CO_2 EMISSION RATES WERE AFFECTED BY SOIL TYPE BUT NOT BY COARSE WOODY DEBRIS IN RECLAIMED OIL SANDS SOILS

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INTRODUCTION

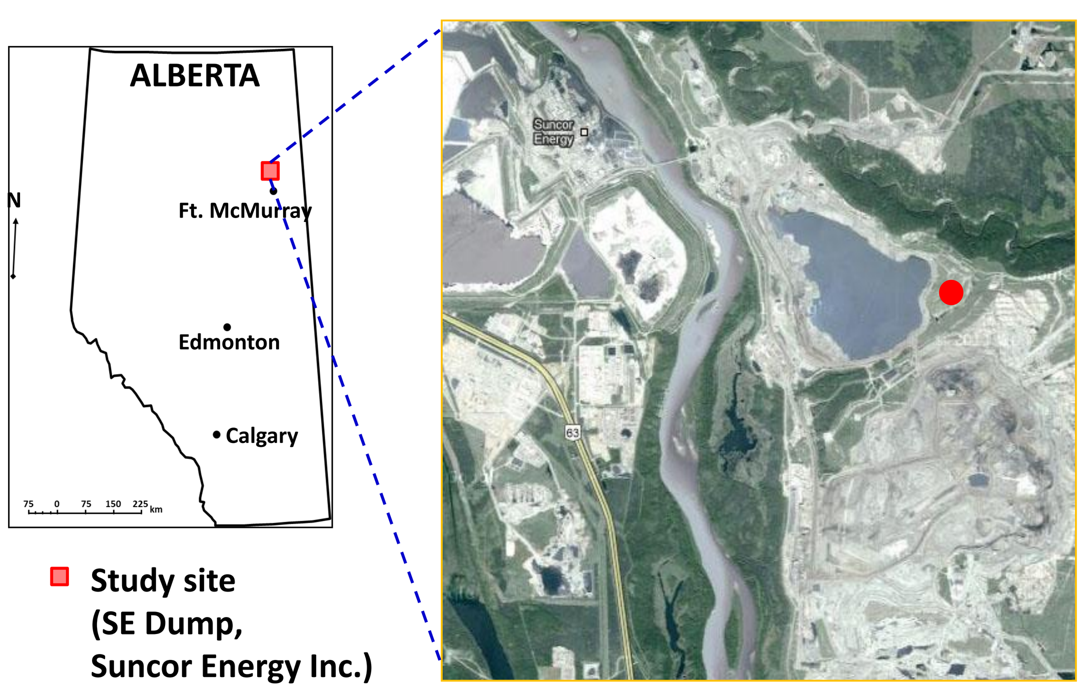
- Oil sands mining in the Athabasca oil sands region has disturbed large areas of mixedwood forest which must be returned to equivalent land capability
- Reclamation is an activity that can sequester atmospheric CO_2 by supporting plant growth but may increase CO_2 emission by enhancing microbial decomposition of soil organic matter (OM)
- Peat and LFH (litter, fragmented and fermenting litter, and humus) are common sources of OM for reclamation after open pit mining, and coarse woody debris (CWD) can be used to increase OM content at reclamation sites

OBJECTIVE&HYPOTHESES

- This study was conducted to evaluate the effect of cover soil type and CWD on CO_2 emission in the reclaimed oil sands landscape
- Hypothesis 1: CO_2 emission rates from the soil will be greater if amended with LFH than with peat
- Hypothesis 2: CWD application may increase CO_2 emission rates by increasing nutrient availability and microbial activities

MATERIALS & METHODS

Study site



- South East Dump at Suncor Energy Inc., about 24 km north of Fort McMurray, Alberta
- From 1981-2010 mean annual precipitation was 418.6 mm, mean annual temperature was 1.0 ℃

