GENERAL INFORMATION

author(s)	Follens S
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MATERIALS & METHODS

study area	5n (measuring tower)
time period	July – September 1996
goal	Draw up and evaluate a model to calculate the net CO_2 exchange during a growing season in a broadleaved mixed forest. Simulation of the effects of global change on the photosynthetic C uptake
set-up	Upscaling principle: lab measurements on leaves + radiation model Investigation of an increased CO_2 concentration and air temperature on photosynthesis
data collection	climatologic data (measuring tower, hourly measurements) radiation - Platform 5: short wave radiation (star-pyranometer, Dome solarimeter and albedometer) - Platform 2: short wave radiation (tube solarimeter), PAR (quantum sensor) - 1 m above ground level: short wave radiation (tube solarimeter) temperature - platform 3 and 5 + ground level (ash and oak-beech stand) - soil temperature at 30 cm depth (ash and oak-beech stand) PAR - sunfleck ceptometer - 1 sunny day (21 July 1996), 1 cloudy day (12 August 1996) - each platform, N (oak) E (beech) S W (ash) directions - at 1 m height and 10 m distance from the measuring tower - hourly measurements LAI - LAI 2000 - 19 September 1996 (uniformly cloudy) - platform 4: above forest measurement - platform 1, 2 and 3: below canopy measurement (beech, oak, ash side of the tower) - 1 m in the oak-beech stand CO_2 exchange (lab Plant Ecology UGent)

	- 26 August – 17 September - branches from the oak, ash, beech trees near the measuring tower - 350 ppm CO_2 at 20 and 25°C - 700 ppm CO_2 at 20°C
remarks	meteorological data used as input for the model - incident short wave radiation: data from the 2 sensors at platform 5 - temperature: data from platform 3 mechanistic model, made in Stella II for Windows multilayer principle: forest subdivided in different horizontal layers

RESULTS

The calculated PAR profiles showed large differences between the tree species, mainly in the upper part of the crowns. Beech showed a large PAR extinction already at the upper layer: only 10 % of PAR was let through. For oak and ash, PAR was, on average, somewhat lower than 10 % below the entire crown.
The calculated LAI profiles showed the differences in crown structure for the three species. The cumulative vertical LAI was highest for beech (4.52), followed by oak (3.12) and ash (2.35).
Based on these two profiles, the extinction coefficient was calculated. PAR showed an exponential extinction; the extinction coefficient seemed larger for direct PAR than for diffuse PAR; the extinction coefficient was also correlated with the solar altitude.

Photosynthesis rate was determined for 3 scenarios:

- 350 ppm CO_2, 20°C: maximum net photosynthesis twice as high for oak and ash than for beech
- 350 ppm CO_2, 25°C: temperature optimum lower for beech than for oak
- 700 ppm CO_2, 20°C: beech and oak showed a decrease in net photosynthesis rate for low PAR levels where no CO_2 saturation occurred; respiration increased for beech, but decreased for oak

The model simulations showed a strong variation in photosynthesis during the growing season due to variations in insolation and temperature. Oak and ash showed a similar uptake of C during the growing season, i.e., 10 ton/ha/yr. Beech showed an uptake of 9.3 ton/ha/yr. If the CO_2 concentration doubled, the total yearly C uptake of beech decreased with 15 % while oak showed an increase of 6 %. This effect was even stronger when temperature also increased. The calculated photosynthetic efficiency varied between 3.1 % for beech and 4.5 % for ash.

The sensibility analysis showed the importance of an accurate determination of the total cumulated LAI and the extinction coefficient of diffuse radiation. The LAI profile and the use of a constant extinction coefficient (independent of solar altitude) were less important. The use of hourly temperature data is to be preferred above daily temperature measures. The simulated PAR levels were higher at some crown layers than the measured PAR levels. Thus, the calculated C uptake might also be higher than in reality.

Some model adjustments are formulated:

- LAI data should be based on repeated measurements, calculations of the extinction coefficients should be based on spatially and temporally integrated measurements at the different crown layers
- Photosynthetic measures at leaf level could be repeated more and the photosynthesis process at leaf level should ideally be described based on the model of Farquhar
- The model could be expanded for photosynthesis of shrub and herb layer and the respiration of the soil to calculate the C exchange for the entire ecosystem. Interaction between C, water and nutrient cycles is desirable.