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PALUDICULTURE – ECOSYSTEM SERVICES OF SPHAGNUM FARMING ON REWETTED BOGS IN NW GERMANY

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SUMMARY

Paludicultures provide a sustainable wet land use option for degraded peatlands. The changes in ecosystem service provision are assessed for a 4 ha large Sphagnum farming site in Northwest Germany. Compared to the former bog grassland we find an improvement of provisioning services (long term perspective, renewable alternative to fossil 'white' peat), regulating services (reduced GHG emissions, rare habitats) as well as cultural services (preservation of palaeo-archives). These external effects should be incorporated in decision making on peatland use and provide good reasons for facilitating paludiculture with public money.

KEYWORDS: bog grassland, Sphagnum biomass, sustainable management, economics, external effects

INTRODUCTION

Ecosystem services are ecosystem functions that provide a benefit to human beings. Ecosystems may affect humans positively but also negatively. Usually neither the benefits nor the damages are fully accounted for in land use decisions since relevant products and services are either not marketable (e.g. nutrient retention) or the prices do not incorporate external effects (e.g. loss of biodiversity through peat extraction). Providing an inclusive and accurate estimate of value is crucial for enabling a more rational and informed use of peatlands (cf. Wichmann *et al.*, 2012). While quantification and monetization is often difficult, already the qualitative recognition of benefits may raise sufficient awareness for ensuring conservation and sustainable use (TEEB 2010).
Sphagnum biomass promises to become a renewable alternative to fossil 'white' peat in horticultural substrates (Gaudig & Joosten, 2002; Emmel 2008). Sphagnum farming may thus help to curb the loss of pristine bog ecosystems by reducing the volume of extracted fossil peat. When implemented on degraded peatlands Sphagnum farming will furthermore – like other paludicultures (cf. Abel *et al.*, this volume) – replace a non-sustainable by a sustainable land use option (Joosten *et al.*, 2012; Barthelmes *et al.*, this volume).
In this paper we present a first analysis of the change in ecosystem services that result from converting bog grassland into a Sphagnum farming site.

MATERIALS AND METHODS

Ecosystem services before and after establishment of Sphagnum farming were assessed for a 4 ha large site in the 'Hankhauser Moor' next to Rastede (Lower Saxony, Northwest Germany), where Sphagnum farming was established in spring 2011 (Gaudig *et al*., this volume; Krebs *et al*., this volume). Before establishment the site had been drained, fertilized and used for many decades as traditional German bog grassland ('Deutsche Hochmoorkultur'). Supplementary field data were collected from a second Sphagnum farming site in the "Esterweger Dose" near Ramsloh (Lower Saxony, Northwest Germany) established in 2004 (Gaudig *et al.*, this volume). Ecosystem services – including provisioning, regulating and cultural services – were described on the basis of field assessment and literature studies.

RESULTS

Provisioning services

Provisioning services from peatlands create marketable products such as food, timber and peat for fuel or growing media. In the past the peatlands in the project region have been drained and turned into pastures and meadows. As the quality demands for fodder for dairy cattle (the most profitable type of grassland use) increased, peatland use was further intensified or changed to subsidy dependent meat production and mulching. Peat oxidation over several decades of drainage has nearly consumed the layer of slightly decomposed 'white' peat, with increasing difficulties for conventional, drainage based agriculture. Traditional German bog grassland seems to be running out with just a short future remaining. Establishing Sphagnum farming as a wet land use could pose a long-term alternative as it stops peat degradation. Sphagnum biomass has shown to be a promising renewable raw material for growing media as an alternative to fossil peat. While Sphagnum farming under current circumstances cannot compete with the low prices for 'white' peat, it can already be profitable through high revenues on existing niche markets.

Regulating services

Peatlands fulfil a wide range of regulating functions such as for carbon and nutrient cycling, water quality and quantity, local climate, and as habitats. In the following we discuss carbon storage and habitat provision.

Carbon storage

Living peatlands have been accumulating peat and sequestering carbon for thousands of years. Even after carbon sequestration stopped because of drainage, peat layers of several meters still contain huge amounts of carbon. During the establishment of the field trial in 2011 drain pipes were found in a depth of ca. 20 cm which had been installed 120 cm deep in 1958. This subsidence of 100 cm within 50 years indicates a loss of 2 cm per year. As a result the area lies nowadays 0.5 m below sea level. The major part of subsidence can be ascribed to peat oxidation which has been causing high greenhouse gas (GHG) emissions. Literature data indicate a clear correlation between GHG emissions of peatlands and mean annual water table

(Couwenberg *et al*., 2011). Assuming moderate drainage, emissions of 15 t CO_2eq $ha^{-1}a^{-1}$ (without N_2O) can be estimated for current grassland use in the project region.

