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The potential to use full inversion tillage to increase soil carbon storage during pasture renewal in New Zealand

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The global atmospheric concentration of CO_2 and other greenhouse gases (GHG) is steadily increasing. It is estimated that, worldwide, soil C sequestration could offset GHG emissions by 400–1200 Mt C per year. Relative to 1990, New Zealand's CH4 and N2O emissions in 2013 had increased by 7% and 23% respectively, which translates to an annual emission increase of 1.09 Mt C that could be offset by a similar annual increase in soil C stock. Recent research has shown that many New Zealand pastoral soils are under-saturated in SOC. Subsurface soil (15–30 cm depth) typically has a greater soil C saturation deficit than topsoil (0-30 cm) because plant C inputs (roots) are lower. Using management practices that expose more of the under-saturated soil to higher C inputs could result in increased soil C storage and stabilisation.

Pasture renewal (destruction and re-establishment of pasture) is promoted to livestock farmers to improve pasture performance. This typically involves shallow cultivation or direct drilling to establish new grass. Whereas shallow cultivation of soil typically results in a loss of SOC, deeper full inversion tillage (FIT) of soil would result in the burial of C-rich topsoil in closer proximity to mineral material that has a higher stabilisation capacity. Buried SOC is expected to have a slower decomposition rate owing to less variable temperatures and more anoxic conditions. Deep FIT would also bring under-saturated mineral soil to the surface, where the deposition of SOC from high producing pastures could increase the stabilisation of SOC. Both the slower turnover of buried SOM and greater stabilisation of new carbon on under-saturated minerals at the soil surface are expected to result in increased SOC sequestration.

There is a lack of experimental data to directly address the effect of FIT on soil C stocks in pastoral soils. We applied a simple empirical model to predicting changes in soil C stocks following a one-off application of FIT (30 cm) during pasture renewal. The model accounts for the decomposition of SOC in buried topsoil and the accumulation of C in the new topsoil (inverted subsoil). The model was used to derive national estimates of soil C sequestration under different scenarios of C accumulation efficiency, farmer adoption of FIT and pasture renewal rates.

Our modelled estimates suggest that 5.1 Mt C could be sequestered by applying FIT (0-30 cm) to 367,000 ha of High Producing Grasslands on suitable New Zealand soils. This estimate is based on 100% accumulation efficiency (i.e. topsoil C stocks are returned to pre-inversion levels within 20 years), 10% farmer adoption of FIT and a 10% annual rate of pasture renewal. In the absence of direct experimental evidence, a more conservative estimate is warranted, where topsoil C stocks are projected to return to 80% of pre-inversion levels, thus sequestering 3 Mt C. This paper will present our modelled estimates of SOC sequestration during FIT pasture renewal and discuss the potential benefits and adverse effects of deploying this management practice.