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Soil carbon accounting in the SEEA – a note on the robustness of soil carbon science

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A note on the robustness of soil carbon science

Information Paper for the London Group Meeting

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Background

Within the System of Integrated Environmental-Economic Accounting (SEEA), asset accounts show stocks and associated changes in stocks, of a number of natural resources. Currently SEEA 2003 asset accounts include the following natural resources: mineral and energy, soil, water, biological, land, and ecosystems resources. It is proposed that stocks of carbon (eg in forests or atmosphere) could be included under ‘other resources’ within the asset accounts. The question addressed in this paper is whether to place stocks of soil carbon, in Volume 1 (the standard) or whether they should be placed in Volume 2 (where they require further investigation and development).

Ideally, it would be possible to fully account for carbon emissions and sequestration within the asset accounts chapter of the SEEA. This would conceptually include the four major carbon stores and the exchanges between them, i.e. atmosphere, living organisms or biosphere (e.g. forests, vegetation and soils), oceans and the Earth's crust/sediments.

Most interest within current policy focuses on atmospheric carbon in the form of greenhouse gases and its link to climate change. Thus there is significant interest in understanding the transfers of carbon to and from the atmosphere in relation to emissions (from respiration and combustion of fossil fuels) and sequestration (in forests/other land cover, and soils). With global action to mitigate against climate change, economic instruments have, and are, being introduced in many countries in relation to emissions and sequestration.

Sequestration of carbon in forests is reasonably well understood and accepted, and so it is planned to include this within Volume 1 of the SEEA. Less is known about the potential of soil to manage and sequester carbon. Consequently an action out of the 14th London Group meeting in Canberra was for the ABS to prepare a note, in consultation with relevant scientists, about the likely robustness of soil carbon storage estimates, given the present status of scientific understanding in this field. This note reflects the current state of soil carbon research in Australia, and largely draws on work done by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

CSIRO Land and Water in conjunction with Universities and Government agencies, are undertaking a national research program aimed at defining the influence of agricultural management practices on the quantity and composition of soil organic carbon. This project is being led by Dr Jeff Baldock.

Soil Carbon - the basics

Soil organic carbon (SOC) is the carbon stored within soil, and is made up of plant and animal materials in various stages of decay.

Soil organic carbon has been characterised into four different components, or fractions:

- crop residues – shoot and root residues greater than 2 mm found in the soil and on the soil surface;
- particulate organic carbon – individual pieces of plant debris that are smaller than 2 mm but larger than 0.053 mm;
- humus – decomposed materials less than 0.053 mm that are dominated by molecules stuck to soil minerals; and
- recalcitrant organic carbon – this is biologically stable; typically in the form of charcoal.

The different types of soil organic carbon not only differ in size but are also composed of different materials with different chemical and physical properties and different decomposition times Differences in decomposition times impact on the 'stability', or length of time, that carbon will be stored within each particular fraction.[1]

The importance of soil carbon is well established and accepted among the scientific research community, and is moderately well understood among land managers.

Factors which influence soil carbon levels

Many factors will determine the total potential of the soil to store carbon. These factors include rainfall, temperature, vegetation, soil type and depth, clay content, (clay soils have greater potential than sandy soils) and mineralology. Some of these factors are fixed (such as soil type and climate), while others can be influenced by management practices.[2]

The factors that influence a soils carbon storage potential are largely well accepted, however the detailed quantitative effect of these different factors is still somewhat speculative and further research is needed in this area.

