



**We need to watch our cold carbon
stores if we develop the north
or
Preventive is easier than finding a cure**

Nigel Roulet

McGill University (nigel.roulet@mcgill.ca)



MuskokaSummit
ON THE ENVIRONMENT

MAY 27-28, 2016

RENE CAISSE THEATRE, BRACEBRIDGE

WWW.MUSKOKASUMMIT.ORG

My argument for a solution for a warming world...

- Factual framework

- 10% (or more) of annual emissions of enhanced GHGs are due to land use change, and prior to 1945 land-use change accounted for 50% of emissions of GHGs; 25% of enhanced GHGs in the atmosphere are from land-use change
- Canada, at present, appears to be an insignificant source of GHGs due to land-use change
- Canada, has one of the largest, if not the largest, reserves of carbon stored in plants and very high density soil deposits (peat) - not renewable as in other ecosystem services because its 99% dead carbon

- Aspiration for a Canadian future

- Canada has expressed a desire to reduce its GHGs significantly (1.5 to 2.0°C target!) - Herculean effort if this is to be done in the necessary time frame
- Several provinces and the federal government have expressed desires to develop the "north" - mineral, hydroelectric reservoirs, etc., but to develop it sustainably

- Proposition

- Canada will not be able to meet its desired GHG goals and develop the north unless we protect the high density carbon deposits and take a substantially different approach to how we developed the "south"
- Canada has a moral obligation to maintain its terrestrial carbon pools

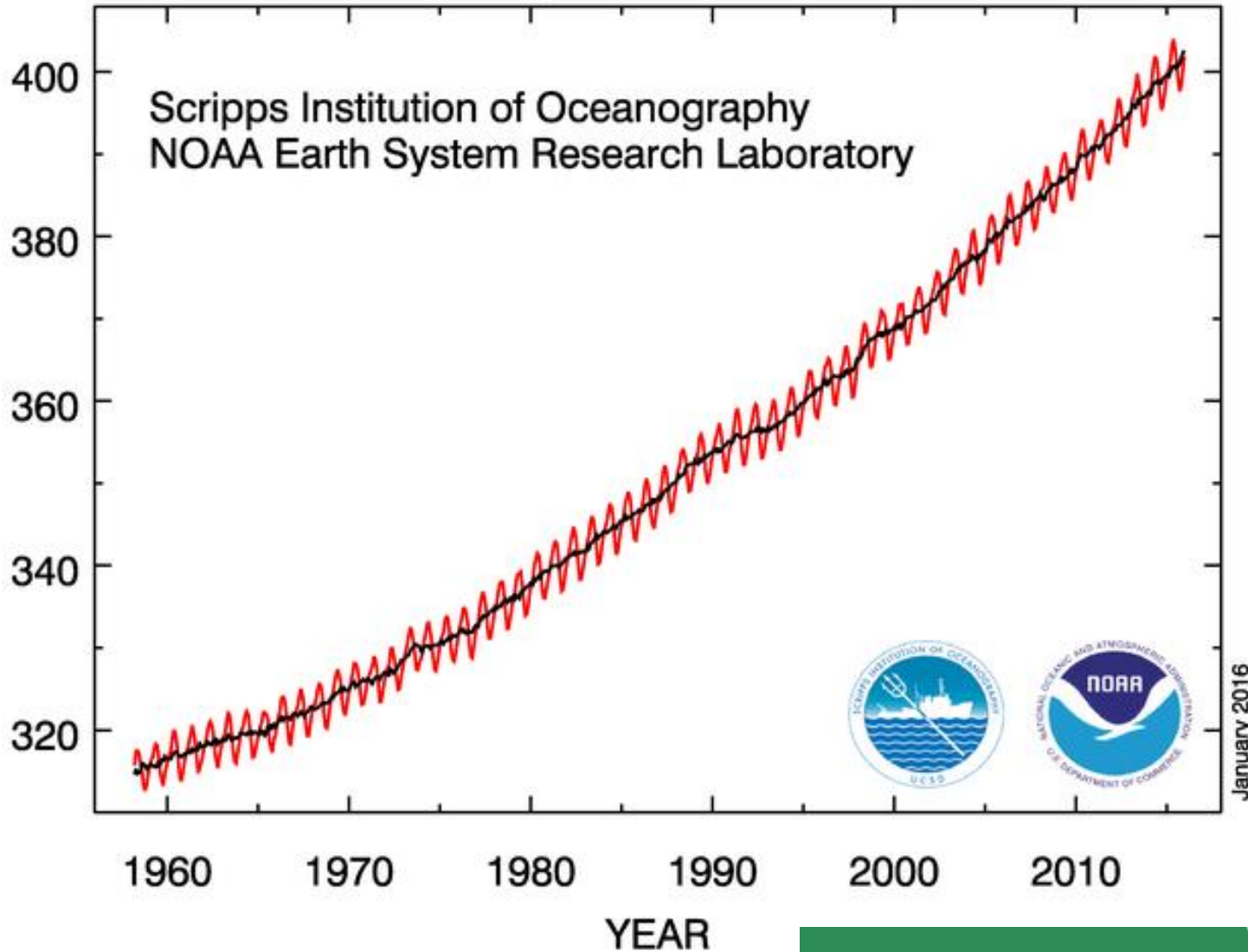
What informs this thinking ?

- Thirty-five years of thinking about the interactions among climate, hydrology and ecosystem processes
 - Inherently non-linear, series of weak to strong feedbacks, lots of delays because of varying turnover times, many poorly defined exogenous variables
 - Irreducible uncertainty - deal with it
 - Makes prediction over climate times scales impossible - projections and scenarios of the future
- Policy side
 - 15+ years of involvement with IPCC (AR2 to AR4)
 - Ontario Far North Science Advisory Panel and various other panels
 - Adapting our models and measurement programs to questions of restoration and novel peatland ecosystems
- Need strategies and policies that are adaptive and maximize resilience, and recognize our ignorance -i.e. need to become learning organizations

Atmospheric CO₂ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory

PARTS PER MILLION



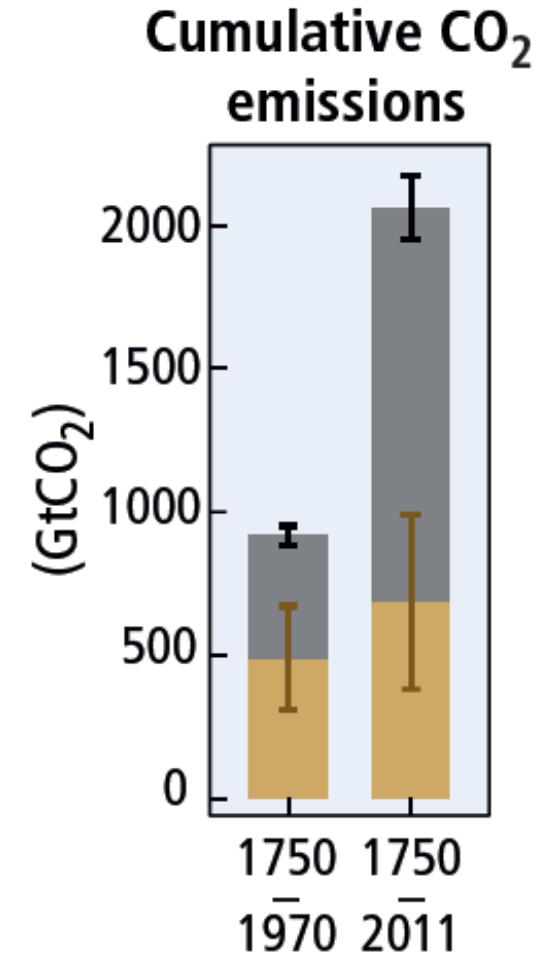
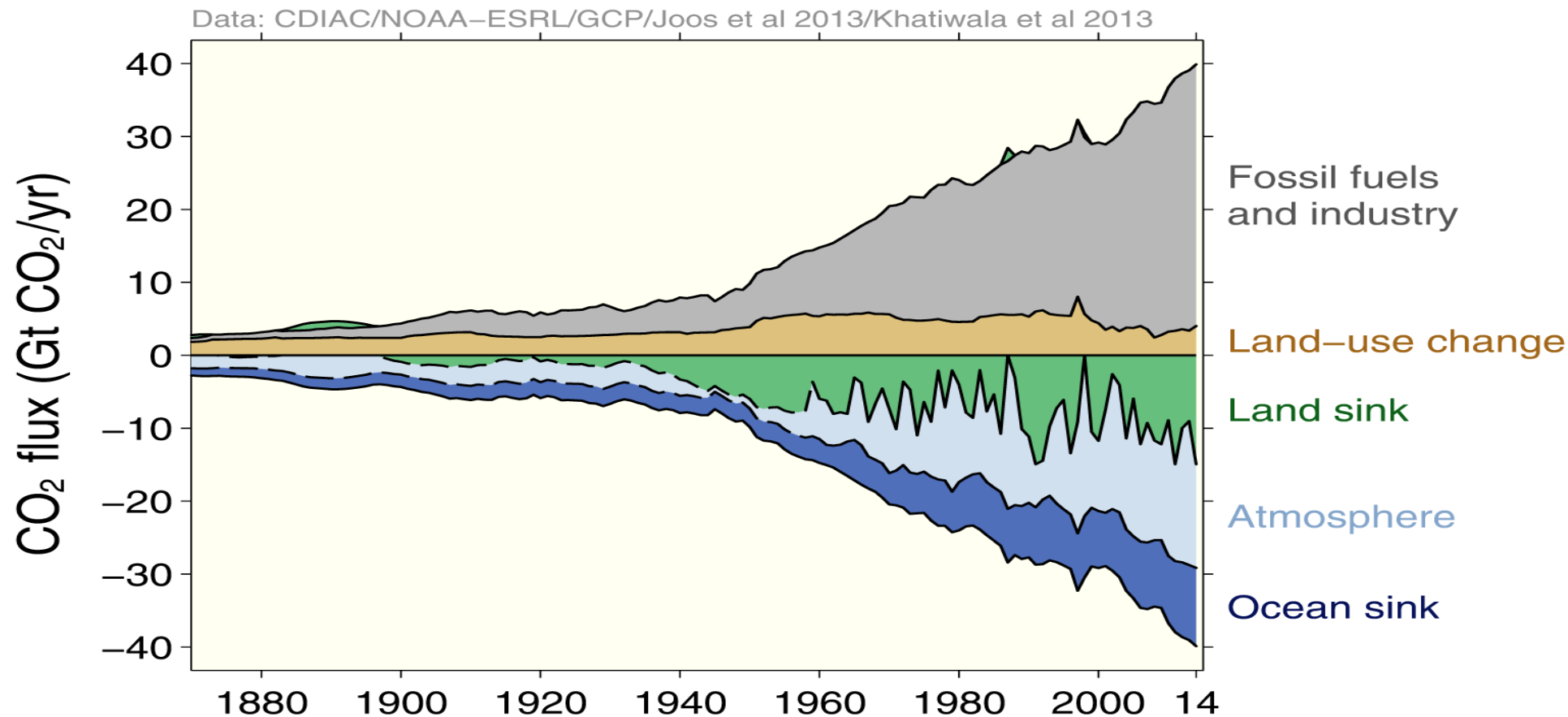
April 2016: 407.42 ppm
April 2015: 403.26 ppm
Last updated: May 5, 2016

