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How plant functional traits cascade to microbial function and ecosystem services in mountain grasslands

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1. There is growing evidence that plant functional diversity and microbial communities of soil are tightly coupled, and that this coupling influences a range of ecosystem functions. Moreover, it has been hypothesized that changes in the nature of interactions between plant functional diversity and microbial communities along environmental gradients contributes to variation in the delivery of ecosystem services. Although there is empirical support for such relationships using broad plant and microbial functional classifications, or from studies of plant monocultures, such relationships and their consequences for ecosystem services have not been quantified under complex field conditions with diverse plant communities.
2. We aimed to provide an explicit quantification of how plant and microbial functional properties interplay to determine key ecosystem functions underlying ecosystem services provided by grasslands. At three mountain grassland sites in the French Alps, Austrian Tyrol and northern England, we quantified, along gradients of management intensity, (i) plant functional diversity, (ii) soil microbial community composition and parameters associated with nitrogen cycling, and (iii) key ecosystem processes related to the carbon and nitrogen cycles including aboveground biomass production, standing litter, litter decomposition, soil organic matter and nitrate and ammonium leaching . Considering that plants strongly determine microbial communities, we used a hierarchical approach that considered first direct effects of plant traits and then effects of soil microorganisms on processes, to determine the relative effects of plant and microbial functional parameters on key ecosystem properties.
3. We identified a gradient of relative effects of plant and microbial traits from properties controlled mostly by aboveground processes, such as plant biomass production and standing litter, to properties controlled mostly by microbial processes, such as soil leaching of inorganic N (NO_3 or NH4). Soil organic matter illustrated an intermediate situations with joint control by plant and microbial traits.
4. Across all sites, we found that increasing management intensity, and concomitant changes in soil fertility, was associated with more exploitative plant strategies (high Specific Leaf Area and Leaf Nitrogen Concentration) and taller vegetation. These vegetation functional properties provided the benefit of greater production, but at the cost of poor carbon and nutrient retention, notably because they were associated with microbial communities dominated by bacteria and with rapid rates of nitrification. Conversely, decreasing management intensity resulted in dominance by plants with conservative strategies (high Leaf Dry Matter Content and C/N ratio), usually low production, but benefits for carbon sequestration and soil nutrient retention by favouring microbial communities dominated by fungi co-occuring with bacteria with slow activities.