Changes in SOC stocks and fractions after natural afforestation of alpine grasslands

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1. Background

In the European Alps, the dominant form of land use change is represented by the **abandonment of mountain grasslands** and their consequent **invasion by tree species**, due to socio-economic reasons. The impact of these changes on soil organic carbon (SOC) is still unclear and the processes which lead to changes in SOC need to be elucidated.

AIM: *study the effect of abandonment and natural afforestation of alpine grasslands on soil organic carbon, considering:*

✓Changes in mineral SOC concentrations and stocks

✓Changes in carbon allocation to physical SOM fractions

2. Site description

The study area, located in a **pre-Alpine area** (Lavarone, Trento 45.9458 N, 11.2515 E), represents a typical situation of afforestation in Trentino region:

✓ elevation 1150 m, south aspect, gentle slope (4-15°)
✓ mixed forest, dominated by Norway spruce (*Picea abies*) and beech (*Fagus sylvatica*)

Four contrasting land uses are compared, along a management gradient:

Managed Grassland
Mown twice a year and manured

Transitional Phase
Abandoned grassland

Natural afforestation
Abandonment after 1973

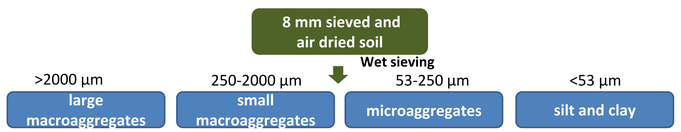
Reference Forest
Already present in 1861 land register

3. Methods

For each land use type three sites were sampled. In each site 8 soil cores were collected to 30 cm depth, and divided in 4 depth increments.

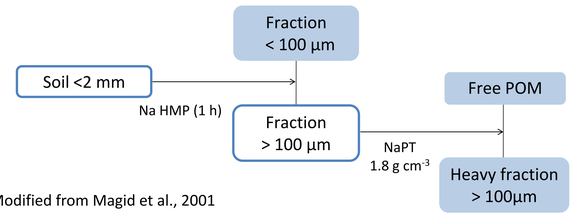
To assess changes in SOC stocks, bulk density, stoniness, root biomass and organic carbon content were determined. Mineral SOC stocks were calculated with both an **equivalent depth** and **equivalent mass** approach.

Aggregate size fractionation



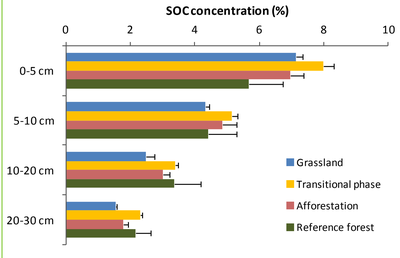
From Cambardella and Elliott, 1993

Size/density fractionation

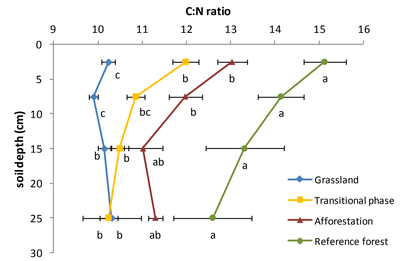


Modified from Magid et al., 2001

4. Results (I). SOC content and stocks

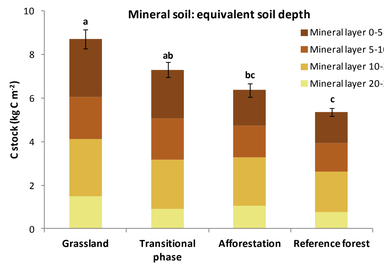


SOC concentration is not significantly different across land uses and depth
The variability is high especially in forest sites.