From Spencer Wearts' "The Discovery of Global Warming" HUP, 2008

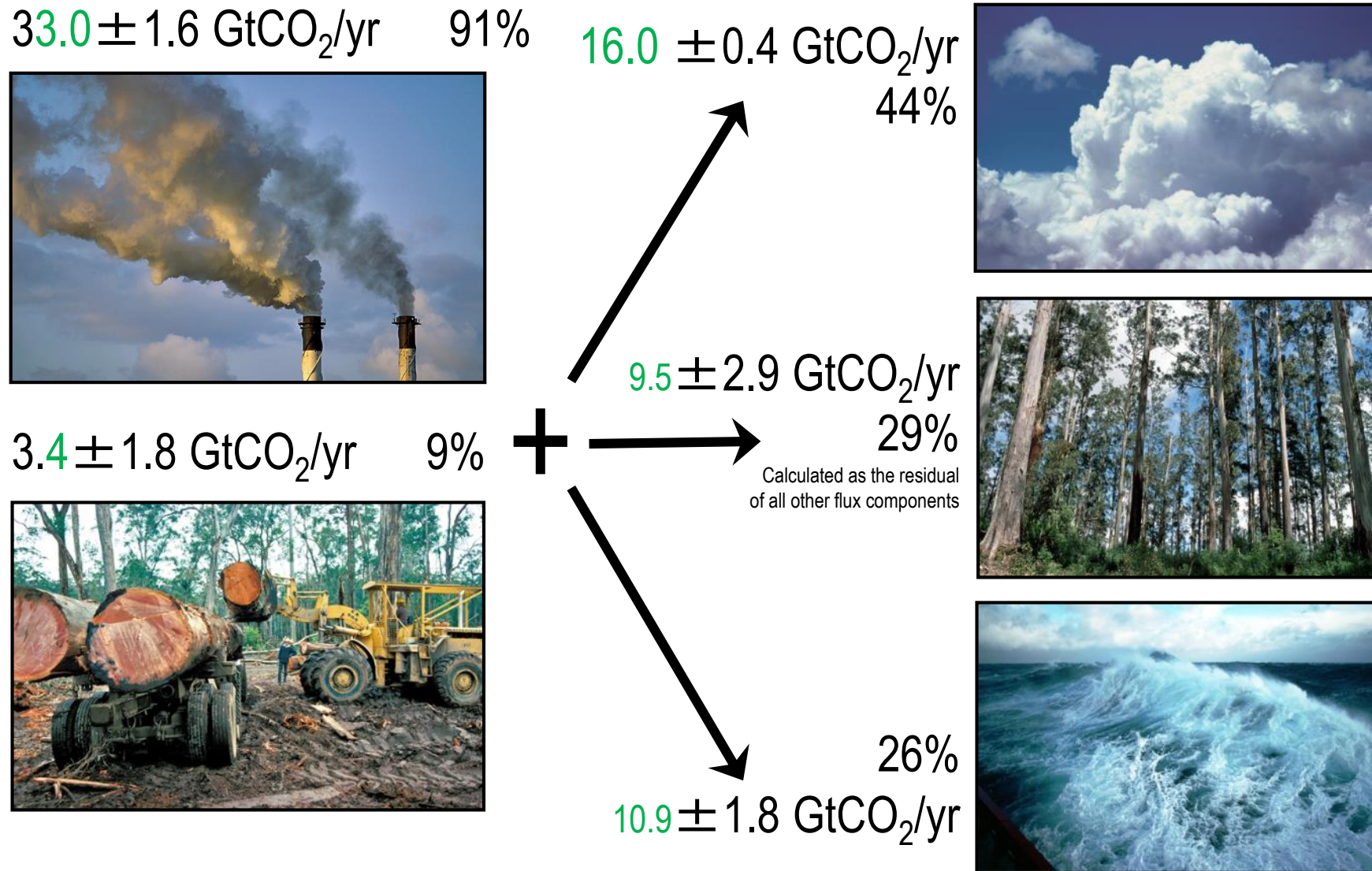
"... **C.D. Keeling** published his data on changes in the level of CO₂. His measurements were so precise that from the outset, they showed a seasonal "**breathing**" of the planet: plants in the northern hemisphere took up carbon from the atmosphere in spring and summer, and returned it to the air when dead leaves and grass rotted away in autumn and winter. One could even use Keeling's data to figure how many tons of carbon cycled through the plants each season."

<https://www.aip.org/history/climate/index.htm>

The carbon sources from fossil fuels, industry, and land use change emissions are balanced by the atmosphere and carbon sinks on land and in the ocean

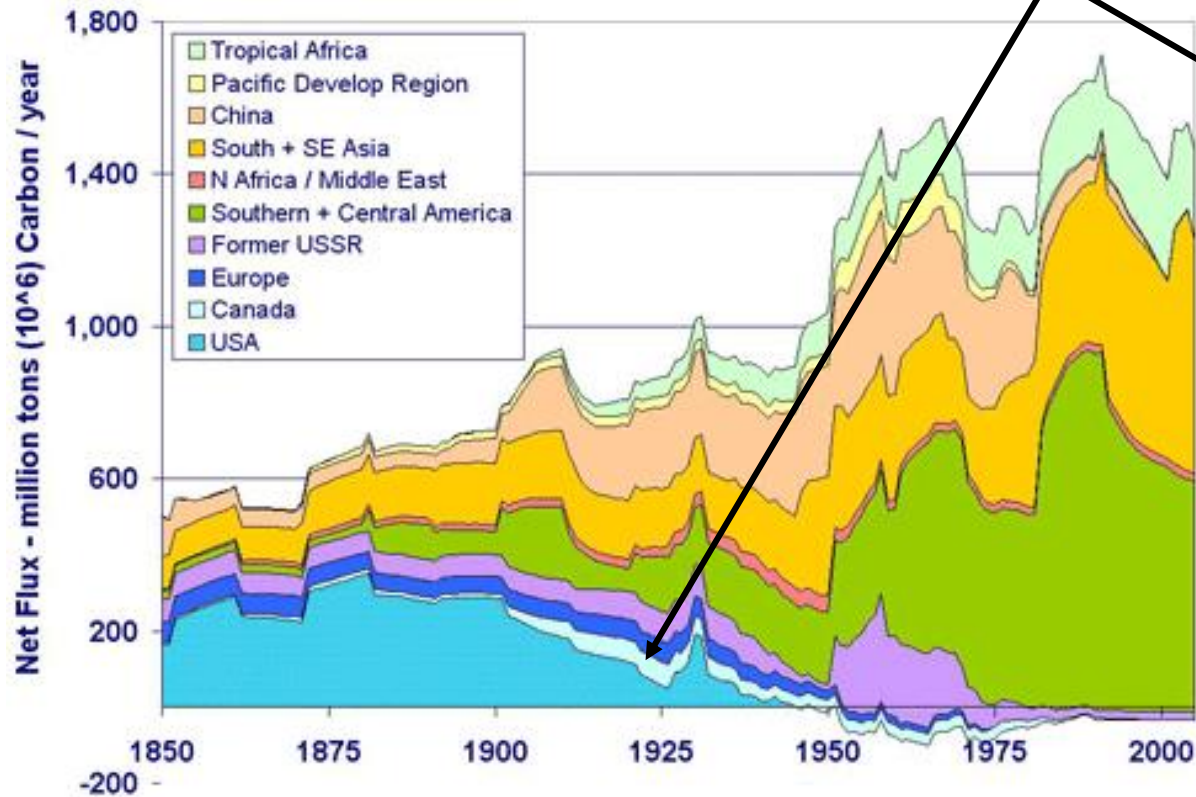


Fate of Anthropogenic CO₂ Emissions (2004-2013 average)