In contrast to conventional, drainage based peatland use, Sphagnum farming demands rewetting and thorough management of the water table since Sphagnum productivity is slowed down or stopped by limited water availability as well as by flooding. Under Sphagnum cultivation emissions of N_2O are halted, CO_2 emissions strongly decrease and methane emissions presumably hardly occur. First results of chamber measurements of gas fluxes on Sphagnum farming sites with well-established moss lawn (Ramsloh, Lower Saxony) indicate a slightly cooling effect by the growing moss lawn and a neutral climatic effect when considering regular moss harvest (Höper, 2012). Taking into account higher emissions from the establishing phase (Albrecht & Glatzel, this volume) and from the infrastructure of the production site (peat dams, irrigation ditches), for which no emission data are available yet, total emissions of 5 t CO_2eq $ha^{-1}a^{-1}$ are assumed for the production system. Thus the avoided emissions amount to 10 t CO_2eq $ha^{-1}a^{-1}$ compared to the moderately drained bog grassland.

Rare habitats/species

Three/four decades ago wet bog grasslands were still important habitats for breeding waders such as Curlew (*Numenius arquata*), Lapwing (*Vanellus vanellus*) or Common Snipe (*Gallinago gallinago*) (Hötker, *et al*., 2007). Intensified land use (e.g. earlier date and increased frequency of mowing) reduces nesting and fledging success and turns these grasslands into ecological traps (Kleijn *et al*., 2001), while restricted use ('extensification') aiming at protecting breeding waders may lead to rush (*Juncus effusus*) dominated grassland with high and dense sward structure unattractive for the target species (Rasran & Jeromin, 2010). Despite protection measurements, populations continued declining and the species are endangered or even extinct in NW Germany (Melter & Welz, 2001). For the project area 'Hankhauser Moor' accordingly no breeding of waders was recorded in recent times.
In contrast to its former importance for breeding waders, bog grassland could in terms of plant biodiversity never compete with species rich, wet fen meadows. Furthermore, intensively used grassland is dominated by regularly sown in species. Vegetation survey of the project site before establishment of Sphagnum farming identified merely trivial pasture species such as white clover (*Trifolium repens*), fodder grasses (e.g. *Alopecurus pratensis, Poa pratensis*) and pasture weeds (e.g. *Cirsium vulgare, Juncus effusus*, *Rumex acetosa*).

For establishing the Sphagnum farming sites the Canadian Sphagnum layer transfer method (Quinty & Rochefort 2003) was applied. With the Sphagnum diaspores from donor sites seeds of other species were spontaneously introduced to the newly established fields. While not being the target in Sphagnum farming it may be a positive external benefit to provide substitute habitats for bog species such as sundew (*Drosera rotundifolia),* beak-sedge (*Rhynchospora alba),* cottongrass (*Eriophorum vaginatum*), and cross-leaved heath *(Erica tetralix).* In addition to those plant species, a very rare myxomycete (*Badhamia lilacina*) and rare bog spiders (*Pardosa sphagnicola*, *Bathyphantes setiger*) were found on the trial site near Ramsloh. Once extensive Sphagnum farming sites are established they might become suitable for rare breeding waders including even Golden Plover (*Pluvialis apricaria*) of which the last few pairs in Germany currently breed on bare milled peat extraction sites. An open question remains whether sufficient invertebrate prey can be provided on site under wet and poor soil conditions or whether a mosaic of different land-use types will be needed. But mowing one to two times a year to reduce dominant weeds such as rush (*Juncus effusus*) and harvesting only every 5 years may create appropriate habitats, certainly when disturbance during times of breeding and rearing chicks is avoided.

Cultural services

Cultural services provided by peatlands encompass inter alia opportunities for recreation, aesthetic satisfaction, inspiration and knowledge development. Compared to cultural services from other ecosystems, peatlands have an outstanding importance for research and education as archives of landscape and climate development as well as of human history. In the peat information of thousands of years is accumulated in systematic layers, including macro- and microfossils such as seeds, plant tissues and pollen and archaeological remains such as bog bodies, tools, ornaments and weapons. Drainage based land use destroys these archives. Only rewetting the peat body, for instance for Sphagnum farming, will preserve the still remaining information.

CONCLUSIONS

Bog grasslands in NW Germany are reaching the end of their economic existence. As a consequence they are progressively used for maize cultivation for fodder and biogas plants, but at the expense of enormous CO_2 emissions from the oxidizing peat (Joosten et al., 2012). On other agricultural sites new peat extraction areas are opened. Also in the project region "Hankhauser Moor" land owners gave up grassland use and sold their land to a peat extracting company which applied for a – so far not granted – licence to extract peat on several hundreds of hectares. All these land use options maximize the provisioning services for marketable goods and / or subsidy support. All of them also depend on deep drainage, which constrains the natural ecosystem services of peatlands and causes negative externalities.

In contrast, Sphagnum farming on rewetted peatlands stops the degradation of agriculturally used peatlands. It ensures the combination of a long term perspective for the provisioning service and the improvement of regulating services (reductions of GHG emissions, substitute habitats for rare species dependent on treeless peatlands) as well as cultural services (e.g. archives of landscape) typical for natural peatlands. Last but not least providing a renewable raw material for growing media would decrease the pressure on pristine mires.

A comprehensive economic valuation of peatland use must go beyond profitability and should take into account external benefits and damages now and their flow over time. Society has good reasons for facilitating paludicultures on degraded bogs and supporting the sustainable production of a promising, renewable raw material for growing media. The ecosystem service concept allows peat extraction companies, farmers, nature conservationists and policy makers to consider the special case of peatlands and rethink financial incentives to land use options in order to serve the principle "public money for public goods".

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