Plot design

- Plots established from November 2007 to February 2008
- Each plot size is 10 x 30 m^2 and each of six plots covered with LFH mineral soil mix (LFH) or peat mineral soil mix (PMM)
- 20 cm of LFH salvaged from a mesic aspen and white spruce mixed forest, over 30 cm of B and C mix horizon subsoil, over 100 cm clean overburden
- 30 cm of PMM (peat:mineral soil ratio 60:40 v:v), over 100 cm clean overburden
- Trembling aspen CWD, which diameter is bigger than 10 cm, was freshly salvaged and applied on each plot in February 2008
- CWD covered 10 to 20% of each plot
- Plots covered with naturally established, not seeded or planted, grasses, forbs and shrubs

Gas sampling and analysis

- CO_2 emission rates were measured using Hutchinson chambers at the end of July, August and September 2012 and 2013 and measured near CWD (N_{CWD}, within 5 cm from CWD) and away from CWD (A_{CWD}, more than 1 m away from CWD) subplots
- Gas samples were collected using an air-tight syringe at 0, 10, 20 and 30 min after placing the chamber over the collar
- CO_2 concentrations were analyzed using a Varian CP-3800 gas chromatograph (GC, Varian Canada, Mississauga, Canada)
- CO_2 emission rates were calculated following Nakayama (1990)

