

# SPECIES EFFECT ON THE WATER USE EFFICIENCY OF A MIXED FOREST OF BEECH (*Fagus sylvatica* L.), DOUGLAS FIR (*Pseudotsuga menziesii* (Mirb.) Franco) AND SILVER FIR (*Abies alba* Mill.) IN BELGIAN ARDENNES.

Rémy Soubie<sup>1</sup>, Marc Aubinet<sup>2</sup>, Bernard Heinesch<sup>2</sup>, Caroline Vincke<sup>1</sup>.

<sup>1</sup> Université Catholique de Louvain (UCL) – Earth and Life Institute, Environmental Sciences.  
<sup>2</sup> Université de Liège – Gembloux Agro-Bio Tech – Unit of Physics.

Contact: remy.soubie@uclouvain.be



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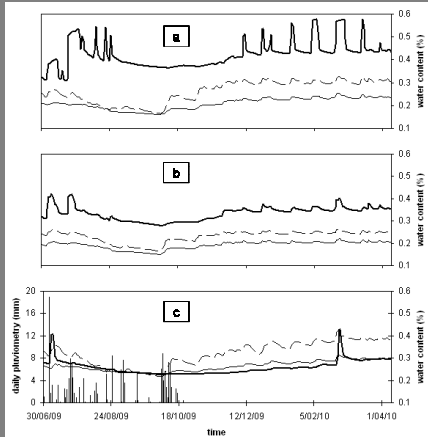
## I. INTRODUCTION

European forests ecosystems, in the context of global warming, are threatened by decline and loss of productivity. Analysis of the extreme climatic event of 2003 showed us that edaphic drought is the primary cause of observed impacts (Granier *et al.*, 2007).

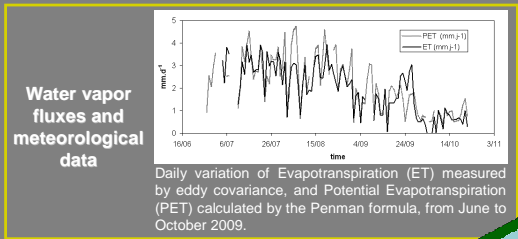
In this context, we propose to analyze the productivity of a Belgium mixed forest, at Vielsalm (Ardennes), through the characterization of the Water Use Efficiency (WUE), at both species and stand level. WUE is defined as the ratio of absorbed carbon by loss of water. Experiments started on July 2009.

Carbon and water vapor fluxes of this forest have been performed for over ten years by the eddy covariance method (Aubinet *et al.*, 2001). This method provides good estimations of carbon uptake and evapotranspiration at the stand scale. In the aim of characterizing species contribution to the stand water vapor flux we used sap-flow sensors to monitor transpiration at the tree scale, and upscaled the results at the stand scale.

The site of Vielsalm allows to compare the eco-physiology of two predominant species in Belgium, beech and douglas fir, in the same edaphic and atmospheric conditions.



Daily variation of soil water content (from June 2009 to April 2010) at 20 cm (dotted lines), 40 cm (thin solid lines) and 90 cm (thick solid lines) deep, measured by reflectometers sensors (CS615, Campbell) for (a) beech stand, (b) ecotone and (c) douglas fir stand, and pluviometry (from June to November 2009)

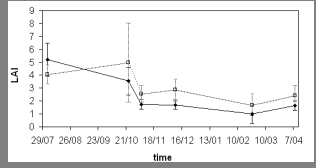


Water vapor fluxes and meteorological data

Daily variation of Evapotranspiration (ET) measured by eddy covariance, and Potential Evapotranspiration (PET) calculated by the Penman formula, from June to October 2009.

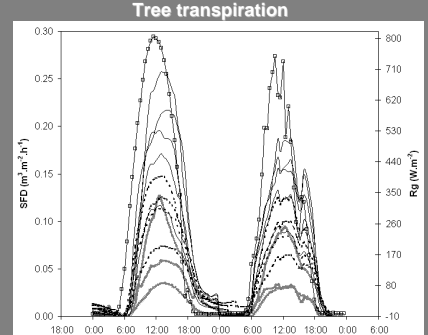
## Soil moisture

## Leaf area index (LAI)

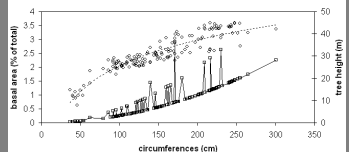


LAI dynamics from August 2009 to April 2010, measured with 3 zenith angles of the LAI2000 (Li-Cor), for beech stand (solid black circles) and douglas fir stand (empty black squares).

## IV. FIRST RESULTS



Sap flux density and global radiation time course (empty squares) for 5 beech (solid black line), 4 douglas fir (dotted black line) and 3 silver fir (hatched gray line) of various circumferences, during two successive days (19 and 20 August 2009).



