Use of dynamic, process-based models of soil C and N turnover to explore tradeoffs between land use change for agricultural production and carbon sequestration

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In order to explore tradeoffs between land use change for agricultural production and carbon sequestration, models are needed that accurately reflect the conditions of all soils across the area of interest. ECOSSE (*Estimation of Carbon in Organic Soils – Sequestration and Emissions*) is a model that allows simulations of soil carbon and nitrogen turnover in both mineral and organic soils using only the limited meteorological, land use and soil data that is available at the national scale. Because it is able to function at field as well as national scale, if appropriate input data is used, field scale evaluations can be used to determine uncertainty in national simulations. An evaluation of the uncertainty expected in national scale simulations of Scotland, using data from the National Soils Inventory of Scotland, suggests that the uncertainty in the national scale simulations will be ~11%. The ECOSSE estimate of annual change in soil C stocks for Scotland between 2000 and 2009 is -810 (±89) kt $year^{-1}$, equivalent to 0.037 (± 0.004)% yr^{-1}. Reducing land use change from grassland to arable has most potential to reduce soil C losses. If the area of land converted from grassland to arable was reduced to 28% of its current rate of conversion, the soil C losses across Scotland would be reduced to zero. However, given the current agricultural market, such a mitigation option may be unrealistic. Other significant losses of soil C occur due to the conversion of semi-natural land to arable or grassland. The results suggest that if policies were designed to reduce conversion of semi-natural land to arable or grassland, net losses of soil C could be reduced to 53% of the current emissions. If this were coupled with an increase in the conversion of grassland to semi-natural land by 125% of the current rate of conversion, net losses of soil C would be reduced to zero. Alternatively, a 63% increase in the current rate of conversion of arable to grassland would also result in zero net losses of soil C when coupled with the reduced conversion of semi-natural land to arable or grassland. This could equally be achieved by decreasing the current rate of conversion of grassland to arable to 77% of its current rate. The implications of these mitigation options are discussed in the context of the need for agricultural production.