# ASSESSING THE PROSPECTS OF FEN RESTORATION BY TOPSOIL REMOVAL: CASE STUDY CAŁOWANIE FEN (CENTRAL POLAND)

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**Abstract:** The major problems in the conservation of fens are desiccation, eutrophication, natural succession and in some cases acidification. Management measures, like mowing and shrub removal, are necessary to stop the succession. However, the impact of these measures is not enough to facilitate the re-development of fen and wet meadow vegetation. Therefore some more radical methods of restoration, like topsoil removal, are becoming increasingly popular. In this paper several examples of topsoil removal are presented. This method is now tested in the Całowanie fen in Poland. The main problem in this area is a high degree of peat mineralisation due to the drainage of the area. The topsoil of 0.27 ha was removed in August 2004. It is expected that within a few years the target vegetation (fen and wet meadow communities) will re-develop on the topsoil removal plots. The effect of three variables on the establishment of target species is being tested: hay spreading, wild boars impact on species dispersal and depth of the removed soil. We discuss the costs and benefits of this restoration method. Possible options for reducing the costs are selling the removed soil to various clients, or at least offering it for free to save on the transport costs. The assessment shows that topsoil removal method could be economically feasible and interesting from the ecological point of view.

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## INTRODUCTION

The semi-natural vegetation of mesotrophic fens (*Scheuchzerio-caricetea*) and species rich wet meadows (*Molinietalia*) is vanishing in Europe due to human-caused transformation of the habitats and the disappearance of traditional management (Bragg & Lindsay 2002). The major factor responsible for vegetation changes is desiccation caused by drainage (Lamers *et al.,* 2002), nutrient enrichment due to subsequent degradation of peat soils (Jansen *et al*., 2001), acidification and consequential loss of species richness (Andrzejewski & Weigle, 2003; Grootjans *et al*., 2002a; Grootjans *et al*., 2002b). Eutrophication and desiccation together lead to an increased succession rate on the abundant land (Schmidt *et al*., 2000). In case of drained fens restoration of soil moisture alone does not help because of the high trophic status of the mineralised peat. Therefore some more radical methods of restoration are being proposed, for example topsoil removal. The topsoil removal method was already tested and proven to be successful in many case studies in Europe (Pfadenhauer & Klötzli, 1996; van Diggelen *et al*., 1997; Brülisauer & Klötzli, 1998; Ramseier, 2000; Verhagen *et al*., 2001; Patzelt *et al*., 2001; Grootjans *et al*., 2002a; Grootjans *et al*., 2002b). An advantage of topsoil removal is an improvement of the water conditions, because the ground surface comes closer to the groundwater level (Ramseier, 2000). The removal of topsoil leads to a fast nutrient impoverishment (Holzel & Otte, 2003) and last but not least the ”weeds”-meadow and ruderal plants and their seeds are removed, which decreases the level of competition for target species (Ramseier, 2000). Most species of fens are considered to be weak competitors, especially with respect to light (Kotowski *et al*., 2001, Kotowski *et al.,* 2004).

There are also some disadvantages of topsoil removal: it is very expensive and logistically difficult to apply (Lamers *et al*., 2002; Patzelt *et al*., 2001). As it has mainly been applied on a larger scale in heathlands and wet meadows, relatively little is known about the effectiveness of this restoration method in the fens, especially in Central European conditions. Also the full understanding of the ecological processes behind the vegetation re-development is still missing. Therefore testing of this method in Poland, together with a careful vegetation investigation was initiated.

## ASSESSING ECOLOGICAL EFFECTIVENESS

In Germany, the Netherlands, Switzerland and the United Kingdom this method was tested for fen and wet meadows (Beltman *et al.,* 2001; Grootjans *et al*., 2002a; Patzelt *et al*., 2001; Ramseier, 2000; Tallowin & Smith, 2001). In the Netherlands and Germany it has also been in other habitats, like coastal dune slacks (Grootjans *et al*., 2002b), heathland (van Diggelen *et al*., 1997; Klooker *et al*., 1999) and floodplain grassland (Holzel & Otte, 2003; Oomes *et al*., 1996). In many cases the first year development of the target species was limited by ruderals (Holzel & Otte, 2003), emerging from the soil seed bank (Grootjans *et al*., 2002a). In a number of studies the topsoil removal method was successful. In the fen meadows the establishment of the target species was recorded after 5 years (Beltman *et al*., 2001; Patzelt et al., 2001), in the flood plain meadows within 4 years (Holzel &

