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RESPONSE TO FIRE OF PLANT COMMUNITIES IN A RESTORED OMBROTOPHIC PEATLAND

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SUMMARY

Sphagnum-dominated peatland restoration aims for the return of a functioning carbon accumulating system. One aspect of the carbon dynamics in natural bogs is the passage of fires. Natural bogs are most of the time resilient to fire. The rare current assessments of the return of C sequestration function of restored peatlands show positive organic matter accumulation, it is a different story for restored bog resilience to fire. Indeed, bog restoration requires time and financial resources and a fire post-restoration might be undesirable. Accidently, a fire that occurred in a restored bog in eastern Canada proved to be an opportunity to test the resilience of the restored ecosystem. Two objectives will be presented in this presentation: 1) to determine if the aboveground biomass production and the plant cover is similar between the burned and unburned restored plant communities after one growing season post-fire and 2) to verify if vegetation recovery trajectories of the burned and unburned portions of the restored sector are similar. The first objective was answered with a biomass sampling and a vegetation survey at the beginning and the end of the first growing season following the fire. A plant community approach was used to see how each plant communities react to fire. For the second objective, vegetation surveys in burned and unburned permanent plots used for the monitoring of the restoration were done before and after the fire passage. Preliminary observations suggest that communities dominated by *Sphagnum* mosses of the subgenus *Cuspidata* lost more biomass than other communities and it appears that sections of the peat fields with a higher *Sphagnum* cover in the form of thicker cushion (thus mostly dominated by Sphagna from the *Acutifolia* subgenus) were more protected from the fire. This project is a rare chance to monitor the fire response of a restored bog after one growing season and can be regarded as a starting point for a more complex study on fire resilience of restored bogs.

Keywords: *Bog; revegetation trajectory*

INTRODUCTION

In North America, bog are restored using a Moss Layer Transfer Technique which comprises field preparation, plant reintroduction by spreading plant material coming from a donor site, applying straw mulch and fertilisation (Rochefort *et al.,* 2003). Generally, ecosystem restoration aims for the return of the ecological functions and the main characteristics of reference ecosystems. For bog restoration, general characteristics include the return of a carbon accumulating system, the return of diplotelmic hydrological layers that characterise intact peatlands and a vegetation cover dominated by *Sphagnum* and typical bog species (Rochefort, 2000). The outcomes of bog restoration for those characteristics have been assessed in term of vegetation change (Rochefort and Lode, 2006; Poulin *et al.,* 2012; Rochefort el al., 2013; Gonzalez *et al.,* 2013, 2014; Gonzalez and Rochefort, 2014); of hydrology (McCarter and Price, 2013); of Carbon accumulation and fluxes (Strack and Zuback, 2013; Andersen *et al.,* 2013b; Strack *et al.,* 2014, 2015); and of nutriments cycling (Andersen *et al.,* 2013a). Resilience to fire is also characteristic of bog ecosystems (Jasieniuk and Johnson, 1982; Kuhry, 1994; Clarkson, 1997; Benscoter, 2006; Clark *et al.,* 2015) and thus bog restoration should also aim at restoring plant communities able to return to their former pre-fire restoration trajectory after a fire. Bog restoration requires time and financial resources and a fire post-restoration might be undesirable. In the fall 2014, a fire occurred in a restored bog near Rivière-du-Loup providing a unique chance to monitoring the response to fire of the vegetation of a restored peatland. The main objective of this project is to assess the impact of fire on the vegetation of a restored bog after one growing season as the first step for a more complex study of fire resilience of a restored bog. To reach this objective, two sub objectives have been identified: the first one is to determine if the aboveground phytobiomass production and plant cover are similar between the burned and unburned plant communities after one growing season and the second one to verify if vegetation recovery trajectories of the burned and unburned portions of the restored sector are similar.

METHODS

Study site

The study site is located near the Saint-Lawrence River in South-Eastern Canada (N 47° 50' 24", W 69° 26' 42"). The study area is composed of two restored sections (14 ha) located in a large peatland complex where most of the surface area is currently under peat extraction. The two sections were restored in 2005 and 2006 with the moss layer transfer technique and monitoring performed 2, 3, 5 and 7 years after restoration showed that both sectors were similar in terms of vegetation cover and composition. In August 2014, an accidental fire occurred in the peatland complex. The fire passed through the section that was restored in 2005 yet, many patches of vegetation were left intact. The sector restored in 2006 was not burned and thus can serve as a comparison to assess the effect of fire on restored vegetation as there is very little difference in plant succession at the stage of 9 and 10 years post-restoration.

