RECOVERY OF DONOR SITES USED FOR PEATLAND RESTORATION

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SUMMARY

In North America, large surfaces of milled peatlands have been restored in the last five years. One of the required steps is the reintroduction of *Sphagnum* and other plant diaspores to the milled surfaces. The ratio of reintroduction recommended is approximately 1: 10, meaning that 1 ha of material has to be collected at a shallow depth (less than 10 cm) to restore 10 ha of peatlands. This plant material is collected mechanically in nearby natural peatlands, and then spread onto the cutover peat surface using a manure spreader. Monitoring of several donor sites show that the recovery is quite rapid with a peatland plant community re-establishing over the next 3 to 5 years. After 5 years, sites can show a close to complete vegetation recovery for two attributes: density and species composition. When plant collection is done in a way to reduce damage to donor sites, there is little need for further management or treatments to the donor site in order to promote rapid recovery.

INTRODUCTION

Throughout North America large areas of milled peatlands for horticulture have been restored following a paludification approach (Rochefort, 2000). This general approach usually consists of the following steps: (1) field preparation, (2) diaspore collection, (3) introduction and protection, and (4) fertilization. Diaspores are any part of a plant that can regenerate a new individual, such as seeds, rhizomes, shoots or branches. The scientific basis of this restoration method is described by Rochefort *et al.* (in press; see also Price *et al.*, in press, for a better understanding of the hydrology of restored sites). The key plant species for peatland restoration are *Sphagnum* species as they are truly the ecological engineers of mire ecosystem (van Breemen, 1995). Because so far no nursery or greenhouse mass production of *Sphagnum* mosses do exist for reintroduction, the fate of donor site used to collect diaspores for restoration purposes has

raised concerns. The situation is different for afforestation projects where a company can buy healthy tree seedlings from professionnal growers for hectares of plantation. In mire restoration, environmentalists might be concerned with biodiversity recovery and industrialists or restorationists can be quite interested to see donor site recover quickly as to re-use the same sites on a cycle basis and reduce impacts on surrounding natural sites.

The aim of this paper is to determine if management of donor sites after diaspore collection is useful for healthy recovery and to examine the recovery of two mire communities after five and seven growing seasons from the time of collection. Data on biodiversity and abundance of all the taxa recorded are presented.

MATERIAL AND METHODS

Management of donor sites

For large scale experiments in 1996, two donor sites of 800 m^2 each in a natural mire were selected. One site was dominated by *Sphagnum fuscum* and the other by *S. capillifolium* (sensu lato). Nine experimental units of 80 m^2 were delineated for each donor site: three experimental units were left to naturally recover without any management, three were covered with a straw mulch as to protect the diaspores left behind during the collection process (for a discussion on the effect of straw mulch in peatland restoration, see Price *et al.*, 1998), and the last three were further sub-divided into four sub-plots where different species of *Sphagnum* were reintroduced. The species were the following : *S. fuscum*, *S. magellanicum*, *S. capillifolium* and an equal mix of the three species. The density of the reintroduced *Sphagnum* was 1:10 (being the area of the collected surface to the spread area). These three later experimental units were also protected with a straw mulch.

In October 1996, percent cover of *Sphagnum* mosses were evaluated for each treatment with a series of quadrats (25 x 25 cm; 40 to 60 of them depending if the plot was subdivided or not). Quadrats were systematically located within each plot. The success of recolonisation has been compared between treatments for each donor site by using the ANOVA of the procedure GLM of SAS (SAS Institute Inc., 1988).

Natural recovery of donor sites

Similarly to the previous experiment in 1996, several other donor sites (800 m^2) were needed for large-scale mechanized restoration trials done in spring 1995 and 1997. These donor sites were located in *S. fuscum* (1995 and 1997) and in *S. capillifolium* (1995 only) dominated communities. Three plots of 5 by 5 m were delimited for each donor site. In October 2001, i.e. after five and seven growing seasons, species diversity and percent cover by taxa were evaluated on each of these plots. Similar plots were also delimited in untouched natural areas adjacent to donor site for comparison purposes.

RESULTS

Management of donor sites

Data taken at the end of the 1996 growing season shown that the addition of straw mulch did not improve significantly the recovery of the donor sites (Figure 1). Likewise the active reintroduction of *Sphagnum* diaspores has not ameliorated *Sphagnum* recolonisation (percent cover) of the donor sites after one growing season (Figure 1). The difference between species treatment is not discussed here as there was no global effect of active *Sphagnum* reintroduction. Qualitative visual observations of the different plots made in 1999 and 2001 showed no noteworthy

differences between treated and non-treated areas (S. Campeau, personnal observations).