Otte, 2003), in the coastal dune slacks after 10 years (Grootjans et al., 2002a and b), in the heathland after 20 years (van Diggelen et al., 1997; Klooker et al., 1999). Several factors facilitating the establishment of target species have been identified. The first one is the presence of target species in the local species pool (Beltman et al., 2001; Grootjans et al., 2002a and b; Klooker et al., 1997; Verhagen et al., 2001). The re-establishment of the target species depends on sufficient seed sources (Grootjans et al., 1998) or can originate from stoloniferous or rhizomatous spread (Tallowin & Smith, 2001). Seeds are likely to come from the soil seed bank, so from a pool of all viable seeds accumulated in the soil, or from source populations in a proximate neighborhood (van Diggelen et al., 1997; Pfadenhauer & Klötzli, 1996; Verhagen et al., 2001). The soil seed bank contains normally only species with a persistent type of seed, whereas most typical fen species have sort-term trancient seeds (Brülisauer & Klötzli, 1998; Verhagen et al., 2001; Grootjans et al., 2002b). If target species are not present in the seed bank nor the direct neighbourhood, planting (Tallowin & Smith, 2001) or hay transfer can be applied (Holzel & Otte, 2003; Brülisauer & Klötzli, 1998; Patzelt et al., 2001; Grootjans et al., 2002a; Grootjans et al., 2002b). With the last method, seeds or parts of plants are brought on a new habitat together with hay mown and collected on the target vegetation. The second success factor is the depth of the removed soil layer, because it determines soil moisture, nutrient status as well as the seed bank composition. Additionally rewetting and mowing are often applied to ensure that the established target species remain in the site (Grootjans et al., 2002a; Holzel & Otte, 2003).

## ASSESSING ECONOMICAL EFFECTIVENESS

The topsoil removal is, in many cases, most effective restoration method, especially in terms of nutrient impoverishment, but also oftent most expensive one. Is it thus possible to make this restoration method sustainable and not fully relay on large founding? It seems that possible savings could be made by finding an interested user of the removed soil. For example village people can use the topsoil in their gardens and yards, the state forestry for a tree nursery or afforestation projects, municipal services for recultivation of the dumping sites and gardening centers can sell it as a low quality garden substrate. However, the topsoil is rather of a low quality, because it contains weed seeds, parasites, fungi and unbalanced quantities of nutrients (Tobolski, 2003).

## CASE STUDY CAŁOWANIE

The method of topsoil removal is currently tested by the Save Wetlands Association in the Całowanie fen (52°00'N 21°21'E) in Poland. Całowanie area was selected for this study, as it is to a large extent transformed by human: it is severly drained and due to that, the organic soils degraded causing eutrophication of the habitats (Kotowski et al., 2001). Całowanie is located in the Warsaw Cirque in the Mazovia region, within the 10 km wide Middle Vistula river valley. It covers an area of around 1200 ha and the peat deposits reach a thickness of 3-4 meters (Oświt & Dembek, 1984; 2001). The Całowanie fen is situated close to the edge of the valley, on a slope of glacial upland (Oświt & Dembek, 2001) in the fossil side river

branch (Schild et al., 1999). The mineral subsoil of Całowanie consist mainly of sand deposits of river accumulation with the sand-gravel and morainic loam underneath (Rudnicka, 1961; Oświt & Dembek, 1984). The impermeable layers of the upland enable the formation of underground water reservoirs (Oświt & Dembek, 2001) that provide sub-artesian water, flowing upwards and feeding the fen system from the bottom (Oświt & Dembek, 1984; Żurek, 1990).The Całowanie fen host a number of rare and protected species of birds, butterflies and plants. Due to the presence of the species protected by European directives, this fen was designated as a NATURA 2000 site.

