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Linking soil functions to carbon fluxes and stocks

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Farming practices causing declining returns and inputs of carbon (C) to soils pose threats to sustainable soil functioning by reducing availability of organic matter for soil microbial activities and by affecting soil structure, and soil C stocks that contribute to regulating greenhouse gas emissions. Declines in soil C also affect availability and storage capacity of a range of essential plant nutrients thus affecting needs for external inputs. Soil degradation is considered a serious problem in Europe and a large part of the degradation is caused by agricultural activity with intensive cultivation in arable and mixed farming system contributing to several soil threats.
About 45% of European soils are estimated to have low SOM content, principally in southern Europe, but also in areas of France, UK and Germany. The European SOC stocks follow a clear north to south gradient with cooler temperatures favouring higher stocks. However, SOC stocks strongly depend on soil and land management, and there is thus a potential to both increase and lose SOC, although the potential to increase SOC strongly depends on incentives and structures for implementing improved management.
Understanding the role of soil C may be better conceptualised by using a soil C flow and stocks concept to assess the impact of C management on crop productivity, soil organic C stocks and other ecosystem services. This concept distinguishes C flows and stocks, which may be hypothesized to have distinctly different effects on biological, chemical and physical soil functions. By separating the roles of carbon flows from the role of carbon stocks, it may become possible to better identify critical levels not only of soil carbon stocks, but also critical levels of carbon inputs, which directly relate to needs for crop and soil management measures. Such critical soil carbon stocks may be linked to soil mineralogy through complexed organic carbon on clay and silt surfaces. Critical levels of soil carbon flows may also be related to specific cropping systems and environmental conditions. Much of the effects of soil C fluxes and stocks in cropping systems on crop productivity and needs for input are linked to N supply for the crops and in some regions to harvesting and storage of water for supporting plant needs. The quality of organic matter inputs and the SOM stock determines soil N supply, and here improved models both at strategic (crop rotation) and tactical (annual) scale may improve the precision of crop management with higher crop productivity and reduced environmental impacts. Targeting the needs to manage water also requires improved management of soil C flows and stocks, and here the vertical soil C profile often needs to be considered.