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The Understanding of Recent and Long-term carbon dynamics of Boreal Peatlands, James Bay Lowlands, Québec, Canada

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INTRODUCTION

The studied peatlands are located in the James Bay Lowlands region (51-54°N-73-78° W) where they cover between 30 to 50% of the land area (Tarnocai *et al.* 2000). Eleven sites distributed along a nordic gradient from low to high boreal region (NWWG, 1997) were studied. They comprise different types of ecosites (Racey *et al.* 1996) on the basis of their similarities in moisture regime, nutrient regime, soil and substrate ranging from rich minerotrophic to poor ombrotrophic.

Recently published Holocene syntheses of peatland development and C accumulation in Canada show the evident lack of data for the boreal region on east (Quebec) and west (Ontario) side of Hudson bay and James bay Lowlands (Gorham *et al.* 2007; Kuhry & Tolonen, 2007). It is now critical to document past and present-day C dynamics in order to contribute to the enhancement of carbon and climate models that will help to predict the impacts of climate change on those ecosystems (IPCC, 2007).

STUDY AREA and SITES

Figure 1. Location map and photographies of the five studied peatlands from La Grande Rivière watershed (A - E): (A) LG1 (L1) (53° 54' N. 78° 46' W), (B) LG2 (L2) (53° 39' N. 77° 44' W), (C) LG3 (L3) (53°34' N. 76° 08' W), (D) Aéroport (AERO) (54° 6'1 N. 72°30' W) and (E) Ours (54° 2'56 N. 72°27' W) and six studied peatlands from Eastmain watershed (F to K): (F) Mosaik (MOS) (51° 59' N. 75° 24' W),(G) Sterne (STE) (52° 03' N. 75° 10' W), (H) Lac LeCaron (LLC) (52° 17' N. 75° 50' W), (I) Grand Détour (GD) (52° 02' N. 75° 56' W), (J) Ruisseau Natel (RN) (52° 08' N. 75° 36' W) and (K) Ruisseau Caché (RC) (52° 02' N. 75° 43' W). Text on photos present peatland extension, maximum peat depth and minimal age of peat inception (^{14}C cal BP).

METHODS

RERCA were measured from 7 peatlands on 13 short cores (50 to 100 cm) collected from hummocks, hollows, strings and lawns with a Box sampler (8.5 x 8.5 x 100 cm) (Jeglum *et al.* 1991) (Table I) .

LORCA were measured from 11 peatlands on 30 cores collected with a Macaulay peat sampler (7.5 x 5 x 100 cm) (Jowsey, 1965).

Carbon concentrations were estimated using the organic matter content estimate of 50% (Roulet *et al.* 2007) determined with LOI at 550° C (Dean, 1974). C and N concentrations of peat samples from the LG1, LG2 and LG3 peatlands short cores were analysed with a "Carlo Erba NC 2500" analyzer at Laboratoire d'Isotopes stables, from GEOTOP-UQAM-McGill research Center, Québec, Canada (Table I).

Chronologies were based on ^{210}Pb dating from samples submitted to Laboratoire des Radio-isotopes, GEOTOP-UQAM-McGill for RERCA calculation. Samples for AMS ^{14}C dating were submitted to BETA Analytic Inc. (FL, USA), ISOTRACE (U of T, Canada) and KECK Lab (Univ. of California, USA) for LORCA calculation (Figure 2; Table I).

The constant rate supply (CRS) model of Appleby and Oldfield (1978) was applied to the ^{210}Pb measurements in order to calculate the age of the recent peat layers. ^{14}C dates were calibrated with version 5.0.1 of the CALIB program (Stuiver and Reimer, 1993) and reported as intercepts with 2 sigma ranges (Table I).

Table I. Cores description, datations, peat accumulation rates (PAR), and recent and long-term C accumulation (RERCA and LORCA) mean values with standard deviation (SD) in brackets. Non SD are showed for RERCA of LGI show cores because only one string and one hummock were sampled at that site.

