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# RETURN OF PEAT ACCUMULATION FUNCTION IN A RESTORED CUTOVER PEATLAND: A QUESTION OF IMBALANCE

Rémy Pouliot, Université Laval, Peatland Ecology Research Group, Centre d'Études Nordiques. 2425 rue de l'Agriculture, Quebec City, Canada, G1V 0A6. Telephone number: 1-418-656-2131. E-mail address: remy.pouliot.1@ulaval.ca

Roxane Andersen, Environmental Research Institute, Castle street, Thurso, Caithness, KW147JD, UK.

Line Rochefort, Université Laval, Peatland Ecology Research Group, Centre d'Études Nordiques.

Flor Salvador, Université Laval, Peatland Ecology Research Group, Centre d'Études Nordiques.

## SUMMARY

Bringing back a healthy plant cover in cutover peatland is not sufficient to reset the capacity to sequester organic matter. It is the imbalance between inputs and outputs that needs to be re-established in restored peatlands. To verify this imbalance, organic matter accumulation potential was estimated as the difference between losses in the aerobic zone and inputs through aboveground net primary production along a gradient going from absence of *Sphagnum* to natural hummock communities. Losses were estimated from a reciprocal transplant experiment of litter bags containing fibric *Sphagnum* or residual peat. Eight years post-restoration, restored habitats had a small accumulation potential that was still lower than natural peatland..

KEY WORDS: above-ground net primary production; Bog; Decomposition; Organic matter accumulation potential; Restoration; *Sphagnum*.

## INTRODUCTION

Following peat vacuum-harvesting and site closure, abandoned sites are hardly colonized by plants (Poulin et al., 2005), therefore ecological peatland restoration is the best option to bring back a plant cover dominated by peatland species including *Sphagnum* mosses (Rochefort and Lode, 2006). However, bringing back a healthy plant cover is not sufficient to reset a self-sustainable system that recovers the capacity to sequester organic matter and form peat. From a functional point of view, we need to re-establish the positive imbalance between input and output in restored peatlands.

In restored sites, small-scale variations in environmental conditions influence the rate of *Sphagnum* establishment and its growth thus leading to differences in the carpet thickness, or microtopographic features (Pouliot et al., 2011). On the other hand, the addition of fresh organic matter in the upper layers after the restoration coupled with many years of alternating periods of water logging and aeration in a large portion of the profile (Shantz and Price, 2006) stimulate the microbial activity, which could delay the recovery of the carbon sequestration and peat accumulation functions (Andersen et al., 2010). Therefore, in restored sites, spatial differences in both *Sphagnum* primary production and decompositions rates could lead to heterogeneous distribution of the organic matter accumulation potential.

Our goal was to characterize organic matter accumulation potential along a gradient of habitat complexity going from absence of *Sphagnum* in non-restored conditions to hummock communities in natural reference peatland. The gradient is also composed of three intermediate stages of *Sphagnum* thicknesses found in a restored peatland. Habitat complexity refers among others to the number of vegetation strata: ground layer (mosses), shrub layer and tree layer.

## MATERIALS AND METHODS

### Study site and habitat complexity gradient

The study took place at the Bois-des-Bel Ecological Field Station (47° 58' N, 69° 26' W), in Québec, Canada and in the natural peatland nearby (47° 78‘ N, 69° 47‘W). In fall 1999, following twenty years of abandonment after peat vacuum-harvesting, an ecosystem-scale restoration was attempted at the Bois-des-Bel cutover peatland by using the *Sphagnum*-moss layer transfer technique (Rochefort and Lode 2006). The gradient of habitat complexity was composed of five different classes (replicated three times) of *Sphagnum* thicknesses: 0 cm (un-restored, UNR), < 5 cm (*Polytrichum strictum* carpets, POL), 10-15 cm (*Sphagnum spp.* Carpets without shrubs, SPH), 10-20 cm (ericaceous shrubs growing on *Sphagnum*, ERI) and > 25 cm (natural communities with ericaceous shrubs, NAT). The study was carried out seven and eight years post-restoration.

