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Conversion of a moderately rewetted fen to a shallow lake – implications for net CO_2 exchange

Franziska Koebsch (1), Stephan Glatzel (1), Joachim Hofmann (1), Inke Forbrich (2), and Gerald Jurasinski (1)

(1) Department for Landscape Ecology and Site Evaluation, University of Rostock, Germany (franziska.koebsch@uni-rostock.de), (2) The Ecosystems Center, Marine Biological Laboratory, Woods Hole, USA

Extensive rewetting projects to re-establish the natural carbon (C) sequestration function of degraded peatlands are currently taking place in Europe and North-America. Year-round flooding provides a robust measure to prevent periods of drought that are associated with ongoing peat mineralization and to initiate the accumulation of new organic matter. Here, we present measurements of net carbon dioxide (CO_2) exchange during the gradual conversion of a moderately rewetted fen to a shallow lake. When we started our measurements in 2009, mean growing season water level (MWGL) was 0 cm. In 2010 the site was flooded throughout the year with MWGL of 36 cm. Extraordinary strong rainfalls in July 2011 resulted in a further increase of MWGL to 56 cm. Measurements of net ecosystem exchange (NEE) were conducted during growing seasons (May-October) using the Eddy Covariance method. Information about vegetation vitality was deduced from the enhanced vegetation index (EVI) based on MODIS data.

Ecosystem respiration (Reco) and gross ecosystem production (GEP) were high during vegetation period 2009 (1273.4 and -1572.1 g CO_2-C m-2), but decreased by 61 and 46% respectively when the fen was flooded throughout 2010. Under water-logged conditions, heterotrophic respiration declines and gas exchange is limited. Moreover, flooding is a severe stress factor for plants and decreases autotrophic respiration and photosynthesis. However, in comparison to 2010, rates of Reco and GEP doubled during the beginning of growing season 2011, indicating plastic response strategies of wetland plants to flooding. Presumably, plants were not able to cope with the further increase of water levels to up to 120 cm in June/July 2011, resulting in another drop of GEP and Reco. The effects of plant vitality on GEP were confirmed by the remote sensed vegetation index. Throughout all three growing seasons, the fen was a distinct net CO_2 sink (2009: -333.3$\pm$12.3, 2010: -294.1$\pm$8.4, -352.4$\pm$5.1 g CO_2-C m-2). However, flooding causes a short-term ecosystem shift with severe consequences for Reco and GEP. Our results indicate that after a relatively short period of time, the plant community can acclimatise to inundation with increasing rates of GEP and autotrophic respiration.