Region	Peatland	Cores	Depth (cm)	^{14}C dates (n)	Basal ^{14}C age: Depth (cm)	Basal ^{14}C age: Age (cal BP)	^{210}Pb dates (n)	PAR (cm yr^{-1})	Total C content (g C cm^{-2})	LORCA (g C m^{-2} yr^{-1})	RERCA (g C m^{-2}yr^{-1})
LaGRANDE Rivière watershed	LG1	L1_C	208	8	166	2540	-	0.071	7.90	27.2 (±16.3)	-
		L1_L1	143	1	140.5	2400	-	0.059	7.11	29.1 (±5.4)	-
		L1_L2	120	1	114.5	2050	-	0.056	7.32	33.8 (±8.2)	-
		L1_Hummock	32	-	-	-	5	0.908	0.82	-	60.1
		L1 _String	46	-	-	-	6	0.901	0.68	-	78.1
	LG2	L2_C	413	8	396	7010	-	0.064	16.0	23.9 (±8.6)	-
		L2_L1	257	1	255.5	7120	-	0.036	13.83	19.3 (±4.9)	-
		L2_L2	258	1	279.5	6690	-	0.038	19.5	28.9 (±25.6)	-
		L2_Hollow	32-46	-	-	-	5	0.250	0.67	-	47.6 (±5.8)
		L2_Hummock	32-62	-	-	-	5	0.610	0.82	-	79.3 (±16.7)
	LG3	L3_C	385	7	374.5	6820	-	0.082	15.55	29.9 (±14.4)	-
		L3_L1	230	1	222.5	6370	-	0.035	12.66	19.2 (±5.1)	-
		L3_L2	292	1	290.5	6740	-	0.043	15.23	22.5 (±5.8)	-
		L3_Hollow	22-46	-	-	-	7	0.201	0.69	-	41.5 (±1.3)
		L3_Hummock	32-56	-	-	-	2	1.028	1.25	-	85.3 (±31.3)
	Aéroport	AERO1	110	3	109.5	5530	9	0.028	5.82	10.1 (±2.5)	36.7 (±9.9)
		AERO4	110	3	105.5	6140	9	0.033	6.20	12.8 (±6.2)	38.9 (±13.1)
		AERO5	110	4	109.5	4300	14	0.063	6.28	15.4 (±5.8)	83.9 (±22.8)
	Ours	OURS1	110	4	110.5	5490	10	0.041	6.44	17.0 (±8.2)	63.5 (±30.5)
		OURS4	105	4	104.5	4820	11	0.069	5.13	30.3 (±35.5)	40.3 (±3.9)
		OURS5	110	3	109.9	5950	-	0.082	5.33	22.3 (±24.4)	-
EASTMAIN watershed	Lac LeCaron	LLC_C	500	1	481.5	7532	-	0.064	18.12	23.2 (±5.8)	-
		LLC_L1	275	1	251.5	6916	-	0.032	11.88	15.9 (±3.4)	-
		LLC_L2	140	1	100.5	4040	-	0.025	7.02	13.2 (±4.9)	-
		LLC_L3	300	1	259.5	6297	-	0.041	15.29	21.0 (±5.5)	-
		LLC_L4	200	1	188.5	4690	-	0.040	9.50	19.1 (±4.2)	-
		LLC_S	105	6	105	2750	10	0.086	4.30	15.2 (±4.9)	57.4 (±22.5)
	Mosaik	MOS_C	300	1	296.5	7080	-	0.038	11.13	16.0 (±3.8)	-
		MOS_L3	226	1	212	6548	-	0.047	10.44	15.3 (±4.6)	-
		MOS_S	105	-	-	-	12	0.104	0.37	-	30.2 (±18.7)
	Sterne	STE_C	300	1	285.5	7165	-	0.040	11.08	15.2 (±4.5)	-
		STE_L1	174	1	163	7154	-	0.023	9.27	13.1 (±5.3)	-
		STE_L2	246	1	245	6550	-	0.037	10.57	16.6 (±3.7)	-
		STE_L4	185	1	175	7095	-	0.025	9.90	13.8 (±3.6)	-
	Ruisseau Caché	RC_L3	250	1	209	5595	-	0.040	10.18	15.7 (±5.5)	-
	Ruisseau Natel	RN_L1	306	1	306	6478	-	0.050	12.13	18.7 (±4.3)	-
	Grand Détour	GD_L1	378	1	375.5	6265	-	0.060	15.63	24.8 (±6.3)	-

RESULTS

The overall results of the studied peatlands show that RERCA (past 100 years) and LORCA (minimal age 7532 cal BP) vary respectively from 36.7 to 83.9 g C m^{-2} yr^{-1} and from 10.1 to 33.8 g C m^{-2} yr^{-1} in fens and, 30.2 to 85.3 g C m^{-2} yr^{-1} and 13.1 to 28.9 g C m^{-2} yr^{-1} in bogs (Figure 3; Table I).

Peat inception and hence carbon accumulation started to accumulate in the La Grande river watershed (52-54° N) slightly after 2540 cal BP in LG1 while at approximately between 5950 and 7120 cal BP eastward.

