What are the opportunities for enhancing ecosystem services from soils through management of soil carbon?

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Abstract
There is a worldwide need for more balanced decision-making in planning the use and management of our soil resources. Such planning needs to fully consider the value of all ecosystem goods and services supported by soil. However, within the context of economic evaluation, soils have been a poor relation when compared to other natural resources such as biodiversity and water. As a consequence there is a dearth of information on the cost/benefit implications of changing soil management to enhance the delivery of ecosystem services. Here we discuss the opportunities to enhance the delivery of ecosystem services from soils through managing soil carbon using case-studies from Scotland. We examine soils inherent capacity to store carbon in agricultural and semi-natural habitats and reflect on the limitations on achieving this biophysical potential. We then contrast these with the potential costs, ancillary benefits of, and uncertainties in, management options. Finally we discuss potential trade-offs and implications of climate change in the development and achievement of land use policies which involve soil carbon sequestration.

Key Words
Carbon capacity, management, valuation, ecosystem services.

Introduction
The emergence of sustainable development on the policy agenda and a broader view of the importance of soils to fulfil societal needs has brought with it expectations that soil scientists can not only deliver the right sort of information to inform a broad range of land user and policy requirements for soil use and management but that we can also contribute to the wider debate on future options for a sustainable planet. Soil is truly the ultimate model for multi-functionality since there is an expectation that soil resource can be managed to help mitigate climate change, to expand urbanisation, to increase agricultural production to address food insecurities, to provide recreational services, to maintain reliable water supplies, all while maintaining soil quality and protecting our natural environment. This is a tall order and meeting this challenge will require a sound appreciation of the values that people place on the ecosystem goods and services they need and want. At a national level, many countries, the UK included, are championing an ecosystem service approach “to secure a diverse, healthy and resilient natural environment, which provides the basis for everyone’s well-being, health and prosperity now and in the future”. Assessing ecosystem service values goes beyond the bounds of soil science and requires an effective interaction between natural and social science disciplines. In Scotland, we have been developing interdisciplinary research to tackle valuation of natural resources, including soils, as part of the Scottish Government’s research programme on Environment, Rural Land Use and Stewardship. In this paper, we identify the opportunities for soil science to harmonise with the developments of the ecosystem services approach, in particular the interface with social and economic disciplines to support more holistic valuations of our fundamentally non-renewable soils resource.

Soil organic matter (SOM) content is a fundamental property of soil because it determines the soil's capacity to deliver many of its functions, including storing, retaining and transforming water, nutrients and contaminants as well as sustaining biodiversity and carbon sequestration and providing nutrients for biomass production. Thus, loss or increase of soil organic matter could have multiple and diverse environmental, social and economic consequences. Although most soils are managed specifically to optimise the delivery of one or two functions, management to achieve these goals in turn may compromise soils ability to perform the other functions. In our research we developing and applying approaches to characterise and quantify trade-offs in managing soil organic matter, and specifically carbon, to meet specific policy objectives.

Our approach

Capacity for soil carbon sequestration

Scottish soils are estimated to contain approximately 3x 10^9 tonnes carbon, which is the majority of the soil carbon stock of the entire UK. This stock is associated with a wide diversity of soil types reflecting climate and topography, which also accounts for the wide range of functions associated with Scottish soils (Scottish Government 2009). We explore the capacity to increase soil C in across this range of soil types using data from the National Soil Inventory for Scotland (NSIS). This inherent biophysical capacity to sequester soil carbon is reviewed against current soil C stocks under different land uses and the likely reasons of these differences, including land use change, management and pollution.

Cost/benefits in soil C management options

Using two contrasting case-studies, we explore the opportunities to enhance soil carbon sequestration in agricultural and semi-natural habitats and the scientific uncertainties around the success of management options. We report the results of a choice experiment study from 600 households to investigate the costs and benefits of a policy-driven management programme to enhance soil carbon sequestration in Scotland.

Potential trade-offs and implications of climate change in soil carbon sequestration

We investigate the role of ancillary or co-effects on economically driven decision-making for soil C management in the land use and environmental sector. Finally opportunities for, and costs/benefits of, soil C sequestration are considered in the context of future climate change by reviewing potential impacts on the biophysical capacity for Scottish soils to store carbon (c.f. Brown *et al.* 2008; Figure 1); the uncertainties associated with soil C management options and potential trade-offs between different land use policy goals to enhance, protect and restore C sequestration.

Figure 1. Location of prime agricultural land (LCA classes 1, 2 and 3.1) a) current b) predicted under 2050's UKCIP02 Med-High Emissions (Macaulay Institute, work in progress; Scottish Soil Framework, 2009)

References

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