Erosion in living soil and life in eroded soil

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Abstract

The relationship between erosion and biodiversity is reciprocal. Soil organisms can both reduce soil loss, by improving porosity, and increase it, by diminishing soil stability as a result of their mixing activities. Simultaneously, soil runoff has ecological impacts on belowground communities. Despite these obvious interactions, soil erosion models do not consider biodiversity in their estimates and soil ecology has poorly investigated the effects of erosion. In order to start filling in these knowledge gaps, a novel biological factor was developed and introduced, for the first time, into a well-known soil erosion model (the revised universal soil loss equation, RUSLE). Furthermore, insights to advance soil erosion ecology were proposed. Thanks to available data on both soil erosion (Panagos et al., 2015) and earthworm diversity (Rutgers et al., 2016), an "earthworm factor" was generated and applied to produce the first maps of a modified soil erodibility. The incorporation of "earthworm factor" reduces soil erodibility and as a consequence soil erosion. On the other hand, also the erosive events affect the soil-living communities. Potential consequences of soil erosion on soil life were also identified: migration, invasion, violence, defence, rebuilding and functional effects were described. The results showed how new estimates of soil loss can be produced by adding biological factors to soil erosion models. The earthworm factor represents the first step towards the inclusion of a wider biological factor, which takes into account the whole soil-living community, into erosion modelling. Fostering the development of soil erosion ecology for better understanding the reciprocal effects of erosion on soil life, will contribute towards this achievement. The increasing availability of large-scale data on soil biodiversity distribution opens up the possibility of incorporating a biological component into bio-physical models such as the soil erosion one. The model integration between the soil ecologists and soil erosion modellers is key point for identifying the interactions between soil organisms and soil loss

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EARTHWORM FACTOR

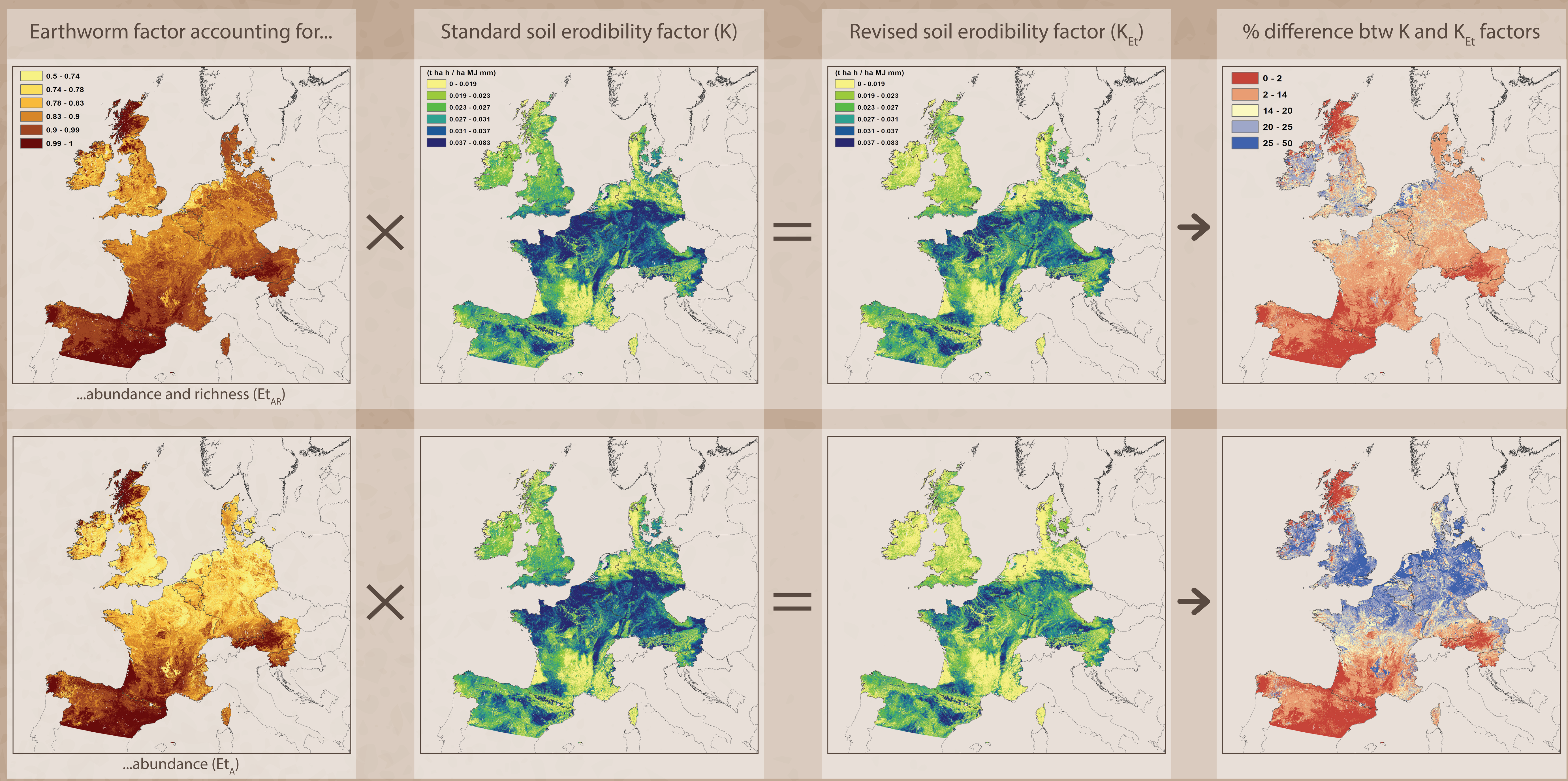
✓ Soil biodiversity affects soil erosion.

