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Carbon storage in soils and plant biomass under future climate and land use pressures

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It is widely accepted in the scientific, business and policy communities that meeting the Paris Agreement targets will require a large-scale deployment of negative emission technologies and practices. As a result, nature-based climate solutions, including carbon sequestration (Cseq) in soils and forests, have received much attention in the literature recently. Several national and global assessments have identified considerable potential for terrestrial Cseq, while other studies have raised doubts regarding its practical limits in the face of the likely future pressures from climate change and land use change. In general, the existing Cseq assessments lack sensitivity to climate change, perspective on local land use and nutrient limitations. Accounting for these factors requires process-based modelling, and is feasible only at national to regional scales at present, underpinned by a wide body of local evidence. Here, we apply an integrated terrestrial C-N-P cycle model (N14CP) with representative ranges of high-resolution climate and land use scenarios to estimate Cseq potential in temperate regions, using the UK as a national-scale example. Meeting realistic UK targets for grassland restoration and forestation over the next 30 years is estimated to sequester an additional 120 TgC by 2100 (similar to current annual UK greenhouse gas emissions), conditional on climate change of <2°C. Conversely, UK arable expansion would reduce Cseq by a similar magnitude, while alternative arable management practices such as extensive rotations with grass leys would have a comparatively small effect on country-wide Cseq outcomes. Most importantly, the simulations suggest that warmer climates will cause net reductions in Cseq as soil carbon losses exceed gains from increased plant productivity. Our analysis concludes that concerted land use change can make a moderate contribution to Cseq, but this is dependent on us cutting emissions from fossil fuels, soil degradation and deforestation in line with a <2°C pathway.