Restoration as a tool to improve the quality of drained spruce mires in conservation areas

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Summary

Boreal spruce mires have high biodiversity value, but as they are naturally forested they have been intensively drained for forestry purposes. Less than 20 % of them are still undrained in southern Finland. Also nature conservation areas include drained spruce mires, especially in southern Finland. Restoration has been highlighted as a tool to enhance the quality of habitats in conservation areas. Our case study includes two restored, one drained and three undrained spruce mire sites in two nature conservation areas in South-Finland. *Sphagnum* mosses responded quickly and positively to restoration measures.

Key index words: conservation, restoration, spruce mire, *Sphagnum*, vegetation

Introduction

Boreal spruce mires area naturally forested mires where *Picea abies* dominate the tree stand. Vegetation is formed by a mixture of forest and mire species in all vegetation layers (Hörnberg *et al.*, 1998; Økland *et al.*, 2001; Korpela, 2004). In site types dominated by dwarf shrubs, *Sphagnum* mosses dominate the ground layer.

The aim of the drainage is to improve the forest growth by lowering the water table level (Laine *et al.*, 2006). In the field and ground layers genuine mire species, such as *Sphagnum* spp., decrease or disappear, and forest species increase or colonize the drained site (e.g. Korpela, 1999). Aim of the restoration of drained spruce mires is by raising the water table level, facilitate the recovery of remaining relict populations of original mire species and the re-colonization of characteristic spruce mire species that have disappeared. A decline of forest species is also aimed for, but not necessarily a total disappearance, since they occur also in pristine spruce mires.

Palmer *et al.* (1997) point out that some species (keystone species) may have a very important role in communities. Successful reestablishment of these species may determine the outcome of restoration and maintenance of function when reestablished (Palmer *et al*,. 1997). *Sphagnum* mosses are the key peat forming species in boreal peatlands (Rydin and Jeglum, 2006). Also in spruce mire ecosystems *Sphagnum* mosses play an important role in peat accumulation and functionality and can be regarded as keystone species. Thus the recovery of *Sphagnum* can be seen as essential for successful restoration of drained boreal spruce mires.

Spruce mires are common in southern Finland (approximately 800 000 ha), but almost 80 % of them have been drained for forestry (Virkkala *et al.*, 2000). Only few per cent of spruce mires have been protected and over one third of them were drained before protection (Virkkala *et al.*, 2000). If we want to improve the situation of spruce mires in nature conservation areas, active restoration is needed.

Our aim was to study, if the restoration can improve the quality of drained spruce mires. As a measure of the quality we used the total cover of *Sphagnum* mosses and the vegetation composition.

Materials and Methods

Study sites

Our case-study includes two restored mires (5 monitoring sites), one drained, unrestored monitoring site and two undrained mires (3 monitoring sites) in two nature conservation areas in southern boreal vegetation zone in South-Finland (Table 1). All sites are dwarf shrub (mainly *Vaccinium myrtillus* and *V. vitis-idaea*) dominated, minerotrophic spruce mires (spruce swamp forests) with spruce (*Picea abies)* dominating the tree stand. *Pleurozium schreberi* and *Hylocomium splendens* or *Sphagnum* spp. dominate the ground layer, depending on the status (drained, restored, pristine) of the site. Maximum depth of the peat layer was over 1,5 m in all sites except E1, where it was 0,6 m.

The study areas represent a typical boreal landscape mosaic of small mires and mineral soil forests. The size of the studied mires varies from 1 ha to 15 ha (Table 1). The rather small (13-25 ha) catchment areas are formed by mineral soil forests that are mainly dominated by pine (*Pinus sylvestris*) or sometimes by spruce, mixed with some birch (*Betula pendula*, *B. pubescens*).