✓ Current models for soil erosion estimates take into account many factors (i.e. soil properties, climate, land cover), but not the diversity of organisms living in the soil. A "biodiversity factor" has never been included into soil erosion models so far.

✓ Earthworms have complex effects on soil loss. The burrowing activity can reduce erosion by favouring water infiltration. Simultaneously, cast production by some species may accelerate erosion processes, as cast material could be easily moved away.

✓ The available data (i.e. earthworm richness and abundance distribution) allow the development of an "Earthworm factor" that may be used to refine soil erosion estimates

FROM PROPOSAL TO MAPS



OUR PROPOSAL

✓ We developed an "Earthworm factor" (Et-factor) to be included into "Soil erodibility factor" (K-factor) of RUSLE, the model most commonly used to predict long-term average annual erosion by water

✓ Based on the few available quantitative studies and personal communication with earthworm ecology/biology experts, we assumed that:

1. Earthworm abundance has a reduction effect on soil erodibility up to 50%
2. Earthworm richness has a dual effect (reduction and increase) on soil erodibility.

✓ Based on this, two formulas for calculating Et-factor were generated. First one (Et_{AR}) accounting for abundance and richness, second one (Et_{A}) just for abundance:

1. $Et_{AR} = (1 - R) + [R / (A + 1)]$
2. $Et_{A} = 1 / (A + 1)$

A is earthworm abundance (no. of individuals per m², normalized to a 0–1 index) and *R* is richness (no. of taxa per m², normalized to a 0–1 index).

✓ Both formulas are developed so that $Et_{A(R)}$-factor ranges from 0.5 to 1, which means that, at most, earthworm diversity halved the erodibility factor of soil (i.e. 50% reduction).

✓ Subsequently, a correction to the standard K-factor was incorporated to generate a revised K-factor (K_{Et}) - see maps beside:

$$K_{Et} = K \times Et_{A(R)}$$

SOIL EROSION ECOLOGY

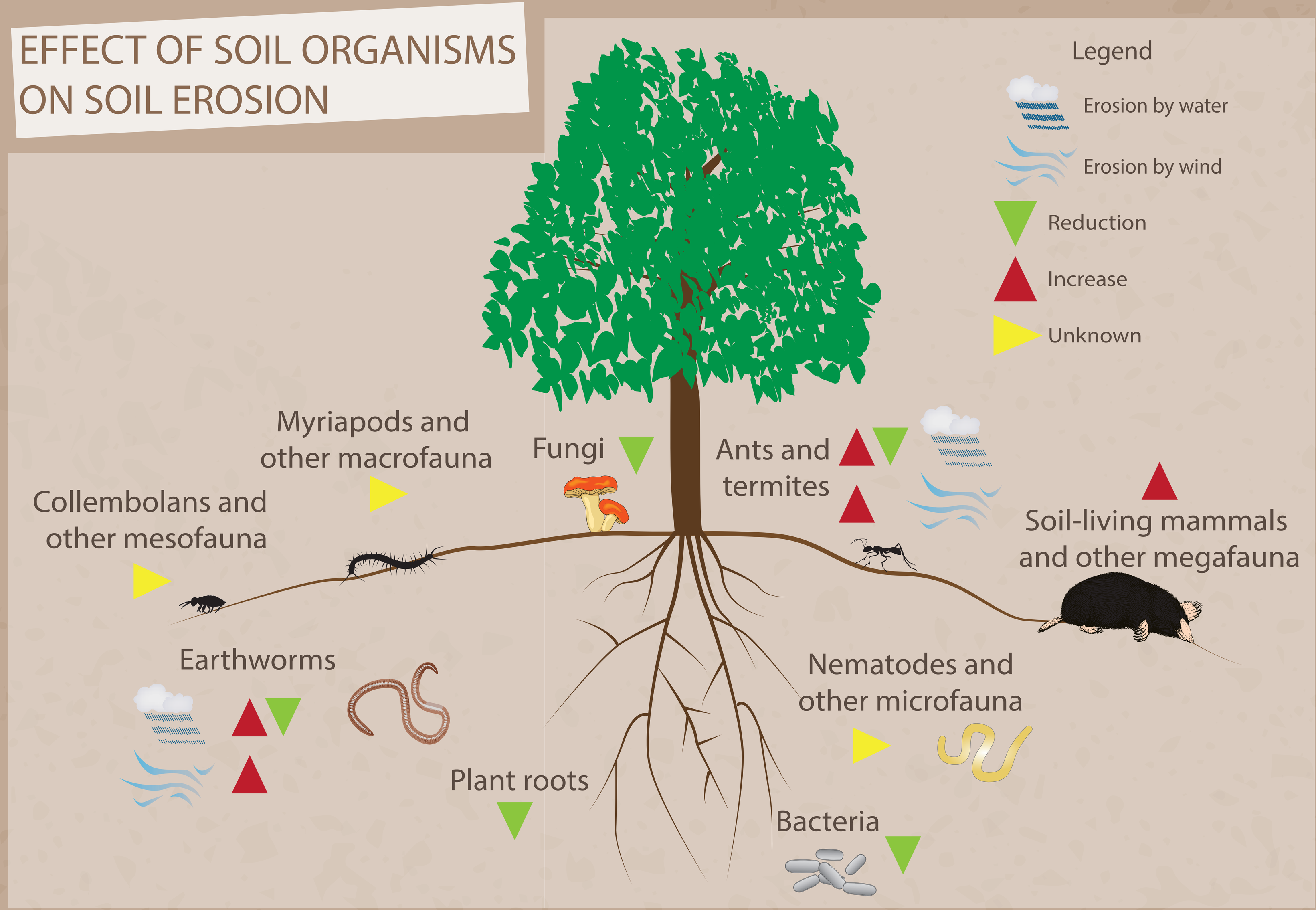
✓ Soil erosion affects soil biodiversity. Given the great abundance of organisms living belowground (e.g. 300 earthworms/m²) and the scale of soil erosion (e.g. mean soil loss rate in European Union is estimated to 2.46 tonnes/hectar annually), this loss surely has an ecological impact on belowground communities.

✓ Soil ecology has poorly investigated the effects of erosion.

✓ We identified six effects that require further investigations to shed light on soil erosion ecology:

1. Migration effect: erosion has a direct impact on soil population dynamics due to the displacemnt of large amount or organisms.
2. Invasion effect: soil runoff can move organisms to considerable distances acting as invasion facilitator.
3. Violence effect: the intensity of erosive events may alter and, potentially, destroy part or entire communities of soil organisms.
4. Defence effect: erosion being a stressor, it is likely that soil organisms have evolved mechanisms for reducing/eliminating potential related damage.
5. Rebuilding effect: some organisms (e.g. fungi) reduce soil erosion. Therefore, soil biodiversity may contribute to ecosystem restoration and promote soil conservation.
6. Functional effect: soil organisms support multiple ecosystem functions and services. By modifying soil communities, soil erosion also infuences the services that they provide.

EFFECT OF SOIL ORGANISMS ON SOIL EROSION



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