Natural recovery of donor sites

After five or seven growing seasons of recovery, the biodiversity of the donor sites has been generally restored. From Table 1, any person acquainted with peatland floristic can see that the differences are of minor importance. For example, lichen is present in the 1997 donor site of *S. fuscum* but not in the 1995 donor site. This is easily explained by the patchy distribution of lichens that are not so common in the lower boreal zone of continental Canada. Likewise black spruce and tamarack are quite patchy in their distribution within a mire and usually donor sites are selected as to avoid the presence of trees to facilitate the work of machinery. It is noteworthy that no species not belonging to mire communities has been invading.

Within *Sphagnum fuscum* dominated communities, *S. fuscum* mosses has steadily recolonised the site over the years. In Figure 1, we have seen that *S. fuscum* had reached just above 30 percent cover after one season of recovery, to increase to 63 and 74% after five and seven growing seasons of recovery (Table 2). The remaining surface is far from being bare however, as an additionnal 36% and 22% moss cover is provided by *S. capillifolium*. A nearby natural site tells us that *S. fuscum* can be present at an abundance of 95% ground cover. At the donor site the *Sphagnum* moss cover is also complete but the species composition is not quite the same. So after five and seven growing seasons of recovery, *S. fuscum* is back to be the dominant

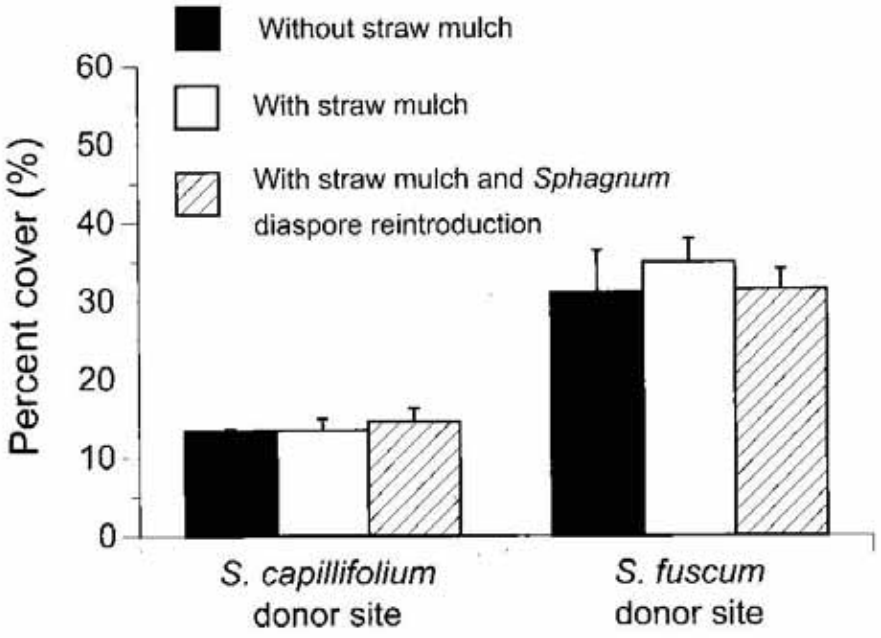

Figure 1. Effect of straw mulch application and active Sphagnum *diaspores reintroduction on the recovery of two donor sites at Sainte-Marguerite peatland, Québec, Canada, after one growing season (data presented are means and standard errors).*

Table 1: Biodiversity of natural areas and donor sites in Sphagnum fuscum *and* S. capillifolium *dominated communities at Sainte-Marguerite peatland, Québec, Canada.*

	S. fuscum			*S. capillifolium*	
	Natural	Donor 1997	Donor 1995	Natural	Donor 1995
Number of growing seasons since collection		5	7		7
Lichens	x	x		x	x
Mosses					
Mylia anomala	x			x	x
Dicranum sp.		x			
Dicranella cerviculata					x
Aulocomnium palustre			x		
Polytrichum strictum	x	x	x	x	x
Sphagnum angustifolium	x	x	x	x	x
Sphagnum capillifolium	x	x	x	x	x
Sphagnum fuscum	x	x	x	x	x
Sphagnum magellanicum	x	x	x		x
Herbs, shrubs and trees					
Eriophorum angustifolium	x			x	x
Eriophorum vaginatum	x	x	x	x	x
Andromeda glaucophylla		x		x	x
Chamaedaphne calyculata	x	x	x	x	x
Vaccinium oxyccocus	x	x	x	x	x
Vaccinium angustifolium	x				
Kalmia angustifolia	x	x	x	x	x
Kalmia polifolia				x	
Ledum groenlandicum	x	x		x	x
Larix laricina			x	x	x
Picea mariana			x	x	
Total number of species	14	13	12	16	16