Study area	Study site	Location	Status	Restoration year	Tree stand manipulation	Monitoring years	No of vegetation plots
Liesjärvi Natura 2000 –area Studied mire 13 ha, Catchment area 25 ha	LR1	60°40´N 23°52´E	Restored	1995	No	1995, 1996, 2000, 2005	24
	LR2		Restored	1995	Yes 25 % felled 25 % girdled	1995, 1996, 2000, 2005	24
Evo Natura 2000 –area Studied mire 15 ha, Catchment area 20 ha	ER1	61°14´N 25°05´E	Restored	2000, 2002	Yes 30 % felled	2000, 2001, 2005	16
	ER2		Restored	2000	No	2000, 2001, 2005	16
	ER3		Restored	2000, 2002	Yes 30 % felled	2000, 2001, 2005	15
	ED4		Drained		No	2000, 2001, 2005	16
Studied mire 4 ha, Catchment area 13 ha	EP1	61°15´N 25°03´E	Pristine			2004	16
	EP2		Pristine			2004	16
Studied mire 1 ha, Catchment area 13 ha	EP3	61°15´N 25°04´E	Pristine			2004	16

Table 1. Characteristics of the nine spruce mire study sites in two nature conservation areas in southern Finland.

The drained and silviculturally managed sites had been drained over 50 years ago. The drainage had been effective and the tree stand was dominated by even-aged and –sized spruce, with characteristics of old-growth forests (e.g. coarse woody debris) found only in site ER2. Drainage had affected also the field and especially the ground layer vegetation.

The studied mire area in the Liesjärvi Natura 2000 area (including sites L1 and L2) was restored in 1995 by building peat dams with an excavator. In site L2 the tree stand was manipulated by felling and girdling some of the trees to increase the amount of dead wood. Otherwise the tree stand was left untreated. In the Evo Natura 2000 area a similar restoration method was used to restore most of the studied mire area in 2000. Part of the drained mire was left untreated to serve as a control site (ED4). The tree stand was manipulated by felling part of the tree stand in restored sites ER1 and ER3 in 2002.

The tree stand in the two pristine reference mire areas is not entirely pristine since tree stumps indicate some selective logging in all sites. Nevertheless they have not been drained so their hydrology is undisturbed.

Sampling

Vegetation was sampled using permanent, 1m^2 plots that were systematically placed on the microtopographically lowest surface. A total of 159 vegetation plots were studied (Table 1). The percentage cover of the species in the field and ground layer vegetation was estimated visually. The cover of unvegetated litter surface was estimated as part of the ground layer. The cover values used were: 0.5, 1, 2, 3,… 10, 15, 20, 25, … 95, 96, 97, 98, 99, 100 %.

In all restored sites monitoring was started before restoration operations and in Liesjärvi monitoring has continued ten years and in Evo five years after restoration (Table 1). The drained control site has been monitored at the same time as the restored sites in Evo. Pristine reference sites have been monitored once.

Results

The mean total cover of *Sphagnum* mosses is lowest, 44 %, in drained plots (Fig 1). Restoration has increased the amount of *Sphagnum* and five years after restoration 67 % of the ground layer is covered by *Sphagnum*. Ten years after restoration the cover percentages are similar to the values in pristine mires. The SD values are high in drained and recently restored sites, but decrease during the succession after restoration, and in ten years are near reference sites.

The starting point (year 0, Fig. 2) for restoration may vary greatly in relation to the total cover of *Sphagnum*. In the site that had changed least after drainage, LR1, the total cover of *Sphagnum* was high (73 %) already before restoration. In LR2, ER1 and ER2 *Sphagnum* covered approximately half of the ground surface before restoration, but in site ER3 the cover was only 10 %. LR1, LR2, ER1 and ER2 showed positive response already one year after restoration, but in ER3 *Sphagnum* cover did not increase immediately after restoration. In all restoration sites the trend is clear and the total cover of *Sphagnum* has increased in five years after restoration. In ten years LR1 and LR2 have reached the values of pristine reference sites. The drained control site had very low *Sphagnum* cover values (6 %) at the beginning of the study and there have been no changes during the five years of monitoring.

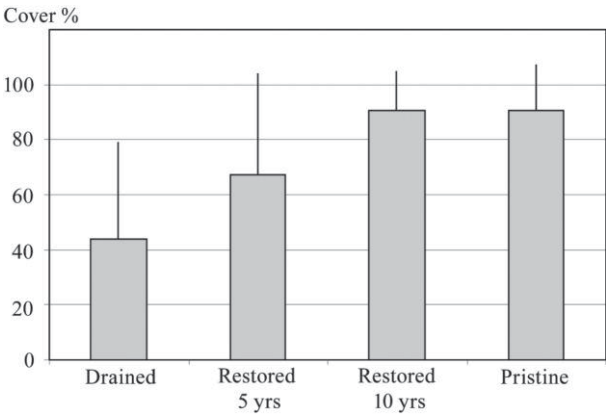

Figure 1. Mean cover of Sphagnum mosses in drained (n=6), five years after restoration (n = 5), ten years after restoration (n = 2) and pristine (n = 3) spruce mire sites in two nature conservation areas in southern Finland. Error bars show SD.

