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Modelling soil bulk density at the landscape scale and its contributions to carbon stock uncertainty

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Much of the uncertainty associated with soil organic carbon (SOC) stock inventory is due to an inadequate representation of soil bulk density (Db). Direct measurement of Db is a time consuming process, meaning it is frequently predicted using surrogate variables. While readily measured soil properties, like texture, can be used to infer Db values at a pedon scale (approximately 1 m^2), this approach has limited value for a landscape scale inventory. This is because the accuracy of the Db values beyond the sampling point at which texture is measured becomes highly uncertain. In response to this problem, we explore the ability of soil landscape models to predict Db using a suite of landscape attributes and derivatives, without using measured soil property data, for both topsoil and subsoil. By modelling Db using changing landscape attributes, it can be viewed as spatially variable, rather than as a fixed soil property. Models were constructed using multiple linear regression, random forests and artificial neural networks.

Artificial neural networks were the statistical technique best able to predict Db for both topsoil (R^2=0.665) and subsoil (R^2=0.485). On the strength of these predictions, we were able to produce landscape scale maps of topsoil Db. Topsoil is generally considered to be the most important component when predicting soil carbon content, in part because OC concentration generally decreases with depth. The advantage of this gridded spatial representation of Db is that it offers a quantifiable level of accuracy and error, which is consistent across the entire landscape. To illustrate the potential improvement of adopting this approach, we calculated regional stock and conducted a landscape-scale inventory of SOC. Regionally, the differences in SOC stock prediction could be quite pronounced, with the gridded estimate of Db predicting stock to be nearly 10 t ha-1 less than using a mean value. Across the entire landscape used for this study, this equated to a difference of nearly 700,000 tonnes of carbon, solely due to the method by which Db is estimated.