Nutrient retention in vegetation of rewetted peatlands in North-eastern Germany

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Summary

In North-eastern Germany large areas of degraded fen peatlands have recently been rewetted. Fully-automated classification of high-resolution satellite data enables mapping of the major dominant successional plant species. The newly established vegetation appears to store large quantities of nutrients and contributes to retention of nutrients mobilised from decomposition and peat soil degradation.

Introduction

Fens once covered more than 10 % of the area of NE Germany. However, due to drainage and intensification of land use, most fens lost their functions for nutrient and water retention, water purification, and soil protection. Vegetation changed from brown moss-sedge-reeds to intensively used species-poor grasslands dominated by polytraphent species like *Phalaris arundinacea*, *Elytrigia repens* and *Dactylis glomerata*.

In order to restore these ecosystems, the federal state of Mecklenburg-Vorpommern initiated a 'Peatland Conservation Programme' in 2000 aiming at reducing peat mineralisation and restoring peat accumulation (Lenschow, 1997). The grasslands were rewetted by damming drainage ditches, opening dikes and pumping out water was stopped. Currently, more than 8,000 hectares of fens have been rewetted, primarily in the valleys of the Rivers Peene and Trebel. The newly developed vegetation is, depending on the hydrological conditions, dominated by *Lemna* spp., *Ceratophyllum demersum*, *Phragmites australis*, *Typha latifolia*, *Glyceria maxima*, *Carex* spp. and *Phalaris arundinacea* (Timmermann *et al.,* 2006).

Rewetting of degraded peatlands leads to nutrient release from decomposing vegetation and degraded peat soil (Zak and Gelbrecht, 2007) and to high concentrations of N and P in the soil pore and surface water (Kieckbusch and Schrautzer, 2004). Nutrient retention in biomass and litter of helophytes and hydrophytes may thus play an important role in protecting surrounding surface waters from eutrophication (Wild *et al.,* 2001).

This paper reports on the development of vegetation and the productivity and nutrient content of the dominant plant species after rewetting of degraded fen grassland. Within our study, we aim at quantifying productivity and nutrient retention by fen vegetation at the landscape level.

Material and methods

The study site 'Polder Priemen' (45 ha, 53°45'15"N, 13°27'45"E) is located in the lower Peene valley near the town of Gützkow. The climate is slightly continental with a mean annual precipitation of 554 mm and a mean annual temperature of 8.0°C. Before rewetting the vegetation consisted of *Phalaris arundinacea* grassland with some sedge species on wetter sites. Rewetting was initiated in 2002 by damming the ditches.

Vegetation was mapped by fully-automated hybrid and hierarchical classification of high resolution satellite data (Quickbird; 0.6 m/pixel) using biotope type and land-use maps as a-priori information. The results were verified in the field (Frick 2006).

Above-ground biomass of *Phragmites australis*, *Typha latifolia*, *Glyceria maxima*, *Carex* spp. and *Phalaris arundinacea* was harvested from randomly chosen sites (0.25 m²) in mono-dominant stands at the beginning of their flowering time when shoot biomass approaches net primary production (Dykyjová and Kvét, 1978). The samples were dried for 48 h at 85 °C, weighed to determine dry mass, and then grinded and homogenized. Carbon and nitrogen concentrations were measured with a CHN-Analyzer 'Vario EL III', potassium with a flame-photometer 'Flavophar'. Phosporus was determined photometrically at 710 nm after digestion in a solution of 2 ml 10 M H_2SO_4, 2 ml 30 % H_2O_2 and 20 ml deionised water at 160°C for 6 h (Zwirnmann *et al.,* 1999).

Results and discussion

Initial results show that the fully-automated classification of satellite data is appropriate to distinguish seven plant species: *Phragmites australis*, *Typha latifolia*, *Glyceria maxima*, *Carex riparia*, *Carex acutiformis*, *Phalaris arundinacea* and *Eleocharis palustris*. It was further possible to distinguish vegetation on morphological characteristics, e.g. floating leaved and submersed macrophytes.