N_{CWD} subplot

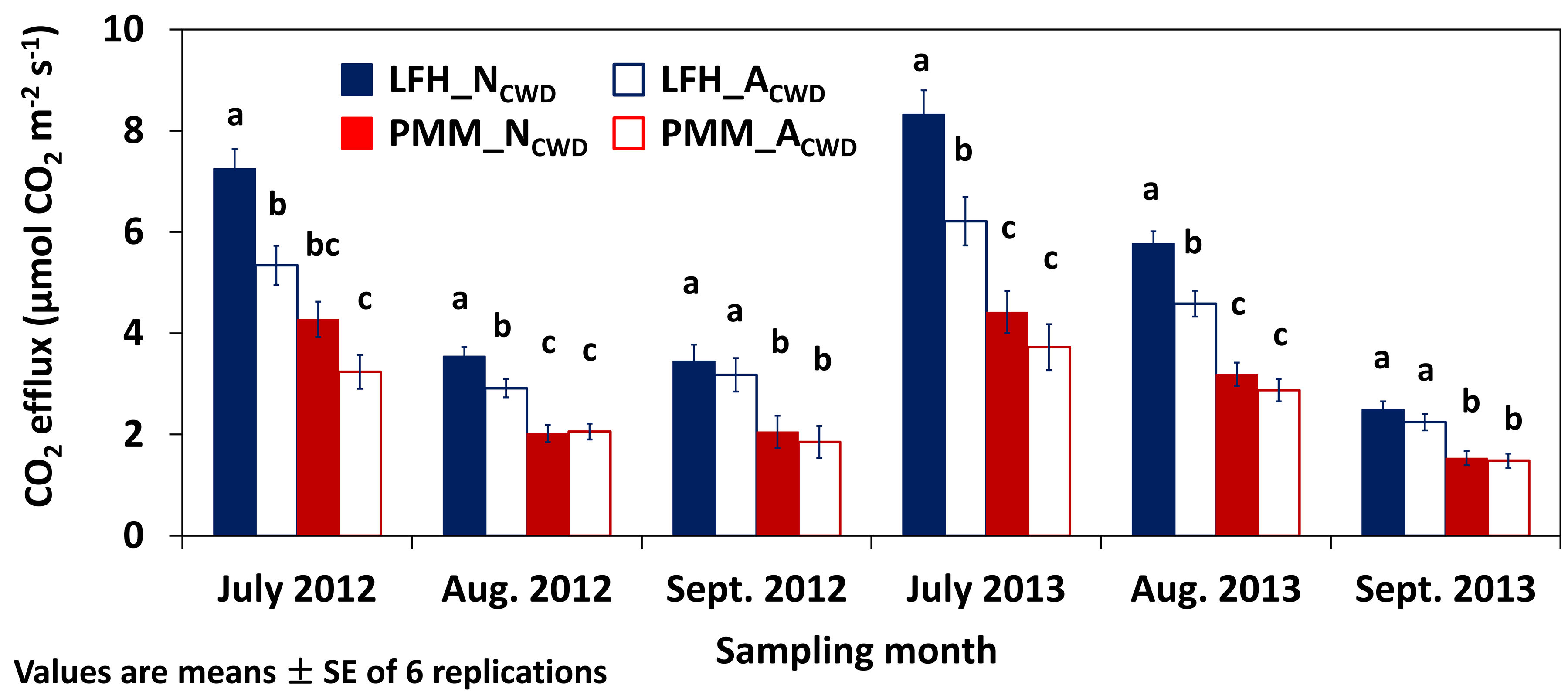
A_{CWD} subplot

REFERENCES

- Nakayama SF (1990) Soil respiration. Remote Sens. Rev. 5:311-321
- Hutchinson GL, Mosier AR (1981) Improved soil cover method for field measurement of nitrous oxide fluxes. Soil Sci. Soc. Am. J. 45: 311-316

RESULTS & DISCUSSION

CO_2 emission rates



Values are means ± SE of 6 replications

Pearson correlation coefficient (r) between CO_2 emission rate and soil properties

	Temp.[1]	WC[2]	NH_4^+-N	NO_3^--N	DOC[3]	DON[4]	MBC[5]	MBN[6]
2012								
July	-0.75***	-0.57*	0.04	0.38	-0.28	0.28	-0.12	0.32
Aug.	-0.61**	-0.59**	-0.04	-0.11	-0.30	0.14	0.28	0.54*
Sept.	0.19	-0.65**	0.02	0.38	-0.31	0.32*	0.01	0.40*
2013								
July	0.14	-0.38	0.05	-0.36	-0.38	0.17	0.22	0.25
Aug.	0.29	-0.60*	-0.26	-0.33	0.48*	-0.03	0.01	0.25
Sept.	0.18	-0.56**	0.01	-0.19	-0.18	0.14	0.34	0.41*

	NAGase[7]	β-1,4-Glucosidase	Cellobiohydrolase
July 2013	0.39	-0.42	0.96***
Aug. 2013	-0.13	0.52*	-0.08
Sept. 2013	0.49*	0.77*	0.47*

* $P<0.05$, ** $P<0.01$ and *** $P<0.001$
[1]Soil temperature, [2]gravimetric soil water content, [3]dissolved organic C, [4]dissolved organic N, [5]microbial biomass C, [6]microbial biomass N and [7]β-1,4-N-Acetylglucogaminidase

- CO_2 emission rates were significantly greater in LFH than in PMM at each sampling ($P<0.001$); rates were 1.7 times greater in LFH than in PMM during overall sampling
  - ✓ Related to greater enzyme activities in LFH than in PMM
  - ✓ Greater N availability in LFH than in PMM may also affect CO_2 emission rates by increasing enzyme and microbial activities
- The CWD application significantly increased CO_2 emission in LFH ($P<0.05$) except in September 2012 and 2013 but not in PMM ($P>0.05$)
  - ✓ CWD application increased MBN and enzyme activities in LFH, but not in PMM
- CO_2 emission rates decreased over time from July to September in both 2012 and 2013; mean monthly CO_2 emission rates were positively correlated with soil temperature ($P<0.05$)
- CO_2 emission rates were positively related to MBN in both 2012 and 2013 ($P<0.1$) and enzyme activities in 2013 ($P<0.05$)

CONCLUSIONS

- Inherent soil properties were main determinants for CO_2 emission in the studied soils and the effect of CWD on CO_2 emission rates was dependent on the cover soil type where the CWD was applied
- Applying CWD for oil sands reclamation will increase OM mineralization and CO_2 emission rates in LFH and will increase carbon storage in CWD biomass itself in PMM without increasing OM mineralization

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