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Environmental Health - The Impact of Oil Sands Mining on Peatland Ecosystems in Alberta, Canada

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Boreal Peatland Ecosystems of Alberta Canada: Impacts of Climate Change & Oil Sands Mining

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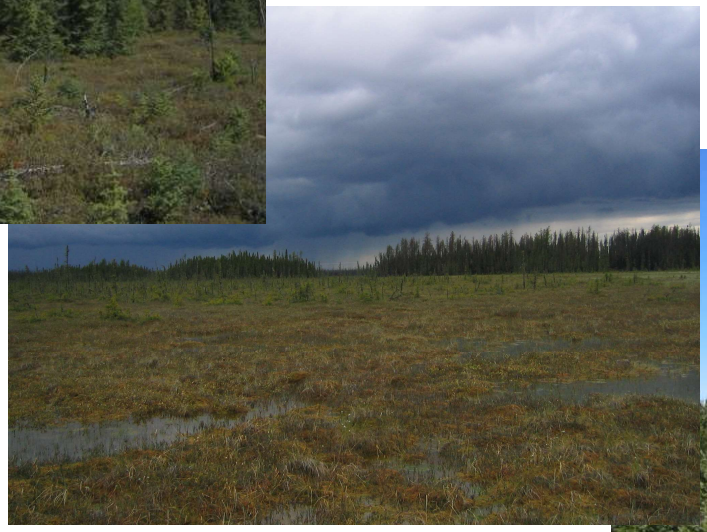
WCU Sustainability Forum, April 14, 2021

Boreal Peatland Ecosystems of Alberta Canada: Impacts of Climate Change & Oil Sands Mining

- What are Peatland Ecosystems?
- Peatland Ecosystem Services
- Climate Change Impacts on Peatlands
- Oil Sands Mining in Alberta
- Past, Current & Future Work

What are Peatlands?

Bog

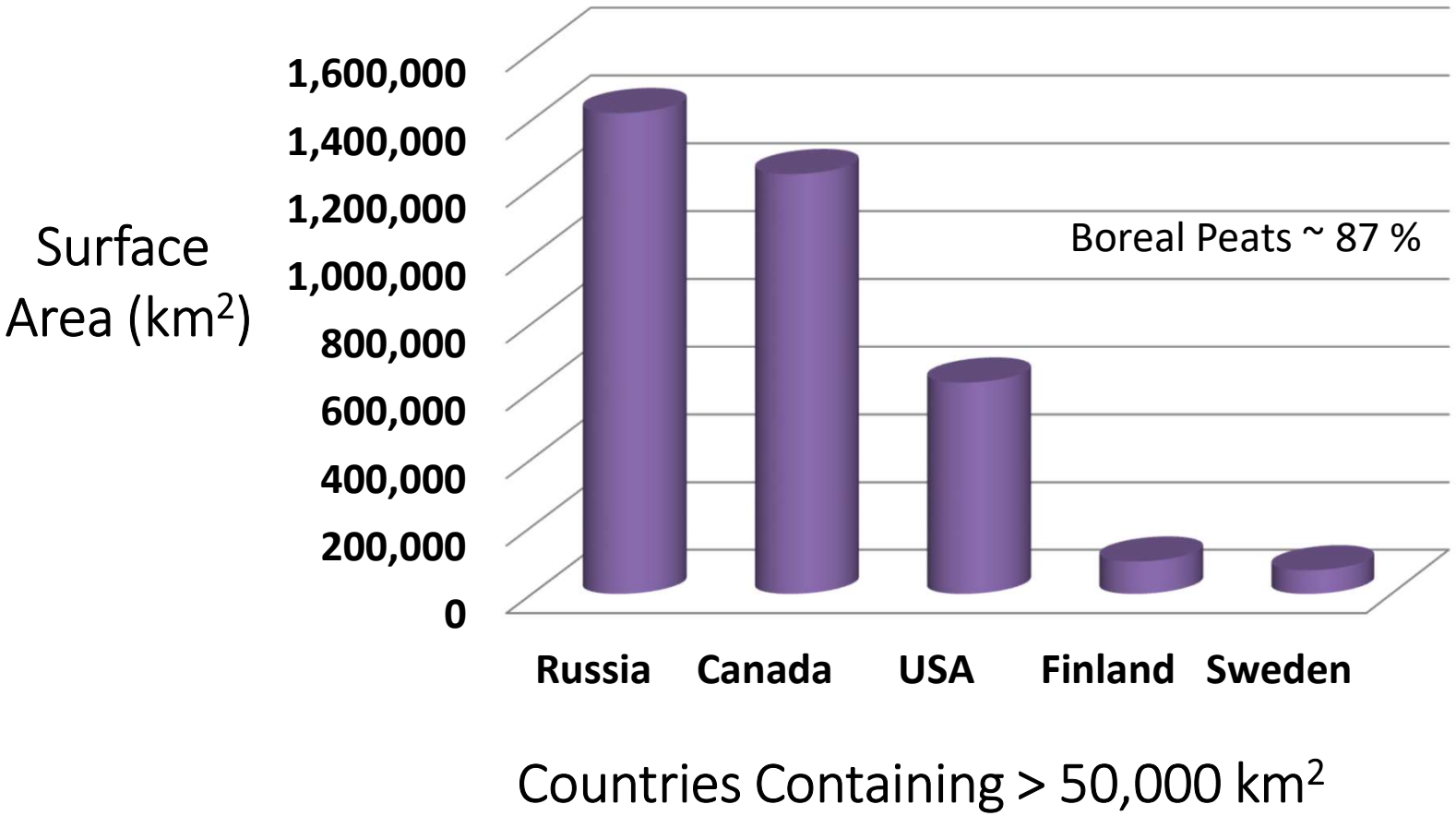


Poor Fen

Rich Fen

Where are Boreal Peatlands Found?

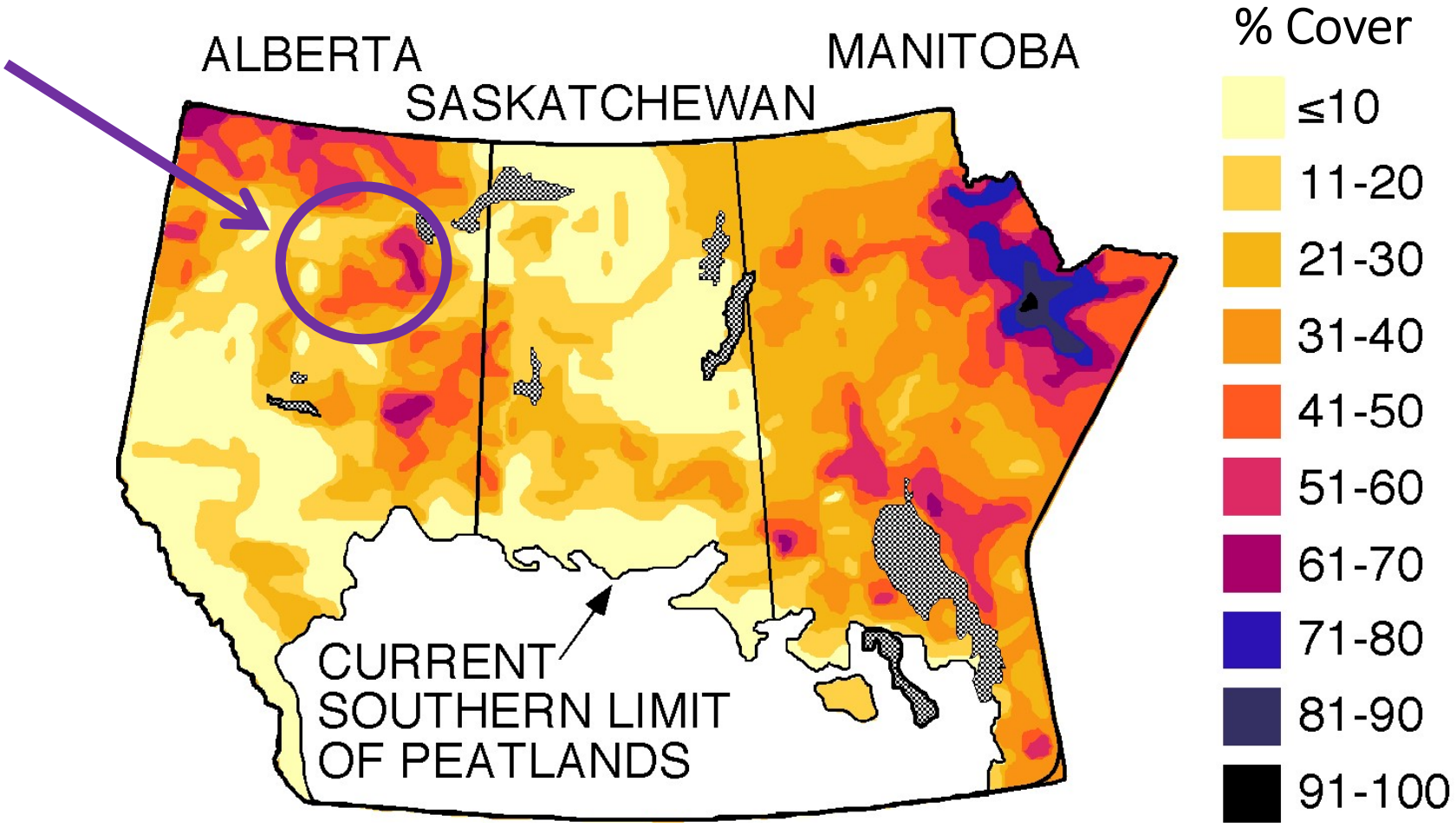
Total Area = 4,000,000 km^2;
Boreal Peatland Area = 3,460,000 km^2