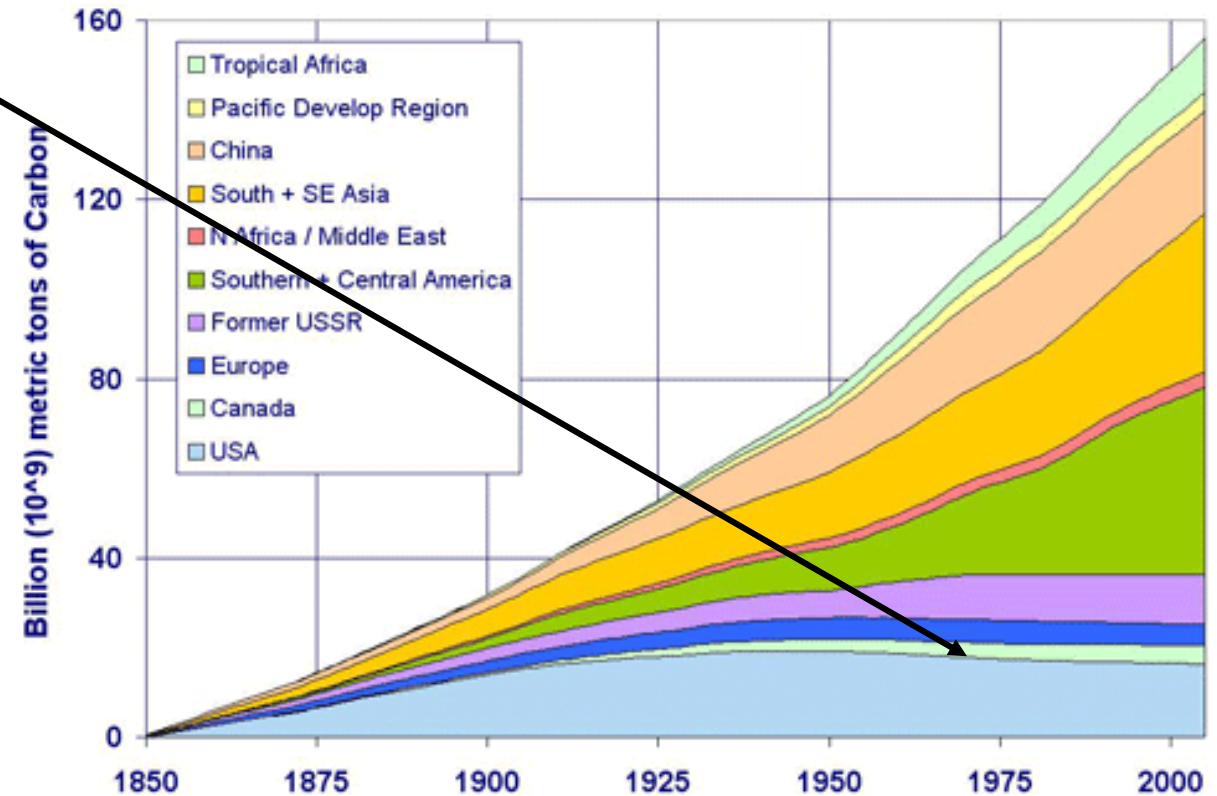


Sources of CO₂ from land-use change

Annual fluxes

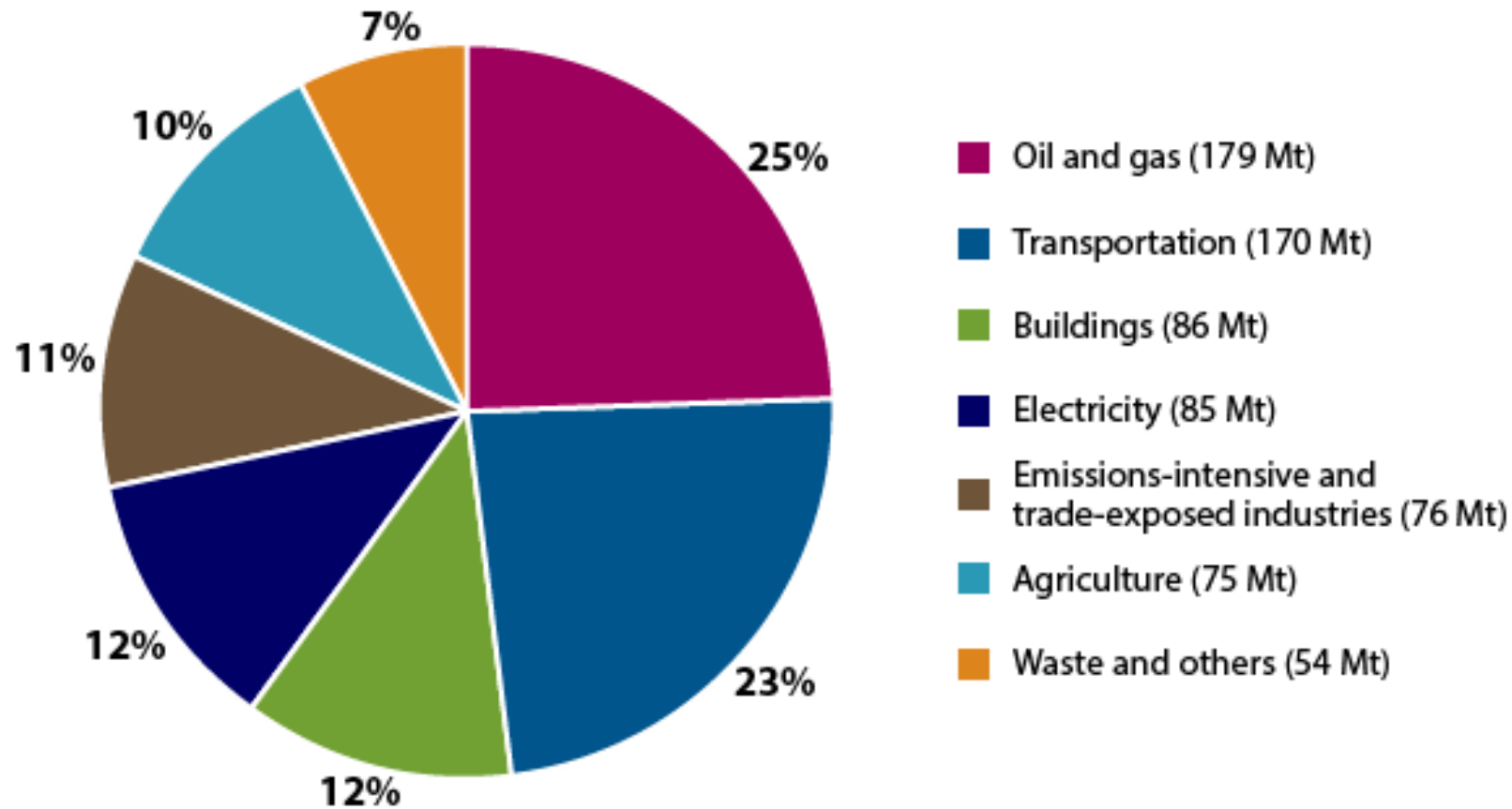


Cumulative flux



The data is from Richard Houghton's work <http://cdiac.ornl.gov/trends/landuse/houghton/houghton.html> but was replotted into nicer graphs and presented on http://petrolog.typepad.com/climate_change/2010/01/cumulative-emissions-of-co2.html

Where does Canada's GHG emissions come from?



