrogen fixing bacteria that are symbiotic to legumes are particularly sensitive to copper; colonial ants tend not to prevail in frequently-tilled soils due to the repeated disruption of their nests; soil mites are a generally very robust group.

Consequences of soil biodiversity



The relationships between biodiversity and function are complex and somewhat poorly understood, even in aboveground situations. The exceptional complexity of belowground communities further confounds our understanding of soil systems. Three important mechanisms underlying relationships between biodiversity and function are:

- **Repertoire**: for a biologically-mediated process to occur, organisms that carry out that process must be present; Interactions: most soil organisms have the capacity to directly or indirectly influence other organisms, either positively or negatively;
- **Redundancy**: the more organisms there are that can carry out a function in a particular soil, the more likely it is that if some are incapacitated or removed the process will remain unaffected; those that remain fill the gap.

There is evidence that soil biotic communities are coupled to their associated vegetation, such that there is a mutual dependence between above-ground and below-ground communities, and hence that compromised soil communities may curtail particular plant assemblages from forming.

In the image, you may view **Simplified soil food web**. Energy and nutrient elements are transferred from one trophic level to another. Note that there is also a continual movement of material from all trophic levels back to the detritus/organic matter pool and the base of the series (Tugel, A.J. & A.M. Lewandowski, eds., Soil Biology Primer.

Consequences of decline in soil biodiversity

Richness per se is of little consequence; rather it is the functional repertoire of the soil biota that is critical. For processes such as decomposition, there is evidence that there is a high degree of redundancy at a microbial level. Other processes, such as nitrification (the oxidation of ammonium), are carried out by a narrower range of bacteria and there is less redundancy in this group, whereas for highly specific symbiotic associations, such as those between orchids and certain mycorrhizal fungi, there is total dependence and hence zero redundancy. A depletion of biodiversity will therefore have differing consequences in relation to different processes.

In some circumstances it has been demonstrated that there are threshold levels of soil diversity below which processes are impaired, although these are usually related to narrow processes and are manifest under experimentally constructed systems of exceptionally low levels of diversity, as opposed to natural systems. From the intrinsic and bequest perspective, any loss of biodiversity is undesirable. Given our limited state of understanding of the consequences of soil biodiversity, it is common sense that a strong precautionary principle needs to be applied.

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