Countries Containing > 50,000 km^2

Boreal Canada Peatland Cover

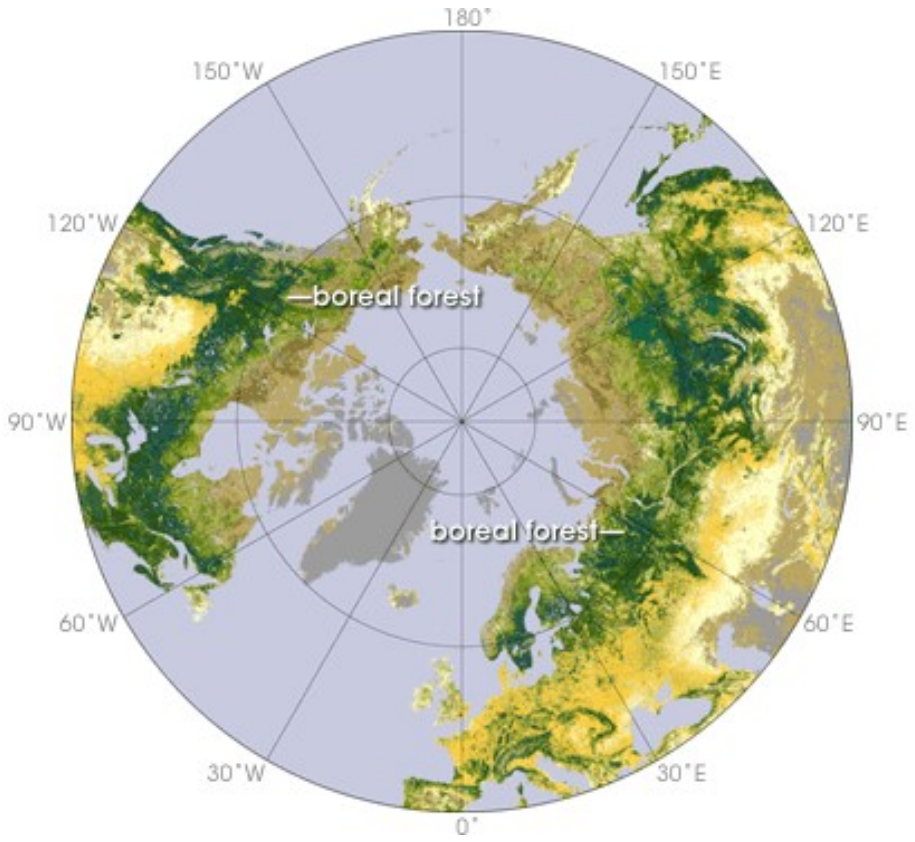
Total peatland area = *365,160 km²*



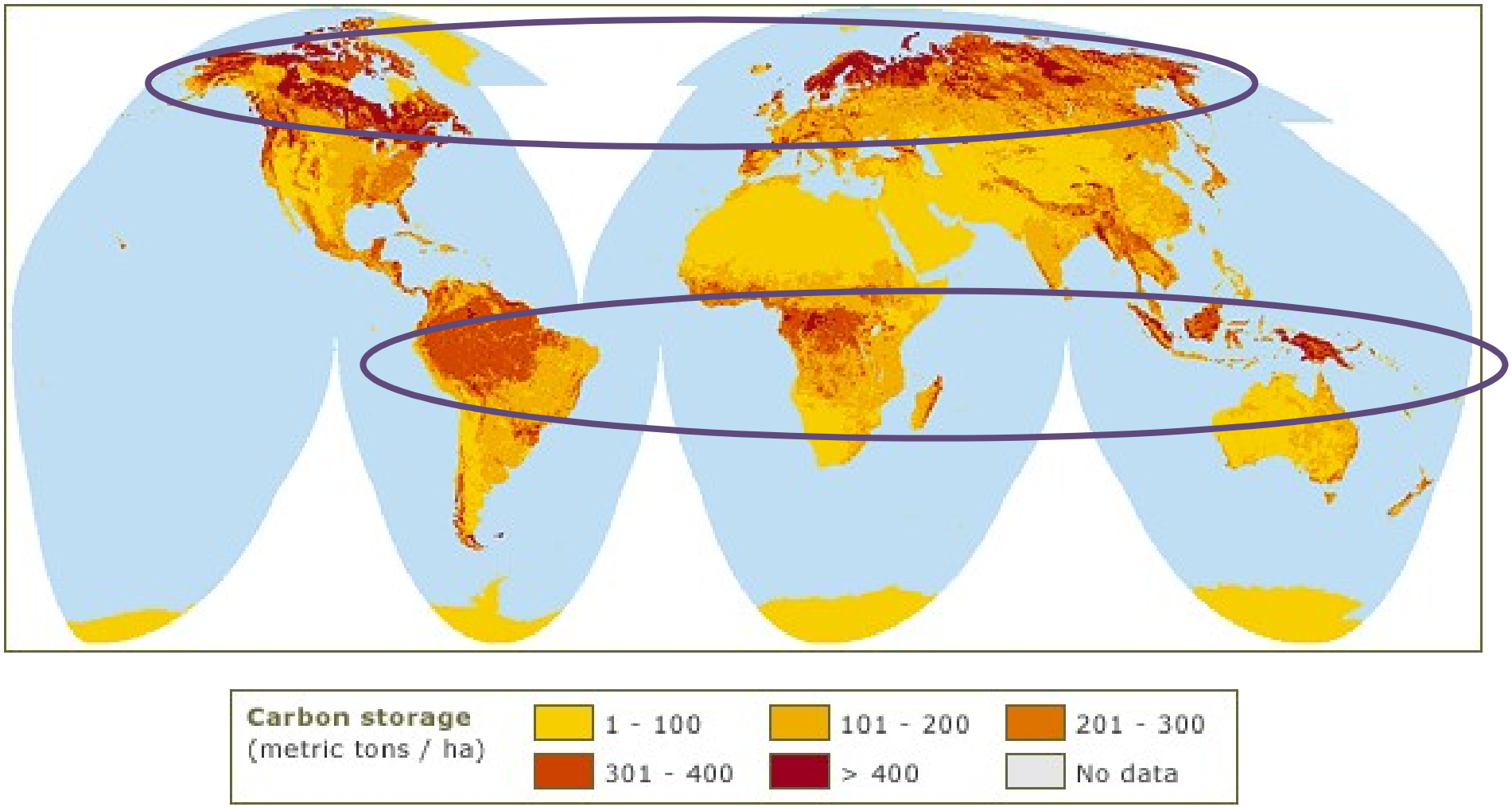
Vitt et al. (2000)

The Global Boreal Forest

- Boreal Forest (BF) occupies ~30% of global forested area
- Most of BF is upland underlain by mineral soil, but 24 % of BF is occupied by peatlands
  - World's largest C storehouse ~ 2 x C per area^{-1} as tropical forests



Global Carbon Stocks



http://earthtrends.wri.org/text/climate-atmosphere/map-227.html

Net Primary Productivity: *Sphagnum* vs. Tropics

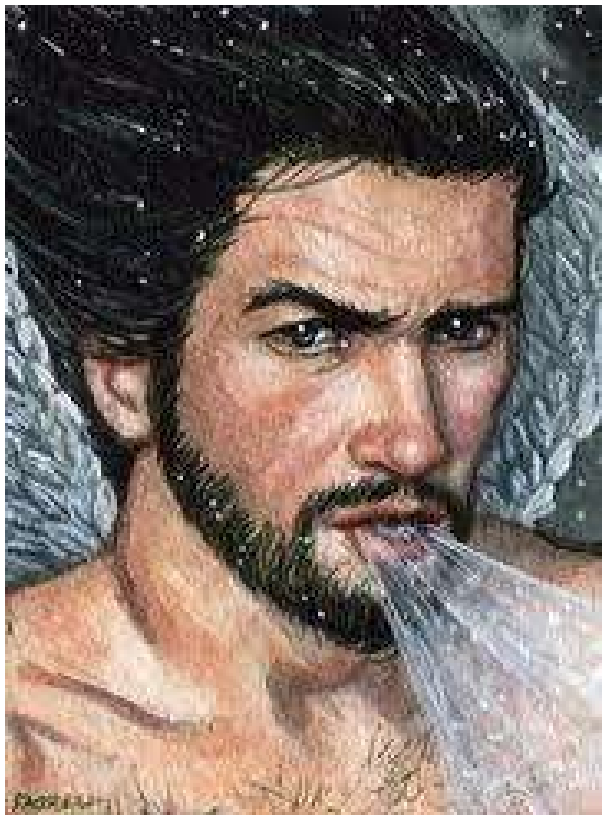
NPP tropics*:
170-1700 g C m^{-2} yr^{-1}

Vs.

Sphagnum NPP**
100-900 g C m^{-2} yr^{-1}

*Houston & Wolverton, 2009, Ecol Mon
**Vile et. al 2014

Global Carbon Stocks: Kudos to Peatlands!



Boreas, Greek God
of the North Wind

Boreal Zone

Mean annual temp 1-3^{o} C

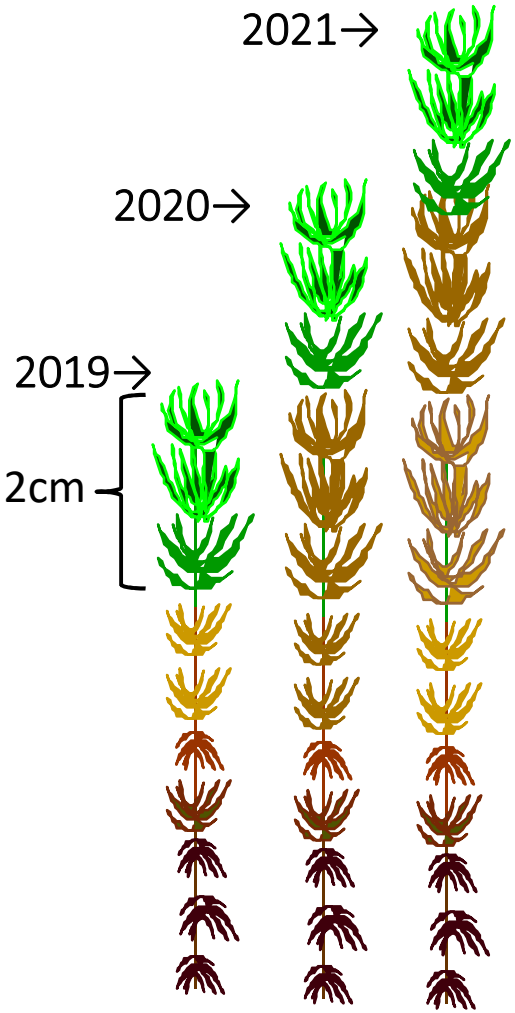
fewer than 120 days
mean daily temp >10 °C

Tropical Zone

Mean annual temp 20-30 ^{o}C

The entire year!