## Main problems and management

The Całowanie fen was extensively managed for centuries, mainly as hay-meadows with limited fertilization and grazing on the margins. This facilitated the development of the mire vegetation. A small-scale extraction of peat for fuel used to be a common practice. It was mainly shallow peat digging (down to 0.5 m) by hand. The pit-cuts were managed as low-quality hay meadows. In the process of land reclamation, the Całowanie fen has been drained and transformed into pastures and moderately intensive meadows. After the drainage, the water levels on the upland dropped about 1.2 m (Oświt & Dembek, 1984). It was evidenced that the groundwater in the summer season (July-September) was gradually decreasing over the last 50 years, from water close to the surface before the reclamation to 0.6 – 0.9 m below surface in 2003-2004 (Rudnicka, 1961; Oświt & Dembek, 1984; Save Wetlands Association, unpublished data). In general the reclamation schemes resulted in seasonal water deficits, increase of the mineralization rates (Rudnicka, 1961) and finally acceleration of the succession processes on the abandoned land. After the land reclamation the fen vegetation was only preserved in the pit-cuts because of the still wet and mesotrophic conditions there. Nowadays, fens and wet meadows are abandoned, because the extensive farming in swampy and hardly accessible sites is not beneficial anymore. Also the overdried, degraded meadows with nitrophilus, ruderal vegetation and low production are becoming abandoned. On the abandoned meadows the process of vegetation succession has re-started. A rapid willow and birch invasion takes place, especially in the old pit- cuts.

## Set-up

The topsoil removal took place in three sites. At 15x15 m site with 40 cm depth of removal the clonal spread of species will be observed. On two 35x35 m sites, three variables are tested: depth of removal, effects of hay spreading and impact of wild boars on the dispersal of species. Set-up of experiment is presented in Figure 1.
On half of each plot the soil was removed on 20 cm and on the other half on 40 cm. The depths of soil removal were defined on the base of investigations of the peat depredation degree and observations of groundwater fluctuations. In the restoration plots the layer of mineralised peat (fine granulate structure) was down to 30 cm thick, whereas the groundwater fluctuations (in 2003) were around 50 cm (Save Wetlands Association, unpublished data). Removing of 20 cm of the soil is expected to decrease the nutrient availability and the removing of 40 cm should

eliminate the entire layer of the degraded peat, as well as soil seed bank of ruderal species and considerably improve the wetness conditions.
The hay was spread on one of the sites in order to test if it facilitates the establishment of target species. The hay was collected on an area of 0.25 ha, that is twice as large as the restoration plot, on species-rich fen meadows. The species-rich meadows are the best preserved fen and wet meadow vegetation in the area and contain a number of species, recognised as typical for these types of vegetation. It was assumed that hay collected on such meadows contain propagules of most of target species. In order to test the influence of animals (mainly wild boar) on the dispersal of the target species, half of each plot was fenced, with a 1.6 m-high fence. In order to assess the possible re-establishment of plants from the seed bank, the soil seed bank will be analysed. The experiment will be further monitored in terms of ground water levels and vegetation development. The second one will be carried out in a 2x2 m grid.

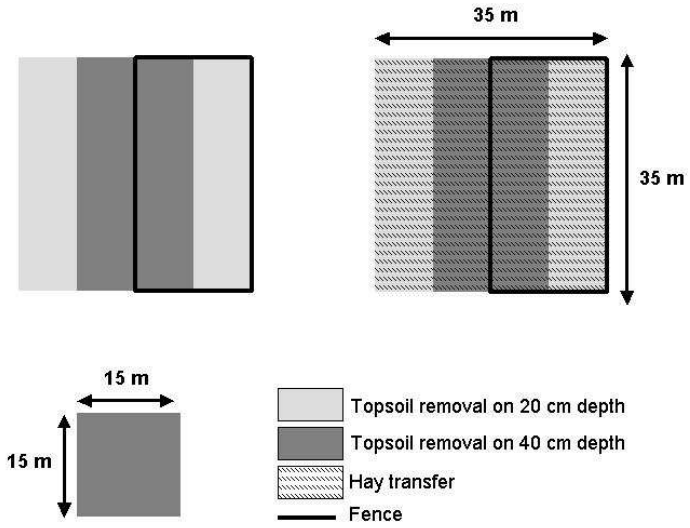


Figure 1: Set-up of experiment (scheme does not resemble the field set-up in terms of size and distances between plots).