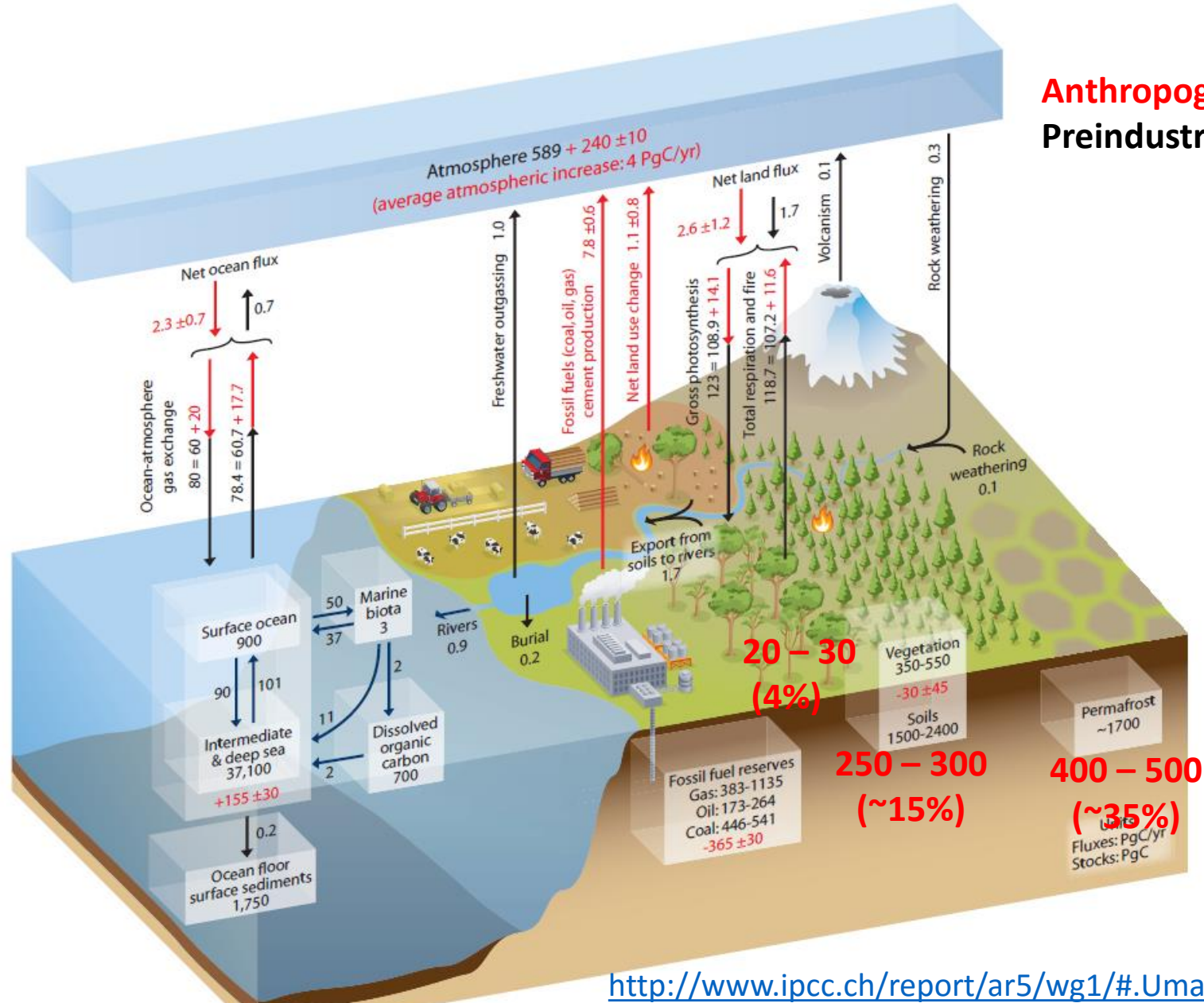
www.ec.gc.ca/indicateurs-indicators

Notice that there are no net emissions from land-use change

2000-2009 C global C cycle

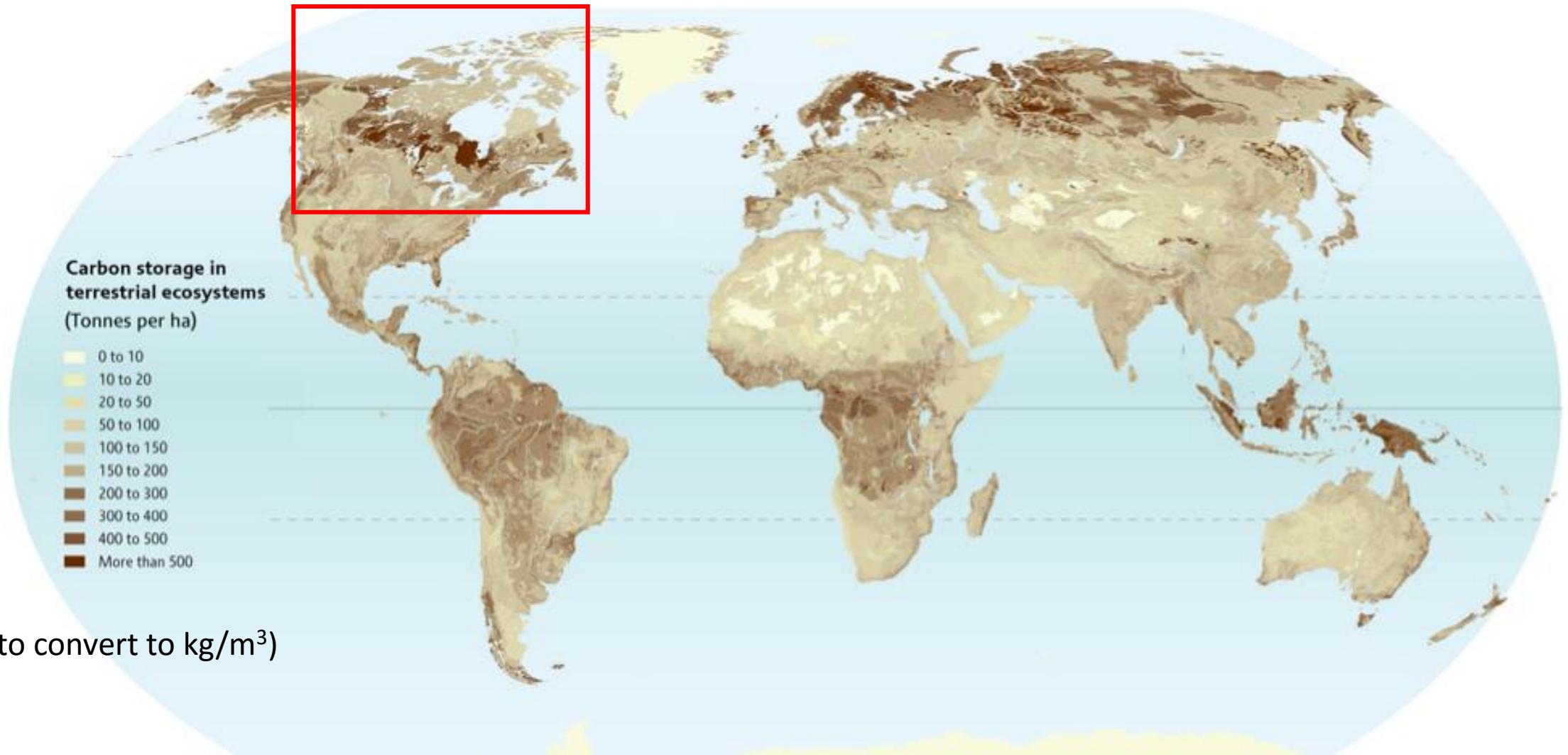


©EnchantedLearning.com

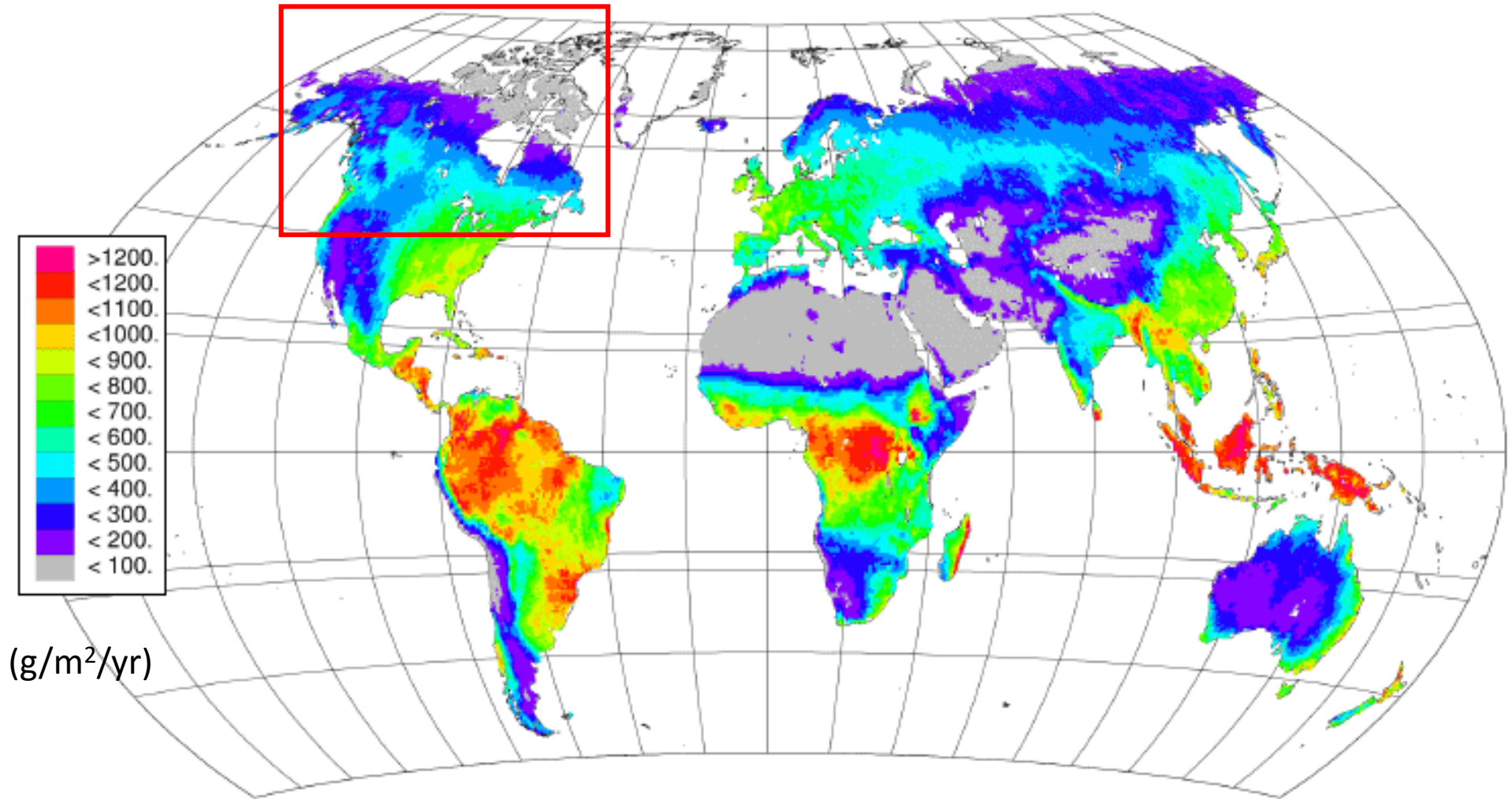


Anthropogenic C
Preindustrial C

The storage of carbon in the north

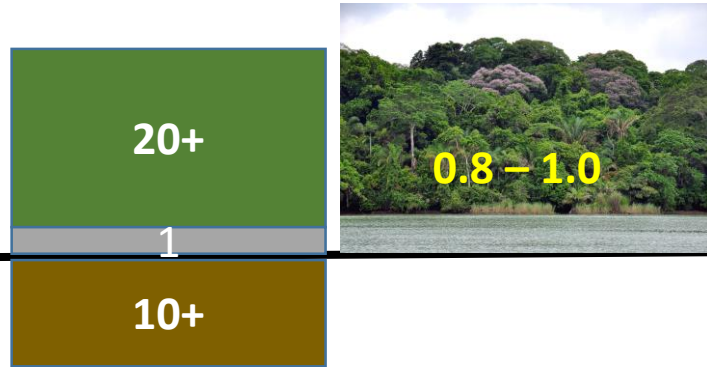


Global terrestrial net primary production

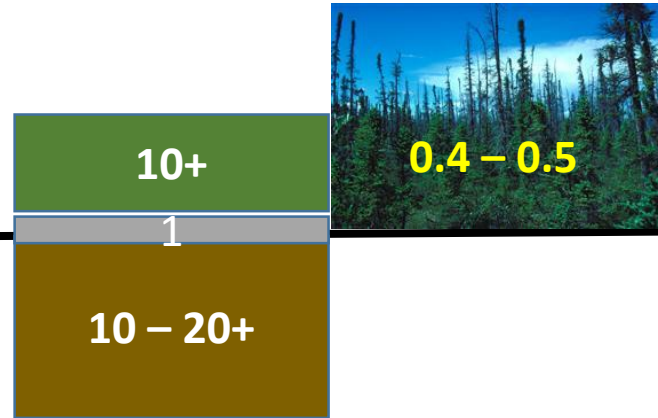


Tropical forest

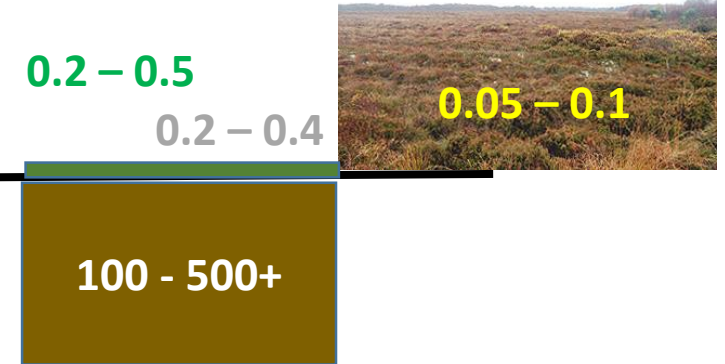
C Stocks kg/m² NPP kg/m²/yr



Boreal forest



Peatlands



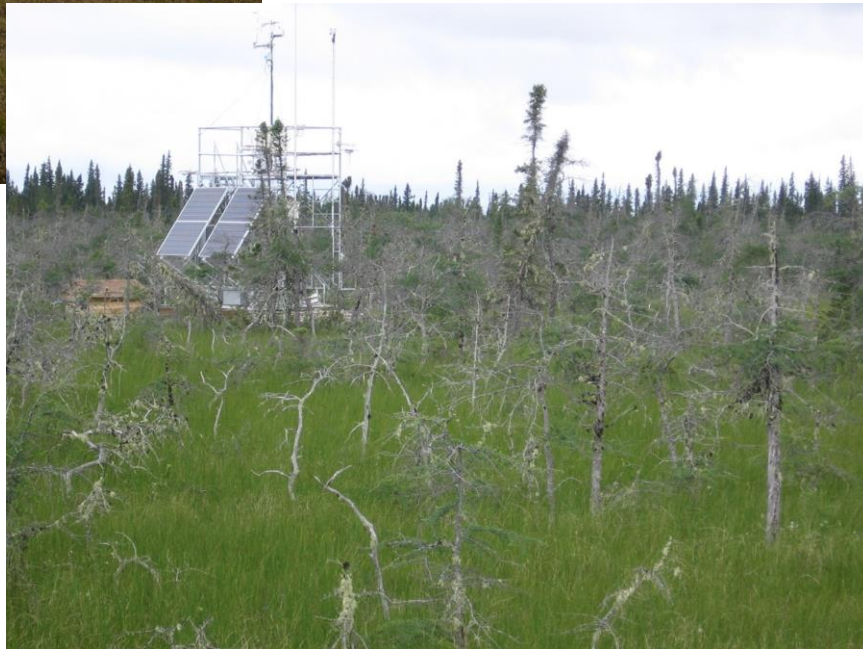
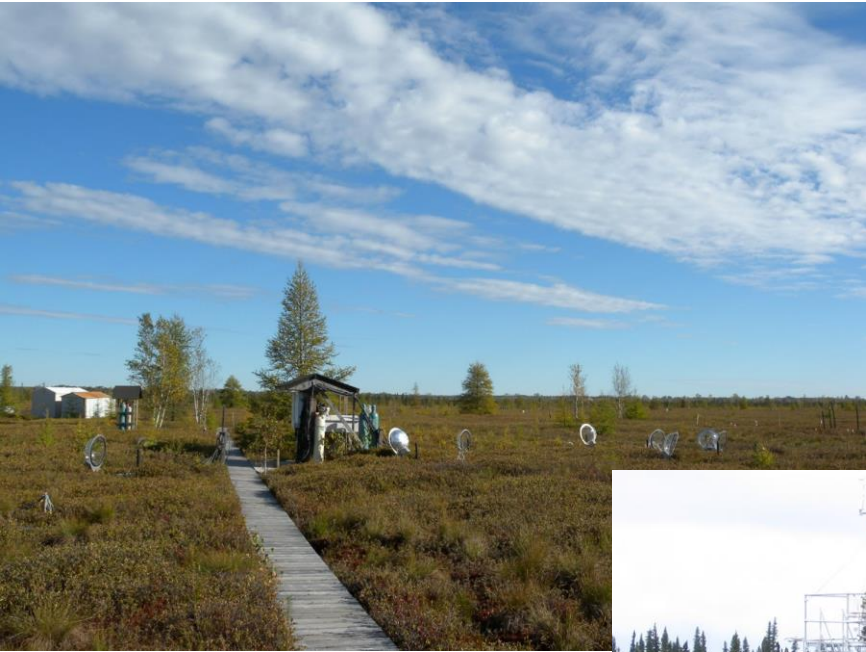
High
uptake
and
short
residence
time

Lower
uptake
and
longer
residence
time

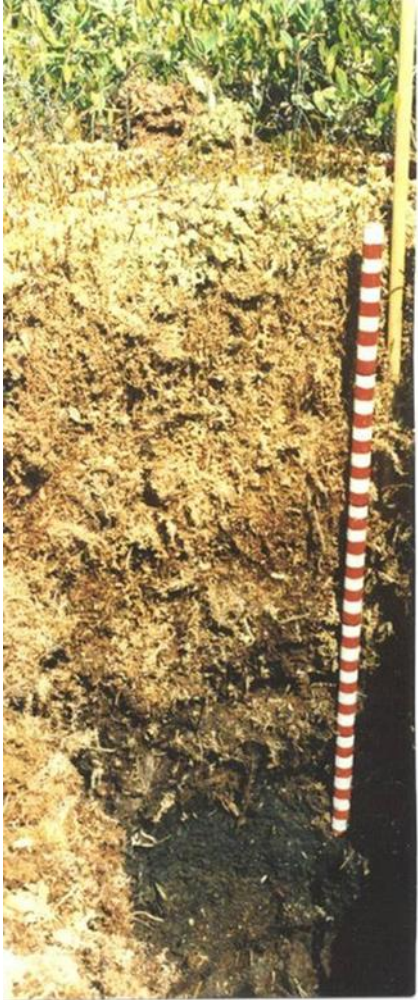
Small
uptake
and very
long
residence
time

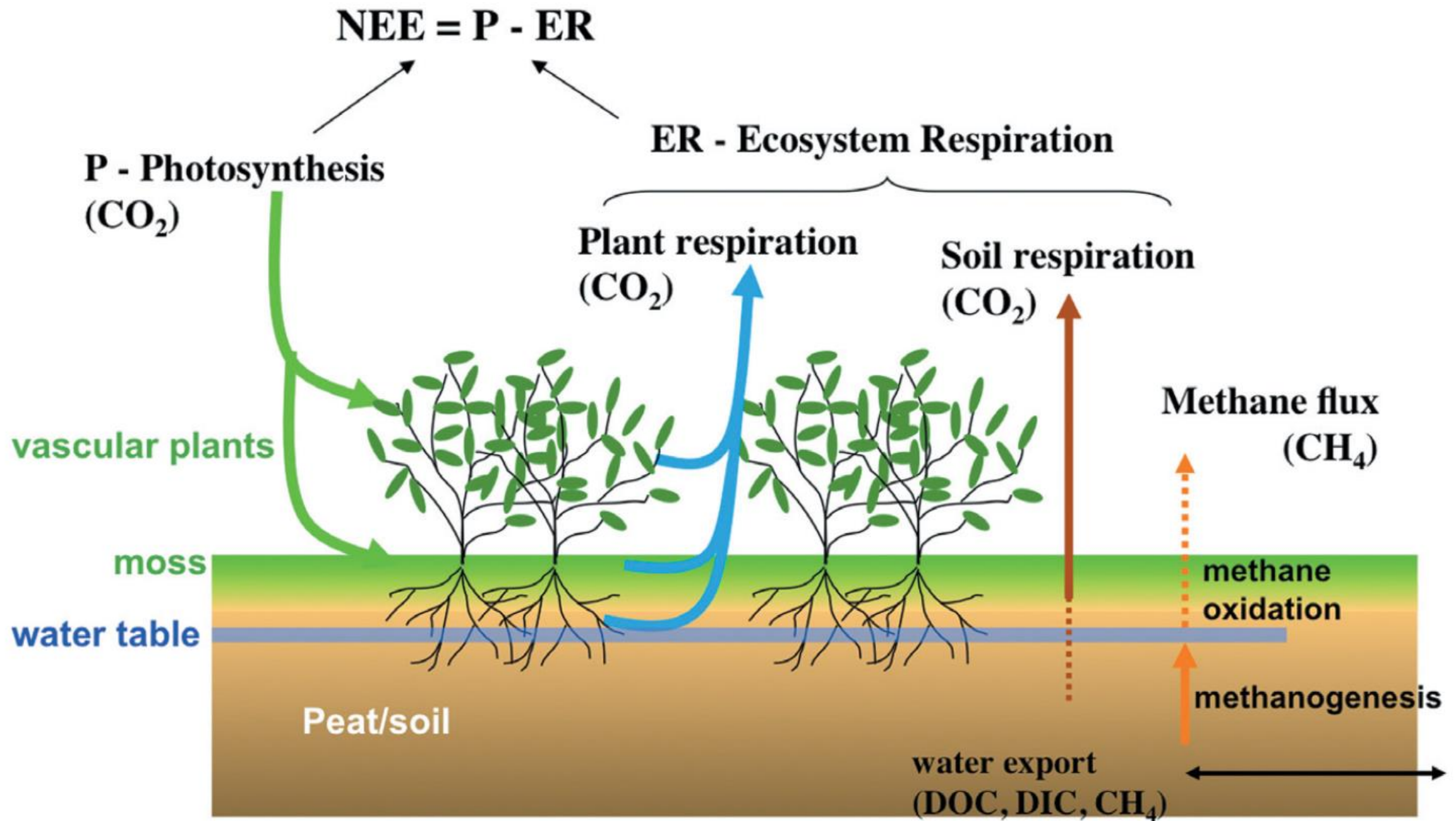


What are peatlands?

