



Editorial: Wetland Ecology and Biogeochemistry Under Natural and Human Disturbance

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Editorial on the Research Topic

Wetland Ecology and Biogeochemistry Under Natural and Human Disturbance

INTRODUCTION

Wetlands are areas where the water level is present either at or near the surface of the soil all year or for varying periods of time during the year (Zedler and Kercher, 2005). They provide essential ecosystem services such as water purification, flood control, biodiversity conservation, carbon sequestration, and greenhouse gas (GHG) regulation (Paar et al.; Zhang et al.). These wetland functions are vulnerable to climate change and human disturbances, however, the extent and direction of their future changes are highly uncertain at present. This has caused a significant uncertainty over how climate change and human disturbances would have affected the ecosystem function of wetlands.

This special issue attempted to help address this knowledge gap with a compilation of 12 original papers and one corrigendum which reported recent findings on the effects of climate change and human disturbances on wetland ecosystem functions. Moreover, various restoration methods proposed by several articles in this special issue have been put forward to evaluate the opportunities and limitations in returning biogeochemical functions in disturbed wetlands towards their natural state.

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THE IMPACTS OF CLIMATE CHANGE AND HUMAN DISTURBANCES ON THE WETLAND C BALANCE

Temperature and precipitation regime alterations are two essential climatic changes predicted for the future. On the one hand, global warming, which is likely coinciding with lower water table levels, may increase organic matter lability and accelerate decomposition in wetlands, thus emitting more greenhouse gases and aggravating global warming (AminiTabrizi et al.). On the other hand, warming may increase vegetation productivity and photosynthetic carbon dioxide (CO₂) uptake in wetlands (Li et al., 2021). Increased substrate supply due to greater vegetation might, however, also enhance CH₄ production (Li et al., 2021). Meanwhile, warmer conditions might coincide with lowered WTL which may enhance CH₄ oxidation and thus decrease net CH₄ emissions. The net effect of warming on the carbon sink function and GHG balance of wetlands depends on these two contrasting effects. Drought spells could lead to an increase in carbon emissions from wetlands (Keane et al.), while

flooding could increase algal production, while it would also decrease decomposition and enhance methane emissions, which benefits carbon uptake and could become important to estimate carbon balance in wetlands (Kane et al.).

Besides climate change, wetlands are vulnerable to human disturbances, resulting in the loss of more than half of the world's inland wetlands (Zedler and Kercher, 2005). Many wetlands have been drained with the purpose to gain land for agricultural, forestry and industrial use. The lowered water table level (WTL) following drainage alters the microbial communities and their activity which can lead to increased carbon emissions (Kitson and Bell, 2020). Transforming a wetland to rice paddy can increase nutrient concentration, which impacts bryophyte distribution (Ma et al.). Moreover, a network of seismic lines due to industrial activities for resource extraction can increase mineralization rates and carbon loss from wetlands (Davidson et al.). Road and dam construction significantly altered the hydrological regime and also influenced nutrients and metals retention, as well as wetland types (Rideout et al.; Sun et al.). Thus, altogether, these special issue contributions highlight that human disturbances considerably impact wetland functions.

RESTORATION METHODS FOR DISTURBED WETLANDS

In order to re-establish key wetland functions, various restoration methods have been put forward and evaluated in the literature (e.g., Taft et al., 2018; Wen et al., 2018; Liu et al., 2020; Evans et al., 2021), and several special methods have been proposed and studied by several contributed papers in this special issue. One common restoration method is rewetting (i.e. raising the WTL by ditch blocking) which can result in reduced CO₂ and N₂O emissions and thus mitigate the climate impact (Taft et al., 2018; Liu et al., 2020). However, rewetting drained wetlands can increase methane (CH₄) emissions (Wen et al., 2018), which may weaken their potential to mitigate global warming.

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Consequently, the critical point of raising water level has been investigated (Evans et al., 2021). In addition, Lemmer et al. introduced one alternate restoration method which is based on partial removal of the well pad's construction materials to near the water table level and the surface elevation of the surrounding ecosystem. They find that this approach is the most effective restoration method to sequester carbon, compared to the method where the foreign clay was partially removed and typical fen plant species were introduced (Lemmer et al.). Furthermore, Leppä et al. demonstrated that selection cutting is an effective tool to control water table level, which plays an essential role in the biogeochemical function of wetland ecosystems. However, Yavitt et al. demonstrate that it is challenging to restore key soil properties and functioning in highly degraded wetlands. Altogether, these contributions highlight the need for improved understanding of various restoration techniques and their effectiveness in restoring the biogeochemical functions of degraded peatlands.

Overall, these 12 Special Issue papers brought together a wide range of aspects related to the impacts of climate change and human disturbances on wetland ecosystems and thereby contribute significantly to an improved understanding of carbon cycling and greenhouse gas emissions from wetlands, wetland hydrology, ecosystem ecology and biogeochemical dynamics of wetlands. In addition, different special restoration methods for disturbed wetlands were tested with the goal to develop management strategies that restore and maintain the natural ecosystem functions of global wetlands.

AUTHOR CONTRIBUTIONS

JW, as the leading guest editor, wrote the first draft of this editorial, and MP and JL helped edit, revise and improve this editorial. All authors contributed to manuscript revision, read, and approved the submitted version.

Zedler, J. B., and Kercher, S. (2005). WETLAND RESOURCES: Status, Trends, Ecosystem Services, and Restorability. *Annu. Rev. Environ. Resour.* 30, 39–74. doi:10.1146/annurev.energy.30.050504.144248

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