Experimental re-introduction of mire plant species in milled, raised bogs in Northern Poland

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Summary

All Baltic raised bogs in Poland have been affected by human impact, mainly by afforestation, drainage or peat extraction (including milling method). As a result, none of them remains in a pristine state. Abandoned, vacuum-mined bogs with very little spontaneous re-vegetation are the most problematic objects for restoration. A project, aimed at elaborating techniques for milled bog rehabilitation, has been in progress in Northern Poland since 2006. After improving bog hydrology, six *Sphagnum* species and five vascular plant species were transplanted into prepared post–mining areas. Preliminary results indicate that blocking the outflow from the bog caused a considerable rise of the groundwater level. The survival rate of particular *Sphagnum* species varies, but so far none of them has become extinct.

Key index words: Baltic raised bogs, vegetation reintroduction, peatland conservation, *Sphagnum*, Poland

Introduction

General characteristics and state of preservation of raised bogs in Poland

Baltic bogs, also known as 'plateau raised bogs' (Eurola, 1962) or 'true raised bogs' (Ellenberg, 1988) are regional subtypes of raised bog. They are distinguished by the morphology of their peat deposits, which are shaped like a cupola, with flat expanse and sloping margin. The total number of such bogs in Poland does not exceed 70 and they cover less than 4% of the primary area of mires. All of them are concentrated in the northern part of the country where they reach the southern edge of their geographical range, conditioned by a relatively humid and cool climate. The cupolas of Polish raised bogs are relatively small, mostly less than 300 ha. They are domed to a height of approximately 1.5 m and are usually underlain by fen peat. The intensive growth of raised bog cupolas started at the beginning of the Subatlantic period and, according to some existing data, was synchronous, irrespective of the topographical conditions and the previous succession paths (Herbichowa, 1998). The main peat forming plant species during the cupolas formation was *Sphagnum fuscum* (Jasnowski, 1962; Pacowski, 1967). The natural plant cover of Baltic raised bogs in Poland is unique because of their geographical location and the transitional type of climate of the country. The flora of Baltic bogs consists of widely distributed raised bog species and some Atlantic (e.g. *Erica tetralix, Sphagnum molle*) and boreal (e.g. *Rubus chamaemorus, Ledum palustre*) taxa.

As an effect of various forms of human activity, no Polish Baltic raised bogs have remained in a pristine state and almost 50% of them have been totally destroyed. Since the end of the 18th century they have been drained, used for peat extraction and afforested. Twelve of them have been damaged by industrial peat mining, and the area of milled bogs is estimated at 700 ha.

Present day vegetation of the remaining mires is differentiated. It is estimated that peat-forming vegetation covers only 9% of its previous area and occurs only on the best-preserved plateau parts of cupolas, untouched by exploitation, or in peat-pits with high water levels (Jasnowski, 1972). The rest of the bog area is covered by treeless plant communities dominated mainly by *Eriophorum vaginatum* or *Calluna vulgaris*, by more or less degenerated pine or birch bog forests, or by secondary vegetation (Jasnowski, 1972; Herbichowa, 1979).

According to Polish law, vacuum-mined bogs have to be reclaimed within five years after the cessation of mining. However, there are no specific guidelines regarding what kind of activities should be undertaken to fulfil this regulation. Peat companies try to afforest such areas, leave them for spontaneous secondary succession or hand them over to local authorities. In dried post-mining fields, the moorshing process starts, spontaneous re-vegetation is scarce and efforts of afforestation end in failure. There is an urgent need to stop the degradation processes in Polish raised bogs and to formulate a method for the successful restoration of bog vegetation, especially in bogs which are protected as nature reserves or Nature 2000 sites.

The project described here is the first attempt at bog species restoration in the milled raised bog areas of Poland. The trials started in 2006 within the LIFE-Nature Project 'Conservation of Baltic raised bogs in Pomerania, Poland' (LIFE04NAT/PL/000208 PLBALTBOGS), co-financed by the Eco-Fund foundation and GEF Small Grants Program. The NGO Naturalists Club coordinated the project with the support of regional authorities. The project was conducted in 24 bogs which were classified as 'having a chance

to be maintained or restored'. The Strategic Project Objective was to maintain or to restore the favourable conservation status of the active raised bogs as well as pine or birch forests within Baltic bog complexes. One of the Operating Project Objectives was to develop a modern approach to the conservation of Baltic raised bogs, including appropriate active management techniques. Currently, the experiments are being pursued with financial support from the Fund for Environment Protection and Water Management in Gdansk.

