How Much Soil Carbon is Stored Under the Signpost Farms

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Summary

- Signpost programme and NASCO are vital to progress to robust Measurement, Reporting & Verification (MRV)
- Accurate national baseline of profile soil carbon is essential
- SOC stocks at depth are responsive to management and contribute substantially to the overall carbon stock
- Different soil types have different capacity to sequester carbon

Introduction

Global climate change is one of the most pressing challenges facing our planet, and soil carbon sequestration has emerged as a promising solution to mitigate this challenge. Soil carbon sequestration refers to the process of capturing and storing atmospheric carbon in soils. Soils, especially agricultural soils, have a huge potential to act as carbon sinks, helping to reduce atmospheric CO2 concentrations and mitigate the negative impacts of climate change. Understanding the dynamics of soil carbon (C) sequestration is critical to developing sustainable land management strategies and achieving climate change mitigation goals.

The National Agricultural Soil Carbon Observatory (NASCO) (Murphy et al., 2024) and the Signpost Programme are coherently combining knowledge, infrastructures and tools to establish Irish specific emission factors for soil carbon sequestration for inclusion in Ireland's National Inventory (EPA, 2023). Through these projects, Ireland has invested in the largest infrastructure in Europe to measure and report emissions and calculate C stored in the soil and biomass. The knowledge developed will further our understanding of carbon sinks and sources in Irish agriculture. Furthermore, it will support a transition to more refined emission factors for Tier 2 and Tier 3 approaches within National Inventory Reporting (NIR) under UNFCCC reporting requirements, rather than the current Tier 1 estimates. Integrating datasets will allow us to create a comprehensive carbon budget for Ireland that captures both dynamic fluxes and stable storage. The advanced techniques and tools used will improve our ability to quantify carbon sequestration, informing how soils can act as more effective carbon sinks, contributing to climate change mitigation.

Soil Carbon Sequestration: Insights from the Signpost Programme

The soil campaign from the Signpost Programme effectively addresses spatial variability with standardised and scientifically sound sampling techniques for a more detailed and accurate assessment of Soil Organic Carbon (SOC) stocks as national baseline of soil C in Irish farming systems (Figure 1).

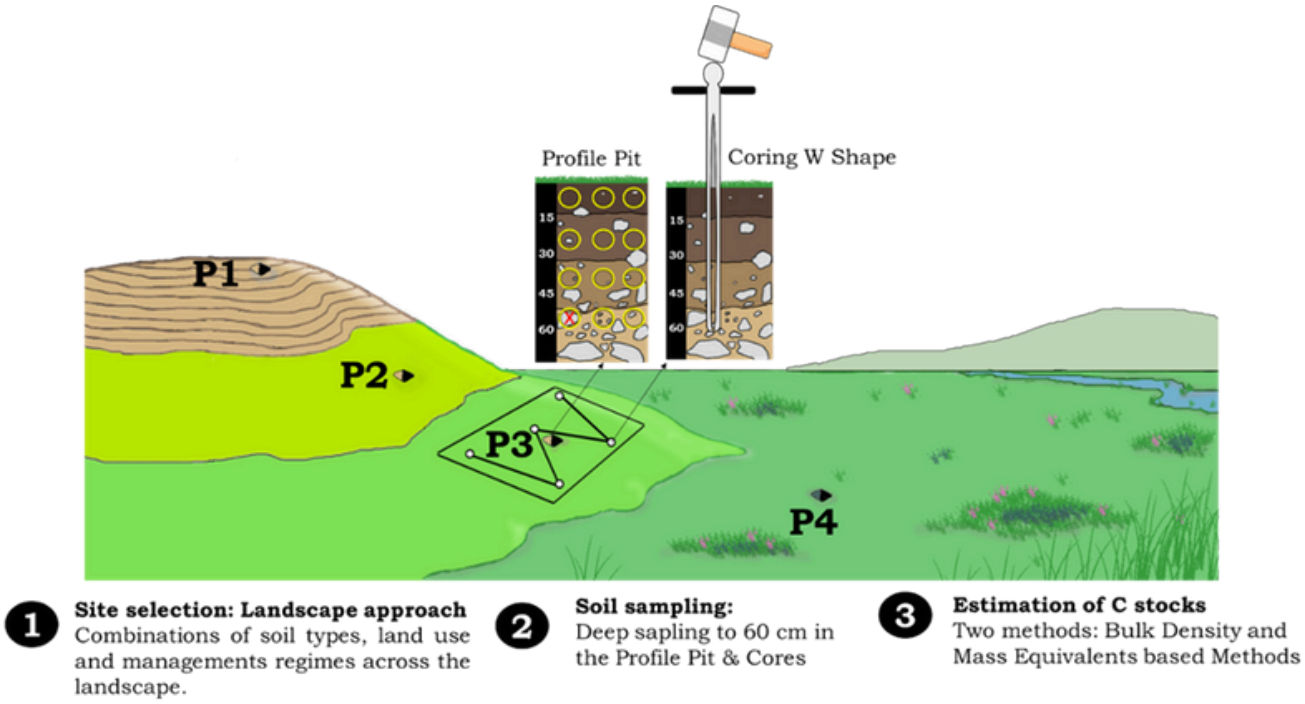

Figure 1: Method scheme for Site selection and sampling within the Signpost Programme

