Absorbing roots and leaves distribution in studies based on whole tree approach in large pines and oaks

Jan Čermák and Nadezhda Nadezhdina

Institute of Forest Botany, Dendrology and Geobiocenology, Mendel University of Agriculture and Forestry, Zemědělská 3, CZ 61300 Brno, Czech Republic.

Operative biometric parameters and seasonal transpiration were studied in two contrasting specie/sites. Mature Scots pine (*Pinus sylvestris* L.) plantation growing on sandy soil (Brasschaat, northern Belgium) and a mixture of species in the floodplain forest (Lednice, southern Moravia) growing on heavy soil, mostly consisting of pedunculate oak (*Quercus robur* L.), ash (*Fraxinus excelsior* L.) and lime (*Tilia cordata* L.) were compared. The general pattern of vertical leaf distribution in canopy layers at different height above ground was estimated on the basis of destructive analysis of series of trees of different size and social positions using the "cloud technology" (for oak Čermák 1998, for pine Čermák et al. 1998), this gives the best results when combined with canopy leaf density measurements using the fish-eye (e.g., Hemi-view) approach. Results calculated for individual trees were up-scaled for the stand level on the basis of forestry inventory data. Relative vertical distribution of absorbing roots was derived approximately from radial sap flow patters in stems (flow rate in different sapwood layers): superficial roots supply water mostly through outer sapwood layers, sinker roots mostly through inner layers (Čermák et al. 2008). Values valid for the mean trees are shown. Transpiration was estimated on the basis of long-term measurements of sap flow rate using the trunk heat balance method (Čermák et al. 1973, 2004, Kucera et al.1977, Tatarinov et al. 2005)) or the heat field deformation method (Nadezhdina et al. 1998 2006). Series of sample trees were studied at both compared sites; typical years were selected out of 3 to 10 years of continual measurements there (pine: Meiresonne et al. 2003, Verbeeck et al. 2007, Čermák et al. 2008; oak: Čermák et al. 1982, 1983, 1991, 2001). Results measured in series of sample trees were up-scaled using tree and stand biometric parameters related to diameter at breast height, DBH. (Čermák and Kucera 1990, Čermák et al. 2004).

Similarities and differences in tree and stand structure and behavior are discussed. Pine forest was a rather homogenous plantation with a single narrow (main part only about 5 m deep) canopy layer and leaf area index (LAI) of 3.0, which is very low for coniferous species (**Fig. 1**). In contrast, floodplain forest represented a multi-layer almost naturally growing canopy (including also frequent shrubs and herbaceous plants), reaching from the ground to over 30 m high tree tops and rather high LAI=5.0, together with shrub and herbaceous layers LAI=7, which is sometimes characterized as the "European jungle"). Estimated fractions of absorbing roots seems very similar in the main contrasting species, pine and oak, reaching for superficial roots 82 to 84 % and for sinker roots 12 to 16%. However, while these results are mostly correct for pine as a wide-sapwood species, they are probably overestimated for superficial roots in oak, which is a typical narrow-sapwood species, where in principle major part of water flows through the latest annual ring. These characteristics are supported for fine roots of pine (Janssens et al. 1999, Xiao et al. 2003) where sinker roots can be active only in periods of time, when they can reach increasing underground water table, i.e., usually in spring. Nevertheless soil water supply can quickly decrease during even slight drought in sandy soil. Seasonal transpiration of about 140 mm is relatively low, but even much lower values were found under extreme site situations (e.g. pine stand transpired only 50 mm on dry sand-rocks – Čermák et al. 1986). Similar spatial root distribution is true for coarse roots of oak (Vyskot 1976, Tatarinov et al. 2008). Its roots are also deep, but mostly in permanent contact with underground water table, allowing high stand transpiration. Presented value of 340 mm is close to the average, maximum values of 450 mm (when water from underground sources represented up to 70% of total) were found there. Furthermore heavy soil holds huge amounts of water, which represents a large buffering capacity. However, soil properties can be critical for transpiration, if for some reasons water table will decrease in long-term, as it happened after water management measures in the region. When soil water content decreased by $4\%_{vol}$, soil water potential dropped by 8 bars, but soil hydraulic conductivity dropped by 100 times (Čermák and Prax 2001). This situation became critical especially in trees with lower root/leaf area ratio, which suffered the highest mortality rate.

The above results represent only a small part of similar studies, however they illustrate rather wide background of the research, applied for practical forestry purposes. This must not be yet crucial for our present scientific activities, but it reasonably seems, that most probably such needs will occur in the nearest future.

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Abstract

Roots represent one of the most important parts of trees similarly like their foliage and naturally deserve high attention in tree water relation studies. However, whole tree approach has been rather rarely applied in routine, landscape applicable forest tree studies. Here we show some examples of such approach, where both below and aboveground parts of trees were examined together. Operative biometric parameters and seasonal transpiration were studied in two contrasting specie/sites. Mature Scots pine (*Pinus sylvestris* L.) plantation growing on sandy soil (Brasschaat, northern Belgium) and a mixture of species in the floodplain forest (Lednice, southern Moravia) growing on heavy soil, mostly consisting of pedunculate oak (*Quercus robur* L.), ash (*Fraxinus excelsior* L.) and lime (*Tilia cordata* L.) were compared. Vertical leaf distribution in canopy layers at different height above ground, relative vertical absorbing root distribution in soils and seasonal transpiration of stands was estimated using specific technologies. Similarities and differences in tree and stand structure and behavior are discussed. The above results represent only a small part of similar studies, however they illustrate rather wide background of the research, applied for practical forestry purposes, which must not be yet crucial for our present scientific activities, but it reasonably seems, that most probably such needs will occur in the nearest future.

