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1. Botanic Gardens Conservation International. *Major threats to plant diversity*. https://www.bgci.org/plant-conservation/threats/

European Commission

Science for Environment Policy

Diverse plant communities improve soil structure and, therefore, ecosystem services

Plant diversity improves soil stability, the results of a greenhouse experiment and a long-term field study show. This study, which covered a range of different soil types, is one of the first to investigate the effects of plant diversity on soil structure, which is important for provision of ecosystem services, such as carbon storage and the mitigation of excessive run-off. The findings could help tackle the problem of soil degradation, the researchers suggest.

Biodiversity declines are a threat to ecosystems worldwide, and upward of 25% of all plant species are threatened with extinction[1]. Several studies have attempted to understand how this loss of diversity is affecting ecosystems, with many showing that by disrupting ecosystem functioning, it affects the delivery of essential ecosystem services.

While valuable, most past studies have focused on the impact of plant diversity loss on soil's biological properties and functions, rather than the impact on its physical structure. As the structure of soil is essential to its function (including delivering critical ecosystem services, such as nutrient cycling, carbon storage and flood prevention), this represents a significant gap in understanding. It is especially important to investigate this connection because soil degradation is affecting one third of the earth's soils and is largely due to deterioration in soil's physical structure.

This study investigated how plant diversity affects soil structure, focusing on the role of roots. Roots influence soil structure in many ways, for example, by binding and compressing the particles in soil to make it stronger, and forming pathways for water to flow through soil, which helps reduce run-off, thereby reducing flooding.

The researchers combined a mesocosm experiment (a study of the natural environment, but under controlled conditions) with a field experiment. The mesocosm, in which common grassland species were grown in glasshouses for 18 months, was used to investigate the impact of different plant species and combinations of plants on soil, and to identify the role of specific root characteristics, such as length and density, in forming soil structure.

The long-term experiment, conducted over 10 years at Jena, central Germany, allowed the researchers to confirm whether the effects detected in the glasshouses were also occurring in the field across different soil types. The experiment comprised 82 plots with various numbers of grassland species in each, ranging from one to 60. Species included grasses, legumes and herbs common to European grasslands. The researchers measured various soil properties, including aggregate stability (the ability of soil particles to bind together and therefore resist disintegration) and organic matter content, and related them to plant diversity.

The results showed that the number of different plant species had a significant effect on stability. In both the mesocosm and field experiment — even though the soils had different physical and chemical properties — plant diversity had a strong, positive impact on all measures of aggregate stability. Diversity was also linked to an increase in the production of plant biomass above ground.

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Diverse plant communities improve soil structure and, therefore, ecosystem services *(continued)*

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The roots of the plants played a major role in both experiments, showing strong associations with soil physical structure. In the mesocosm experiment, for example, the researchers found that greater plant diversity increased the length of roots in soil, which is an important contributor to stability. This shows that root characteristics are important to soil's physical properties, which are, in turn, key to soil function.

Specific species of grasses and legumes also affected the physical properties of the soil. For instance, fine rooting grass species, such as *Lolium perenne* (perennial ryegrass), had a beneficial effect on soil aggregate stability, suggesting an increased resistance to soil structural breakdown during flood events. By contrast, legumes with thicker roots such as *Lotus corniculatus* (bird's-foot trefoil) did not show a positive effect on aggregate stability, but increased soil shear strength, a different type of erosion-resistance relevant for landslips and bank erosion. The researchers posit that this plant's wider roots and greater root mass improve its ability to prevent the soil shearing away.

The researchers also suggest that growing a combination of the species identified could have complementary effects on soil structure and help to combat soil degradation, which is widespread across Europe and the world. Developing diverse plant communities could help to restore soil function, the researchers suggest, enabling the maintenance and restoration of soil ecosystem services that are essential for human wellbeing.