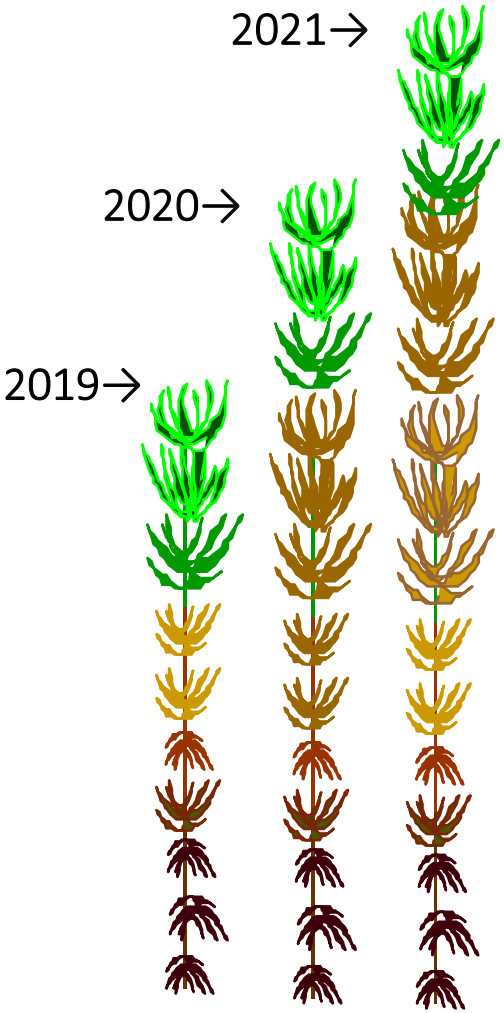
Peatland Ground Cover is Moss Dominated



Sphagnum growth

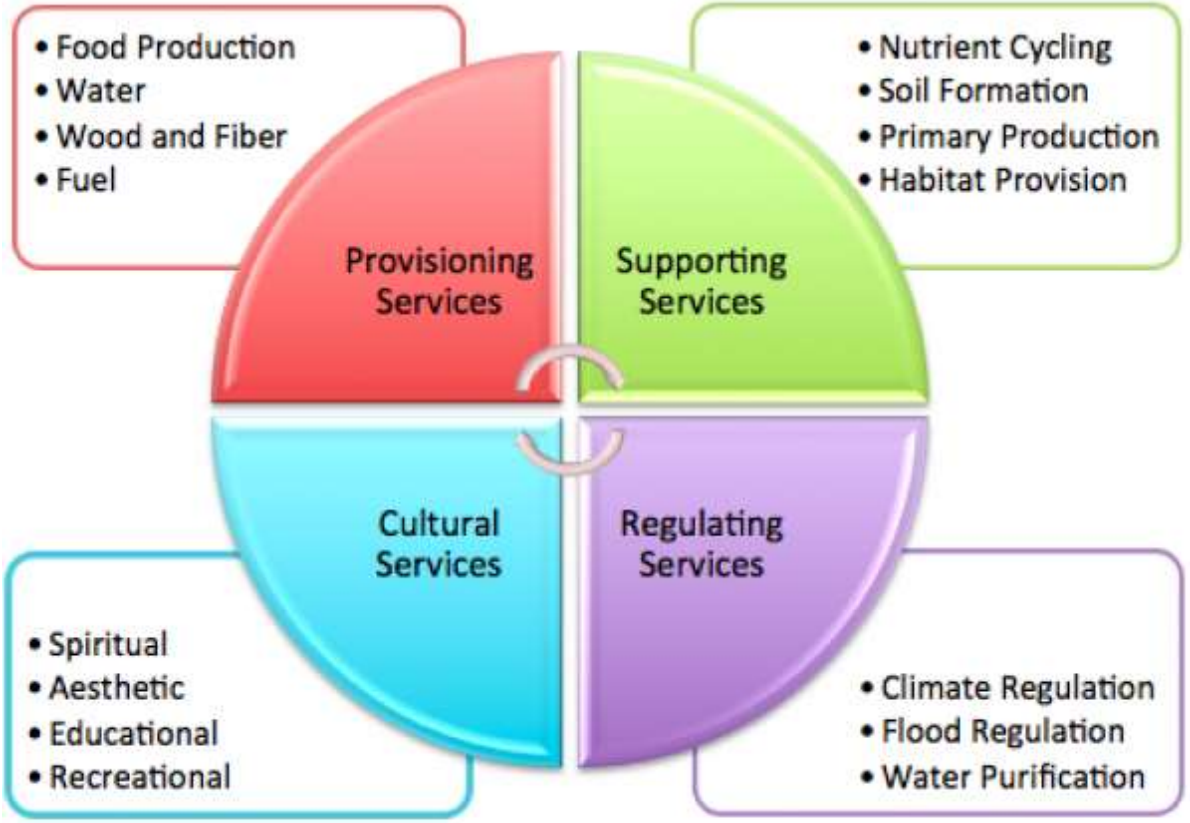
Sophisticated Sampling Equipment

Peatland Ground Cover is Moss Dominated



Sphagnum growth

Peatland Ecosystem Services



Source: Millenium Ecosystem Assessment, 2005.

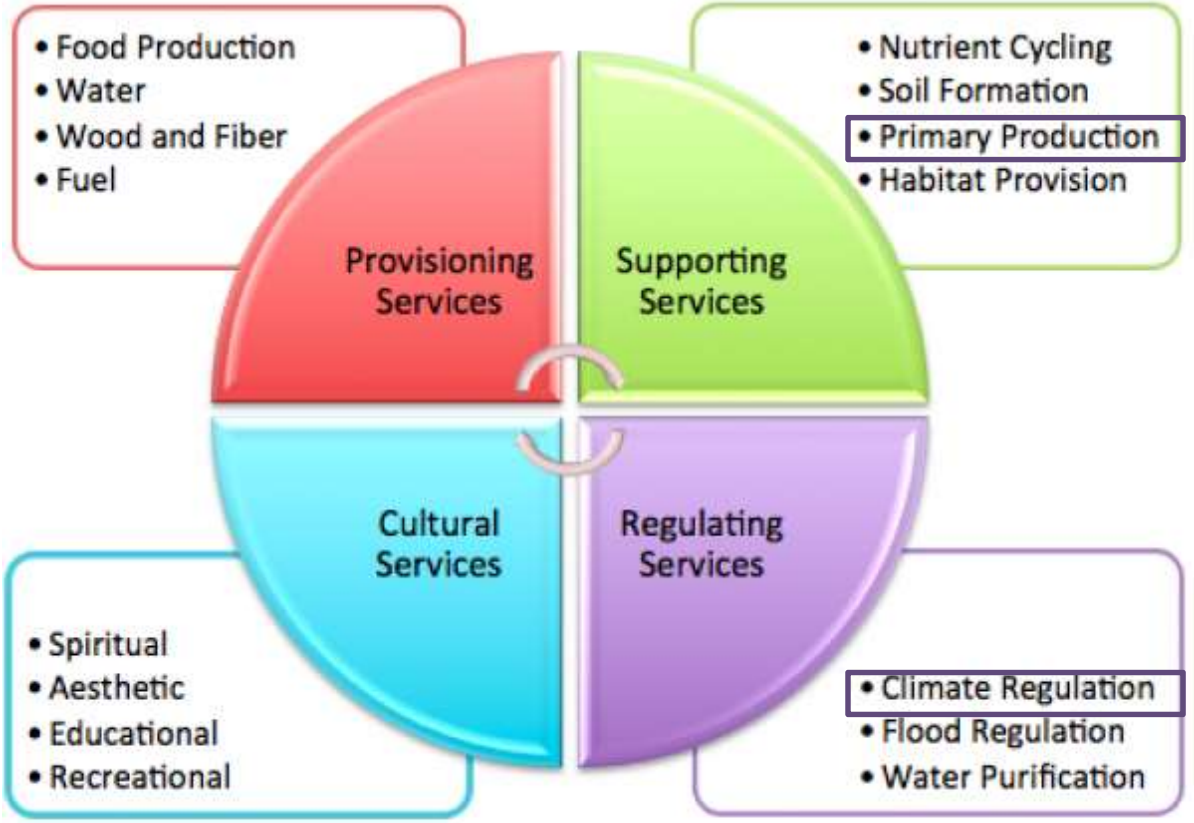
Peatland Provisioning Ecosystem Services





Peatland Provisioning Ecosystem Services: First Nation Peoples

Peatland Supporting & Regulating Ecosystem Services

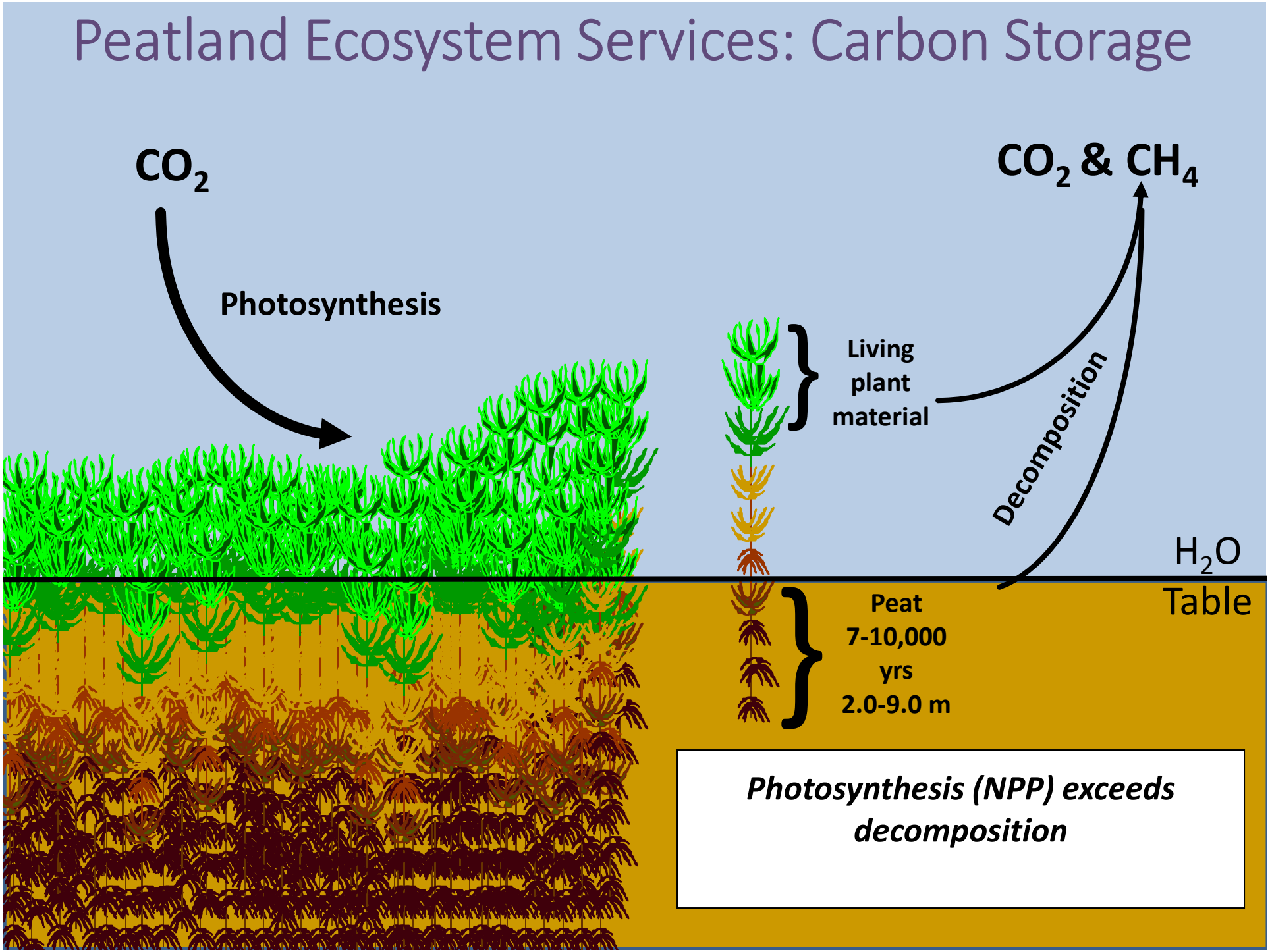


Source: Millenium Ecosystem Assessment, 2005.