Through a network of participating farms, the Signpost programme collects comprehensive data on soil carbon stocks, greenhouse gas emissions and land management practices. This information is essential to understand the factors that influence carbon dynamics in Irish soils and to develop targeted strategies to maximise carbon sequestration potential.

Quantifying Soil Carbon Stocks: These data serve as a basis for assessing changes in carbon stocks over time in response to different management practices. (Bondi et al., 2024).

Assessing the Influence of Management Practices: The Signpost programme investigates the impact of different management practices, on carbon sequestration. By assessing the performance of different management practices, the programme aims to identify those that enhance carbon sequestration while minimizing greenhouse gas emissions (Bondi et al., 2024).

Developing Measurement, Reporting and Verification (MRV) Systems: The Signpost programme is involved in developing robust MRV systems to monitor and verify changes in SOC stocks. Accurate MRV systems are essential to assessing the effectiveness of carbon sequestration strategies and ensuring transparency and accountability in climate change mitigation efforts (Green et al., 2024).

The Deep Soil Sampling Campaign

In 2023-2024, the Signpost team sampled 67 farms, analysing 268 soil profiles and collecting more than 1000 soil samples. On each farm, four distinct sampling locations were selected at different landscape positions to capture diverse combinations of soil types, agricultural systems, and land management practices (Figure 1). Samples were taken at four soil depths (0-15, 15-30, 30-45, and 45-60 cm).

SOC stocks values for our farms range from 47.66 to 198.71 t ha^{-1} SOC stock up to 60 cm of soil. The results indicate that tillage farms overall exhibit the lowest SOC stocks, with an average of 89.81 t ha^{-1} SOC stock in the 0-60 cm soil profile. The topsoil in tillage farms recorded relatively low SOC stocks levels (34.56 t ha^{-1}) due to continuous tilling and harvesting activities. In contrast, SOC stocks in permanent grasslands were higher, with an average of 96.65 t ha^{-1} recorded within the full soil profile, and 45.69 t ha^{-1} concentrated in the first 15 cm — 32% more than in croplands. This increase can be attributed to the permanent grass cover, which reduces erosion and minimizes carbon loss to the atmosphere. For both systems, the highest carbon sequestration capacity, can be attributed to the Luvisols and Gleysols, associated with high clay content especially at depth (30-60 cm), which helps to protect carbon from microbial breakdown and retains it in the soil for longer periods of time (Torres et al., 2017). In general, SOC stocks are influenced by the interplay of soil types, agricultural systems, and management practices. Furthermore, SOC stocks at depths of 30-60 cm, though often overlooked, contributes meaningfully to total carbon stocks and remains responsive to management interventions.

Implications for Stakeholders

The Signpost Farm programme's findings highlight the significant potential of agricultural soils to act as carbon sinks, contributing to climate change mitigation efforts. Continued research and innovation in this space is crucial to unlocking the full potential of soil carbon sequestration for a more sustainable future. The Signpost programme provides valuable insights into soil carbon sequestration in Irish farming systems that can benefit several stakeholders.

Farmers: Signpost programme results provide farmers with practical information on management practices that can improve carbon sequestration on their farms. By adopting these practices, farmers can store carbon and mitigate the impacts of climate change, improve soil health, and potentially access economic incentives associated with carbon markets.

Policy makers: Signpost data supports the development of evidence-based policies and guidelines related to soil carbon sequestration in agriculture. This information can inform national climate change mitigation strategies, incentive programmes and reporting frameworks.

Industry: Carbon sequestration information generated by the Signpost programme can guide industry in developing innovative technologies, products, and services that support sustainable agricultural practices. This includes the development of soil carbon assessment tools, soil amendments, and management practices that enhance carbon sequestration.

Accurate SOC measurement and monitoring are key for identifying trends and enhancing sequestration strategies. Future research should focus on integrating C datasets to improve Tier 3 modelling for national inventories and decision tools like AgNav. Developing precise soil carbon models that reflect varied soil types, practices, and climates, along with enhancing MRV systems using remote sensing and machine learning, will ensure transparent carbon tracking. Improved soil mapping through high-resolution data will provide more accurate assessments. Additionally, understanding climate change impacts on soil C will guide adaptive management, strengthening Ag Nav's support for sustainable agriculture.

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