Above-ground phytobiomass and plant survey

To determine if the aboveground biomass production and vegetation cover are similar between the burned and unburned portions of the restored sectors, a plant community approach was chosen. At the beginning of the 2015 growing season, when the evidences of fire were still clearly visible by the structure of the charred vegetation, a map of the portions affected by the fire was drawn. At the same time, the location of the different plant communities (characterised by their moss and vascular plant cover) present on the field was also recorded. Five plant communities, including burned and unburned portions, were considered for this study. For each plant community, 25 sampling points were randomly located in their burned and in the unburned portions, for a total of 50 sampling points by community. At each of those sampling locations, biomass (all vegetation that have grown as a result of restoration activities down to the remnant peat) was collected in two $1m^2$ quadrats: one in the beginning of the 2015 growing season and the other one at the end of the same growing season. At each sampling point, a plant survey was also performed at the beginning and at the end of the growing season in a 65 cm diameter circular quadrat. Vegetation cover was visually estimated by plant strata and for all plant species. The end of season quadrat was positioned at the same place as the one used at the beginning of the growing season. For this presentation, these five plants communities were regrouped in two major communities presented in table 2.

Table 1: Plant cover description of the two major plant communities

Community name	Vascular Plant Cover Description	Mosses Cover Description
Cuspidata	Vascular strata: dominated by *Scirpus sps*. and *Carex sps.*	Dominated by *Cuspidata* (*Sphagnum*) sps. with presence of *Acutifolia* (*Sphagnum*)
Acutifolia	Dominated by *Eriophorum Vaginatum*	Moss layer dominated by *acutifolia* (*Sphagnum*) sps and *Polytrichum strictum*

Revegetation trajectories

To verify if vegetation recovery trajectories of the burned and unburned portions of the restored sector are similar, a temporal approach was favoured. Monitoring of the development of vegetation in the 2005 restored sector was performed 2, 3, 5 and 7 years after restoration in 5 permanent plots (25 m^2). For each plots, plant surveys were done by strata and by species in 4 quadrats of $1m^2$ for vascular plants and in 12 quadrats of 25 cm^2 for mosses. During the 2014 fire, 3 permanent plots were burned while 2 plots were spared. A plant survey was done at the beginning and the end of the 2015 growing season on the burned plots and one time at the end of the growing season for the unburned plots. That allows observation of the vegetation recovery trajectories of the plots, before and after the fire and comparison of the trajectories between the burned and the unburned plots.

Statistical analysis

The biomass and plant survey data will be analysed with a two-way ANOVA. The vegetation trajectories will be compared using regression curves. The data will be analysed using SAS Software.

PRELIMARY RESULT

Aboveground biomass and plant survey

The fire affected more the *Cuspidata* community than the *Acutifolia* community. First, the *Cuspidata* community lost more biomass (g per m^2) than the *Acutifolia* community (respectively, differences of 44% *vs* 20% between the burned and the unburned sectors as assessed by biomass measures at the beginning of the growing season) (figure 1).

Second, we can observe that the phytomass production (g per m^2 per year) of the burned portion in the first growing season after the fire is much lower in the *Cuspidata* (21g of dry mass) than in the *Acutifolia* (496g of dry mass) community. Indeed, in the Acutifolia community, the biomass collected at the end of the growing season in the burned portion is equivalent to the biomass collected at the beginning of the season in the unburned portion (figure 1). This is not the case for the *Cuspidata* communitiy. However, for the unburned parts, the annual plant production after one growing season (difference between beginning and end of the growing season) was very low for the *Cuspidata* community compare to the *Acutifolia* community (figure1). The biomass increase between the beginning and the end of the growing season for the *Acutifolia* community was of 38% and 45% for the burned and unburned portions, respectively.

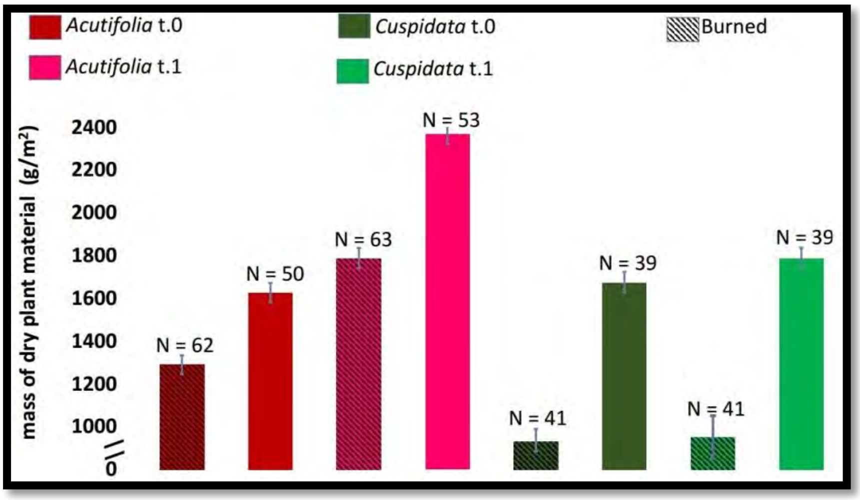

Figure 1: Burned and unburned biomass (g. ± SE of dry plant material) sorted by *Sphagnum* communities and time of collect (beginning of the growing season t.0 and end of growing season t.1).