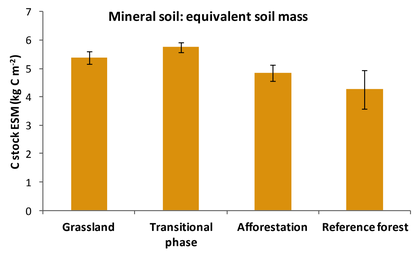


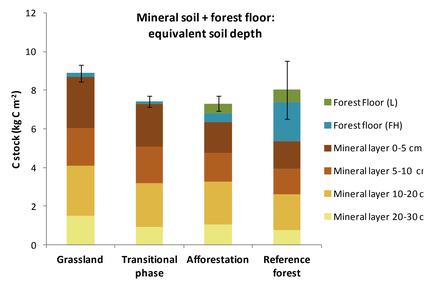
The **C:N ratio** is a good indicator of land use change. It is significantly affected by land use in all soil depth increment, with more pronounced differences in the upper layers.

SOC STOCKS: EQUIVALENT SOIL DEPTH

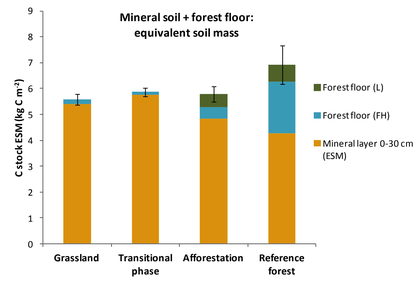


SOC STOCKS: EQUIVALENT SOIL MASS





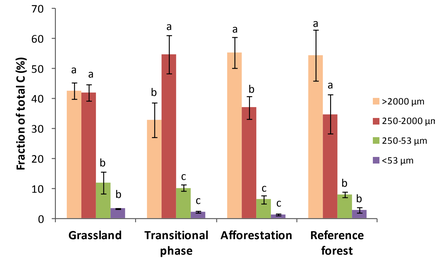
Mineral C stocks are lower in the forest sites compared to grassland, due to lower **bulk density** and higher **stoniness**. If litter and forest floor are included, C stocks are not significantly different between land uses.



Using an **equivalent soil mass** approach, mineral C stocks are not significantly different between land uses. Adding litter and forest floor, the reference forest shows higher but still not significantly different soil C stock.

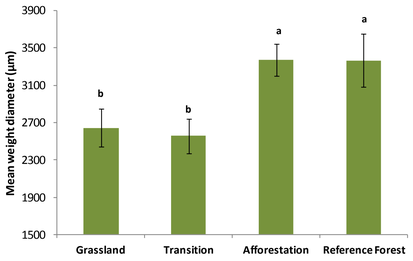
4. Results (II). SOC fractions

AGGREGATE SIZE FRACTIONATION



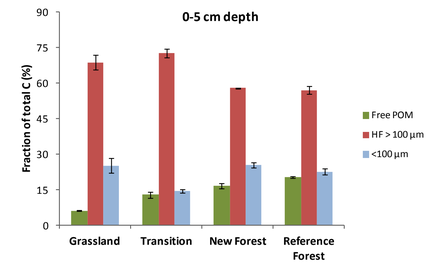
SOC is stored mainly in **large macroaggregates** following afforestation: different rooting system between grassland and forest ecosytems.

0-5 cm depth



In the 0-5 cm depth layer, the mean dimension of aggregates is higher in forest sites.

SIZE/DENSITY FRACTIONATION



- Increase in C stored (more than 3 times) in **free POM** from grassland to forest;
- Decreasing trend of **HF > 100 µm**
- With grassland afforestation: shift from stable to more labile SOC pools

"Take-home" messages:

✓Using an equivalent soil depth approach, forest sites have lower **mineral SOC stocks** compared to grassland, while no significant difference is detected if an equivalent soil mass approach is applied.
✓SOC is stored mainly in **large macroaggregates** following afforestation.
✓With grassland afforestation, there is a shift from stable to more labile SOC pools.

References

- Cambardella, C.A., Elliott, E.T., 1993. Carbon and nitrogen distribution in aggregates from cultivated and native grassland soils. Soil Sci. Soc. Am. J. 57, 1071-1076.
- Magid, J., Kjærgaard, C., 2001. Recovering decomposing plant residues from the particulate soil organic matter fraction: size versus density separation. Biol Fertil Soils 33, 252–257.