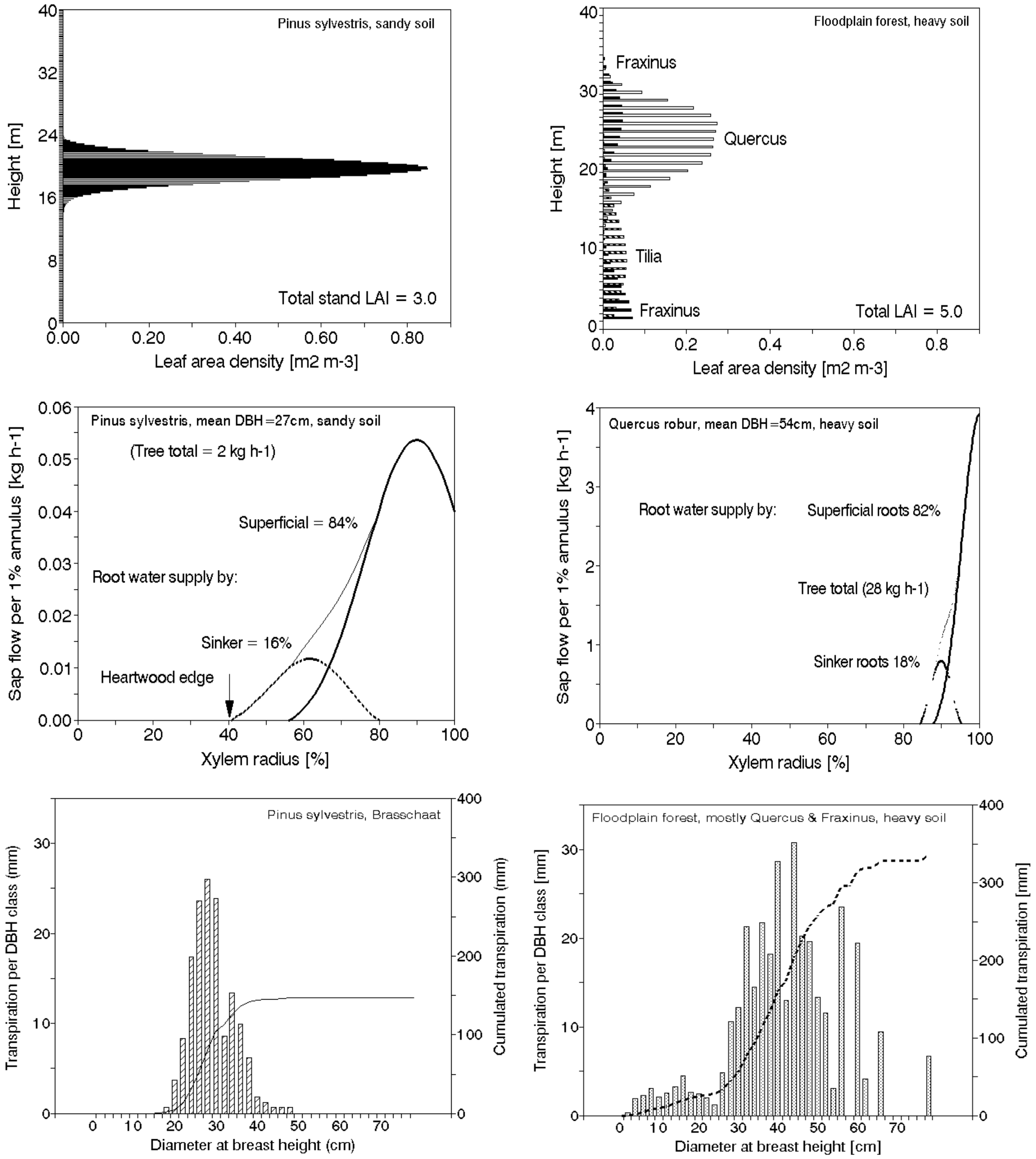

Fig. 1. Operative biometric parameters and seasonal transpiration in two contrasting specie/sites. Mature Scots pine (*Pinus sylvestris* L.) plantation growing on sandy soil and a mixture of species in the floodplain forest growing on heavy soil, mostly consisting of pedunculate oak (*Quercus robur* L.), ash (*Fraxinus excelsior* L.) and lime (*Tilia cordata* L.) were compared. Pine forest was a rather homogenous plantation with a single canopy layer, while floodplain forest represented a multi-layer canopy, almost naturally growing "European jungle". Upper panels characterize vertical leaf distribution on the stand level (layer depths in pine 0.2 m, in oak 1.0 m). Medium panels show relative vertical distribution of superficial and sinker absorbing roots (such supplying water through different layers of sapwood). Lower panels characterize transpiration of individual DBH classes over the growing season and their cumulated values giving stand total.