How well can we estimate soil carbon stocks at the Swiss CarboEurope site Lägern?

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In the framework of international climate conventions (Kyoto Protocol), the uptake and storage of carbon in ecosystems is recognised as a sink for atmospheric CO_2. However, net carbon sequestration in ecosystems can only be offset against CO_2 emissions, if the actual size of the carbon flux into an ecosystem is known. Therefore, the goal of CarboEurope IP (Integrated Project) is the quantification of the carbon budget of the most important ecosystem types within Europe. At more than 100 sites CO_2-exchange between the atmosphere and the ecosystem is measured using the eddy covariance method. Wind speed, wind direction and atmospheric CO_2 concentration are recorded at sensors above an ecosystem, and are used to calculate the carbon budget of this ecosystem. In Switzerland, the main site Lägern (near Wettingen, AG) has been established to quantify the carbon budget of a montane mixed forest. Usually, at least half of a temperate forest's carbon is stored in the soil; therefore carbon fluxes to and from the soil contribute significantly to the overall ecosystem carbon budget. Interpretation of measured flux data therefore requires detailed information on soil carbon pools of the ecosystem. Additionally, inventory-based carbon budgets yield independent and complementary data to support flux measurements. The present study aimed at the determination of the size, the spatial distribution, and the factors controlling soil carbon stocks at the experimental site. A special focus was upon the uncertainty of the soil carbon stock estimates, as this determines the magnitude of the change that can be detected in a subsequent inventory after 5 or 10 years.

Across the investigation area (approx. 77 ha), 27 sampling sites were chosen, which represented the main vegetation types and soil water regimes. The number of samples from each class was approximately proportional to the frequency of its occurrence. At each sampling site, mixed samples were taken from the litter layer and three depths (0-10 cm, 10-20 cm, 20-40 cm). Additionally, at 4 sites, the reproducibility of the sampling strategy was tested.

Calculation of the carbon stocks revealed that neither vegetation type nor water regime has a significant influence on soil carbon stocks but that the main factor is the parent material from which the soil was formed. Although five parent materials occur in the investigation area, four of them cover 96% of the area. Carbon stocks (mean +/- 2 s.e.) in the upper 10 cm range from 30 +/- 7 t C/ha (soils derived from sandstone of the Lower Freshwater Molasse) to 71 +/- 6 t C/ha (soils derived from Jurassic limestone). Averaged over all soils, carbon stocks are 5.2 +/- 1.1 t C/ha in the litter, 52 +/- 6 t C/ha in the top 10 cm and 119 +/- 14 t C/ha in the top 40 cm. Thus, the error of the carbon stock estimate in the present study is about 12% of the mean for the mineral soil and about 20% for the litter layer. For a subsequent inventory, this would mean that relatively large changes in the carbon stocks would have to occur before they can be detected reliably at the forest stand scale. However, comparison of variability within a site with variability between similar sites showed that this uncertainty is mainly due to the geological heterogeneity of the area, while the sampling strategy resulted in a low variability between replicate samples taken at a specific site. Therefore, we strongly recommend that a future inventory be conducted at exactly the same sites. If at all, it is only with this strategy that we can realistically expect to detect measurable changes in soil carbon stocks within a time frame of 5-10 years.