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Shrub growth on Arctic tundra triggers a significant carbon sink: evidence from a site in eastern Canada

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The microbial respiration of ancient permafrost carbon represents a positive feedback to climate warming. However, warming-induced shrub expansion in circumpolar latitudes may partly offset these emissions, due to greater biomass and litter inputs than that of primary tundra vegetation. Quantifying this carbon sink has been impeded by the concomitant mineralization of ancient carbon which renders the attribution of changes in soil carbon stocks uncertain. By working at a low Arctic site where ancient carbon stocks are among the lowest in the Arctic, we were able to reduce uncertainties in quantifying the impact of shrub growth on carbon stocks. The site near the eastern shore of the Hudson Bay, Canada, (56.5°N, 76.5°W) is experiencing rapid expansion of dwarf birch (*Betula glandulosa)* throughout lichen tundra. Shrub age was measured by tree ring dating. We find that a cover of low to medium-size shrubs (<60 cm) triggers an increase of 3.9 $\pm$ 1.3 kg m^{-2} in terrestrial carbon stocks, regardless of canopy age. The absence of age dependence shows that litter respiration prevents further carbon accumulation about 20 years after shrub establishment. Using maps of vegetation change from 1994 to 2010, we estimate the carbon sink associated to shrub expansion in our study area (5.228 km^2) to have been 2.4 $\pm$ 0.8 Gg or 29 $\pm$ 9 g m^{-2} yr^{-1}. Although the carbon sink provided by the shrubs can be expected to vary across the Arctic, our local findings nevertheless indicate that shrub expansion deserves serious consideration in assessing future circumpolar carbon budgets.