MANAGE SOIL BIODIVERSITY FOR DELIVERING ECOSYSTEM SERVICES

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Global issues, local solutions

Maintaining soil biodiversity can have a positive impact on many large-scale challenges currently facing society. These include the need to produce food, fibre, biomass and fuel sustainably, to store and filter water, reduce greenhouse emissions, and the need to contribute to a wide range of other ecosystem services in the managed and unmanaged environment, including in urban settings. Although these are recognised as global scale challenges, management of soil and its biodiversity can only be achieved at a local scale. The mosaics of land-uses, land ownership and conflicting land-uses, plus the practicalities of soil management mean that soil biodiversity management is rarely practised at a scale larger than the field, farm, park, or occasionally small catchment (watershed) or sub-catchment. Attempts to apply blanket soil management solutions on top of these mosaics are unlikely ever to be successful. Any attempt to manage ecosystems needs to be undertaken with due regard to natural processes, which for soil biodiversity means managing the plant community or organic matter inputs to soil because this is the easiest and most direct way to affect the soil community.

Diversity and function

There is no single answer to what is good, or the correct level of diversity in soil, because this depends on the function. However, it is accepted that biodiversity is more than just the number of species in soil; it is a multifaceted property of the community, and the many trophic interactions that occur within the soil food web, which can affect its ability to deliver ecosystem services. Also, it is generally accepted that soil communities that most resemble those of natural communities, which tend to be more complex and species rich than those of managed systems, have greater functional capability and are more stable, and that high species richness is less likely to be a challenge to ecosystem service delivery than is low species richness. That said, the circumstances under which low species diversity in soil negatively affects ecosystem services are limited, which is most likely due to the tremendous functional redundancy in soil communities, in which the ability to perform a particular function is widely distributed across many taxa. For example, many of the biogeochemical transformations involved in the decomposition of organic matter or the mineralization of nitrogen, or the stabilization of soil structure through the production of adhesive extracellular polysaccharides, are performed by wide range of soil organisms. In contrast, some soil functions, such as nitrification and nitrogen fixation, and formation of specific mycorrhizal associations, only occur in a narrow range of specialized organisms. Obviously, ecosystem services dependent on these specialized functions are far more vulnerable to declines in diversity than those dependent on generalized functions. Addressing a deficiency in soil biodiversity, particularly one attributable to the loss or absence of a specific function, is always possible, but simple introduction or reintroduction of specific organisms is unlikely to be successful if the environmental conditions are not conducive to its survival, or are not ameliorated to allow its survival. Rather, modification of the environment, for instance through the introduction of organic matter, amelioration of acidity through liming, or the growth

of particular plants, offer more practical solutions. There are also the attendant problems of deliberate or accidental introductions of non-native invasive species. In addition, it is possibile that incomplete knowledge of the soil biological community at a particular location has caused the desired function to simply be overlooked and alien introductions may not actually be necessary.

Land-sparing and land-sharing

Some uses of land and therefore the harnessing of the biological processes conducted in the soil are currently achieved by very intensive management in which any deficiencies in ecosystem services, such as nutrient supply or disease control, can be remedied by large and often energetically rich inputs, such as fertilizers, pesticides and fuel (for tillage). However, neither the long-term sustainability nor the survival of functional soil communities is assured under extremely intensive usage. Therefore, connected refugia in the landscape which are not so intensively managed are needed to conserve soil biodiversity. Similarly, multifunctional land uses will become increasing important in which packets of land are spared the most intensive single use, e.g. intensive agricultural production, in the interests of providing other potentially competing land uses, e.g. water storage, leading to land-sharing.