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Framework to stratify mixed farming systems to estimate soil organic carbon in eastern Australia

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Abstract: Delivering high integrity carbon credits based on robust, science-based methods is essential to support businesses in meeting their emissions reduction targets, and for the successful adoption of carbon farming in Australia. This paper proposes a framework to stratify soil carbon projects by incorporating a range of biophysical, agricultural production and remotely sensed data with a goal of open science and a transparent carbon industry.

The 2021 Soil Carbon Method requires baseline and monitoring sampling points to be allocated randomly within strata. Well-defined strata can manage systematic spatial variation and generate meaningful sampling units that relate to factors that drive soil carbon accumulation. These factors include: climate, topography, landform, soil properties, land management and ground/vegetation cover (Wang et al. 2017).

The proposed framework for stratification considers determinant factors initially (or 'controlling variables'; those that cannot easily be changed), then factors that can be altered such as land use and management practices. Initially, a digital terrain model representing topography and landform is classified into representative similar units with Jenks natural breaks classification. Landform is then compared to soil type information and amalgamated to generate preliminary macro strata in ArcGIS Pro by using the union geoprocessing function. These are spatially explicit and used to constrain further strata.

Next, we consider land use, for this paper we will focus on perennial pastures with limited woody vegetation cover. Utilising the macro strata to constrain the formation of additional strata, we then apply temporal seasonal fractional cover to develop well-defined strata with the goal of reducing spatial variation in sampling for soil carbon stocks. Seasonal fractional cover displays representative values for the proportion of bare, green and non-green cover, which predicts vegetation cover at medium resolution (10 m per-pixel) for each 3-month calendar season, created from Sentinel-2 imagery by the Joint Remote Sensing Research Program (2022).

Framework performance and reliability is evaluated through field validation of strata, specifically measuring variance in the key metrics of soil organic carbon (SOC %), texture, pH, ground cover and vegetation composition. In-field observations of these variables, within and between strata boundaries ensures accurate representation of the major topographical, soil and botanical features that influence SOC stocks. Stratification effectiveness in estimating SOC stocks (including variance) is calculated through comprehensive project baselining.

Potential challenges that may arise during the implementation of the framework are considered, including atypical areas such as containment paddocks, areas of pasture dieback, header trails, windrows, corners of paddocks, close to fences or tracked areas. These may skew validation information reinforcing the need for detailed and spatially explicit land management data.

Incorporating a producer's active land management into the stratification process can enhance the amalgamation of a soil carbon project into existing operations, reducing project risks and carbon variance discounting. While individual components of this framework are not new, presenting this framework approach provides an opportunity to operationalise spatial data science in the design of carbon projects based on the variables that are most dominant in influencing soil carbon accumulation.

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