Table 2: Plant cover (%) in natural areas and donor sites in Sphagnum fuscum *and* S. capillifolium *dominated communities at Sainte-Marguerite peatland, Québec, Canada.*

	S. fuscum			***S. capillifolium***	
	Natural	Donor 1997	Donor 1995	Natural	Donor 1995
Number of growing seasons since collection		5	7		7
Lichens	<1	<1		<1	<1
Mosses					
Mylia anomala	<1			1	1
Dicranum sp.		<1			
Dicranella cerviculata					<1
Aulocomnium palustre			<1		
Polytrichum strictum	<1	1	1	4	1
Sphagnum angustifolium	<1	<1	<1	5	14
Sphagnum capillifolium	4	36	22	76	52
Sphagnum fuscum	95	63	74	18	8
Sphagnum magellanicum	<1	<1	3		1
Total Sphagnum moss cover	100	100	100	100	77
Herbs, shrubs and trees					
Eriophorum angustifolium	<1			6	6
Eriophorum vaginatum	2	15	18	1	9
Total herb cover	2	15	18	7	15
Andromeda glaucophylla		<1		<1	<1
Chamaedaphne calyculata	3	2	1	<1	4
Vaccinium oxyccocus	<1	1	<1	<1	1
Vaccinium angustifolium	<1				
Kalmia angustifolia	4	1	4	<1	3
Kalmia polifolia				<1	
Ledum groenlandicum	20	12	18	12	4
Larix laricina			<1	1	<1
Picea mariana			<1	<1	
Total shrub cover	27	16	23	14	13

species but not quite at the same level as the untouched area.

For the *Sphagnum capillifolium* dominated communities, the moss layer is not complete yet after seven growing seasons of recovery (77% compared to 100% in natural conditions; Table 2). For both donor site communities, it can be noticed that cotton-grass (*Eriophorum vaginatum*) has been favored during the recolonisation process.

DISCUSSION

Management of donor sites

In 1996, the growing season was relatively wet (with well above normal range of rainfall in July and August) and the addition of mulch or diaspores had no effect on the recovery of the donor sites. In a drier year, the effect of mulch has been found to positively ameliorate the recolonisation of donor sites by *Sphagnum* mosses (Rochefort *et al.*, 1997) but this effect disappeared in the following growing season. In the long run, the addition of mulch seemed to be of little benefit to the recovery of donor sites, especially in relation to the extra work and cost involved. So overall, the management of the collecting site per say is not needed if only 10 cm of surface diaspore material or less has been extracted. This does not mean that no management of operations is needed. Indeed great care must be taken to the access ways to the collecting site. Several passages of the machinery on the same trails is well known to create deep ruts into the peat and those will greatly disturb water flows and plant communities. Making sure that deep frost can occur during the winter time is one way to reduce mechanical damages to the site. It can be accomplished by removing a certain layer of snow with a snow blower to allow frost penetration.

After diaspore collection, the surface of donor sites tends to be fairly level, due to the smoothing of the microtopography of hummocks and hollows typical to natural mires. In the long term, a flat surface could facilitate the work of the machinery if donor sites are to be used repeatedly. The remaining surfaces of donor sites are also slightly lower than surrounding areas. This allows them to stay wetter, which are conditions known to be favorable to *Sphagnum* establishment (Price *et al.*, 1998, in press; Rochefort, 2001).

Natural recovery of donor sites

S. capillifolium would need to increase by 20% and *S. fuscum* by 10% in order to get species composition similar to nearby natural communities but overall the community structure of the donor sites after five and seven growing seasons is quite similar to the nearby natural mire. One exception is the greater abundance of cotton-grass from 1 to 2 percent cover in natural conditions to 10 to 18 percent on the donor sites. Cotton-grass is well adapted to colonize bare ground in peatlands (Campbell *et al.*, in press) and has great dispersion capabilities. Most likely the removal of the thick moss acrotelm has permitted them to resprout easily and florish in conditions of lessened competition from growing *Sphagnum*. It will be interesting to see if in the long run species composition of donor sites completely regains its past conditions as observed in adjacent sites.

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