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Land-use affects the radiocarbon age, storage and depth distribution of soil organic carbon in Eastern Australia

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Land-use has been shown to affect soil organic carbon (SOC) storage, with natural systems generally storing larger quantities of SOC than anthropogenically managed systems in surface soils. However, these effects are often difficult to detect deeper in the soil profile. Little is known regarding the effects of land-use on the radiocarbon age of SOC, both at the surface and deeper in the soil profile. We investigated the storage, radiocarbon content and depth distribution of soil organic carbon from across the state of NSW, Australia. A total of 100 profiles were analysed for total SOC concentration at numerous depths (up to 1 m) and a machine learning approach implementing tree ensemble methods was used to identify the key drivers of SOC depth distribution. Surface SOC storage was strongly associated with climate (predominately precipitation, to a lesser degree relative humidity and temperature), whereas SOC depth distribution was predominately influenced by land-use, soil type and to a lesser extent temperature. A subset of 12 soil profiles from a range of climate zones were analysed for radiocarbon content with a view to contrasting three land-use systems: natural, cleared/grazed and cropped. Radiocarbon content was affected strongly by land-use, with effects most pronounced at depth. Native systems appeared to have the youngest carbon throughout the profile, with cropped and grazed systems having older SOC. Radiocarbon content was also strongly associated with SOC content. Our results indicate that natural systems act as a carbon pump into the soil, injecting young, fresh organic carbon which is vertically distributed throughout the profile. In contrast, managed systems are deprived of this input and are depleted in SOC at all depths, leading to higher radiocarbon ages throughout the profile.