The aim of the experiment and research area

The main goal of the experiment is to formulate effective methods of restoring raised bog vegetation in the post-milling areas of Northern Poland and to find out which species are the most effective in this process.

The Czarne Bagno raised bog was chosen for this purpose. It is located in the central part of the Pomeranian Coast (17°35'E, 54°33'N). The average yearly temperature of the region is 7.4° C; the yearly temperature amplitude is 19.3°. The annual precipitation is 670 mm, but from February to May, monthly values are very low (between 25 and 47 mm). Since 2006 the Czarne Bagno bog has been a nature reserve with an area of approximately 103 ha, protecting the remnants of the original 226 ha raised bog area. The whole bog has been seriously damaged by long-term drainage, especially intensive since 1970s, extensive hand peat extraction up to 1950s, afforestation and superficial fires. In the years 1987-1989 industrial peat extraction was managed in the area of 13.47 ha. A layer of *Sphagnum* peat approximately 1 m thick was removed using the milling method, and only a thin layer of raised bog peat has been left, underlain by a few-metre-thick fen peat layer. The surface pH of *Sphagnum* peat ranges from 4.0 to 4.5 and high water table fluctuations were observed throughout the entire post-mining area. In 1995, birch and alder trees were planted, but after a short time the plantation failed completely. The spontaneous secondary succession was extremely scarce – less than 5% of the surface has been covered by *Calluna vulgaris* and *Eriophorum vaginatum* and no re-establishment of *Sphagnum* species was observed.

Methods

The first action involved blocking water outflow from the bog. Over 100 wooden dams were built in ditches and a set of piezometers was installed. In November 2006, the 0.5 ha area for *Sphagnum* transplantation was prepared. Three main plots were established with different thicknesses of moorsh removed (10, 30 and 50 cm). Each main plot was divided into three subplots. In order to stabilise soil moisture, two subplots were supplied with different doses of the polymeric absorbent AgroHydroGel (25 g m^{-2} and 40 g m^{-2}) whereas the third was left without application. In the prepared area the diaspores (shoots fragments) of six *Sphagnum* species (*Sphagnum palustre*, *S. magellanicum*, *S. russowii*, *S. rubellum*, *S. cuspidatum* and *S. fallax*) were spread manually and covered with a layer of straw in order to avoid desiccation, freezing and being blown away. In late spring 2007, the same experimental design was replicated in another part of the post-excavation field (0.5 ha).

In order to identify the abilities of some vascular plant species to colonise the post-exploitation area, two experimental plots were established in 2007. The list of species chosen for the survey consists of both hummock and hollow taxa: *Carex limosa*, *Oxycoccus palustris*, *Erica tetralix*, *Eriophorum vaginatum* and *Drosera rotundifolia*. The following factors are taken into account: the presence of a moorsh layer, the use of AgroHydroGel and the use of phosphorus fertiliser. The species were collected from donor sites with small chunks of upper-layer peat. After application of diaspores, the plots were covered with a layer of straw about 10 cm thick.

Results

The obtained results are preliminary because of the short period of monitoring that could be done so far. No biomass measurements have yet been taken.

As far as water conditions are concerned, it was found that after blocking the ditches the water level within the whole post-mined area generally rose. The fluctuations of the water table were still relatively high and correlated with the precipitation. Water levels within the subplots varied greatly (Fig. 1). Some parts of them were almost permanently flooded, whereas in others water never appeared on