Chronology of peatland development in the Eastmain river watershed (51° N) is relatively similar ranging from 5595 cal BP (Ruisseau Natel) to 7532 cal BP (Lac Le Caron): minimal ages from the central (deepest) parts of the basins.

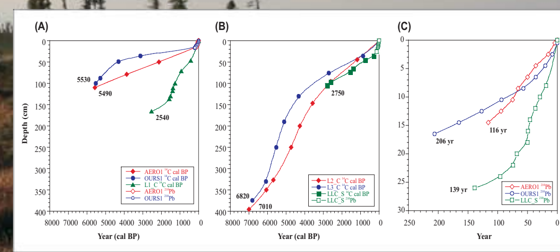

Figure 2. Age-depth model of selected peat sequences from: (A) three fens in the LaGrande Rivière watershed : Aéroport (AERO1), Ours (OURS4) and LG1 (L1_C) and (B) ombrotrophic bogs from LaGrande Rivière and Eastmain watersheds : LG2 (L2_C), LG3 (L3_C) and Lac LeCaron (LLC_S), and (C) close-up on age-depth model with ^{210}Pb dates of the top of AERO1, OURS1 and LLC_S cores.

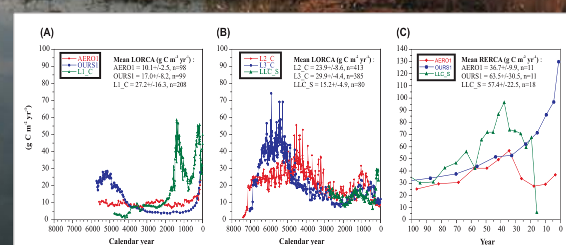

Figure 3. Long-term apparent rate of carbon accumulation (LORCA) of selected peat sequences from: (A) Fens: Aéroport (AERO1), Ours (OURS1) and LGI (L1_C) peatlands, (B) Bogs: LG2 (L2_C), LG3 (L3_C) and Lac LeCaron (LLC_C), and (C) Recent apparent rate of carbon accumulation (RERCA) for the last 100 years of selected peat sequences from Aéroport (AERO1), Ours (OURS1) and Lac LeCaron (LLC_S) peatlands. n correspond to the number of C content estimation measured point.

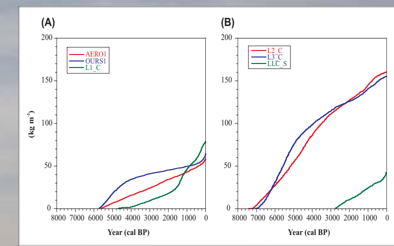

Figure 4. Cumulative carbon mass (kg m^{-2}) of selected peat sequences in (A) Fens : Aeroport (AERO1), Ours (OURS1), LG1 (L1_C) peatlands; (B) Bogs : LG2 (L2_C), LG3 (L3_C) and Lac LeCaron (LLC_S) peatlands. Curves show cumulative C from below to upward peat sequences.

DISCUSSION and CONCLUSION

Results show that Recent (RERCA) and long-term of C accumulation rates (LORCA) vary considerably between cores from the same peatland and among the peatlands as well. Local variability in RERCA and LORCA is much higher in minerotrophic (fens) than in ombrotrophic (bogs) peatlands (Figure 3; Table I).

Values of LORCA from the James bay region (10.1-33.8 g C m^{-2} yr^{-1}) correspond broadly to those presented by Kuhry & Turunen In: Wieder and Vitt (eds) (2006), Vitt *et al.* 2000; Clymo *et al.* 1998) for Finnish and Canadian (western Canada) peatlands (range 17-21 g C m^{-2} yr^{-1}).

The RERCA values calculated for James bay (30.2-85.3 g C m^{-2} yr^{-1}) present less variability than the results from Finland and Canada (range 10-300 g C m^{-2} yr^{-1}) (Wieder *et al.* 1994; Tolonen & Turunen, 1996; Turetsky *et al.* 2000).

The main distinguishable difference in the regional values is the present-day carbon accumulation (ARCA) where James bay peatlands currently sequester a mean of 97.5 g C m^{-2} yr^{-1} compared to 19.4 g C m^{-2} yr^{-1} from Vitt *et al.* (2000) (Table I).

Cumulative carbon curves from bottom upward indicate that input from acrotelm and decay of organic matter was not constant at most of the sites and varied more between fens than bogs (Figure 4).

These results represent an important contribution to the lack of data that existed for the understanding of carbon dynamics in peatlands from northeastern Canada that can be incorporated to feed future development of carbon and climate model.

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