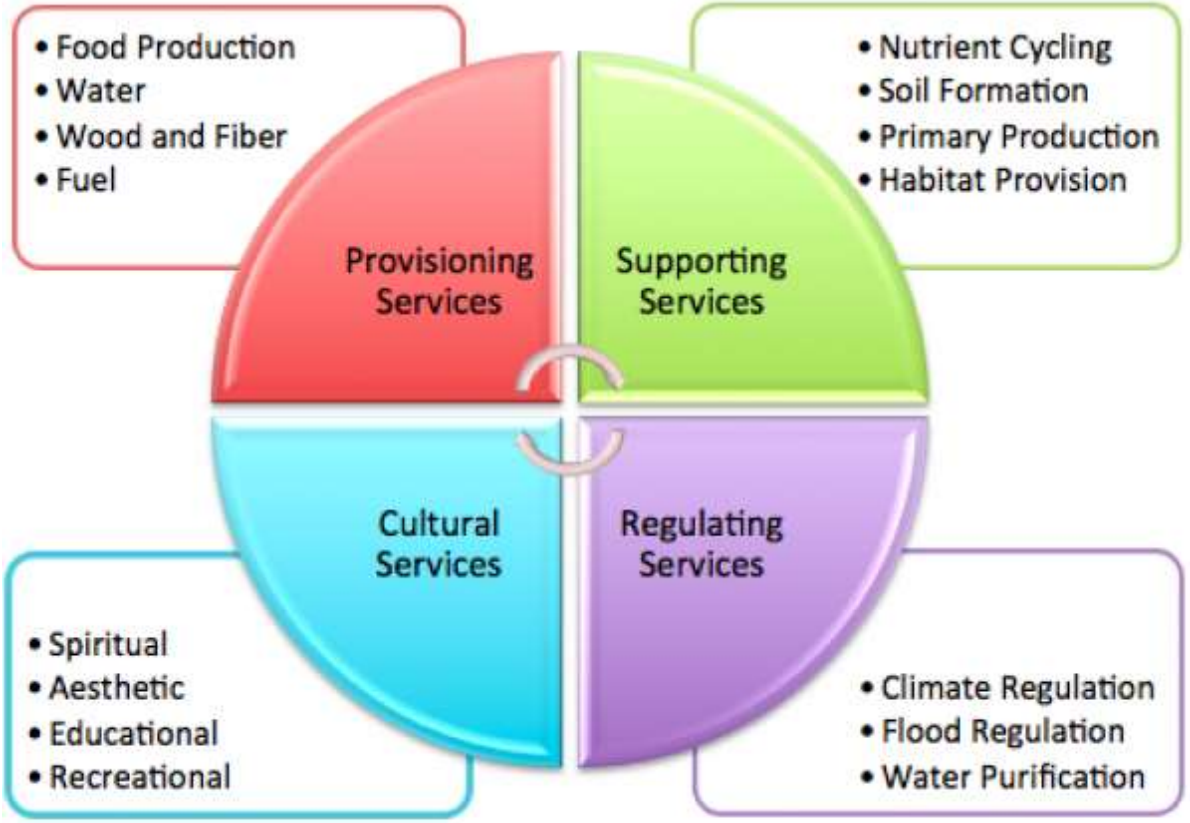
Peatland Ecosystem Services: Carbon Storage

- Peatlands occupy 3 % of earth's land surface
- Yet store ~ 30 % of earth's soil C
- How you ask?

Peatland Ecosystem Services: Carbon Storage



Peatland Cultural Ecosystem Services



Source: Millenium Ecosystem Assessment, 2005.

Peatland Ecosystem Services: Aesthetics

Photo: Kim Scott

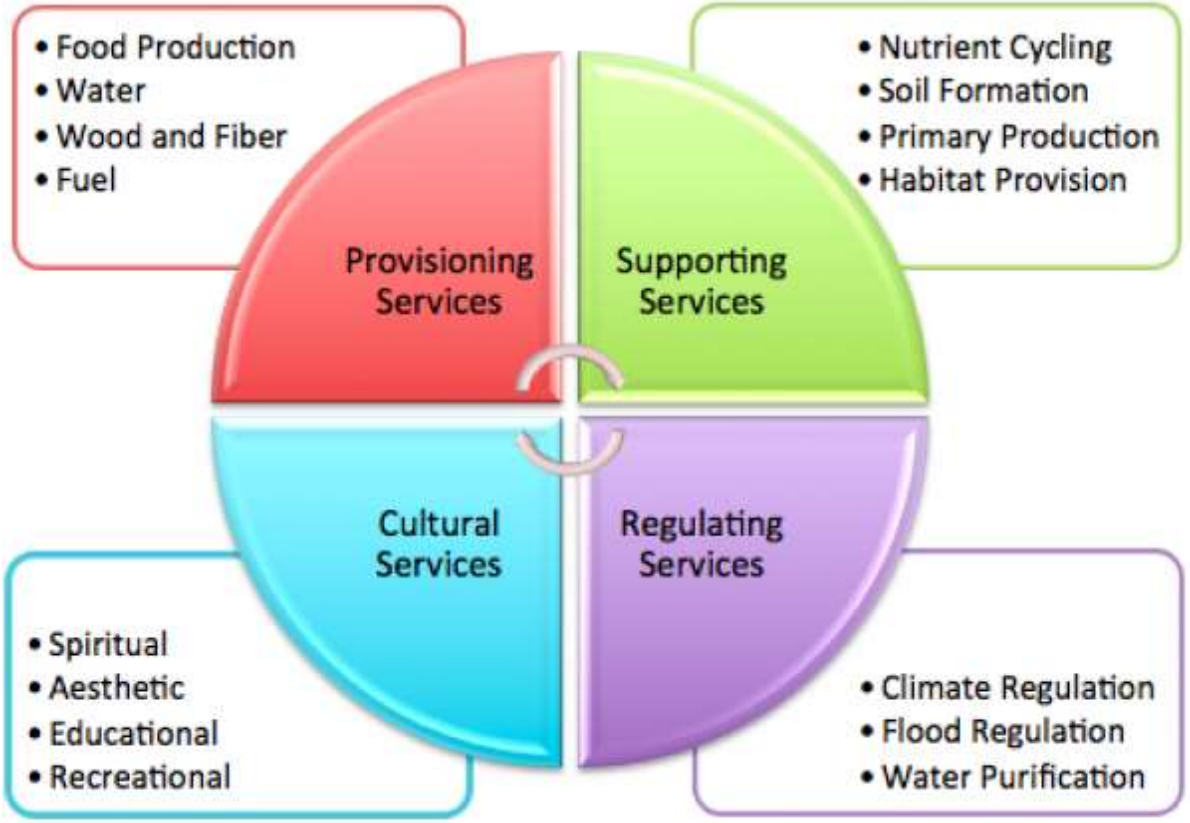
Peatland Ecosystem Services: Aesthetics & Function!

Chic décor & Moss powered electricity

Theoretically,
any plant could
be used, but Felder believes
moss is
“beautiful and undervalued,”