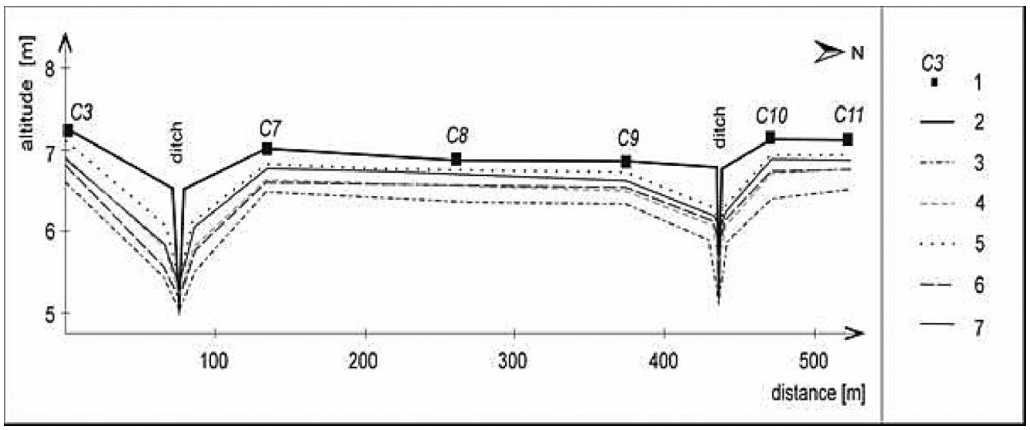

Figure 1. The average ground water level recorded in Czarne Bagno reserve. 1 – number of piezometers, 2 – ground surface, 3-7 – period of measurements: 3 – August 2006, 4 – September – October 2006, 5 – November 2006 – February 2007, 6 - March – June 2007, 7 – August – September 2007.

the surface. This differentiation did not correlate with the thickness of the removed peat layer but mostly with the distance to ditches and efficiency of water damming.

Most of the *Sphagnum* shoots implanted in late autumn 2006 survived the relatively warm and wet winter. During the drought period in late spring 2007 all species showed symptoms of desiccation, but after rainfall they regenerated well and continued to develop. The material applied in spring 2007 has been growing less successfully, probably because of the dry and hot weather conditions after application, but none of the transplanted *Sphagnum* species had became extinct by the end of 2007.

Generally, the transplanted species survived better in periodically flooded plots than in drier ones. In the first case, the best survival rate was seen in *Sphagnum cuspidatum* and *S. palustre* whereas *S. russowii* appeared to be the least sensitive to desiccation in drier plots. *Sphagnum magellanicum* and *S. fallax* regenerated poorly regardless of water conditions. Some vascular plants (*Drosera rotundifolia*, *Eriophorum vaginatum*, *Rhynchospora alba*, *Oxycoccus palustris* and *Erica tetralix*), brought by chance to experimental plots with *Sphagnum* material, have established and produced flowers and seeds.

Discussion

There are several factors which inhibit spontaneous succession of bog species in milled areas: the lack of vital plant diaspores after removing the acrotelm layer, exposing underlying fen peat, hard micro-habitat conditions (unstable and extremely dry ground surface, freezing in winter and very high temperature in summer), weak dispersal abilities of bog species (Salonen, 1987; Lavoie *et al.*, 2003; Rochefort *et al.*, 2003). The experiment was prepared according to a generally applied model of bog restoration, consisting of the following steps: (1) blocking water outflow, (2) active reintroduction of bog plant diaspores, and (3) mulching (Quinty and Rochefort, 1997; Rochefort and Campeau, 1997; Rochefort, 2000). All *Sphagnum* species used in the experiment are components of the present flora of the reserve and, with the exception of *S. fallax* and *S. russowii*, were identified in the fossil flora. The implementation of vascular plant diaspores with some amount of upper peat layer was tested by Cobbaert *et al.* (2003) in the restoration of fen plant communities. Beside the vegetative parts of plants, this method will also provide their seeds, and some shoots of mosses that can improve (on the micro scale) the habitat conditions for colonisation.

The water table fluctuations observed within the restored area are unavoidable. It usually takes about 10 years to achieve a stable, high water table, especially in intensively drained, vacuum-mined peatlands (Rochefort *et al.*, 2003). In the case of the Czarne Bagno reserve, some additional management activities are planned, such as birch and pine tree removal, which will probably affect the water regime. Current field observations suggest that flooding, even prolonged, does not negatively affect the introduced species, which is consistent with the results of Rochefort et al. 2002. Under wet conditions, *S. cuspidatum* seems to develop better than other implemented species, but biomass measurements are needed to confirm this assumption. Desiccation is considered to be critical for *Sphagnum* to survive (Clymo and Hayward, 1982). In our experiment most species suffered from desiccation in the driest plots, with the exception of *S. russowii*. This species is contemporarily expansive in Polish treeless and wooded bogs under different moisture conditions, which indicates its high adaptive abilities.

Conclusions that are more exact will be available in a few years, when species interactions and flora composition are more stable and the production of innovations, biomass and species cover will be measured. Nevertheless, even preliminary results show that there is a chance to restore at least some *Sphagnum* species to Polish raised bogs degraded by drainage and peat extraction. One of the serious problems which occurred during the field works was a shortage of diaspore sources. We observed that species such as *Sphagnum magellanicum, S. rubellum, S. capillifolium* and *S. fuscum*, which were formerly widely distributed, have now become rare. Against this background, and because the whole *Sphagnum* genus in Poland is protected by law, the cultivation of these species for restoration activity purpose is needed.

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