Frequency of stem circumferences (empty black squares) and tree height (empty black circles) for all species in 2009, Vielsalm site.

For the beech we observed a strong diminution of density during the last years. Strong attacks of scolytes in 1999 & 2000 (xylophagous insect) occurred on Belgian beech forest, inducing a loss of 40% of the population.

Mean annual increment was:  
 - 0.9 cm/yr for the beech,  
 - 3.2 cm/yr for the douglas fir,  
 - 2.7 cm/yr for the silver fir.

## Forest inventories

## Tree transpiration : sap flow measurements

The thermal dissipation technique (Granier, 1985) is used. 18 trees are equipped (9 beech, 6 douglas fir, 3 silver fir) with respect to each species circumference distribution and proportion within the stand. Scan interval every 30 sec. Data averaged every 30 min.



UP GmbH and Dynamax sensors

## Forest inventories and radial trees growth

Inventories : trees circumferences and height



Girth increment

## Retrospective growth

Cores will be taken for dendrochronological analysis.

## Leaf water potential :

Seasonal trends for each species (Scholander pressure chamber).

species	circumferences distribution	number of trees by classes	trees equipped by classes	effective sapwood area (cm²)
beech	[30,90]	14	2	219
	[90,110]	21	2	516
	[110,130]	19	3	706
	[130,190]	17	2	1169
douglas fir	[170,210]	13	2	1197
	[210,230]	15	2	1449
silver fir	[100,140]	6	1	715
	[140,180]	11	1	1304
	[180,200]	6	1	2376

## III. MATERIALS AND METHODS

## Carbon & water vapor fluxes:

### Eddy covariance method

Data acquisition since 1996, every 30 min.

Discrimination of the flux between beech and douglas fir by the foot print method (Aubinet *et al.*, 2002)

New tower of 52 m installed in 2009.

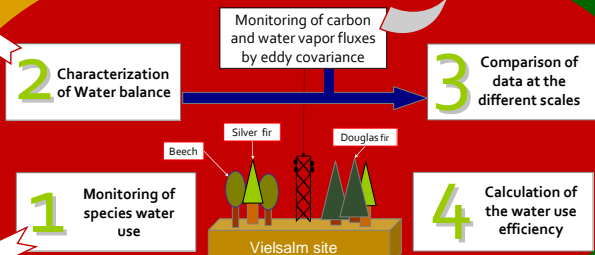


### Meteorological data:

- Radiation
- Air temperature and relative humidity
- Atmospheric pressure

### Precipitation above canopy

## II. OBJECTIVES

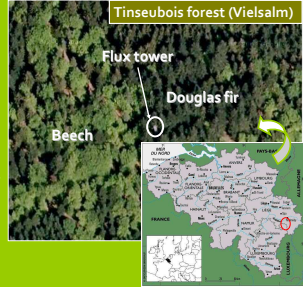
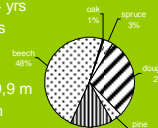


Elevation: 450 m  
 Mean annual temperature: 7°C  
 Annual precipitation: 1000 mm

Tree age:  
 - douglas fir: 74 yrs  
 - beech: 102 yrs

Tree height:  
 - douglas fir: 39.9 m  
 - beech: 25.6 m

Cambisols: 1.5 m deep  
 Roots depth: 0.9 m



## V. REFERENCES

Aubinet, M., Chermant, B., Vandenhaute, M., Longdoz, B., Yernaux, M., Laitat, E. (2001) Long term carbon dioxide exchange above a mixed forest in the Belgian Ardennes. *Agricultural and Forest Meteorology*, 108, 293-315.  
 Aubinet, M., Heinesch, B., Longdoz, B. (2002) Estimation of the carbon sequestration by a heterogeneous forest: night flux corrections, heterogeneity of the site and inter-annual variability. *Global Change Biology*, 8, 1053-1071.  
 Granier, A. (1985) Une nouvelle méthode pour la mesure du flux de sève brute dans le tronc des arbres. *Annales des Sciences Forestières*, 42 (2), 193-200.  
 Granier, A., Reichstein, M., Bréda, N., Janssens, I.A., Falge, E., Ciais, P., Grünwald, T., Aubinet, M., Bernhofer, P., Bernhofer, C., Buchmann, N., Facini, O., Grassi, G., Ilvesniemi, H., Kerónen, P., Knchl, A., Köstner, B., Lagergren, F., Lindroth, A., Longdoz, B., Loustau, D., Mateus, J., Montagnani, L., Nys, C., Moors, E., Papale, D., Peiffer, M., Pilegaard, K., Pita, G., Pumpanen, J., Rambal, S., Rebmann, C., Rodrigues, A., Seufert, G., Tenhunen, J., Vesala, T. and Wang, Q. (2007) Evidence for soil water control on carbon and water dynamics in European forests during the extremely dry year: 2003. *Agricultural and Forest Meteorology*, 143 (1-2), 123-145.