

Using functional diversity as an indicator of restoration success of cut-over bog



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In the beginning.....

A trait-based approach was used to evaluate the long term restoration success of the herbaceous community in a peatland restored following the moss layer transfer technique (Rochefort et al., 2003). The herbaceous layer has been shown to be more abundant and diversified in comparison to a reference ecosystem (D'Astous, 2011) where it represents a minor component of the total biomass as opposed to *Sphagnum* and shrubs (Moore et al., 2002). The great establishment success of herbs in the restored peatland is worth investigating into more details. Thus, we 1) evaluated if the traits of the restored peatland converged toward the reference ecosystem, we 2) identified traits critical to restoration success (see Table 1 for hypotheses and traits description) and we 3) estimated species, functional and trait diversity through time after restoration.

How we worked.....

- ♦ A systematic inventory of species occurrences of 5675 points was conducted in dry peat fields and wet ditches of Bois-des-Bel (BDB) peatland (47°48'N, 69°31'W),
 - Prior to restoration (PRI)
 - 1, 3, 5 years after restoration (RESEarly)
 - 7 and 10 years after restoration (RESlate).
- ♦ REF : seven natural peatlands where ground cover (%) of species was measured in 1x1 m² plots (n = 10/site).
- ♦ Communities mean weight analysis combined with a principal component analysis (PCA) linked the importance of traits to the stage pre- and post-restoration.
- ♦ Species and functional diversity were measured with the Shannon-Weaver species diversity index (H' ; Whittaker, 1972) and the functional dispersion of the traits was estimated using the FD_{dis} index (Laliberté and Legendre, 2010).

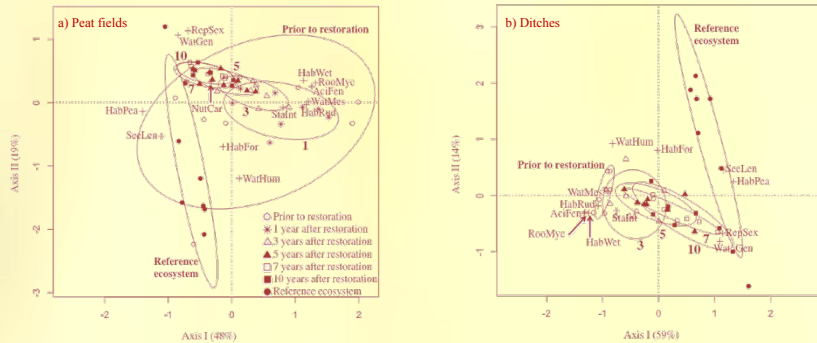
Table 1 Plant traits description and code used in Figure 1.

Traits	States	Code	Description
Acidity Tolerance	Fen	AcIFen	pH > 5.7
	Bog		pH ≤ 5.7
Habitat	Forest	HabFor	Species found in forest
	Peatland	HabPea	Species mainly confined to bog or fens
	Ruderal	HabRud	Species colonizing disturbed areas like road side
	Wetland	HabWet	Species that generally prefer wetland
Nutrient uptake	Presence	RooMyc	Presence of any kind of mycorrhiza
	Absence		Absence of any kind of mycorrhiza
Nutritional adaptations	Carnivorous	NutCar	Carnivorous
	Absence		Not carnivorous
Reproduction type			Mostly asexual reproduction
	Sexual	RepSex	Mostly sexual reproduction
			Only sexual reproduction
Seed size	Length	SeeLen	<0.1 mm; very small
			0.1-1.99 mm; small
			2-2.99 mm; medium
			3-4.99 mm; large
			5-10 mm; very large
Status in Québec	Introduced	StaInt	Exotic
	Indigenous		Native
Water preference	Generalist	WatGen	Soil goes from xeric to wet conditions (large amplitude)
	Mesic	WatMes	Soil is moist for part of the growing season
	Humid	WatHum	Soil wet in the growing season (i.e. water table close to surface)

What we found!!!!

Figure 1

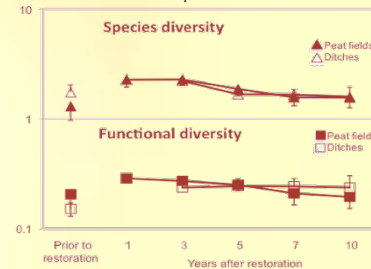
Principal Components Analysis diagram (axis 1 and 2) of the community weight mean matrix of the traits (see Table 1) of the herbaceous community studied.



- ♦ Traits changed through times in RES and seemed to converge toward the REF 10 years after restoration (see axis I on Figure 1).
- ♦ Traits of the herbaceous present in RESEarly did not persist in RESlate (Figure 1). This confirms that vegetation dynamics is hard to predict based on the early stage following restoration (Kellogg and Bridgman 2002).
- ♦ In PRI and RESEarly, dominant herbaceous species were associated to soil with a fen-like pH (AcIFen) or with mesic conditions (WatMes), were mostly from a ruderal (HabRud) or a wetland habitat (HabWet), had mycorrhiza (RooMyc) and were exotic (StaInt; Figure 1). As vegetation found prior to restoration was removed and left in the ditches during one of the step of the moss layer transfer, its propagules, its rhizome or its seed seem to have been able to reestablished once conditions were improved following restoration.
- ♦ Species classified as carnivorous (NutCar), associated to a large amplitude for water preference (WatGen) and mostly showing sexual reproduction (RepSex) were found in RESlate (Figure 1). As it takes a longer time for carnivorous species to develop their structure, they were expected to become prominent in the community of RESlate (Karagatzides and Ellison 2009).
- ♦ In REF, herbaceous species found had large seed (SeeLen), were mostly linked to humid conditions (WatHum) and to a forest (HabFor) or a peatland habitat (HabPea; Figure 1). The presence of species linked to the forest habitat confirms the increasing disturbance of natural peatlands of the region (Pellerin and Lavoie 2003).
- ♦ In RESlate, peat fields traits diversity shown was homogeneous (Figure 1a; small ellipse including 75% of peat fields while it was heterogeneous in REF (Figure 1a; large ellipse including 75% of peatlands composing REF). Opposite trends for ditches are showed as traits diversity has increased in RESlate (Figure 1b; large ellipse) but it remained lower than in REF (Figure 1b; large ellipse).
- ♦ In RESlate, species diversity decreased in both peat fields and ditches whereas functional diversity decreased only in peat fields (Figure 2).

Figure 2

Species diversity and functional diversity of the herbaceous community in peat fields and ditches prior and up to ten years after restoration. Standard deviation is presented.



Key messages

- ✓ Long term monitoring to assess restoration is needed as shown by trait changes through time.
- ✓ Species with large seeds should be sown in the latter stage after restoration.
- ✓ The restored ecosystem is homogeneous compared to the reference ecosystem.
- ✓ Contrasting habitats (i.e. peat fields and ditches) in the restored site increased functional and trait diversity.
- ✓ Vegetation spontaneously established prior to restoration should be removed or peatlands restoration needs to be practiced as soon as exploitation is ceased for avoiding undesirable species to establish.

What we read throughout our study....

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