NACP 2015
Large stocks, larger uncertainties:
The role of soils in the North American carbon cycle

The future of boreal forest soil C
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Rationale: Why soil C matters

• Nearly 60% (or 272 ± 23 Pg C) of the huge amounts of carbon stored in the boreal forest ecosystem is in the soil

• Boreal soils have high C densities of boreal soils (150 Mg/ha) compared to that of temperate forests (72 Mg/ha)

Ref: Pan et al. 2011 Science 333(6045): 988-993

• Are boreal soil a Carbon bomb?

Source: Greenpeace 2008: Turning up the heat, Global Warming and the degradation of Canada’s boreal forest
What are we looking for?

A. Mapping C stocks; note that most of it is passive

B. Estimating fluxes (short term <1-10 yr to rotation length)

C. Vulnerability to change (with transient climate change, extreme events, vegetation, management, disturbance....)
Different goals- different approaches

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A) Can we map forest soil properties over a continental scale?

538 NFI soil carbon plots over 290 Mha
kNN imputation:
250m cells: predictors = topography and climate; geology, spectral bands: not selected.

Uncertainty analysis:
- RMSE
- pixel-level accuracy: variance estimator $\sigma_i$ in the absence of spatial auto-correlation among the $k$ neighbors for each soil variable (McRoberts et al., 2007)
- independent dataset

Independent dataset: expert judgement

kNN imputed sand% values

a) FFOC (g/kg); RMSE% = 22.24
b) FFTN (g/kg); RMSE% = 30.76
c) MBD (g/cm³); RMSE% = 34.18
d) Msand (%); RMSE% = 36.64
e) FCC:N; RMSE% = 36.63
f) Msilt (%); RMSE% = 40.18
Can we improve with more data and better resolution (?)
No magic bullet! Uncertainty remains high.

From 538 groupplots for 290Mha: Mansuy 2014 National map: 1: 500,000ha
To 150 for 2500 ha Cyr et al. 2015: 1/17ha
Mapping soil C: Yes we can ....

But:

-Uncertainty remains enormous
-Stocks are not important it is stock change that matters (are they related?)
-can soil mapping tell us anything about vulnerability to soil C stock change?
Can we use total stocks as a surrogate for unprotected soil C?

FLUXNET CANADA sites:

Total versus recalcitrant C

Total vs labile C

\[ y = 0.9121x \]

\[ R^2 = 0.9892 \]

\[ p=0.0001 \]
How about C models: short term fluxes: ok
Stocks: 😞
B) C models: short term fluxes and soil C accumulation

Then why?

SOC (Decomposition) Models

- Organic matter chemistry (lignin, C/N)
- K’s (climate, source)
- Soil as a modifier

Speak to decomposition

- Where is solid-solution interface?
- Where is hydrology & transport?
- Belowground soil environment?

Speak to stabilization

From Helga Van Miegroet Utah State U
How soil C cycling works:
Large slow pool
Small active pool

Primary succession studies show rapid accumulation of Soil C and N pools
Productivity versus soil C stocks

The model says: Productive sites = more soil C

Ground plots say: productive = less soil C

Modelled C in organic layer vs productivity

National forest inventory groundplots

Bernier, Cyr, Paré, in prep.
Forest floor accumulation rates with time since fire in black spruce forests: Chronosequence approach (rotation time)

Abitibi: Lecomte et al. 2006 Ecosystems 9: 1215-1230
Stabilization of soil C 101

Agregate (>250 μm)

Agregate (<250 μm)

clay (<2 μm)

Absorbed C

C protection

LF

iPOM

S&C

Young, ↑ quality (e.g. recent plant tissue)

Physically protected C inside aggregates

C chemically bounded to mineral particles.

von Lutzow et al. 2006
Theoretical soil C protective capacity based on soil texture

Assessing vulnerable soil C: the new frontier
...heard several times this week:

Variability describes the process

Uncertainty describes our ignorance

- Soil C stocks are by nature highly variable, we should nevertheless try to reduce our ignorance
- Soil C cycling in a changing world: new approaches, multiple verification/validation approaches needed