Revegetation trajectories

The two unburned permanent plots exhibited higher *Sphagnum* cover prior to fire than the one that were burned (Figure2). It also appeared that both burned and unburned plots were affected by the 2014 fire (Figure 2).

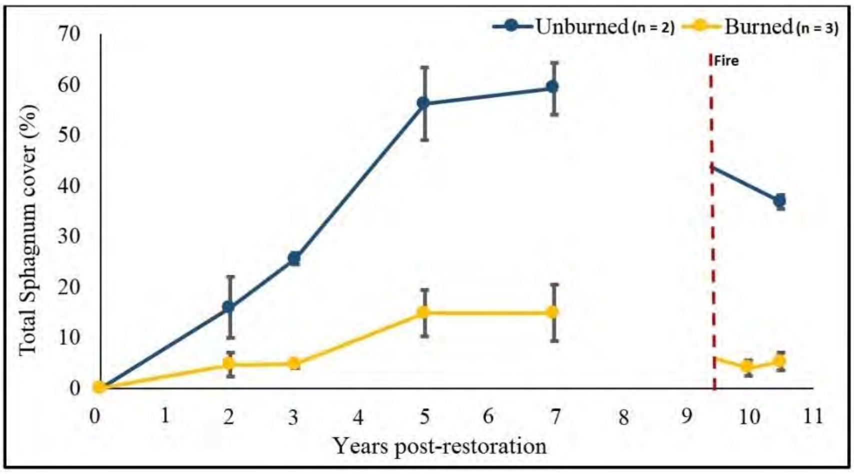

Figure 2: Total *Sphagnum* cover (% ± SE) in burned and unburned permanent plots. The red line represents the fire occurrence.

DISCUSSION

Aboveground biomass

The fire affected more seriously the *Cuspidata* community. *Cuspidata* species are usually found in biotopes composed of wet lawns, depressions and hollows whereas *Acutifolia* peat mosses are found in dryer biotopes of lawns or hummocks. *Sphagnum* hollow species are susceptible to water loss because of their loosely arranged populations (Rydin, 1993) thus they are burning more easily than hummocks species (Benscoter *et al.,* 2011) which form dense population and retain water more efficiently (Rydin, 1993). Previous studies showed that bulk density and fuel moisture influence the combustion (Frandsen 1987, 1991; Hartford1989; Van Wagner 1972; Frandsen 1997; Lawson *et al.,* 1997; Miyanishi and Johnson 2002; Reardon *et al.,* 2007) and the thermodynamics of downward combustion propagation (Benscoter *et al.,* 2011). Since *Cuspidata* species form loosely populations, they probably have a lower bulk density than *Acutifolia* species, making them less resistant to fire in period of drought when fires are most likely to occur. Moreover, Clark *et al.* (2015) present a study in which burned sites with more intact *Sphagnum* patches present a quicker vegetation recovery than the more severely burned site with few intact patches. That could explain the slower biomass recovery of the *Cuspidata* community which burned more severely and have few intact *Sphagnum* population in opposition to the *Acutifolia* community. It is possible that the vascular plants also influence the resistance to fire. *Eriophorum vaginatum* is the vascular plant dominating the *Acutifolia* community. This species forms tight tussocks giving a protection to the inner core of the plant even if the external parts of the tussocks burn.

Revegetation trajectories

All the permanent plots were installed in the same plant community (*Acutifolia* community) so the differences between the burned and the unburned plots couldn‘t be explained by a difference in plant communities. The total *Sphagnum* cover is more likely an influencing factor. As mentioned above, the plots with a higher *Sphagnum* cover were the ones spared by the fire. This could be explained by the soil humidity and the characteristics of the *Sphagnum* carpet which affect the fire combustion (Jonhson 1992) and propagation (Van Wagner, 1972). Further investigation is required. As for the *Sphagnum* cover drop in the unburned plots, it is hard to explain because it is impossible to know if the drop began before the fire or because of the fire, since the last plant survey was done in 2012. The fire possibly changed the soil and underground water chemical characteristics.

CONCLUSION

Production rate recovery indicates a good recovery of the burned vegetation. The moss strata was not completely nor irremediably lost and even showed promising signs of recovery during the first growing season after the fire. Moreover, the biomass production of the burned portion of the *Acutifolia* community is not so far from the one observed in the unburned portion. Even if we‘ll have to wait for a few more years to assess the whole vegetation response to this fire, that bodes well for the future of this restoration. With the preliminary results, it is reasonable to suggest that the resistance to fire of restored *Sphagnum* dominated communities depends on its characteristics (cover and species composition). This project is a rare chance to monitor the fire response of a restored bog after the first growing season and can be seen as a starting point for a more complex study on resilience to fire of restored bogs.

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