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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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$^2$

Russia  Canada  USA  Finland  Sweden

Surface Area (km$^2$)

Boreal Peats ~ 87%
Boreal Canada Peatland Cover

Total peatland area = 365,160 km$^2$

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

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!

**Boreal Zone**
Mean annual temp 1-3\(^\circ\) C
fewer than 120 days
mean daily temp >10\(^\circ\) C

**Tropical Zone**
Mean annual temp 20-30\(^\circ\) C
The entire year!

_Boreas, Greek God of the North Wind_
Peatland Ground Cover is Moss Dominated

*Sphagnum* growth

2019→

2020→

2021→

2cm
Sophisticated Sampling Equipment

- Rubber mallot
- Bread knife
- PVC
Peatland Ground Cover is Moss Dominated

*Sphagnum* growth

2019→

2020→

2021→
Peatland Ecosystem Services

Provisioning Services
- Food Production
- Water
- Wood and Fiber
- Fuel

Supporting Services
- Nutrient Cycling
- Soil Formation
- Primary Production
- Habitat Provision

Cultural Services
- Spiritual
- Aesthetic
- Educational
- Recreational

Regulating Services
- Climate Regulation
- Flood Regulation
- Water Purification

Source: Millenium Ecosystem Assessment, 2005.
Peatland Provisioning Ecosystem Services
Peatland Provisioning Ecosystem Services: First Nation Peoples
Peatland Supporting & Regulating Ecosystem Services

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Source: Millennium 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

Photosynthesis (NPP) exceeds decomposition

Peat
7-10,000 yrs
2.0-9.0 m
Peatland Cultural Ecosystem Services

Source: Millennium 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

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Source: Millennium Ecosystem Assessment, 2005.
Alberta: The Texas of Canada
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
Oil Sands Development 1984-2021
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
Total disturbance in 2002: 155,162 ha


Land Disturbance by The Alberta Oil Industry 2002 was 708 km

Photo by Kel Wieder
Sulfur Pyramids of Alberta
Sulfur Pyramids of Alberta

By Volume
Total Inorganic Nitrogen 1860, 1990’s, & 2050

< 1 kg N ha\(^{-1}\) yr\(^{-1}\)

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
As of 2009, peatlands functioning as a net sink for atmospheric 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.
N Pollution in China During the COVID-19 Pandemic
Interactive Effects of Fire and N Deposition
Nitrogen Pollution Results

Atmospheric deposition of $\text{NH}_4^+ - \text{N}$ $\text{NO}_3^- - \text{N}$

Oil sands stack and truck $\text{NO}_y$ emissions

$\downarrow \text{N}_2$-fixation

$\uparrow \text{Sphagnum magellanicum}$ and shrub NPP

$\uparrow$ Shrub cover; $\downarrow \text{Sphagnum fuscum}$ cover

$\uparrow$ Root biomass and production

Uptake of new N inputs shifts from mainly Sphagnum to mainly shrubs

Shading by shrubs could lead to loss of Sphagnum mosses

Net CO$_2$-C sink function may be compromised
MORDOR	TAR SANDS
Any questions?