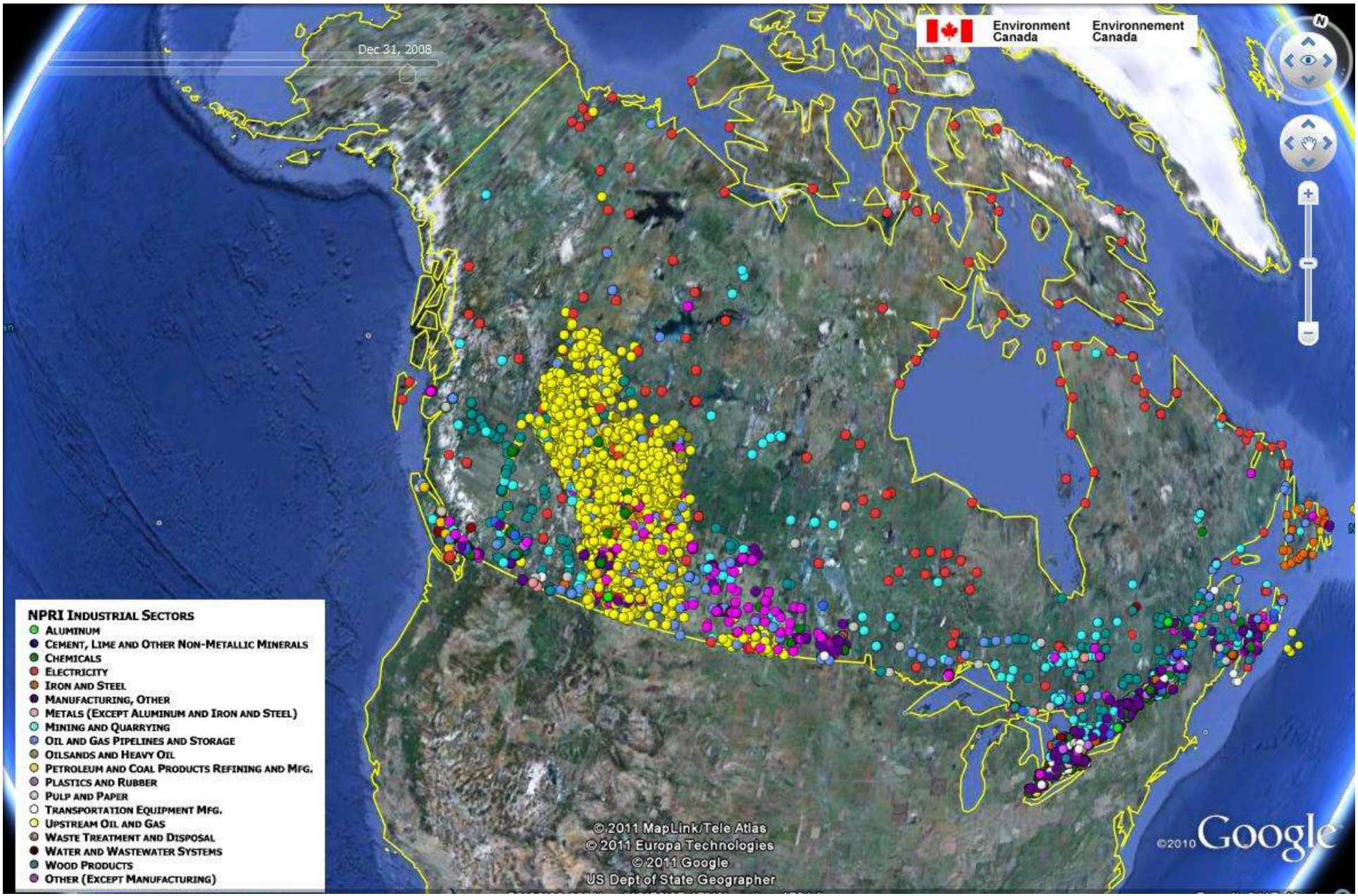
http://www.utne.com/

Peatland Ecosystem Services

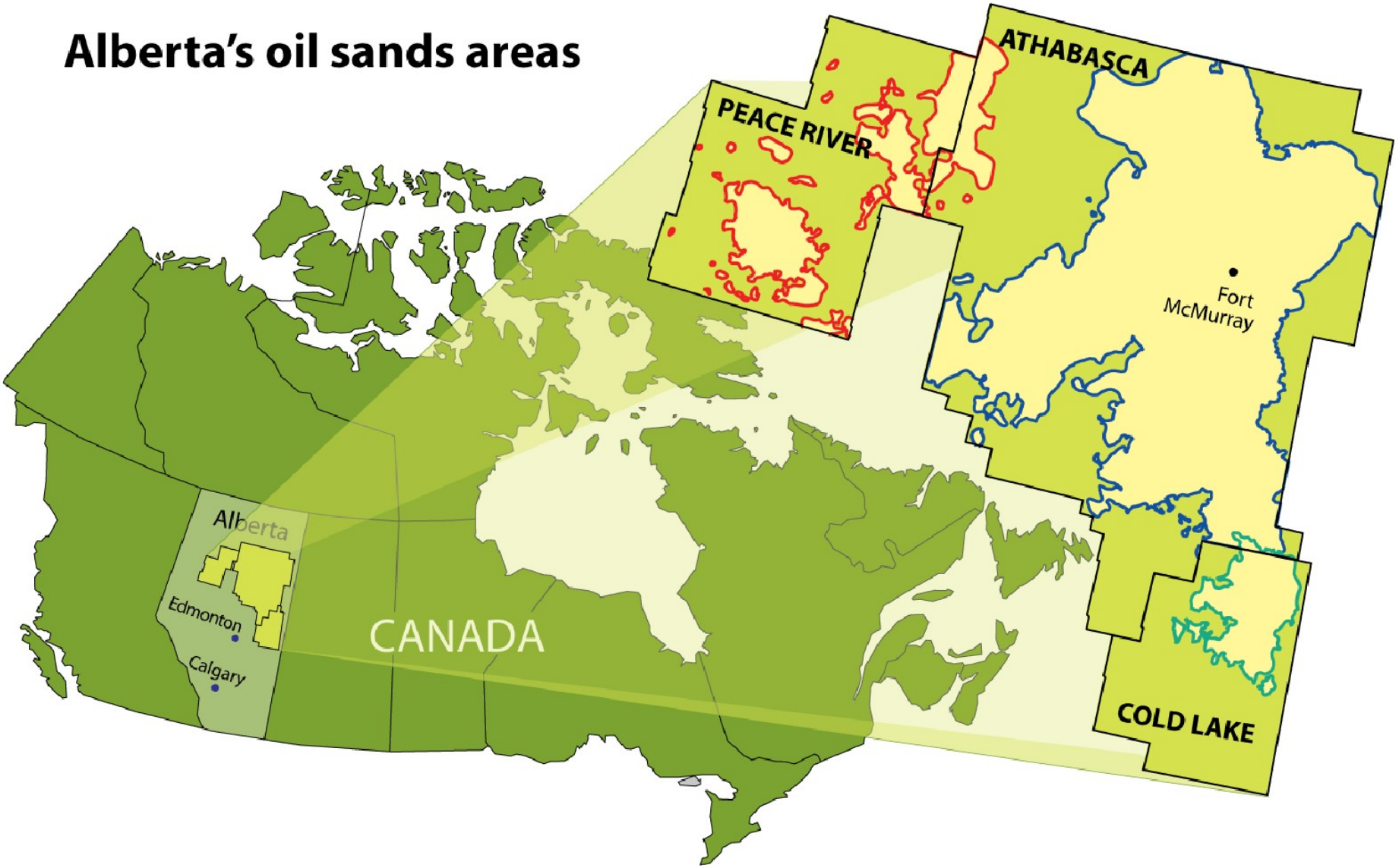


Source: Millenium Ecosystem Assessment, 2005.

Alberta: The Texas of Canada



Oil Sands Deposits in Alberta

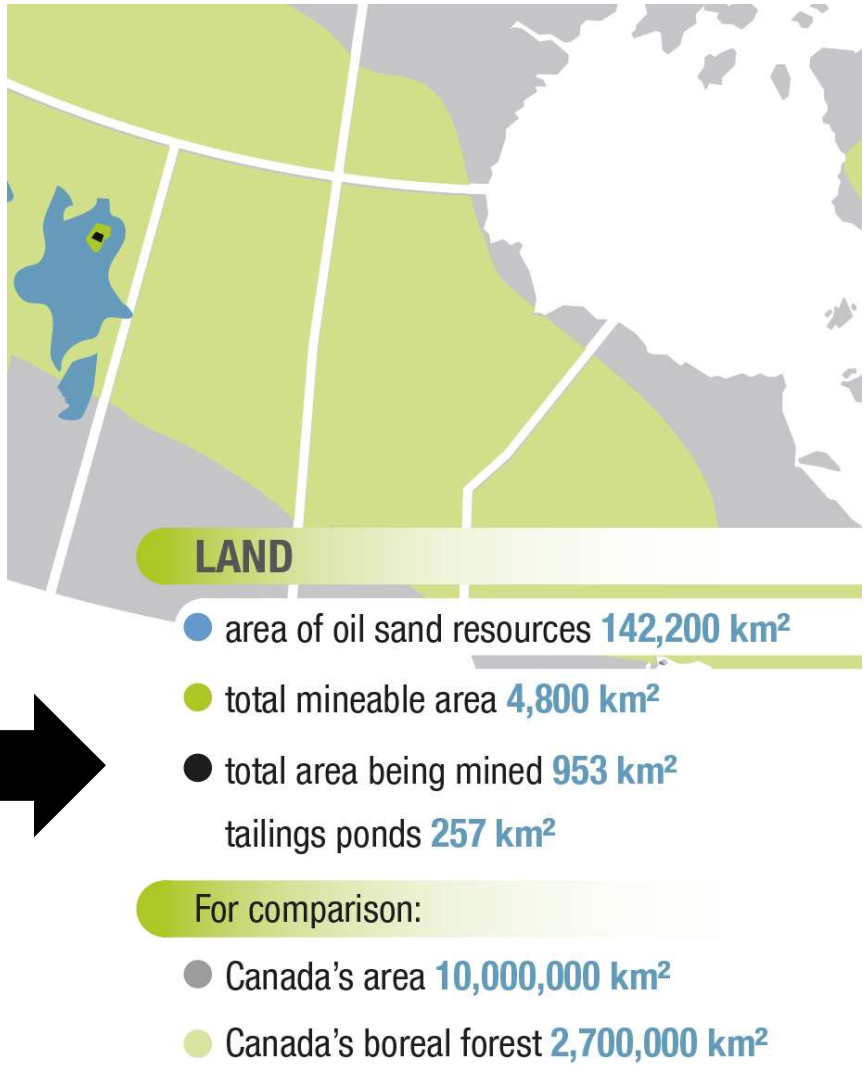


Oil Sands Deposits in Alberta

- In 2004 US oil imports from Canada surpassed imports from Saudi Arabia; 2009-Persian Gulf
- As of 2019, 98 % of our oil imports are from Canada
- Oil Sands→ 1.7 trillion barrels
  - Economically recoverable→ 178 Billion or 10%
  - Reserves - 3rd largest in World

Oil Sands Mining in Alberta

Roughly 3% of total land area has been mined



Oil Sands Development 1984-2021

1984

1994

2004

2014

Oil Sands Development 1984-2021

1984

1994

2004

2021

EROI of Oil Sands

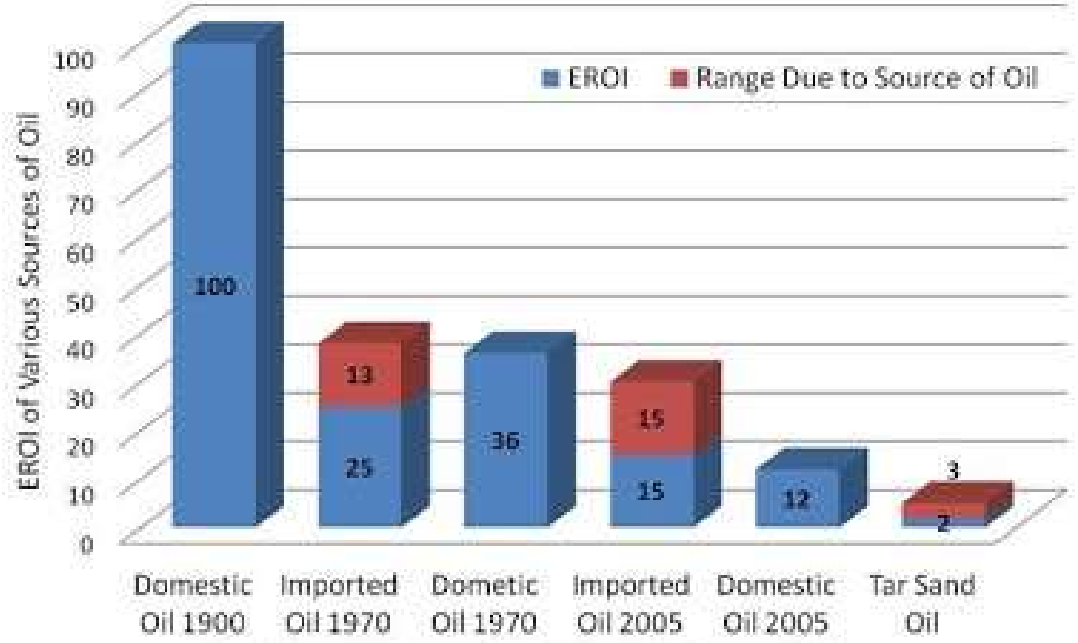


Fig. 1 Comparison of EROI from Various Oil Sources

Nitrogen Pollution: Heavy Haulers

Haul 400 tons, Height 7.6 m, Length 14.5 m, Fuel Capacity 7,000L, Cost: $5-6 million, Single Tire 4 m high & costs $35K

- More NOx from Trucks Than Stacks!

