Geophysical Research Abstracts
Vol. 12, EGU2010-3308-1, 2010
EGU General Assembly 2010

On the functional role of tree species in two forest ecosystems

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Ecosystems can be characterized in different ways depending on the point of view or the scientific background. Summarizing these views, one can describe ecosystems by their structure and metabolism. The species composition is part of the ecosystem structure. Moreover, ecosystem structures are detailed by biomass or soil and canopy architecture. Ecosystem metabolism represents the functional side. It can be described by primary production, nutrient retention, or control and use of water resources.

Structure and function are connected. The biomass that is produced by the ecosystem metabolism is used to construct the ecosystem structure, which vice versa the structure controls the efficiency of the ecosystem metabolism. One hypothesis is that ecosystems with many species provide a more efficient metabolism than ecosystems with fewer species. We tested this hypothesis by using two ecosystems functional parameters in several deciduous forest ecosystems.

The first example are possible relations between canopy carbon uptake capacity ($F_{P,max}$) as measured with the eddy covariance technique (ecosystem metabolism) and LAI as well as spatial and temporal variability of leaf traits (ecosystem structure). We investigated leaf traits of four tree species in a mixed deciduous forest in northern Germany in search for an explanation for the differences in canopy photosynthetic capacity between different forest sectors consisting of different species and species numbers (*Quercus robur* + *Fagus sylvatica*, *Fraxinus excelsior* + *Alnus glutinosa*, pure *Fagus sylvatica*).

We identified leaf traits that were adjusted to the canopy light profile in species-specific ways, and for these traits the plasticity indices were calculated. Canopy photosynthetic capacity did neither correlate with leaf area index (LAI) alone nor with canopy plasticity indices which were almost similar between the three sectors although it differed at the species level. It is suggested that the spatial variability of $F_{P,max}$ in deciduous forests can be explained by a combined effect of LAI and some species-specific reference leaf traits, rather than by the plasticity index or by pure LAI.

In a second study we compared a mixed canopy of *Fagus sylvatica* and *Fraxinus excelsior* to a pure *Fagus sylvatica* stand during a drought period in summer 2006. Leaf gas exchange measurements suggested that beech trees responded faster and stronger to soil drought and changed stomatal sensitivity to leaf to air water vapour pressure deficit, while ash trees remained more progressive. Scaling these results in a modelling approach resulted in an lower impact of drought in a two-species canopy than in a beech monoculture and an increase of the *Fraxinus* contribution to total ecosystem carbon uptake.

Both results support the hypothesis that multi-species canopies may buffer unfavourable environmental constraints and increase efficiency in the use of resources.