

Science for Environment Policy

Species diversity throughout the food chain maintains multiple ecosystem services more effectively

Biodiversity's contribution to ecosystem services in grasslands — at different levels of the food chain (known as trophic levels¹) — has been assessed in a new study. Higher species diversity across trophic levels — particularly for plants, insects and soil microbial decomposers — is important for the provision of multiple ecosystem services related to food production, recreational benefits, or climate regulation. Species diversity across different trophic groups was also found to be just as important in controlling ecosystem functioning as the management intensity of grasslands and environmental factors, such as climate or soil type.

Globally, biodiversity is being lost due to factors such as habitat loss, land use and climate change, pollution and invasive species. The changes in biodiversity can lead to a reduction in species richness — the number of different species — and changes in the abundance of organisms within multiple trophic levels. Understanding how this loss of biodiversity can result in changes in ecosystem functioning is important for conservation and regional policy and planning because of its impact on ecosystem services, such as pollination and climate regulation.

This study, one of the few to have looked at the whole trophic chain, analysed the relationships between the richness and abundance of nine trophic groups in 150 grassland sites in Germany. Sites were chosen to cover land managed at a range of intensities, including different grazing, mowing and fertilisation regimes. Information on management was obtained from questionnaires sent to landowners. The different trophic groups were measured directly and comprised: plants and mosses (primary producers); insects and insect larvae which feed on plants (above- and below-ground herbivores); carnivorous insects and insect larvae, spiders and centipedes (above- and below-ground predators); insects and millipedes which feed on leaf litter (detritivores); soil bacteria (soil microbial decomposers); mycorrhizal fungi, which colonise plant roots and contribute to nutrient uptake (plant symbionts); and protists that feed on bacteria (bacterivores). Abundance and richness was measured using appropriate sampling methods for each group (for example, vegetation cover was recorded to measure the abundance of plants and mosses).

The simultaneous provision (termed 'multifunctionality') of 14 ecosystem services was also assessed, covering the four main ecosystem service types: **provisioning**; **regulating**; **supporting**; and **cultural** services. **Provisioning services** were related to agricultural value, and comprised fodder production, measured as above-ground biomass, and fodder quality, based on protein and forage value. **Regulating services** measured included soil carbon levels (related to climate regulation), and variables related to regulation of crop diseases and pollination. **Supporting services** (that foster the other ecosystem services, including nutrient cycling or soil stability) comprised potential nitrification (the process by which bacteria in soil oxidize ammonia and form nitrates and nitrites), phosphorus retention, root biomass and decomposition rate, colonisation of roots by mycorrhiza and soil stability. **Cultural services** were assessed using flower cover and bird diversity as an indication of the benefits derived from using the grasslands for recreation.

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Contact:
santiago.soliveres@ips.unibe.ch

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1. Trophic levels are stages in the food chain, e.g. plants are eaten by herbivores, which in turn are eaten by predators, each class of organism occupying its own trophic level.

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2. This study aimed to filter out the effects of management on biodiversity, quantify the effect of biodiversity *per se*, and compare this effect with that of environment or management. A detailed study of the effect of management on biodiversity was the main question in another study, published from the same project: Allan *et al.* (2014). Interannual variation in land-use intensity enhances grassland multidiversity. *PNAS*, 111 (1): 308–313.

Statistical models were used to explore the relationship between the richness and abundance of species within the nine trophic groups and each ecosystem service. The results of these models were compared with models that considered only plant-species richness as well as with models that included the richness and abundance of each individual trophic group. The researchers also accounted for other variables, including land-use intensity, soils and climate.

Results showed that higher species richness across different trophic groups (multitrophic richness) had stronger positive effects on ecosystem services than richness in any individual group. This included plant-species richness, the most widely used measure of biodiversity. For example, both plant and predator richness were related to high levels of pest control. Multitrophic richness was particularly beneficial for 'regulating' and 'cultural' services, whereas the abundance of individuals (or total biomass) across different trophic levels was important for supporting services. Species diversity across different trophic levels was as important as land-use intensity and environmental conditions, such as climate, as a driver of ecosystem functioning. The diversity of primary producers, herbivorous insects and soil-microbial decomposers were all positively associated with multiple ecosystem services and, therefore, also considered particularly important drivers of ecosystem functioning.

According to the researchers, previous studies on ecosystem functioning have focused on single species groups, such as plants, and may, therefore, have underestimated the importance of biodiversity across multiple levels. The organisms included in this study total 4 600 above- and below-ground plant, animal and microbial species (groups). Overall, the results demonstrate the important effect of species richness on the functioning of ecosystems. Management efforts² should, therefore, aim to protect diversity across different trophic levels so as to ensure a variety of ecosystem services are maintained as part of conservation and planning efforts. This should also include groups of species, such as soil microbial decomposers, which are often not the focus of conservation efforts.