- Oil sands oil contains, on average, 6x more N than conventional oil

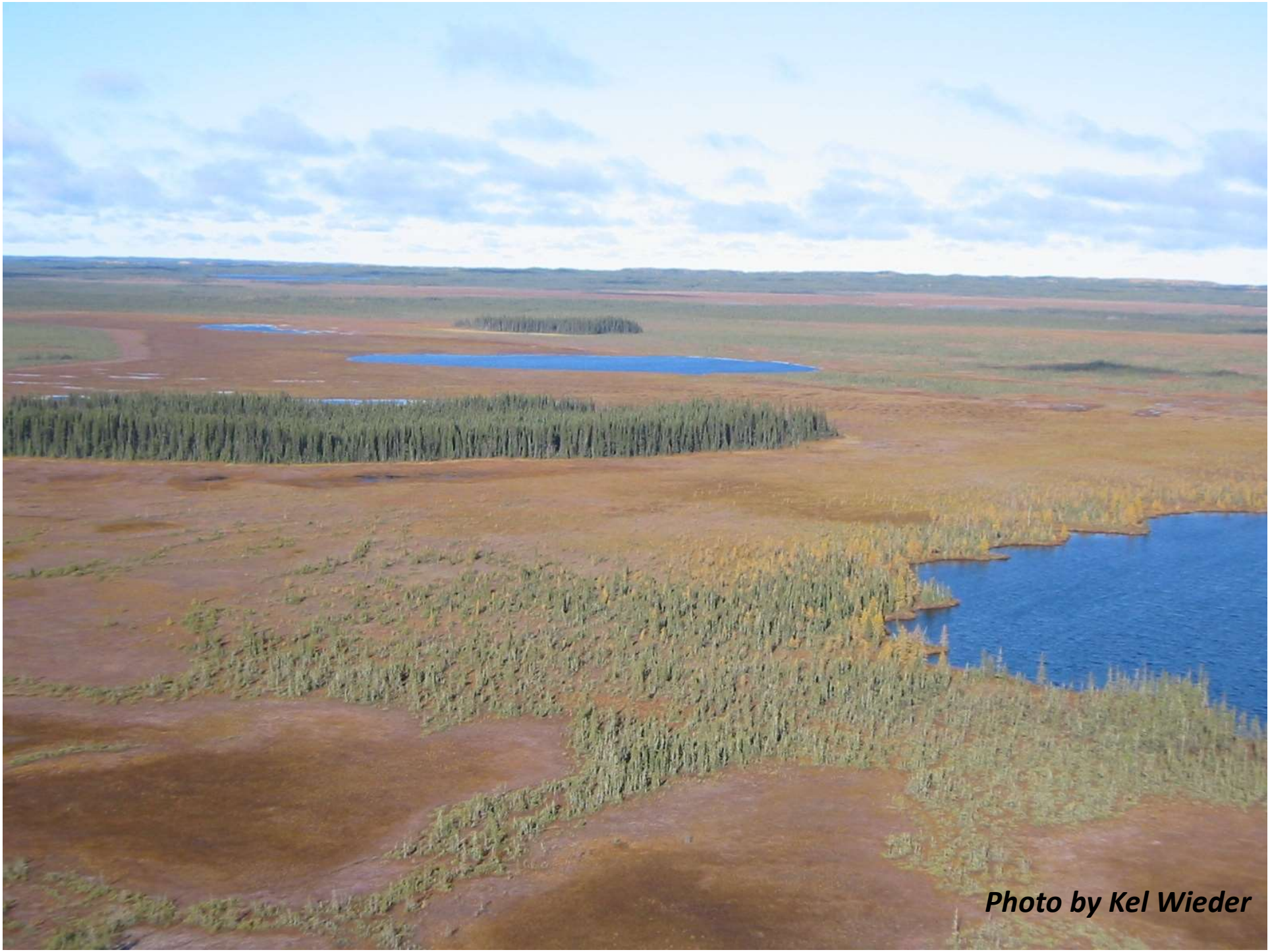


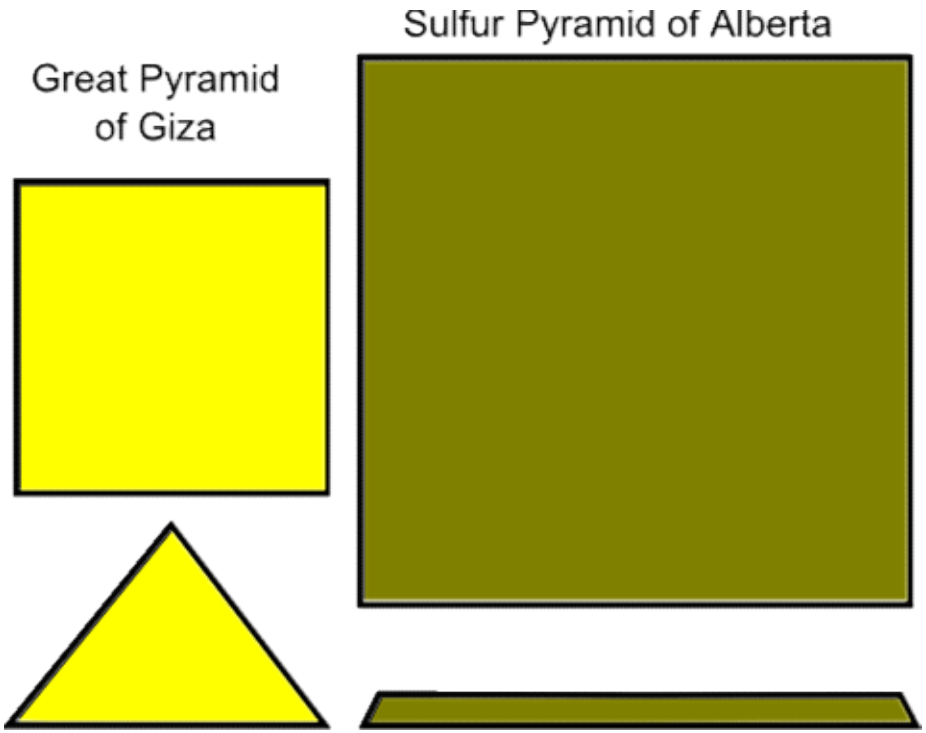
Photo by Kel Wieder


NO_x
SO_x

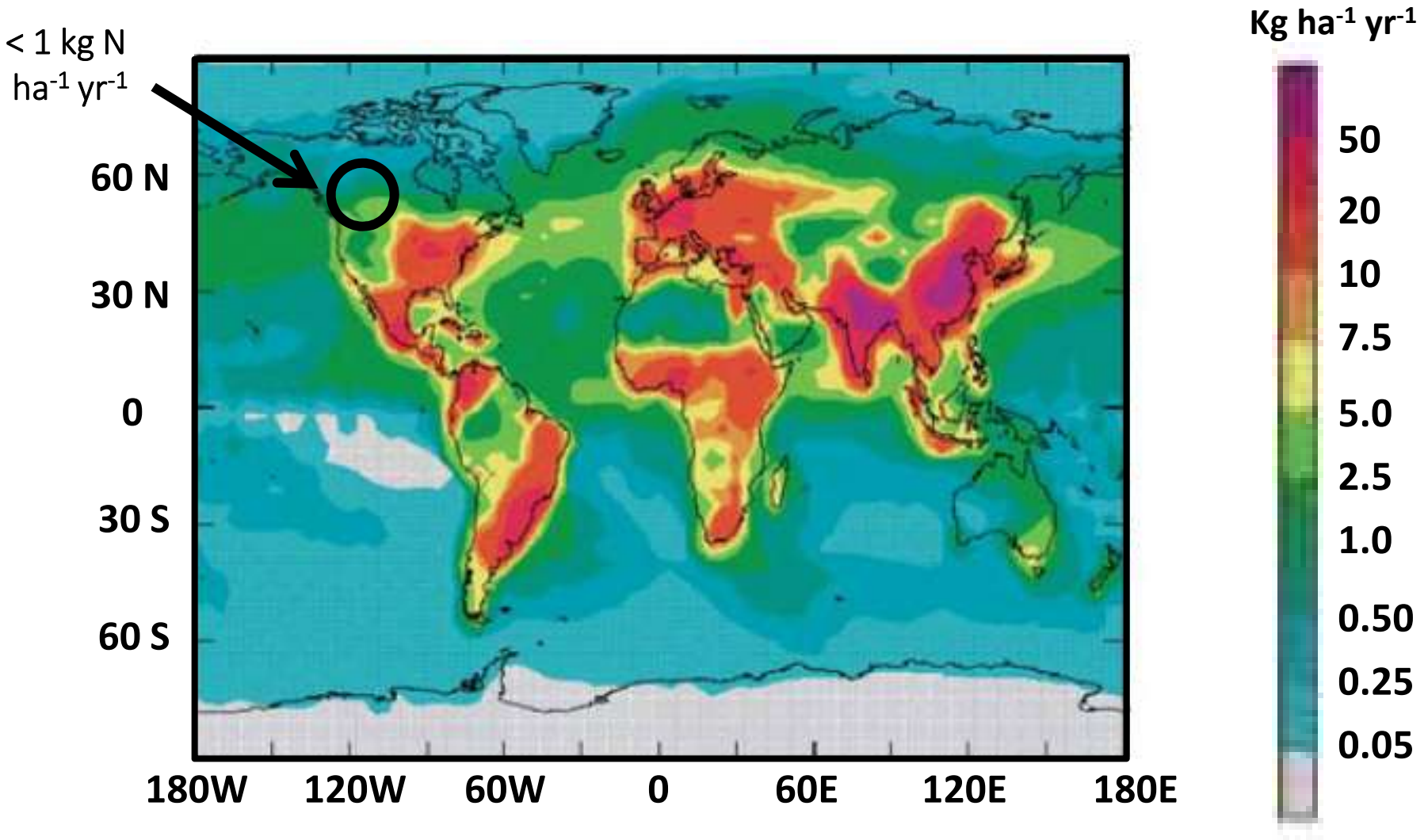
Sulfur Pyramids of Alberta

Sulfur Pyramids of Alberta

By Volume



Total Inorganic Nitrogen 1860, 1990's, & 2050



Galloway et al. 2004

Research Questions (2000 - present)

- Are peatlands of Alberta currently functioning as net sinks or net sources of atmospheric C?
- How does fire impact peatland C storage?
- How does drought stress impact carbon storage in peatlands?
- Can we use early warning indicator species for monitoring purposes?
- What are the interactive effects of fire and nitrogen pollution on peatland carbon stores?