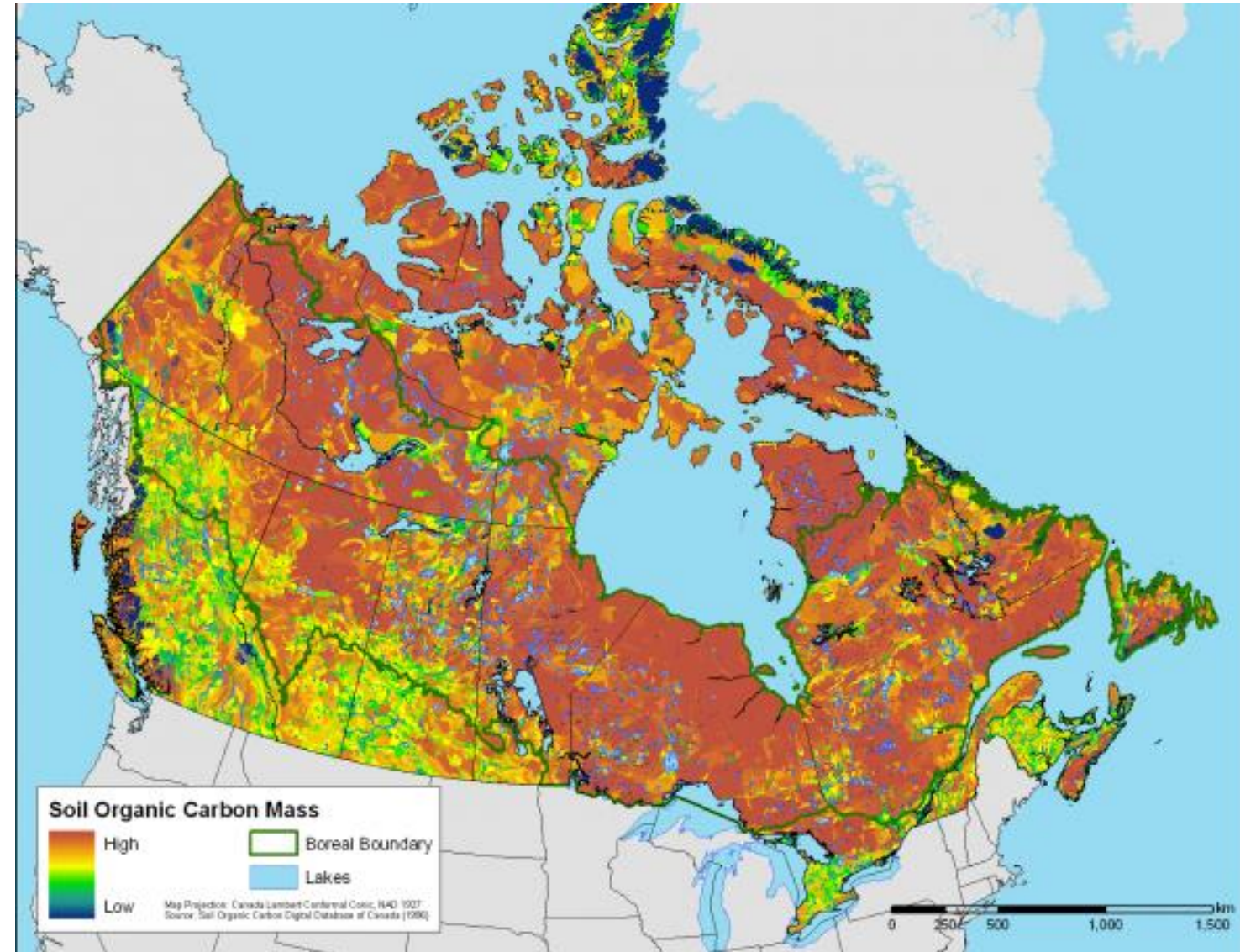
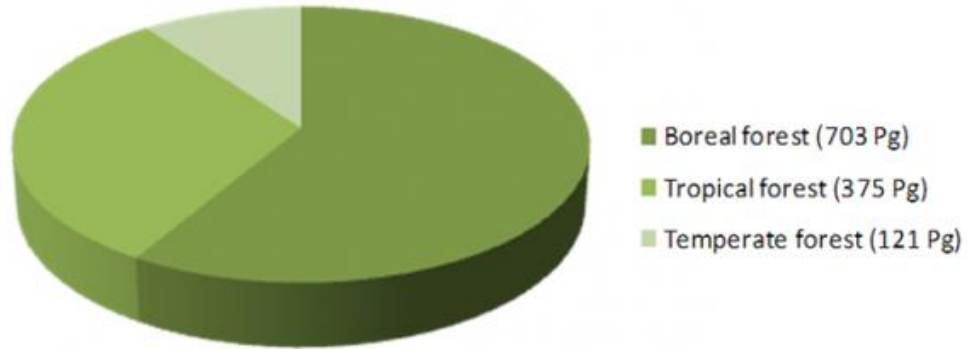