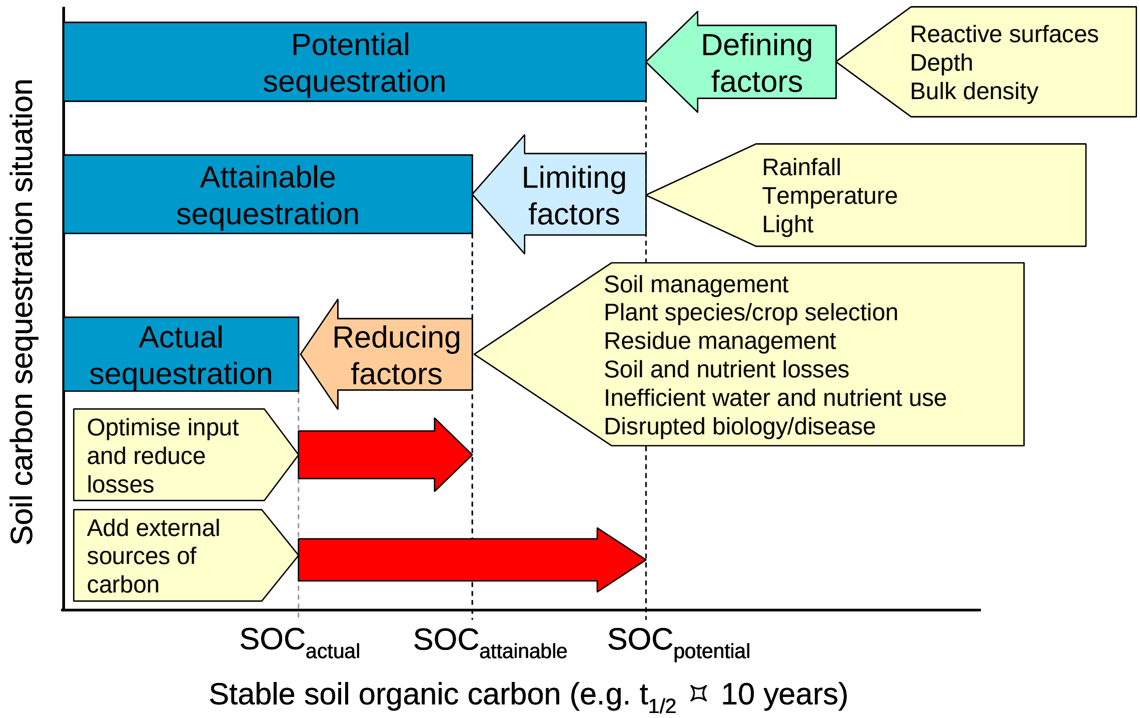
The amount of carbon in a soil is a balance between inputs (plant litter) and losses.

The majority of carbon enters the soil as decomposable plant residues, which are significantly effected by climatic conditions and land management. Decreased plant productivity due to low nutrient availability, disease, or subsoil constraints may limit the amount of carbon returned to a soil. Carbon can enter the recalcitrant pool when fire events convert residues to charcoal.

Losses of carbon from soil result from decomposition of plant residues and conversion into carbon dioxide. Factors that influence decomposition include:

- type of plant and animal matter entering the soil;
- climate conditions (rainfall, temperatures),
- soil clay content, and
- management practices e.g. cultivation, stubble burning or removal and overgrazing.

The following diagram illustrates the influence of different factors on potential soil carbon, attainable soil carbon and actual soil carbon.



Measurement of soil carbon

Measurement of soil carbon can be complicated, labour intensive and costly. While the technology and tools exist to accurately measure soil carbon content in a given sample, taking into account the soil bulk density, there are issues with extrapolating these sample measurements over a wider scale. Numerous, and repeatable, samples are needed to produce reliable estimates, and expanding this out over a wider scale is labour intensive and therefore costly.

The main measurement issues arise from the variability of soil carbon across a single paddock, necessitating numerous samples to be taken to produce a reliable estimate, thereby increasing the cost. Soil carbon content can also vary with depth. Most sampling occurs to a depth of 30cm, however in some soils there can be considerable carbon at deeper levels.

To be able to measure changes over time, sampling regimes need to be repeatable. Further, as changes in carbon content in some of the fractions is quite slow, a high level of reliability in estimates would be required to detect changes over time.

In Australia, the Australian Government Department of Climate Change (formerly Australian Greenhouse Office) has established the National Carbon Accounting System (NCAS). NCAS incorporates a revised version of the RothC soil carbon model calibrated to Australian soil and environmental conditions. NCAS models changes in soil carbon based on the inputs of organic matter from dead plant material and soil carbon decomposition rates. Plant residues are firstly split into decomposable and resistant plant material. Soil carbon is fractionated into various soil carbon pools, generally defined by classes of resistance to decomposition. Turnover rates for each soil fraction are determined by rainfall, temperature, ground cover and evaporation.[3]

Thus NCAS is capable of predicting spatial and temporal changes in soil carbon in response to land use change under agricultural and forestry activities. NCAS uses a wide range of data inputs including remote sensing to detect land use change and a combination of databases and GIS spatial layers for obtaining data required on land use/management, climate and soil. NCAS caters for both continental scale (as feeds into Australia's National Greenhouse Accounts) and project based applications.[4]

The science and tools exist to determine the carbon content in a given soil sample, however numerous samples are required to produce relatively reliable estimates over an area. This is labour intensive, and therefore costly, to implement over a wider scale.

Conclusions

Ideally, soil would be included in the SEEA carbon accounting framework. The inclusion of soil carbon offsets in an emissions trading scheme would formalise an economic and environmental link.

The importance of soil carbon is well established and accepted among the scientific research and rural communities. However uncertainties exist around the quantifiable effects of different land management options on total soil carbon potential.

While the science and tools exist to determine soil carbon content for a given sample, significant costs are involved in ensuring that sufficient samples are taken to account for variability of soil carbon across the landscape.

Australia has developed modelling tools to estimate the carbon content of soils at a landscape level.

Recommendation

It is recommended that detailed soil carbon stocks be included in accounts within volume 2 of the SEEA.

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