Phragmites australis reached the highest net primary production with a mean above-ground biomass of 17 t/ha. Values decreased in the order *Typha latifolia* (13 t/ha) > *Glyceria maxima* (10) > *Carex riparia* (8) > *Phalaris arundinacea* (7) > *Carex acutiformis* (6 t/ha) (Fig. 1).

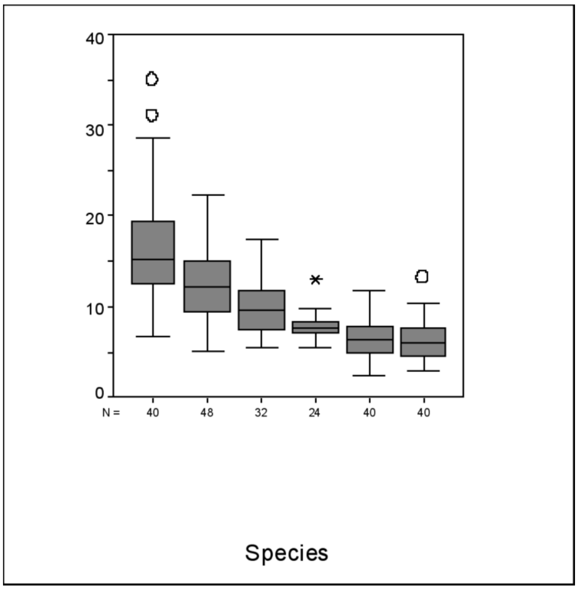

Figure 1. Dry mass of the dominant plant species Ph. au. = *Phragmites australis*, Ty. La. = *Typha latifolia*, Gly. ma. = *Glyceria maxima*, Car. rip. = *Carex riparia*, P. au. = *Phalaris arundinacea*, Car. acut. = *Carex acutiformis*.

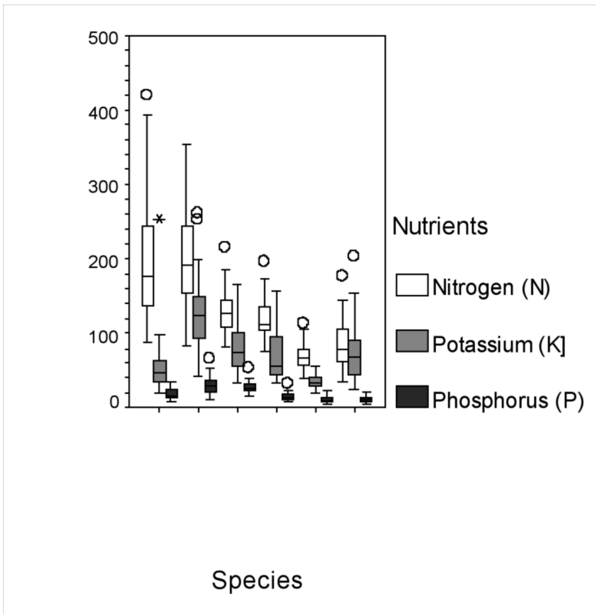

Figure 2. Nutrient stocks in the dry mass of the dominant plant species (Abbr.: see Fig. 1.)

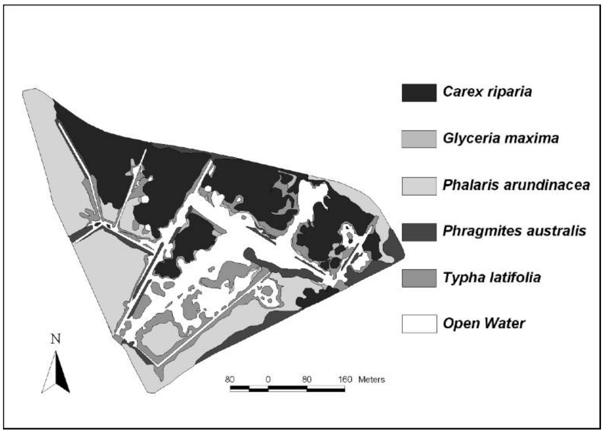

Figure 3. Vegetation distribution in Polder Priemen (2007).