## Technical

The topsoil removal was carried out in August 2004, during four weeks. The limitation of the work was the soft soil with low carrying capacity, which constrained use of heavy machines for digging and transport. Therefore, a tractor with a trench digger (volume 0.2 $m^3$) of 5 tons weight have been used for the soil removal. For transport to a temporal storage place, small farming tractors with trailers where used (volume about 2 $m^3$). This equipment is not specially designed for such a

work, but it appeared to be most practical, because it could easily drive on the surface of peatland without additional improvements or building an extra road. Altogether, a volume of 825 m³ of soil was removed from the surface of 0.27 ha.

## Costs

The cost of the removal of the soil was 3500 €. Costs of soil transport depended on the distance and were estimated as 1000 € assuming transport to the nearest village for storage. In addition, costs of building a road of metal or concrete plates on which trucks could transport the soil were calculated and turned to highly overcome the project budget. In order to lower the costs we planned the topsoil removal plots close to an existing road and light machinery, which could drive on the peat surface itself, was used.
Giving the soil for free to the local community lowered the costs of transport (farmers brought the soil to their gardens and yards by light tractor-trailer) (Figure 2). However, this is not a sustainable solution for a larger area of topsoil removal, because after the local needs for soil are saturated, transport will still be necessary.

Figure 2: Farmers waiting for topsoil material digged from one of the restoration plots.

## Potential benefits

It seems that potential benefits of topsoil removal could be generated by selling the removed soil. Almost the entire removed soil was given away for free, so the benefits of selling were not yet explored. But some potential benefits of selling the soil can be assessed. A commercial soil bought in a garden center in Poland costs 28-40 Euro/m³. A company that operates nearby the restoration site and builds fishponds, sells the digged out peat for 7 Euro/m³. This peat originates from deeper layers and therefore has a better quality than the topsoil from the restoration sites, which should therefore be sold for a lower price. Another option is to sell the soil after composting. Composting can be done with the standard method or in a high temperature, in containers, which leads to higher quality compost. Benefit from the compost will be higher than the immediate selling of the material, but costs of processing, storage, labor and marketing have to be calculated. Further economical analyses of this method in the selected case study have to be carried out, including not only the direct benefits, but also long-term effects, as well as social and environmental aspects (use for recreation, water storing capacity, soil protection, protection of the groundwater resources) (Bołtromiuk, 2003).

## CONCLUSIONS

Regarding the advantages and disadvantages of topsoil removal method, question emmers: Is it a small-scale measure only? Some authors (Lamers et al., 2002; Patzelt et al., 2001; Ramseier, 2000) recommend using the topsoil removal method only on a limited spatial scale. Patzelt et al. (2001) argued that the target species can establish on small areas of the topsoil removal which can later serve as a source for dispersal of target species to the surroundings. The method is expected to be ecological effective and in previous studies it was recommended as a measure for a restoration of a fen area (Grootjans et al., 2002a), although the results on peat soils are often difficult to predict. It seems to be also suitable tool for nature restoration on a heavly degraded peatland, like Całowanie, but the experiment should be carefuly monitored for at least few years. To make it economically more attractive, the costs can be reduced by limiting the transport costs and generating profits from selling the soil. Also using the modern maschinery – bigger, more cost effective but also lighter and adjusted to work on soft soil could reduce the cost and time needed. It would be desirable to use this method on a larger scale. However it is questionable if the ecological results of the experiments can be directly translated to a larger scale. Also the increase of the costs of the topsoil removal and complication of the logistics is unavoidable. Concerning the different economical situation in Western Europe and in Poland, the large scale and rather costly restoration projects are not likely to be financed by state and regional or municipal authorities. In future large projects of this type could be co-funded by nature funds and soil enterprises. In general, if effective utilization of the removed material can be found, the topsoil removal can possibly be used as a restoration option on large areas of drained and eutrophied fens.

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