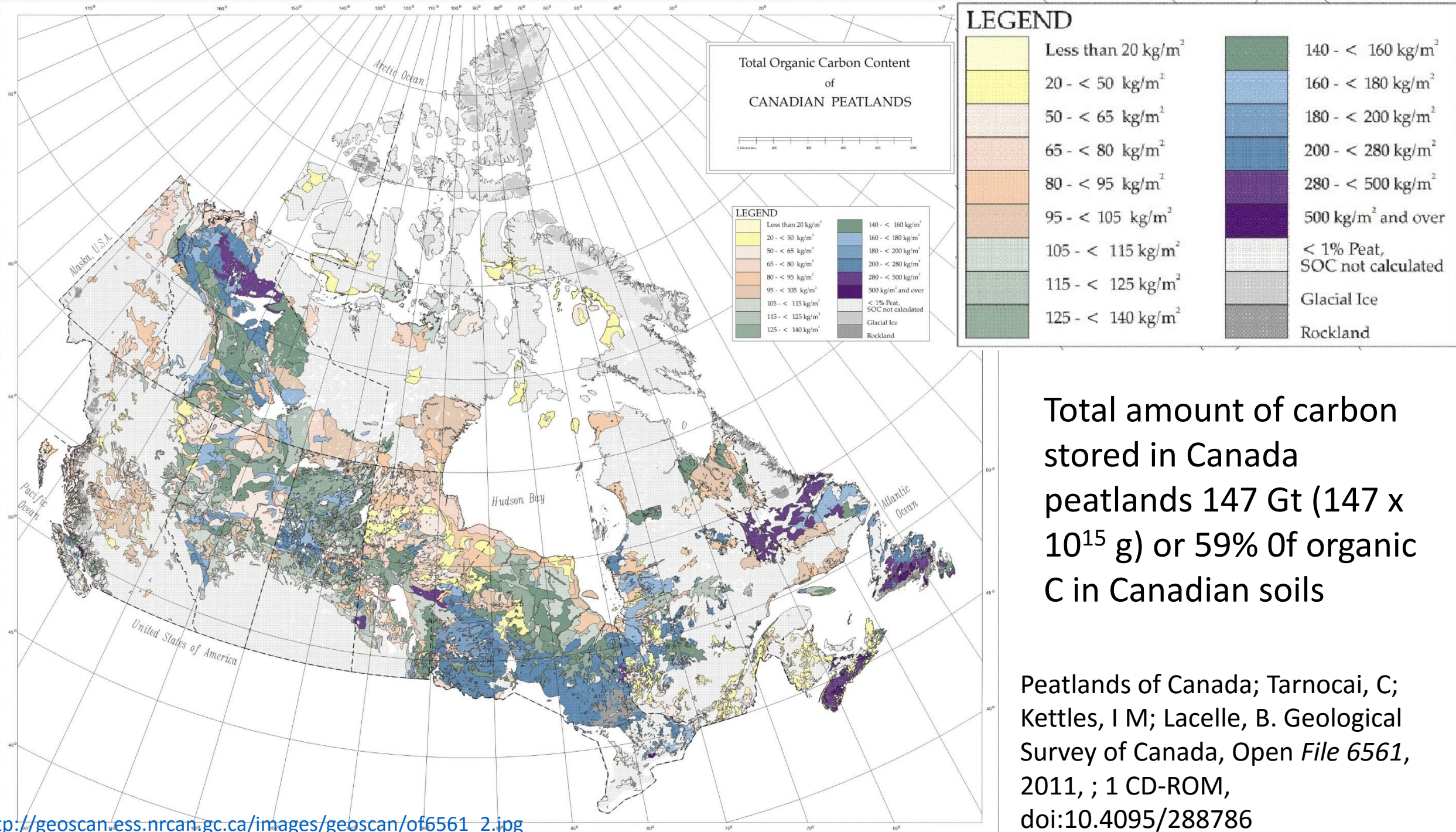
Things get preserved in peatlands





Carbon storage by global forest biomes





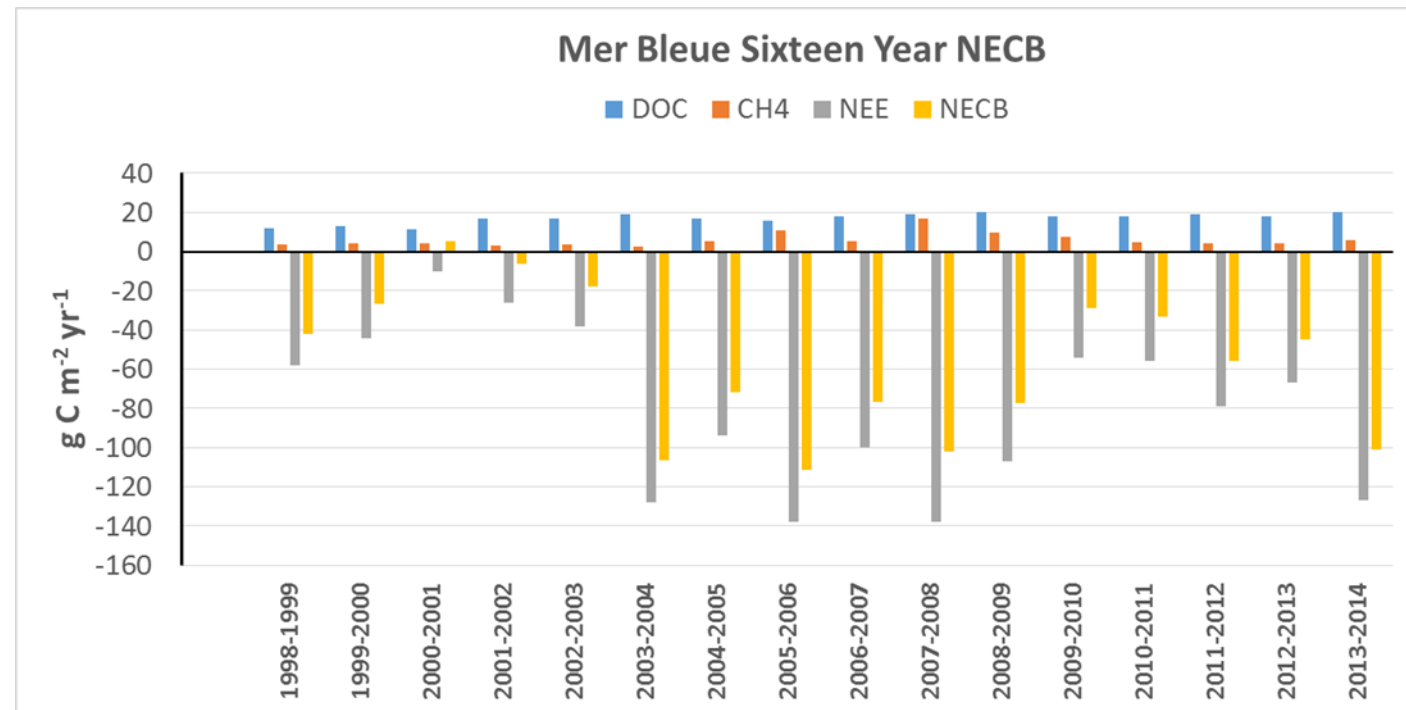


“Historic Paris Agreement on Climate Change “

- “195 Nations Set Path”
 - “The universal agreement’s main aim is to keep a global temperature rise this century well below 2 degrees Celsius and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels.”
- “The 1.5 degree Celsius limit is a significantly safer defense line against the worst impacts of a changing climate.”
 - In the actual wording of the agreement (<https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>) refers to the need to hold total emissions to less than 40 Gt CO₂-eq/yr by 2030 rather than our current trajectory to 55 Gt CO₂-eq/yr (a ~37% decrease in emissions)

Two issues of concern about the future of the peatland carbon stocks ...

1. The response of peatlands to climate change: things we need to prepare for, attempt to understand but cannot do anything about
 - along to the ride but influence adaptation
 - Current sink/source relation
 - Sensitivity of the carbon stored in peatlands to climate change
 - Relationship between peatlands and permafrost
 - Fire and peatlands
2. Land-use change and peatlands: we control this!
 - Conversion of the existing stores of atmospheric carbon in peat into active CO_2 and CH_4



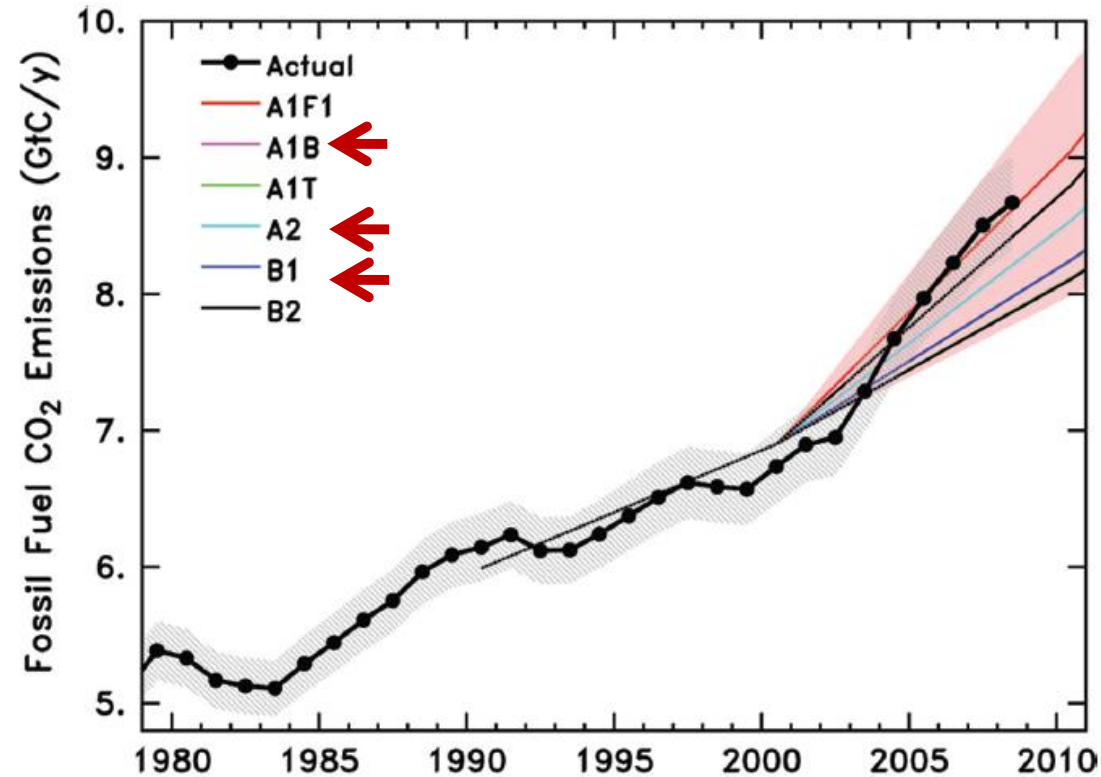
1998-2014 $-56 \pm 36 \text{ g C m}^{-2} \text{ yr}^{-1}$

Found all peatlands to be sinks: ~ 30 to $50 \text{ g C m}^{-2} \text{ yr}^{-1}$

Area of peatlands in Canada: $1.6 \times 10^{12} \text{ m}^2$

National Scale sink $\sim 50 \text{ Mt C}$ or 180 Mt CO_2 ($\sim 20\%$ of Canada's 2014 emissions)

