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Vegetation and carbon gas dynamics under a changed hydrological regime in central European peatlands

RNDr. Thesis

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Annotation

The effect of drainage and restoration on the ecology of different types of peatlands in the Šumava Mountains was investigated. The study was focused primarily vegetation dynamics, carbon gas fluxes and their linkages under the affected hydrological regimes.

Declaration [in Czech]

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České Budějovice, 24.10. 2012 .....

Zuzana Urbanová

Co-author´s agreement

We hereby declare that Zuzana Urbanová had a major contribution of paper
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Zuzana Urbanová was responsible for basic field measurements, vegetation monitoring, gas fluxes measurement, data assembly and evaluation, gas fluxes modelling and carbon balance estimation, and writing the manuscript

Ing. Tomáš Picek, Ph.D. RNDr. Tomáš Hájek, Ph.D.

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Vegetation and carbon gas dynamics under a changed hydrological regime in central European peatlands

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Background: Northern peatlands are known for having significant stocks of terrestrial soil carbon (C). However, little is known about how peatlands function under various land uses and what impacts land-use change has on their functioning in central Europe.
Aim: The objective of our study was to quantify the variability and controls of typical plant communities in terms of C gas dynamics on bogs and fens affected by a changed hydrological regime in the Bohemian Forest, Czech Republic.
Methods: Carbon dioxide (CO_2) exchange and methane emissions (CH_4) were measured in bogs (pristine, drained, restored) and in fens (pristine, drained) during the 2009 growing season. We applied cluster analysis to define plant communities and non-linear response models to quantify the variation in CO_2 dynamics among the communities.
***Results*:** Drainage had a strong impact on vegetation; forest and meadows species were dominant on drained peatland sites and the vascular green area was higher than on pristine sites. The net ecosystem CO_2 exchange (NEE) varied from –27 to 241 g CO_2–C m^{-2} per growing season on the bogs and from 27 to 153 g m^{-2} on the fens. The most-drained parts of the bog and fen with the most changed vegetation structure acted as both net C sources and very weak C sinks; however, areas dominated by *Molinia caerulea* acted as a strong C sink. Plant communities on the wetter parts of drained sites had a positive seasonal NEE, comparable with NEE on pristine sites. Seasonal CH_4 emissions were relatively low (0–9 g CH_4–C m^{-2}) at all sites and did not influence net C balance, with the exception of pristine fen where CH_4 emissions with average 90 g C m^{-2} led to a negative total growing season C balance. Water regime restoration caused neither a significant change in plant composition nor any major changes, such as plant die-back or increased CH_4 emissions during the first season after restoration.
Conclusions: Our results showed that C gas fluxes, and in turn the C balance of the whole ecosystem, were largely determined by plant community type. Drainage did not necessarily lead to a negative ecosystem C balance; however, a significant change of species composition occurred on most drained areas. The less-drained parts on drained sites, where original peatland species and original functions are preserved, could facilitate future ecosystem restoration.

Keywords: bog; carbon balance; CH4; CO2; drainage; fen; NEE; plant community; respiration; restoration

Introduction

Natural peatlands play an important role in the global carbon (C) cycle as long-term sinks of atmospheric CO_2 and are sources of methane (CH_4) (Gorham 1991); at the landscape level, they contribute significantly to biodiversity. These natural functions are significantly altered by drainage, for example, for forestry, agriculture or peat extraction (Laine et al. 1995; Waddington and Price 2000). Drainage may turn peatlands from long-term sinks to sources of CO_2 (Silvola et al. 1996; Ojanen et al. 2010) while concurrently decreasing CH_4 emissions (Nykänen et al. 1995; Minkkinen et al. 2002).

During the first decade of the twenty-first century, there has been an increasing focus on restoring disturbed peatlands and their C sink, biodiversity and flood control functions (Kimmel and Mander 2010). Currently, peatland restoration is also implemented in the Bohemian Forest, Czech Republic, where almost 70% of peatlands have been affected by drainage. The main goal of restoration is to recover disturbed hydrology by blocking the drains and so to halt peatland degradation (Bufková 2009).

In pristine peatlands, the rate of soil respiration is limited by a high water table and therefore a part of CO_2 fixed in photosynthesis accumulates in the form of peat. Part of the C entering the system is converted to CH_4 under anaerobic conditions and returned back to the atmosphere. Dissolved C exported in water is also an important component of the total annual net C balance. The rate and direction of C fluxes is controlled by many interacting biotic and abiotic factors including water table, temperature, nutrient status and plant community structure (Waddington and Roulet 2000; Riutta et al. 2007; Lund et al. 2010; Maanavilja et al. 2011). The net ecosystem C exchange can switch from positive to negative over short periods of time as a result of relatively small changes in some of the factors mentioned above (Silvola et al. 1996; Bubier et al. 1999; Ward et al. 2009). The composition of peatland plant communities is considered as one of the most important factors controlling

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