Role of belowground biomass of woody plants for carbon accumulation in mountain forest ecosystems

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Summary

The aim of the present study is to characterise the root system structure and biomass of two important forest tree species and to evaluate their role for carbon (C) sequestration in mountain forest ecosystems in Bulgaria. Four different stands, two European beech (*Fagus sylvatica* L.) forests and two Douglas fir (*Pseudotsuga menziezii* Mirb. Franco) plantations, located in the Central Balkan and the Rhodope Mountains, respectively, were selected. Important root traits that characterise the root system distribution (e.g., root mass vertical allocation), root system dynamics (e.g., fine roots annual production and turnover rate) and C-related functional traits (concentration, stock and flux) were investigated.

Two methods for studying tree root systems were applied. A direct method (Rodin et al. 1968) was used to study the total root mass and the distribution of fine (0–2 mm), medium ($2 < d < 10$ mm) and coarse ($d > 10$ mm) roots up to 0–40 cm soil depth. An indirect Sequential soil coring method (Persson 1978) was applied to study the root system vertical distribution and dynamics of three root diameter size classes (0–2, 2–5 and 5–10 mm) sampled at three soil depths (0–15, 15–30, 30–45 cm). Root annual production and turnover rate were analysed and quantified using Decision Matrix and Maximum-Minimum estimation approaches, respectively. The carbon and nitrogen (N) concentrations of the fine roots were measured and used for C and N stock and flux calculations (Xia et al. 2015).

Species-specific patterns of vertical distribution of the overall root biomass and the root classes were revealed. The total root biomass (fine, medium and coarse roots) was significantly higher in the Douglas fir than in the European beech (2562 and 745 g m^{-2}, respectively). A gradual increase of the total root biomass along the soil depth was found, reaching its maximum between 20–30 cm in the Douglas fir, and concentrated in the surface soil layers (0–20 cm) in the European beech. The coarse root biomass had the highest proportion in the Douglas fir (76% of the total root biomass), whereas the medium sized roots ($2 < d < 10$ mm) prevailed in the European beech (50% of the total root biomass).

Both methods revealed similar results in biomass assessments of roots up to 10 mm diameter. However, the Sequential soil coring method was more precise in vertical distribution assessment of the fine and small sized (d = 2–5 mm) roots. More than half of the fine and small root biomass of the Douglas fir stands was allocated in the uppermost soil layer and decreased significantly with soil depth, while in the beech forests the biomass was more uniformly distributed and decreased gradually along the soil depth. Although both tree species belong to two different functional plant types and the stands were situated in two distantly located regions with specific climatic and soil characteristics, the trends of the root biomass and necromass dynamics, annual production and turnover rates were similar. Based on the mean and maximum biomass data, we calculated 1.11 yr^{-1} and 0.76 yr^{-1} mean turnover rate, respectively. These were similar to the mean values reported for Central and Northern European forests and higher than those reported for Southern Europe.

In conclusion, our data suggest that European beech forests exhibit a higher fine root production, C concentration, C stock, and fine and medium root flux, thus having a greater potential for C sequestration into SOC pools. In contrast, the Douglas fir contains a higher C stock in the coarse roots, thus contributing for the carbon long-term accumulation.