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Ecology and Systematics

Author – Tekijä – Författare
Schulman, Leif Edvard

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Carbon dioxide exchange and carbon balance of a boreal bog: exceptional results in a year with a dry growing season

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Abstract – Tiivistelmä – Referat

This study was part of the Finnish Research Programme on Climate Change (SILMU). CO_2 fluxes, and environmental variables controlling them, were analysed in an intact boreal *Sphagnum fuscum* bog during one growing season, and the seasonal C balance for the bog was reconstructed. A yearly C budget for the studied mire type was also compiled, and the applied methods were developed. The study was conducted in 1994, in Ilomantsi, eastern Finland. The temperature and precipitation sums of the study year were not exceptional, but the growing season precipitation sum was 30 % lower than the long-term mean. This caused a considerable drop in water-table level (WT) in the height of the growing season (July–August).

A static chamber technique was used in measuring CO_2 fluxes at high temporal and spatial resolution. Total community respiration, R_{TOT}, and net photosynthesis, P_N, were monitored separately. Gross photosynthesis, P_G, was calculated as $P_N + R_{TOT}$. Peat temperature, WT, and irradiation (PAR) were monitored together with the fluxes. The results were used for constructing response functions of CO_2 fluxes to these variables. The mire was divided into four microsite types (hollows, HW; *Sphagnum* lawns, SL; low hummocks, LH; high hummocks, HH). The typification was tested using multivariate techniques (DCA and CCA). The classifying variables were: vegetation composition, mean WT, and plot microtopographical character. CCA analyses were used to study whether CO_2 fluxes can be predicted from vegetation cover. The chamber technique was tested by measuring within-peat CO_2 concentration gradients. Phenological development of tracheophytes and water content of *Sphagnum* mosses were followed and compared with seasonal changes in CO_2 fluxes. Time series for air and peat temperature, WT, and PAR were used in reconstructing a seasonal CO_2 balance for the different microsite types. The balance for the whole bog was calculated by weighting with the relative coverage of each type. Yearly C balances were estimated using the equation: $A = P_G - R_{TOT} - D - W$ (where D = yearly CH_4 emissions from anaerobic decomposition; W = leaching in runoff water). P_G and seasonal R_{TOT} were results of reconstructions in this study, winter-time R_{TOT} and D were measured in the same year in the same bog, and W was an estimate adopted from the literature.

The multivariate analyses suggested that high-resolution microsite classification should be based on vegetation composition and microtopographical features. WT alone is not a sufficient criterion, even though it accounts for most of the compositional variation between the main types. The CCA analyses indicated that CO_2 fluxes can largely be predicted from vegetation cover. The flux measurements revealed a deficiency in the static chamber technique. The testing of the method indicated that the basic assumption regarding the moss carpet surface as a sharp CO_2 concentration boundary is invalid under certain circumstances. However, the error caused by this drawback to the estimation of C balances in the present study was estimated to be small. Maximum measured R_{TOT} values were –554 (HW), –639 (SL), –897 (LH), –889 (HH) mg CO_2 $m^{-2}h^{-1}$. The range of measured P_N was +478 to –233, +546 to –42, +495 to –227, and +423 to –610 mg CO_2 $m^{-2}h^{-1}$, respectively. The trends in R_{TOT} changes followed those in WT. Mosses on high hummocks were severely damaged during the drought in July–August. This was manifested as lowered P_G. The reconstructed seasonal P_N (g C m^{-2}) was positive only in the SL plots (+41), while the other types showed values of –10 (HW), –46 (LH), and –117 (HH). All types had negative annual C balances, the average for the bog being –90 g C m^{-2}.

This study provides new evidence for that significant net C release from bogs can occur even in years with average annual temperature and precipitation. It seems likely that climatic change could result in more frequent dry growing seasons. This would increase CO_2 emissions from boreal bogs and, hence, accentuate their greenhouse impact. The present results emphasise the importance of high temporal and spatial resolution in the study of the C cycle of mires.

Keywords – Avainsanat – Nyckelord
CO_2 exchange, C balance, dry growing season, bog microsites, mire ecology, SILMU

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