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A faunal manipulation study to quantify the impact of earthworms on soil physical properties

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We investigated the effect of earthworms on the physico-hydraulic properties of arable soil that was converted to ley. Seven undisturbed monoliths were collected from each of four arable fields which had been cultivated under arable crops for at least 8 years. The soil in each field was a Cambisol, soil texture varied between fields. For each field three treatments were produced: a control (Control, n = 1), a treatment that was defaunated by freezing at -20 °C for three weeks (F, n = 3) and a treatment that was defaunated by freezing at -20 °C for three weeks and then repopulated with earthworms at a density and diversity based on a nearby pasture field (F+E, n = 3). The monoliths were planted with ryegrass-clover ley and placed within 2-year-old ley transects established in each field. Hydraulic conductivity at potentials of -6, -3, -1 and -0.5 cm (K0.5) was measured once a season over the experiment period and the contribution of different pore size classes (<0.5, 0.5-1, 1-3 and >3 mm in diameter) to water flow was calculated. After one-year, earthworms were recovered, plant material was collected, and soil samples were collected from the monoliths for the measurement of water release curves (SWRC), water-holding capacity (WHC), bulk density (BD), percentage water-stable aggregates (WSA), organic matter (%OM) and total nitrogen content (%N). Wheat bioassays were conducted on the soil from each monolith.

Following the year under ley the monoliths showed a decrease in BD and an increase in %OM relative to the initial soil conditions ($p < 0.05$). Earthworm diversity in the F+E monoliths was preserved and the total earthworm numbers and weights was significantly higher in those monoliths than the F treatments ($p < 0.001$) but not significantly different from the control treatments. K0.5, used as a proxy for saturated hydraulic conductivity, was significantly greater for the F+E than the F and control treatments ($p < 0.001$). Across all treatments, K0.5 increased in Summer and Spring and decreased in Winter ($p < 0.01$). At the end of the experiment, the relative flow of water through pores wider than 1 mm was significantly greater in the F+E compared to the F treatments ($p < 0.05$). SWRC showed significantly higher soil water content at saturation, at field capacity, and plant available water in the F+E compared to F and control treatments ($p < 0.05$). WHC, %OM, %N, %WSA and grass-clover shoot dry biomass were also significantly higher in the F+E than the F treatments. The wheat in the bioassays had higher total dry biomass in the soil from the F+E treatments compared to the F and control treatments ($p < 0.01$).

Our results show improved soil properties after one-year conversion from arable to ley even in the absence of earthworms but further improvement in the presence of earthworms.