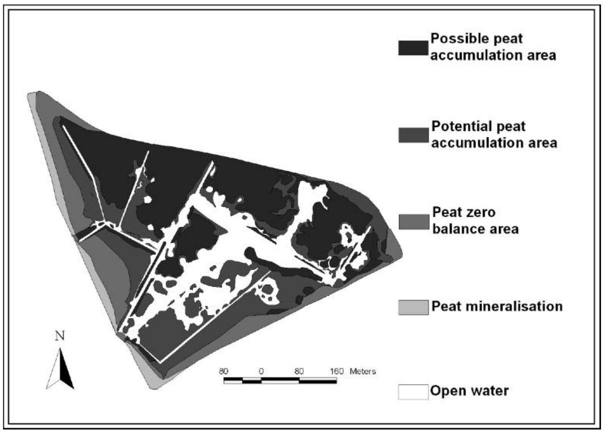

Figure 4. Distribution of peat accumulation/mineralisation conditions in Polder Priemen.

Typha latifolia biomass appeared to have the highest stock per area of potassium (125 kg/t DM/ha) and phosphorus (30 kg/t DM/ha) (Fig. 2). *Phragmites australis* had the highest value for nitrogen with 200 kg/ t DM/ha.

Six years after rewetting, the vegetation of the 'Polder Priemen' has changed from a *Phalaris arundinacea* grassland to a vegetation dominated by helophyte stands (Fig. 3). In particular, the potentially peat forming species *Carex riparia* has become abundant.

On the basis of the distribution of dominant plant species (Fig. 3) we calculated an aboveground net primary production of 252 t in Polder Priemen (on 45ha) (Table 1). The above ground biomass stock included 5 t of nitrogen, 2 t of potassium and 0.3 t of phosphorus. Peat accumulation by peat-forming plants is likely to take place under conditions of long-term or permanent inundation (Koska 2001), but only by a small selection of plant species, i.e. some *Carex* species and *Phragmites australis* (Richert *et al.*, 2001). More than one third of Polder Priemen provides these conditions (Fig. 4, Tab. 1). Over a small area peat will still be mineralising because of the groundwater levels being too low.

Our results indicate that substantial amounts of nutrients are stored in the above ground biomass of the vegetation of rewetted fens. A substantial amount will also be stored in the belowground biomass. In future studies we will estimate belowground primary production and nutrient storage by using root/shoot ratios and nutrient contents from literature. For assessing the nutrient storage of rewetted fen peatlands at a landscape level also decomposition, nitrogen fixation and gyttia accumulation of these new and dynamic ecosystems have to be studied.

Table 1. Peat accumulation/mineralisation conditions in Polder Priemen in relation to vegetation and water level.

	Possible peat accumulation area	Potential peat accumulation area	Peat zero balance area	Peat mineralisation area
Vegetation	With peat forming vegetation (*Phragmites australis*, *Carex* spp.)	Without peat forming vegetation (*Typha latifolia*, *Glyceria maxima*)	Moist grassland (*Phalaris arundinacea*)	Humid grassland (*Phalaris arundinacea*)
Median winter water level in cm relative to surface	0-30 cm to > 60	0-30 cm to > 60 cm	-15-0 cm	-35 to -15 cm

Conclusions

Vegetation mapping with high resolution satellite data allows identification of successional trends, in particular the development of peat-forming vegetation. Next to re-instated peat formation, rewetted fen peatlands may contribute to disposing nutrients from the landscape by retention in the luxurious biomass.

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