Peatland Carbon Storage Methods

Peatland Carbon Storage: Results

- As of 2009, peatlands functioning as a net sink for atmospheric C

Postfire carbon balance in boreal bogs of Alberta, Canada

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Abstract

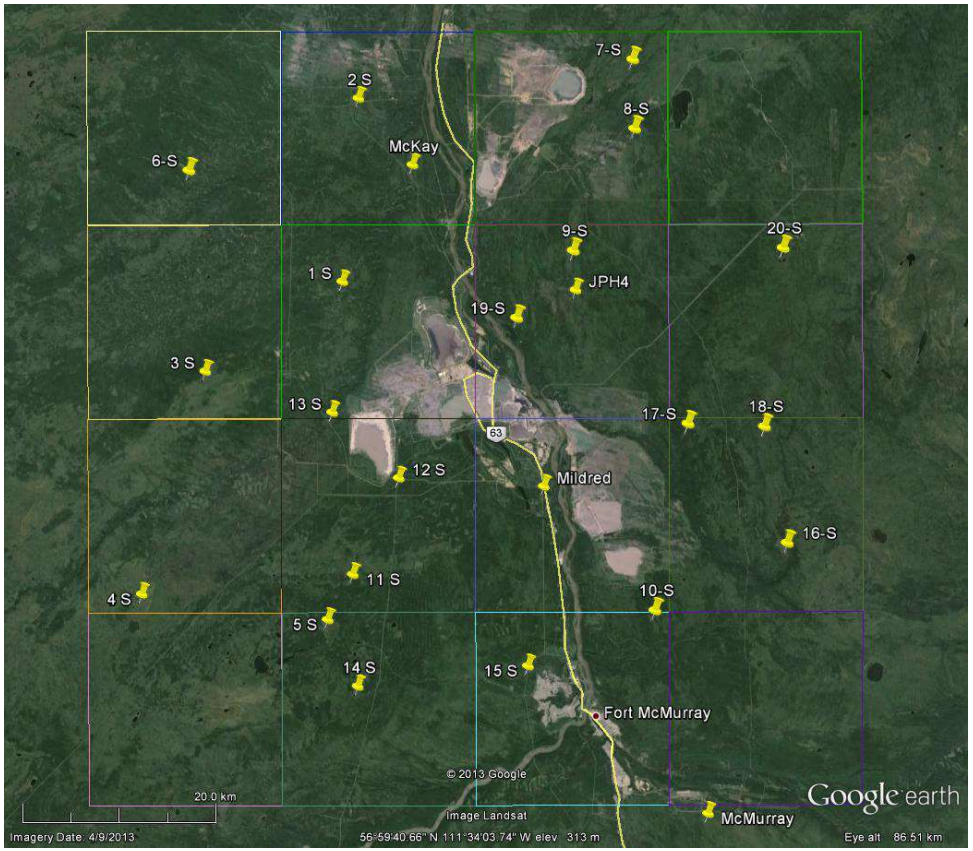
Boreal peatland ecosystems occupy about 3.5 million km^2 of the earth's land surface and store between 250 and 455 Pg of carbon (C) as peat. While northern hemisphere boreal peatlands have functioned as net sinks for atmospheric C since the most recent deglaciation, natural and anthropogenic disturbances, and most importantly wildfire, may compromise peatland C sinks. To examine the effects of fire on local and regional C sink strength, we focused on a 12 000 km^2 region near Wabasca, AB, Canada, where ombrotrophic *Sphagnum*-dominated bogs cover 2280 km^2 that burn with a fire return interval of 123 ± 26 years. We characterized annual C accumulation along a chronosequence of 10 bog sites, spanning 1–102 years-since-fire (in 2002). Immediately after fire, bogs represent a net C source of 8.9 ± 8.4 mol m^{-2} yr^{-1}. At about 13 years after fire, bogs switch from net C sources to net C sinks, mainly because of recovery of the moss and shrub layers. Subsequently, black spruce biomass accumulation contributes to the net C sink, with fine root biomass accumulation peaking at 34 years after fire and aboveground biomass and coarse root accumulation peaking at 74 years after fire. The overall C sink strength peaks at 18.4 mol C m^{-2} yr^{-1} at 75 years after fire. As the tree biomass accumulation rate declines, the net C sink decreases to about 10 mol C m^{-2} yr^{-1} at 100 years-since-fire. We estimate that across the Wabasca study region, bogs currently represent a C sink of 14.7 ± 5.1 Gmol yr^{-1}. A decrease in the fire return interval to 61 years with no change in air temperature would convert the region's bogs to a net C source. An increase in nonwinter air temperature of 2 °C would decrease the regional C sink to 6.8 ± 2.3 Gmol yr^{-1}. Under scenarios of predicted climate change, the current C sink status of Alberta bogs is likely to diminish to the point where these peatlands become net sources of atmospheric CO_2-C.

- BUT→ changes in fire frequency with no change in air temperature would convert peatlands to a net source of C

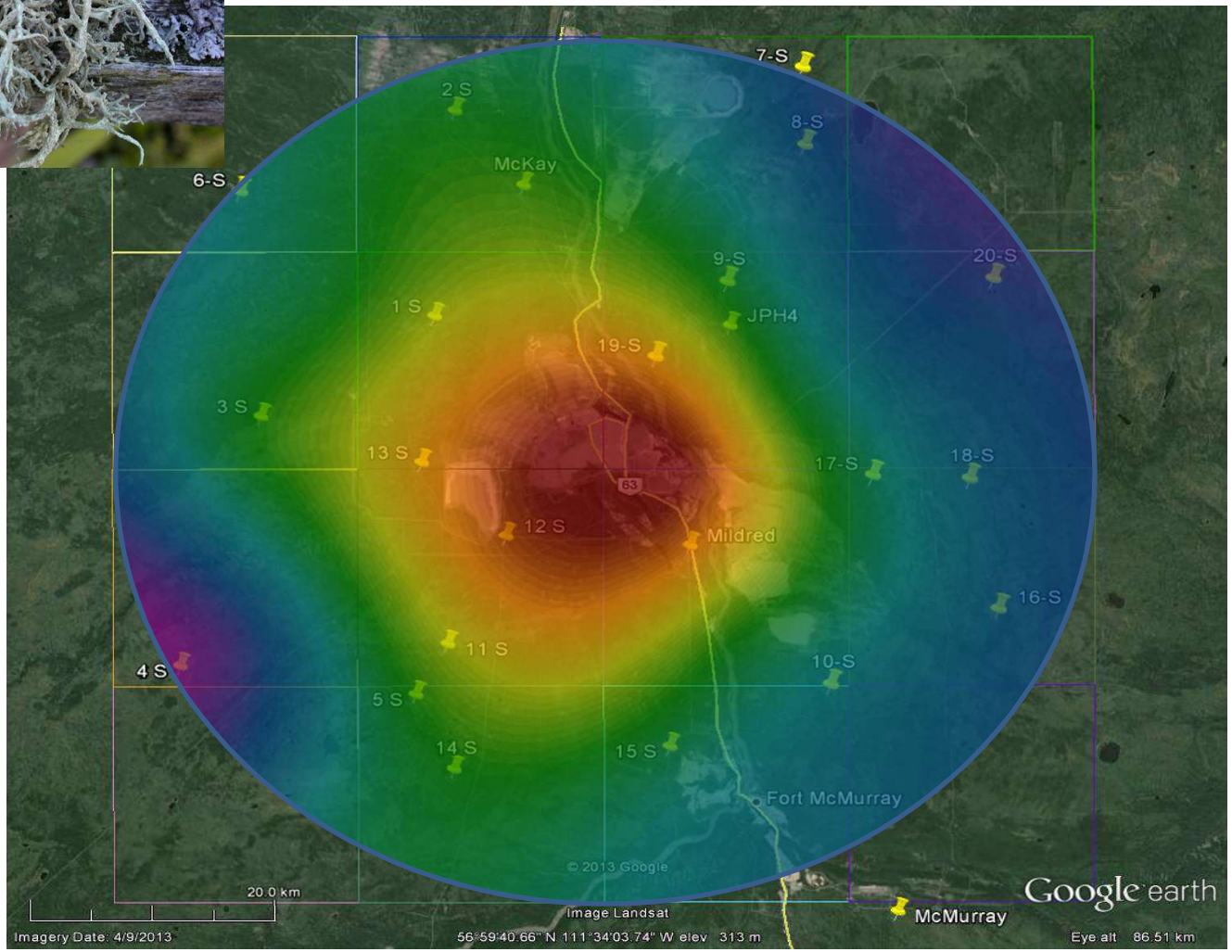
- AND → an increase in nonwinter air temperature of 2 °C would decrease the regional C sink by 37 %

Early Warning Indicator Species

synoptic survey



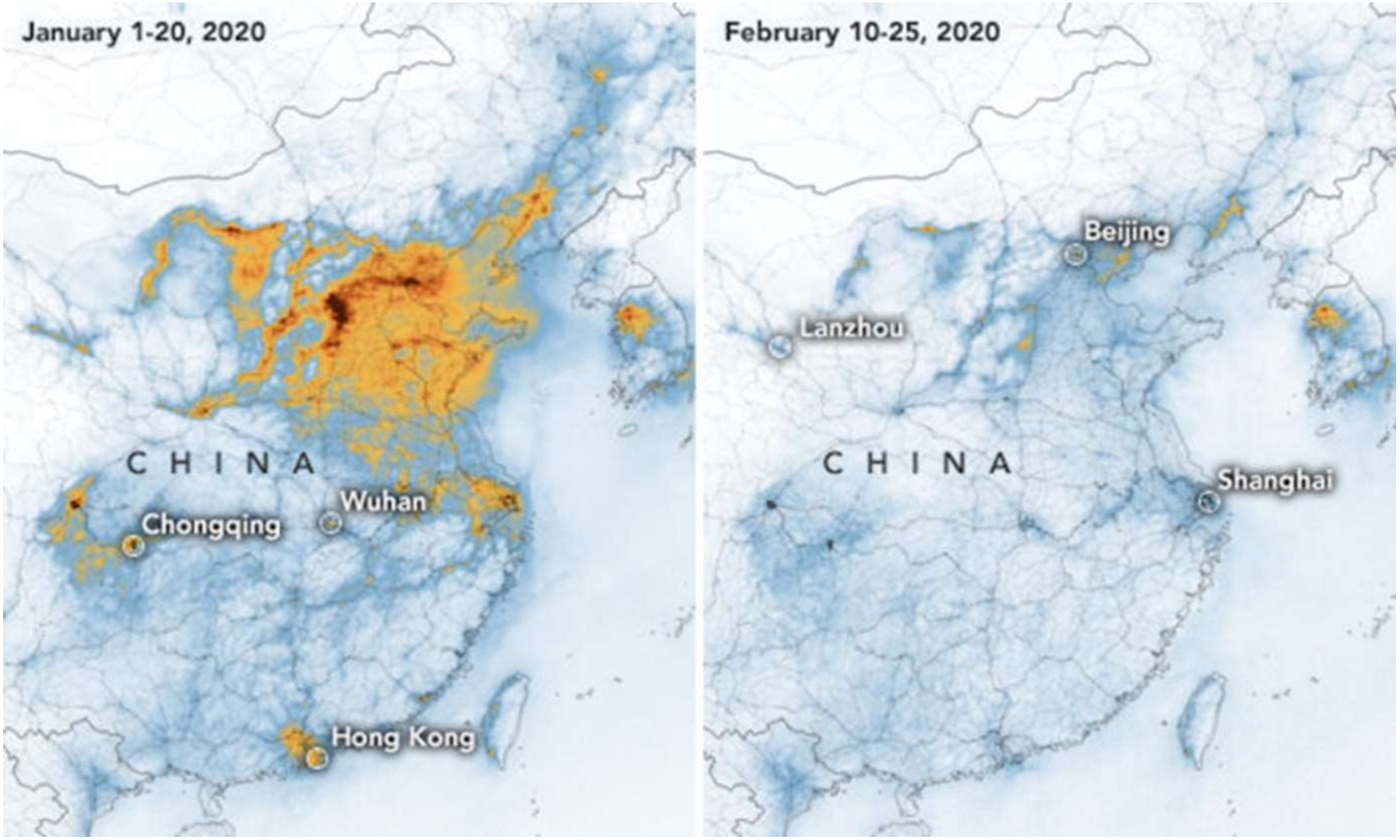
Early Warning Indicator Species synoptic survey-*Evernia m.*