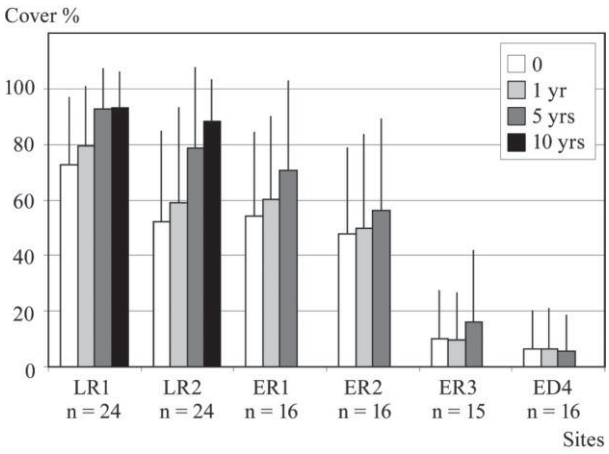

Figure 2. Changes in the mean cover of Sphagnum mosses before (year 0) and one, five and ten years after resto-ration in five restored sites (LR1, LR2, ER1, ER2, ER3). ED4 shows changes in mean Sphagnum cover in a drained site during five years of monitoring. Error bars show SD.

In pristine spruce mire sites *Sphagnum girgensohnii* is clearly the dominant species and S. *angustifolium* is also common. Other *Sphagnum* species (*S. centrale*, *S. magellanicum*, *S. wulfianum* and *S. russowii*) occur more or less sporadically. In drained sites the forest species *Pleurozium schreberi*, *Hylocomium splendens* and *Dicranum polysetum* were the most abundant species. Of the *Sphagnum* species *S. girgensohnii*, *S. russowii* or *S. angustifolium* is the most abundant species in drained sites. Also *S. magellanicum* and *S. wulfianum* occur, but only with very low values.

The number of vascular plant species in the field layer varied from 9 to 16 in pristine sites and 3 -13 in drained sites. *Carex loliacea*, *Calamagrostis purpurea*, *Listera cordata* and *Dactylorhiza maculata* were found only in pristine sites. Both in pristine, drained and restored sites the most common species in the field layer were *Vaccinium myrtillus* and *V. vitis-idaea*. In older restoration sites there were some pioneer species typical for disturbed sites, such as *Epilobium angustifolium* and *Rubus idaeus*.

Discussion

As *Sphagnum* mosses are essential for the natural functioning of spruce mires, their recovery can be regarded as necessary for successful restoration. Restoration increased the total cover of *Sphagnum* mosses in all restored sites, while in the drained site there was no change. The recovery of *Sphagnum* started rapidly after restoration, and already a year after the operations there were increase in the cover values. So restoration operations were able to initiate a change towards a right direction. There are no published results from other restored spruce mires, but results from fen and bog restoration sites in Finland show also increase in total cover of *Sphagnum* three years after restoration (Jauhiainen *et al.*, 2002).

The starting point for restoration seems to be important for the rate of recovery. The more *Sphagnum* there is to start with, the more rapidly the site reaches the values of pristine reference sites. Even though in site with lowest values (ER3), the *Sphagnum* cover has almost doubled in five years, it is still far from the pristine sites. In Finnish conditions we can usually rely on spontaneous succession in *Sphagnum* recovery after restoration, because there are almost always some relict patches of *Sphagnum* left. Although the abundance ratios of *Sphagnum* species have changed after drainage, the same species occur in both drained and pristine sites.

There are still approximately 6 500 ha of drained spruce mires in nature conservation areas (6 % of all protected spruce mires) (Tuomas Haapalehto, pers. comm.). Because the evaporation of mature trees in drained spruce mires can keep the water table level down, it is not enough to rely only on spontaneous re-wetting. In the future restoration is likely to play an important role in improving the habitat quality and species diversity of drained spruce mires in nature conservation areas, especially in southern Finland.

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