Climate change scenarios



The Copenhagen Diagnosis: www.copenhagendiagnosis.org/

Victor fen and bog, HBL

Bogs - small changes
because the internal
feedbacks are strong

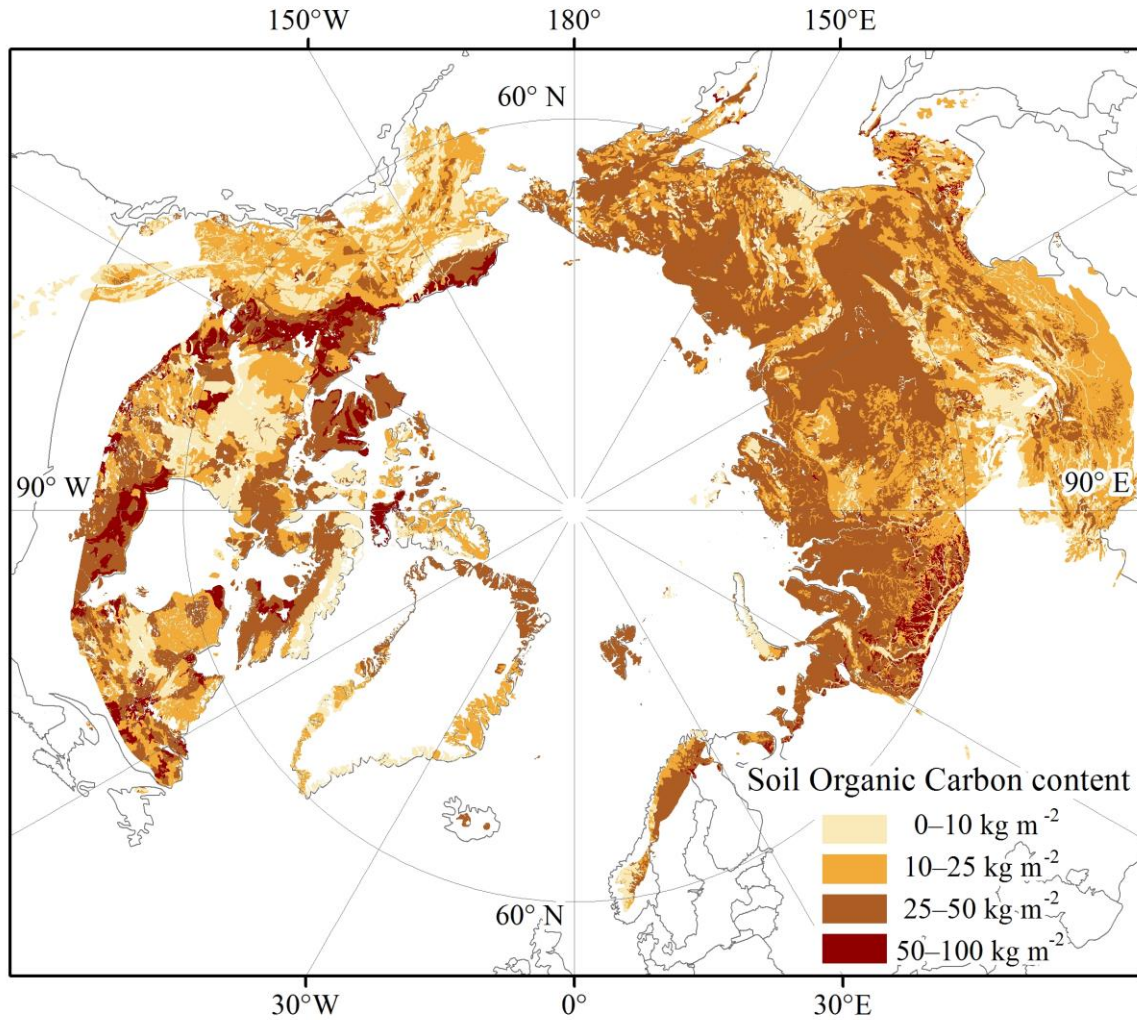
STABLE

Fens - possibly big
changes because of
weaker internal
feedbacks

LESS STABLE

Lorna Harris

Peatlands & permafrost



<http://bolin.su.se/data/ncscd/>



<http://www.nap.edu/read/11013/chapter/5>

Peatlands & permafrost



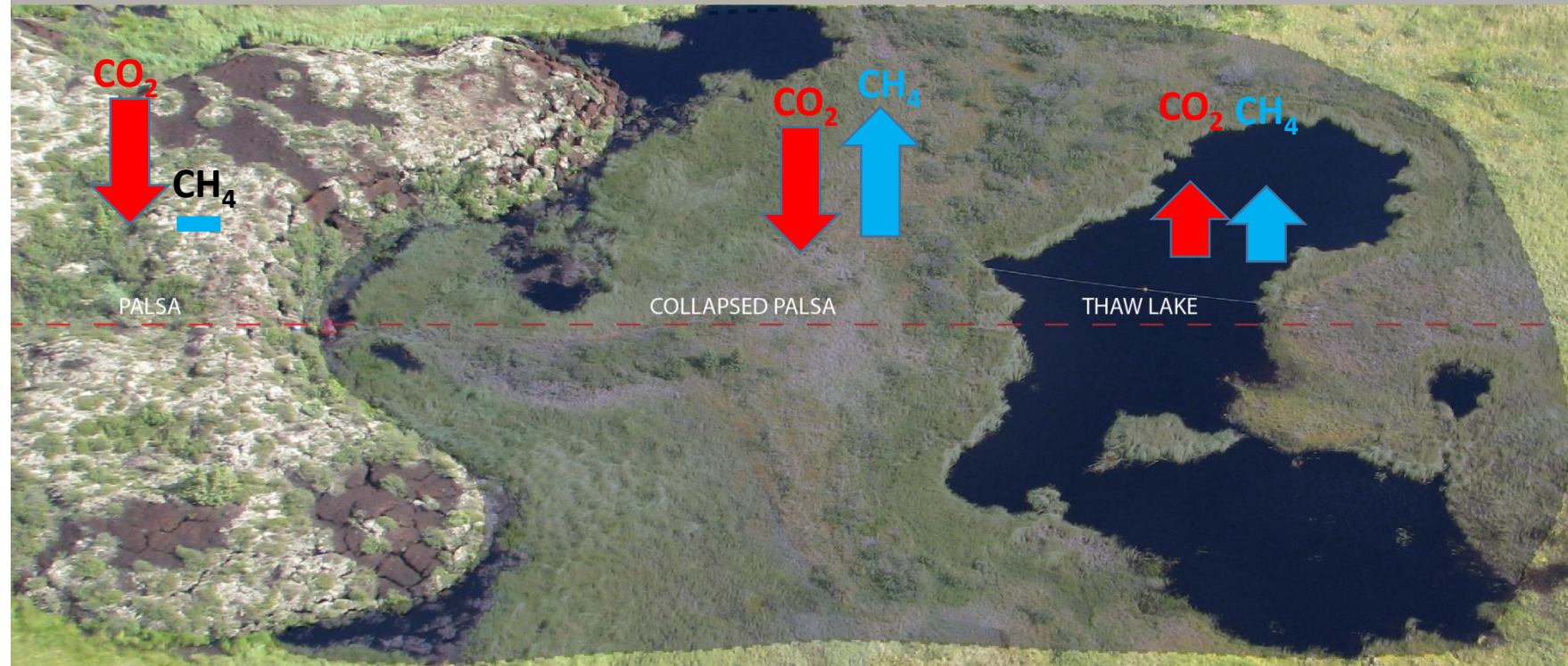
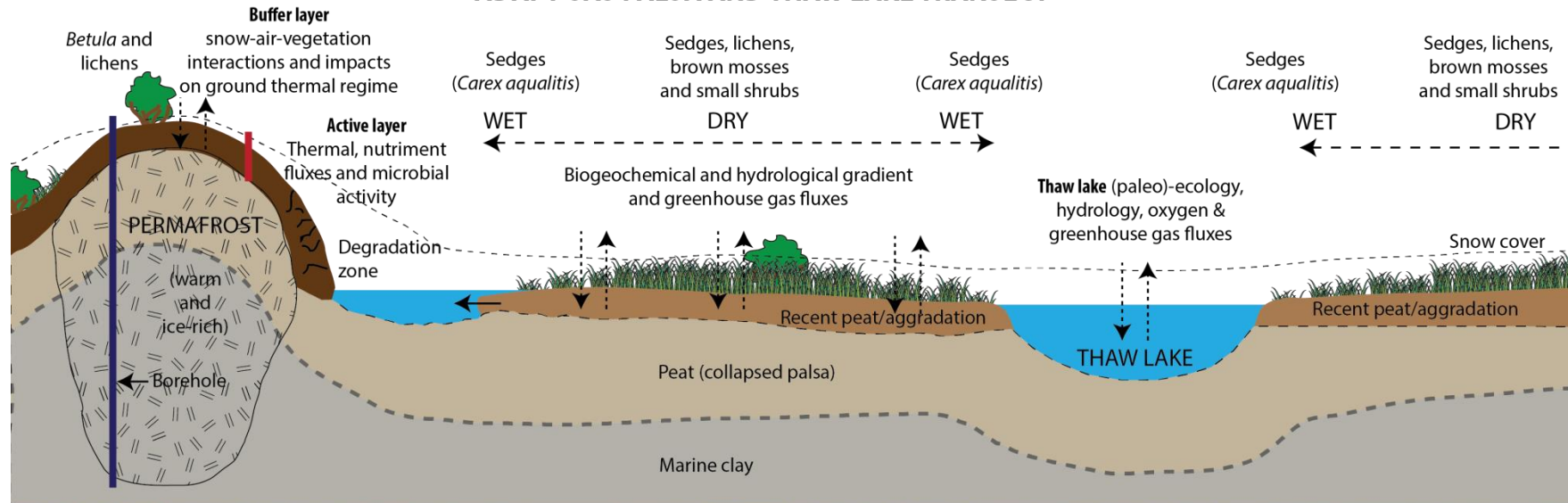
SAS palsa bog, Kuujjuarapik, Quebec

Z. Wang



Stordalen peat complex, Abisko, Sweden

ADAPT-SAS PALSA AND THAW LAKE TRANSECT





Alaska

Merritt Turetsky



Scotty Creek, NWT

David Olefeldt



Rivière-du-Loup

Line Rochefort

2014 - 2015

Ontario Consolidated Act,
Regulations & Related Provisions

Far North Act

**“the maintenance of
biological diversity,
ecological processes and
ecological functions,
including the storage and
sequestration of carbon
in the Far North”**

Codify Legal Publishing

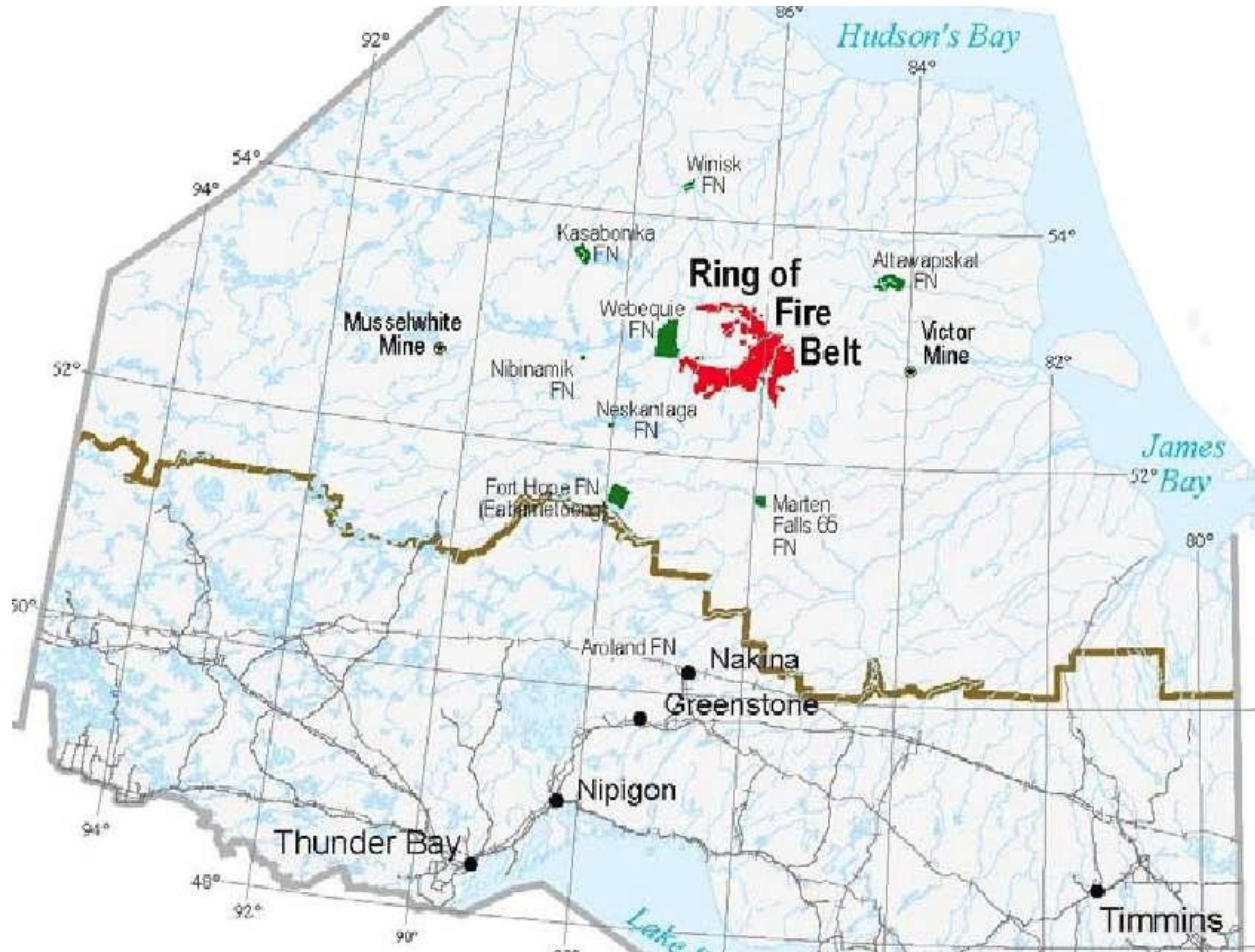


A Message from Minister Pierre Arcand

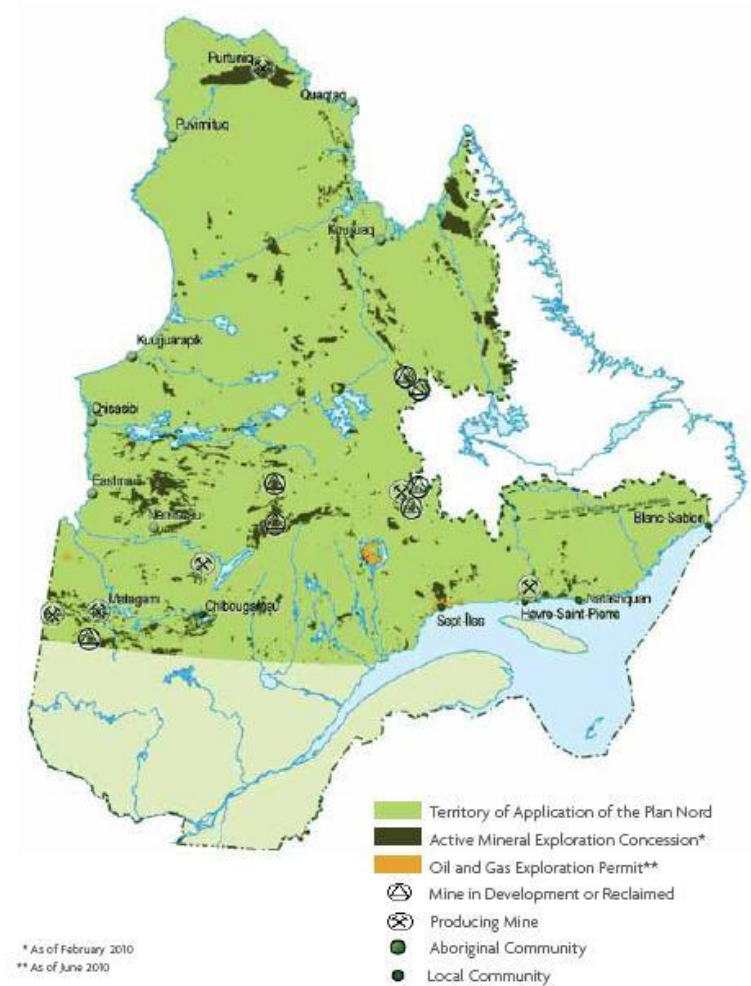
The aim of the Plan Nord is to promote the potential for mining, energy, tourism, and social and cultural development in Québec north of the 49th degree of latitude. It will create jobs and wealth for northern communities and for Québec as a whole, while ensuring respect for the northern population and the environment. By harmonizing the economic, social and environmental aspects of the Plan Nord, the Québec government intends to make it a responsible, sustainable and unifying project for Québec society. Enjoy reading!

<http://www.plannord.gouv.qc.ca/en/>

Quebec's Plan Nord - Ontario's Far North



MINING, OIL AND GAS RESOURCES



Canada is now committed to reducing its GHGs emission ...