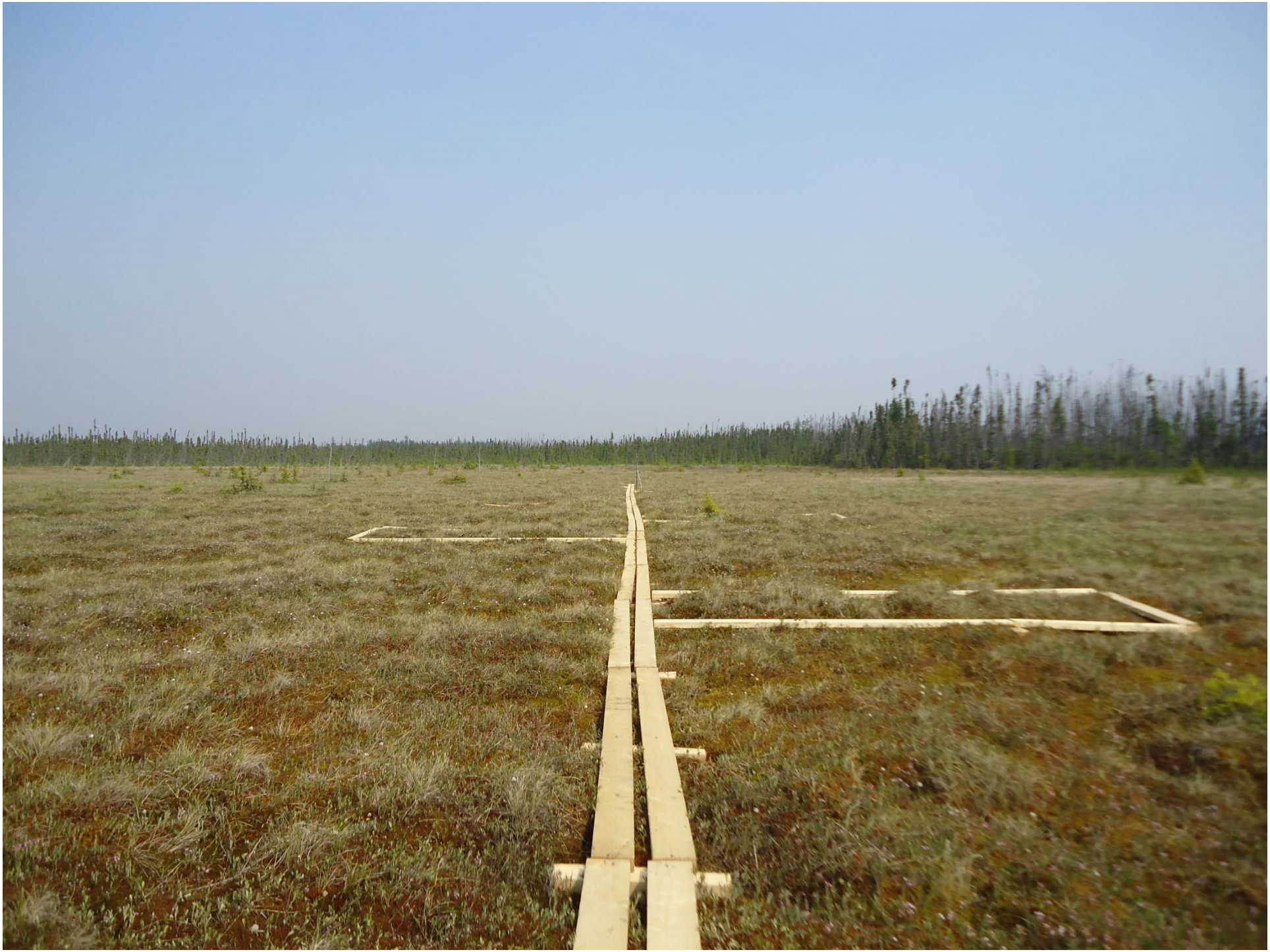
Evernia mesomorpha **N conc. (mg/g)**

- 4.5-4.9
- 5.0-5.4
- 5.5-5.9
- 6.0-6.4
- 6.5-6.9
- 7.0-7.4
- 7.5-7.9
- 8.0-8.4
- 8.5-8.9
- 9.0-9.4
- 9.5-9.9
- 10.0-10.4
- ≥10.5

N Pollution in China During the COVID-19 Pandemic



Interactive Effects of Fire and N Deposition

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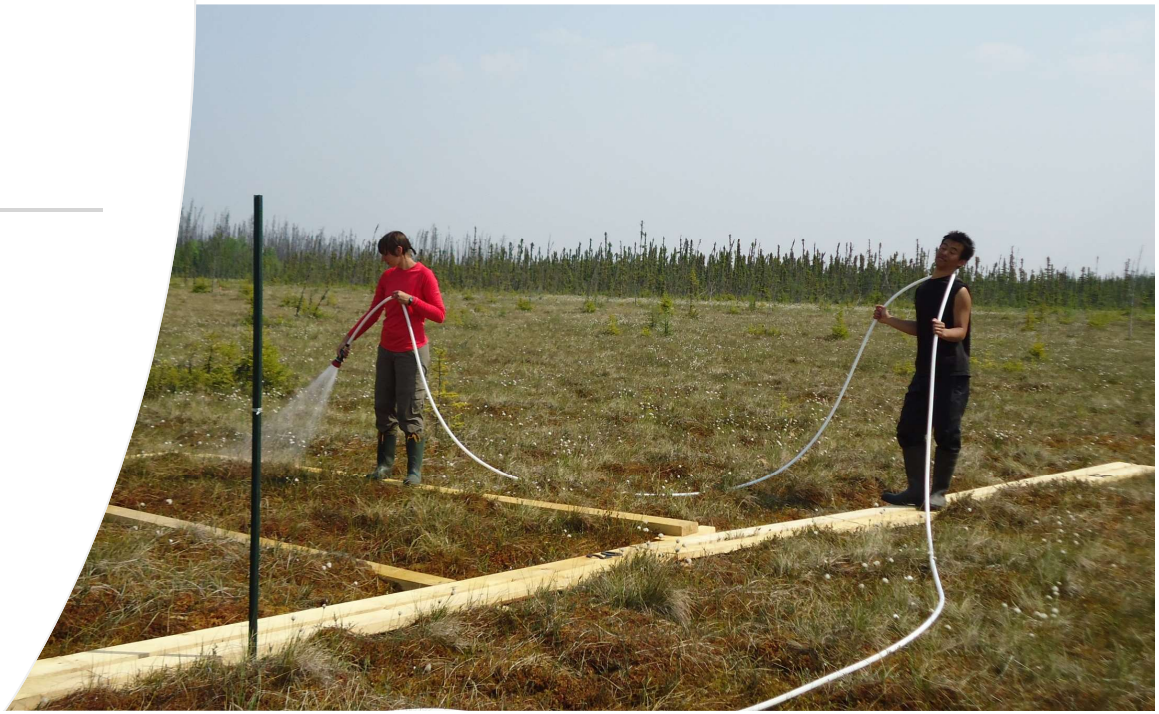
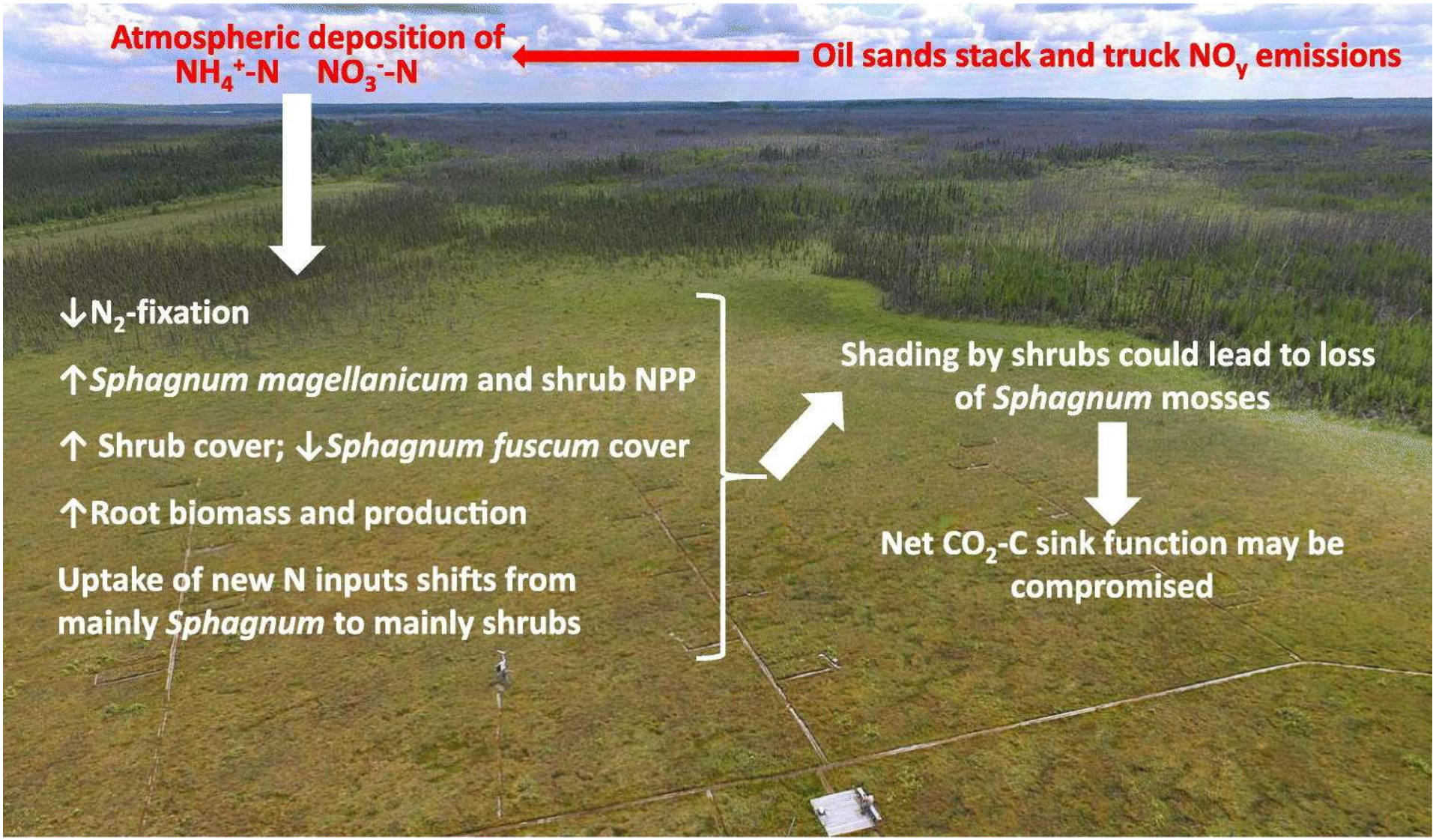
25

N Fertilization in the Bog

N Fertilization in the Fen



Nitrogen Pollution Results



WBEA

CEMA

NSF

Alberta Environment and Parks


MORDOR
TAR SANDS
Any questions?