### How to estimate the organic matter accumulation potential

First, a reciprocal transplant experiment was set up with litter bags containing fibric *Sphagnum* collected or residual peat. Five bags per replicates were buried horizontally no deeper than 15cm below the surface in residual peat (UNR, POL), in fibric *Sphagnum* carpet (NAT) or in both peat type, as they co-occur in ERI and SPH for a burial period of two years. The losses associated with *Sphagnum* in the aerobic zone were estimated for a cubic meter of peat for each replicate as (WT-SphTh x $BD_B$) x $M_B$ + (SphTh x $BD_A$) x $M_A$, where WT is the average depth of the water table over the two seasons, SphTh is the thickness of newly formed Sphagnum carpet, BD is the bulk density of either the residual (B) or the fresh (A) peat in which the bags were buried, M is the mass loss (%) of the residual peat (B) or fibric *Sphagnum* litter (A). We used average WT because the large fluctuations in WT occurring in the restored site are not common in natural sites (Price et al., 2003 and J.S. Price, personal communication) where lowest WT position might have been more relevant (Belya and Moore, 1999). For losses of other vascular species, it was estimated as $NV\text{-}NVe^{-kt}$ where NV was the Non-Vascular biomass (kg), t was set as 2 years, and k, the average decomposition rate, was set at 0.20 $yr^{-1}$, a conservative average taken from the reviews (Bragazza et al., 2009; Moore et al., 2007). AGNPP of *Sphagnum* was estimated during two years at each burial site with the following equation (adapted from Vitt and Pakarinen, 1977): YI * D * SW * SC where YI = annual vertical increment of *Polytrichum strictum* (used as innate markers, see Vitt, 2007) in cm, D = density of *Sphagnum* mosses in stem $m^{-2}$, SW = weight for 1 cm of *Sphagnum* stem in g $cm^{-1}$ $stem^{-1}$ and SC = cover percent of *Sphagnum* mosses. AGNPP for ericaceous species was estimated by collecting new leaves, young branches (light green parts), flowers, fruits or seeds. For herbs, all above-ground biomass was considered as AGNPP of the current year. The organic matter accumulation potential over the two years was estimated as the difference between losses in the aerobic zone and inputs through AGNPP for *Sphagnum* + vascular plants.

## RESULTS

Mass losses in fibric and residual peat as well as total AGNPP (Sphagnum mosses + vascular plants) and organic matter accumulation potential are presented in the figure 1. Overall, for a given peat type, the decomposition rates were rather homogeneous between habitats. *Sphagnum* AGNPP was similar between the two years of the study, but varied significantly between the different habitats according to *Sphagnum* dominance (UNR and POL < SPH, ERI, NAT). Over