Vancouver pre-meeting

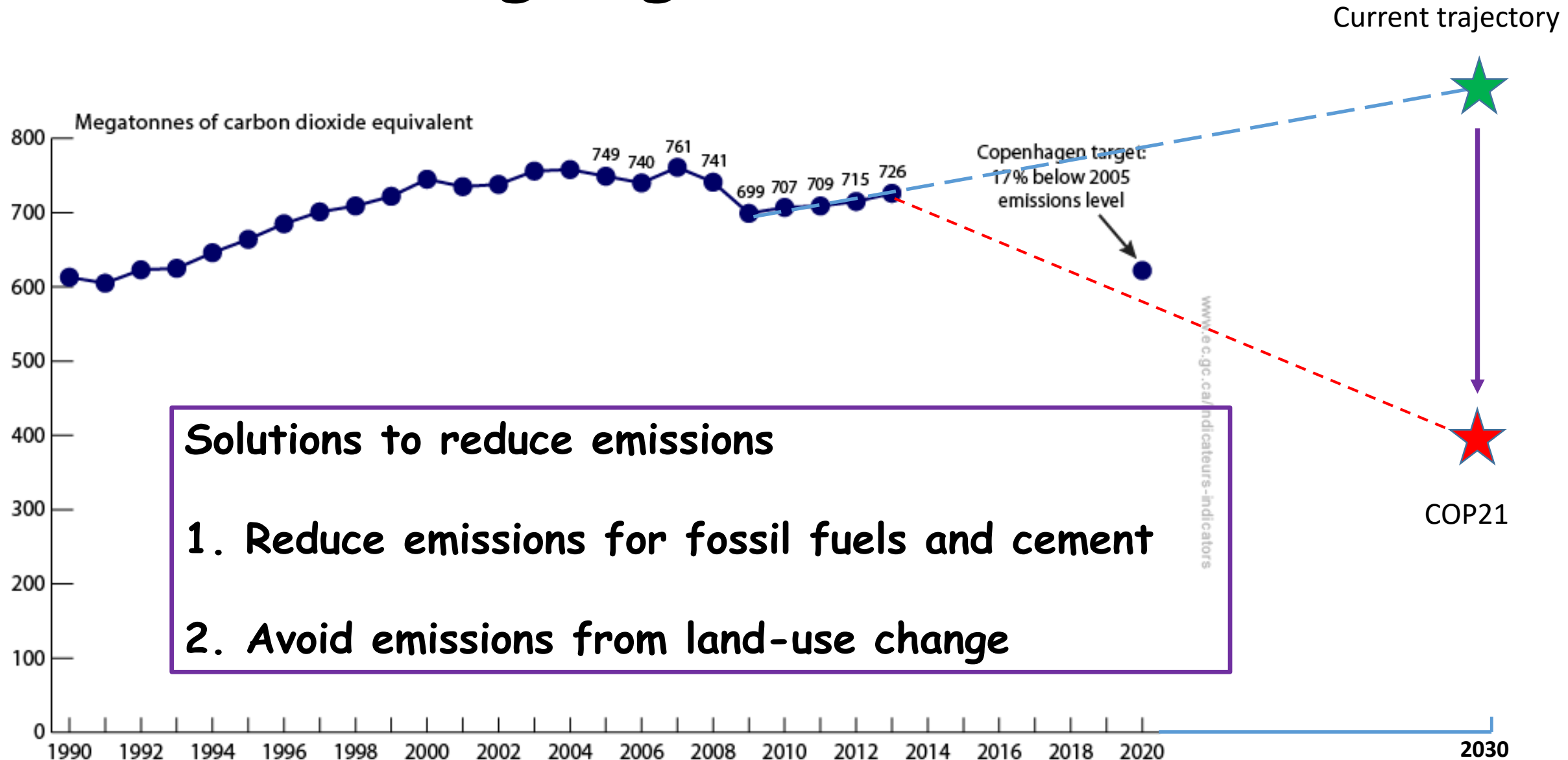


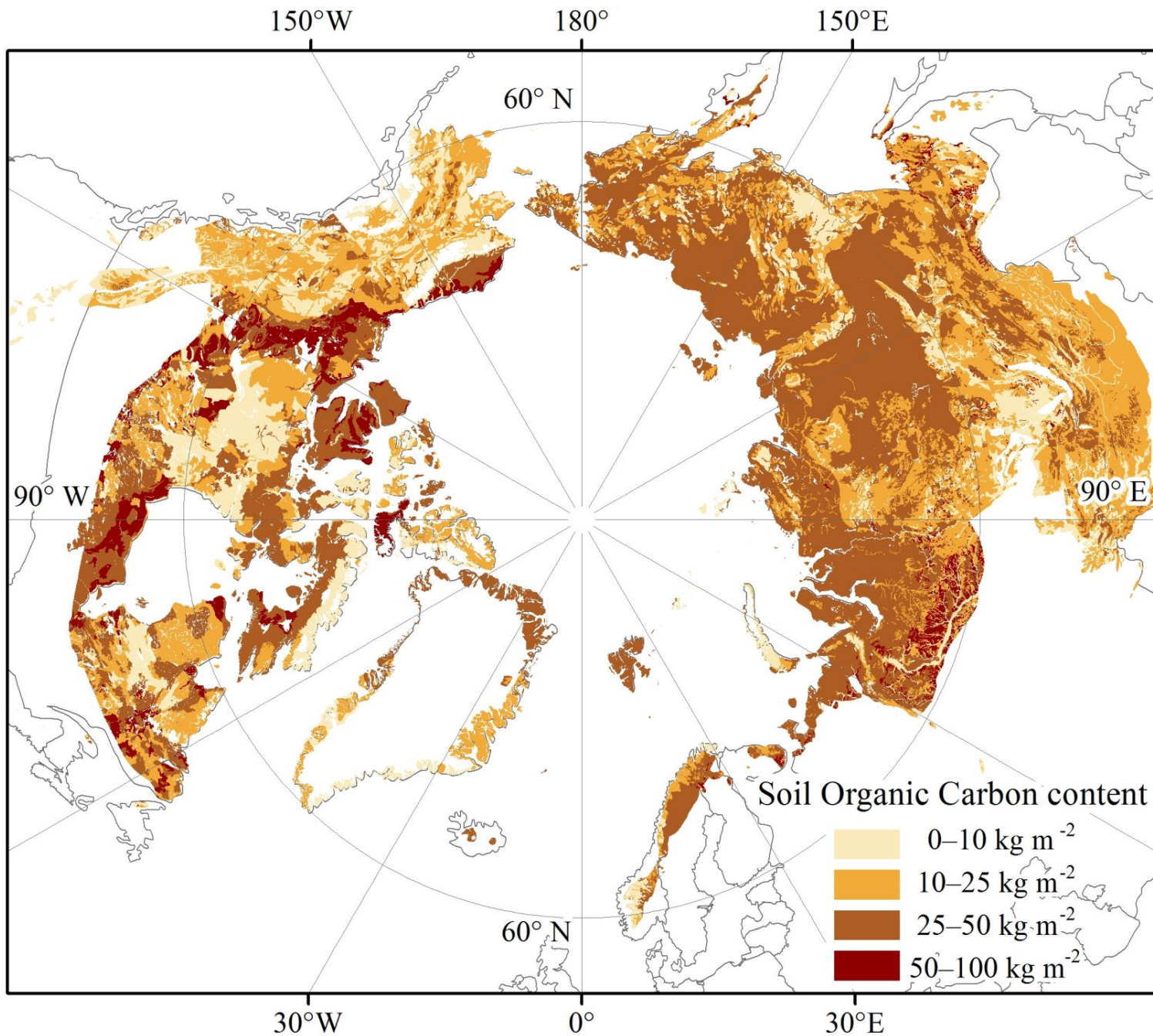
Cap and Trade Carbon plans: Ontario,
Quebec & California ...

March 3, 2016



How is Canada going to reduce...?





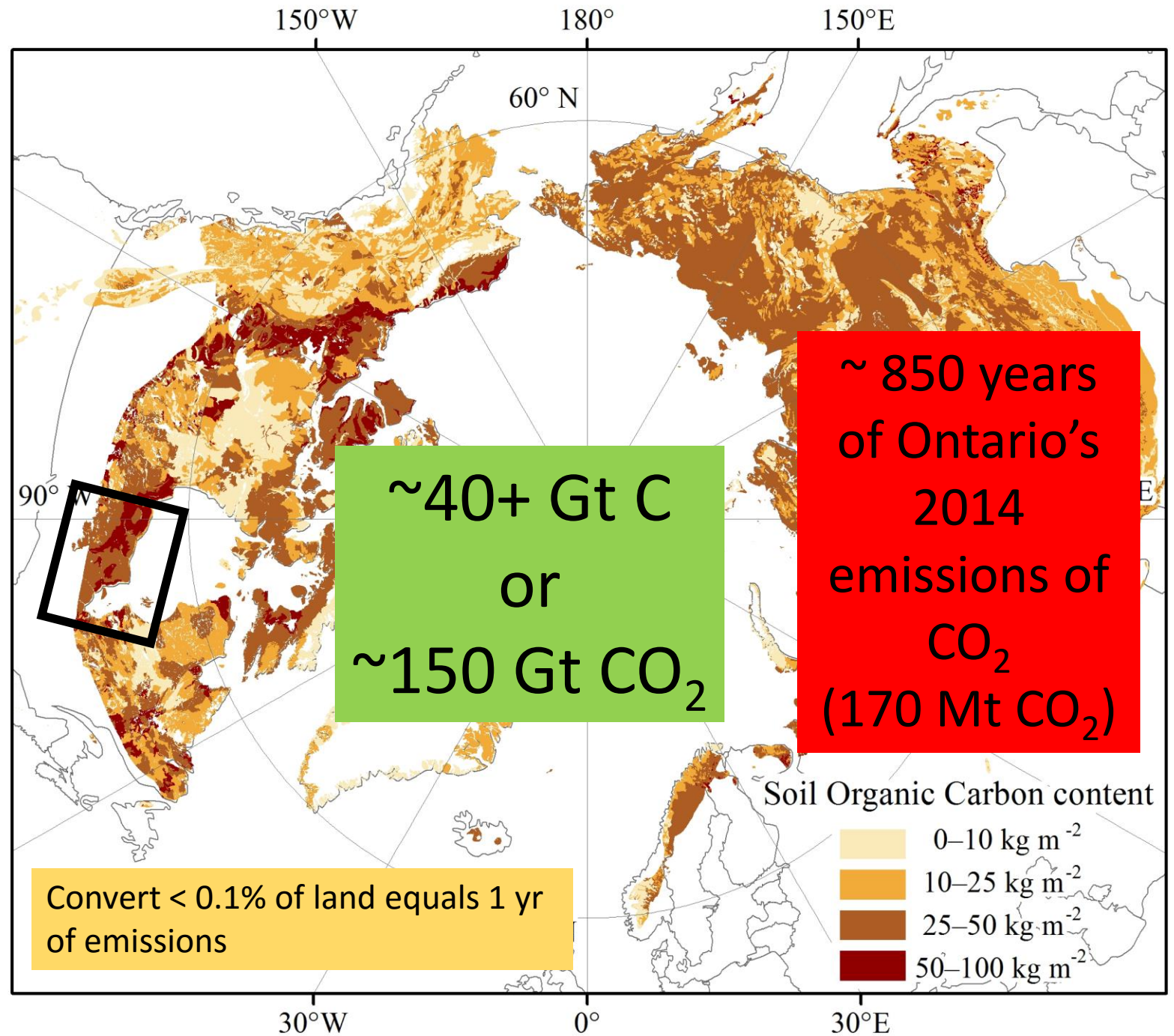
Development in northern Ontario

For Canada

Emissions 2014: ~ 860 Mt CO₂

CO₂ eq. in peatlands alone: 540 Gt

≈ 600 years of emissions



Summary

- We have a problem!
- We have committed to reduce our emissions
- Right now Canada's CO_2 is from fossil fuels and land-use, but not from land-use change
- But Canada wants to develop the north (needs to?)
- The north hold globally significant stores of ecosystem carbon
- What does the next fifty years have in store for us?




Questions for us to think about ...

- What moral obligation does Canada have for carbon stewardship of its northern terrestrial ecosystem?
- What role should carbon management play in northern development decisions?
- What mechanisms could Canada use to ensure carbon sustainably if the north is developed?

Solutions and strategies

- Preserve the high density carbon deposits: avoid or design around them
- Mitigate against loss of medium density deposits
- Offset the land-use carbon release from disturbance to living biomass





Thank you for your attention ...

Happy to answer questions ...

nigel.roulet@mcgill.ca