~~The~~ This study aimed to evaluate the SOC sequestration potential of afforestation on severely degraded soils in southern Iceland due to the forecasted high potential of these soils. ~~For this, we measured the SOC stocks of differently aged afforested birch stands and compared them with those of eroded and degraded soils, re-vegetated grasslands and non-degraded woodlands which have escaped the soil erosion, respectively. In addition, the SOC quality of all sites was analyzed through physical soil fractionation. The present study differentiated between the physically separated SOC pools, which allowed evaluating the success of afforestation by mountain birch on a landscape with highly diverse soil patterns and SOC distributions.~~

Afforestation with mountain birch leads to an ~~significant~~ increase of the SOC stock (0-30 cm) between the age of 15 and 50 years. ~~In addition~~ Since ~~after 50 years of birch establishment,~~ the 50-year birch stands still contained ~~still~~ a ~~significant~~ lower SOC stock than naturally, old growth birch woodlands~~.~~ it appears ~~This means~~ that the SOC stock equilibrium is not reached yet ~~after 50 years~~. Consequently, afforestation with the native mountain birch species is a successful strategy to sequester atmospheric carbon in ~~the mineral phases of~~ severely degraded volcanic soils by about 20 t C ha^{-1}. However, stored C is likely relatively labile with a disproportional rise in the POM fraction SOC (> 63 µm, < 1.8 g cm-3) compared to mineral-associated OC stored in the HF and '< 63 µm' fractions, especially in the top 10 cm. Indeed, the proportion of the latter SOC fraction declined to just more than half of the 0-30cm SOC stock in the afforested plots as opposed to over 90% in un-vegetated soils. As a consequence much of the newly stored C may not be sequestrated at all but is probably prone to loss again in the event of future change in OM inputs. Our approach thus reveals that detailed measurements on the SOC quality are equally needed to appreciate the SOC sequestration potential of restoration activities on severely degraded volcanic soils, rather than only measuring SOC stocks. Lastly, we found that severely degraded volcanic soils are surprisingly variable in their SOC stocks, with often inverse SOC profiles resulting from an interplay between soil erosion and burial by ash from volcanic eruptions. This highly local occurrence of specific SOC depth profiles even more so than normal necessitates a depth differentiated approach to deduce SOC storage resulting from land-use changes.

~~The tested severely degraded volcanic soils showed an unexpected heterogeneity, such as the SOC properties due to landscape and soil development.~~

~~Only measuring the commonly used unfractionated SOC socks can therefore lead to misinterpretation of the sequestration potential of these soils. The study clearly shows that un-vegetated soils can contain certain amounts of SOC before afforestation activities begins. This, it is difficult to use un-vegetated sites and its SOC stocks as initial status before restoration activities begin. Under such conditions, it is advisable to use a depth resoluted sampling approach as well as a physical fractionation technique to extract the SOC deriving from the afforestation process. These fractionation analyses revealed that at least 56 % of the total SOC stock (0-30 cm) is stored in the HF and '< 63 µm' fractions. At the un-vegetated soils, this ratio is even higher than 90 %. And during the establishment of bush vegetation, the ratio of the concentration, the mass and the SOC stock in the POM fraction (> 63 µm, < 1.8 g cm-3) significantly increases, especially in the top 10 cm. Thus, the SOC change deriving from the afforestation effect can easily be disturbed by organic carbon originating from past vegetation which is found in the '< 63 µm' fraction and by sampling the top 30 cm. Instead of applying the space-for-time substitution approach (e.g. chronosequences), we therefore suggest investing more effort in depth-resoluted and qualitative SOC analyses or using permanent plots or a long-term monitoring approaches to assess soil development during vegetation restoration.~~

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Commented [SS2]: I would mention this, but more explanation was needed -> see the above track-changes version

Commented [SS3]: Awkward term: better 'depth-differentiated'

Commented [SS4]: No implications were connected to all of this. In the version above a link is made to proneness to loss of C after any future change in C-input

Commented [SS5]: Not a very astonishing conclusion