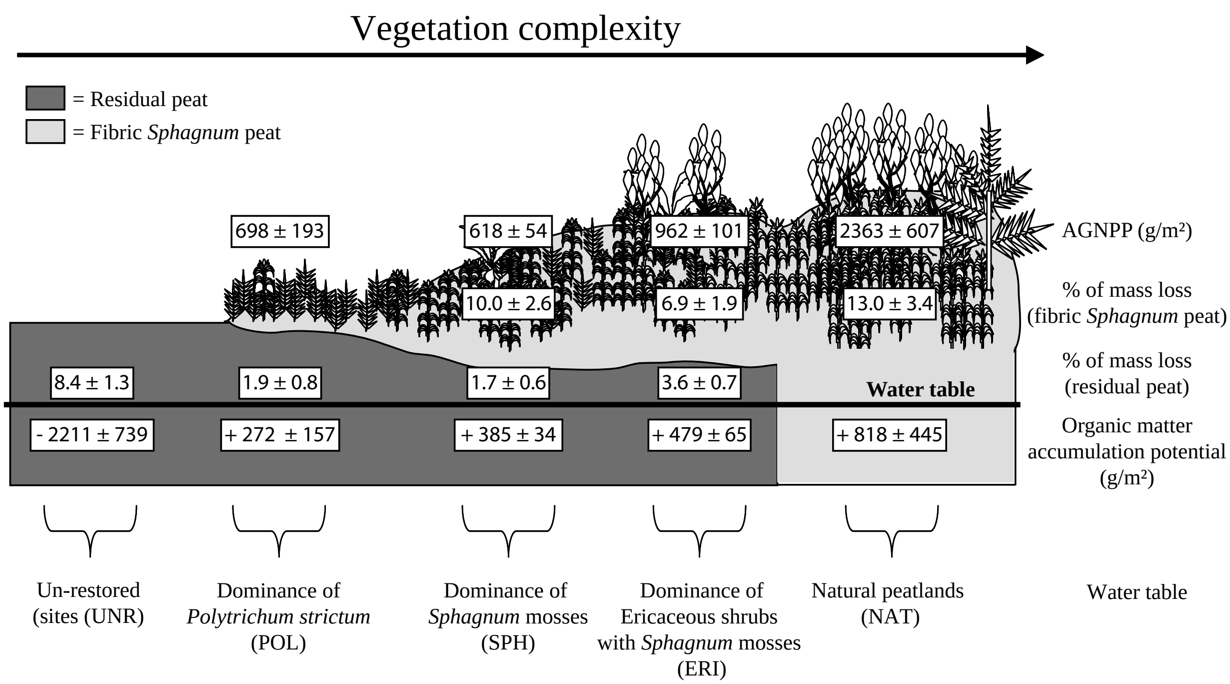


Fig. 1. Schematization of decomposition dynamics (% mass loss with a burial time of two years) in fibric *Sphagnum* peat and residual peat, total aboveground net primary production (AGNPP; total for two years) and organic matter accumulation potential (total for two years) along a gradient of habitat complexity going from absence of *Sphagnum* in non-restored conditions to hummock communities in natural reference peatland with three intermediate stages in restored conditions. Values are expressed as mean ± SE (n = 3 for all values). No data are available for % of mass loss for residual peat in natural sites and for fibric *Sphagnum* peat in *Polytrichum strictum* and un-restored sites.

the two years, the natural site stands out with highest accumulation potential (818 ± 445 g OM $m^{-2}$; mean ±SE), and unrestored site stands still showed higher losses than inputs (-2212 ± 739 g OM $m^{-2}$; mean ±SE). The three restored habitats (POL, SPH, ERI) were in between, showing a small accumulation potential (around three time lower than for the natural habitat).

## DISCUSSION / CONCLUSION

Eight years post-restoration, organic matter accumulation potential was rather influenced by above-ground vegetation composition (and thus, the AGNPP) than by differences between decomposition rates and mass losses associated to the complexity of selected habitats. AGNPP were divided into two classes: low-productivity sites without a well developed *Sphagnum* carpet, and high productivity sites with a well developed *Sphagnum* carpet. *Sphagnum* mosses are the main peat-accumulating species in bogs. However, as the *Sphagnum* AGNPP was similar across all the in habitats with *Sphagnum* mosses (with a carpet thickness > 10 cm), the contribution of vascular plants became important to shift the organic accumulation potential towards an organic matter sink.

We showed that the organic matter accumulation potential is heterogeneously distributed in restored bogs. Integrating this heterogeneity into predictive models could provide more accurate figures for the assessment of restoration. Indeed, successful restoration is often linked to the return of the carbon sequestration function, which is partly related to organic matter accumulation. Ensuring a rapid establishment of *Sphagnum* mosses and promoting the growth of vascular peatland species might help achieving a positive balance of organic batter accumulation more quickly.

To our knowledge, it was the first time that the dichotomic nature of the aerobic layer in the restored area, with residual compacted peat being covered with newly formed *Sphagnum,* was taken into account for estimating both decomposition and organic matter accumulation processes.

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