Alberta Peatlands: A Valued Resource under Stress

Kel Wieder, Villanova University

Land Acknowledgment

Our research group would like to acknowledge the traditional, ancestral, unceded territories of the Cree, Denendeh (Dënësųłinë Nëné), Michif Piyii (Métis), Beaver, Beaver Lake Cree, Bigstone Cree, and Woodland Cree First Nations on which our bog and fen field sites lie (Native-land.ca). As researchers, we often refer to field sites as "ours," but we are ever vigilant that we are but transient and humble visitors to these lands. Further, we acknowledge the systems of oppression that historically have dispossessed Indigenous people of their lands and rights. Bogs and fens on these lands are now subject to two substantial anthropogenic threats, climate change and oil sands development, the central foci of our research. We view our research as relevant beyond western science, with economic, social and environmental justice implications. We are committed to listening to and learning from First Nations communities and to sharing our findings.

Alberta Wilderness Association
15 March 2022

Outline for Today:

- Peatlands 101
- Wildfire and the Peatland CO_2-C Sink
- Oil Sands Development - Implications

WBEA

2009-2012 (Intensive Monitoring)

2013 (Synoptic Survey)

CEMA

2005-2006

2011-2016

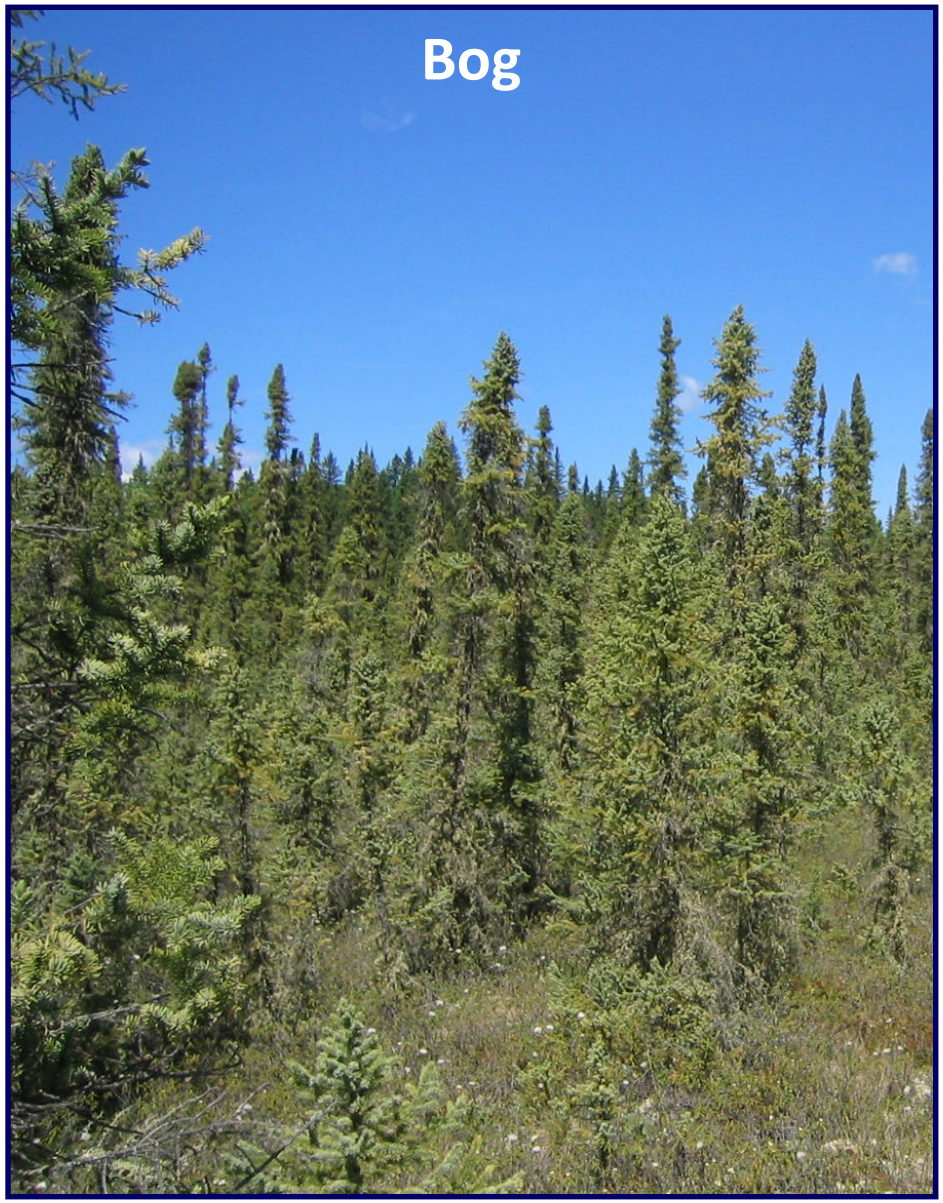
NSF

2011-2016

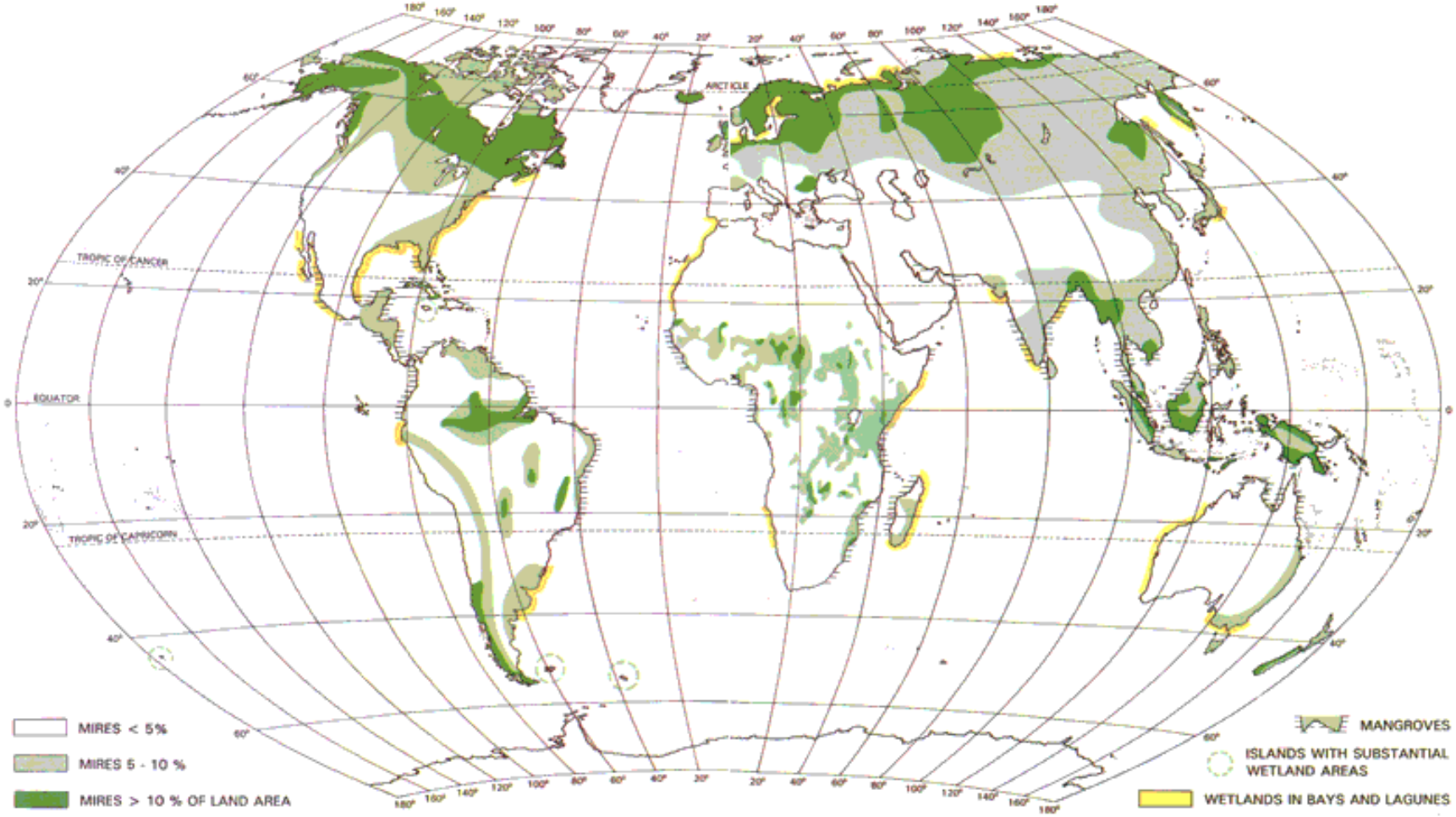
Alberta

2017-2020

Peatlands: Bogs vs. Fens

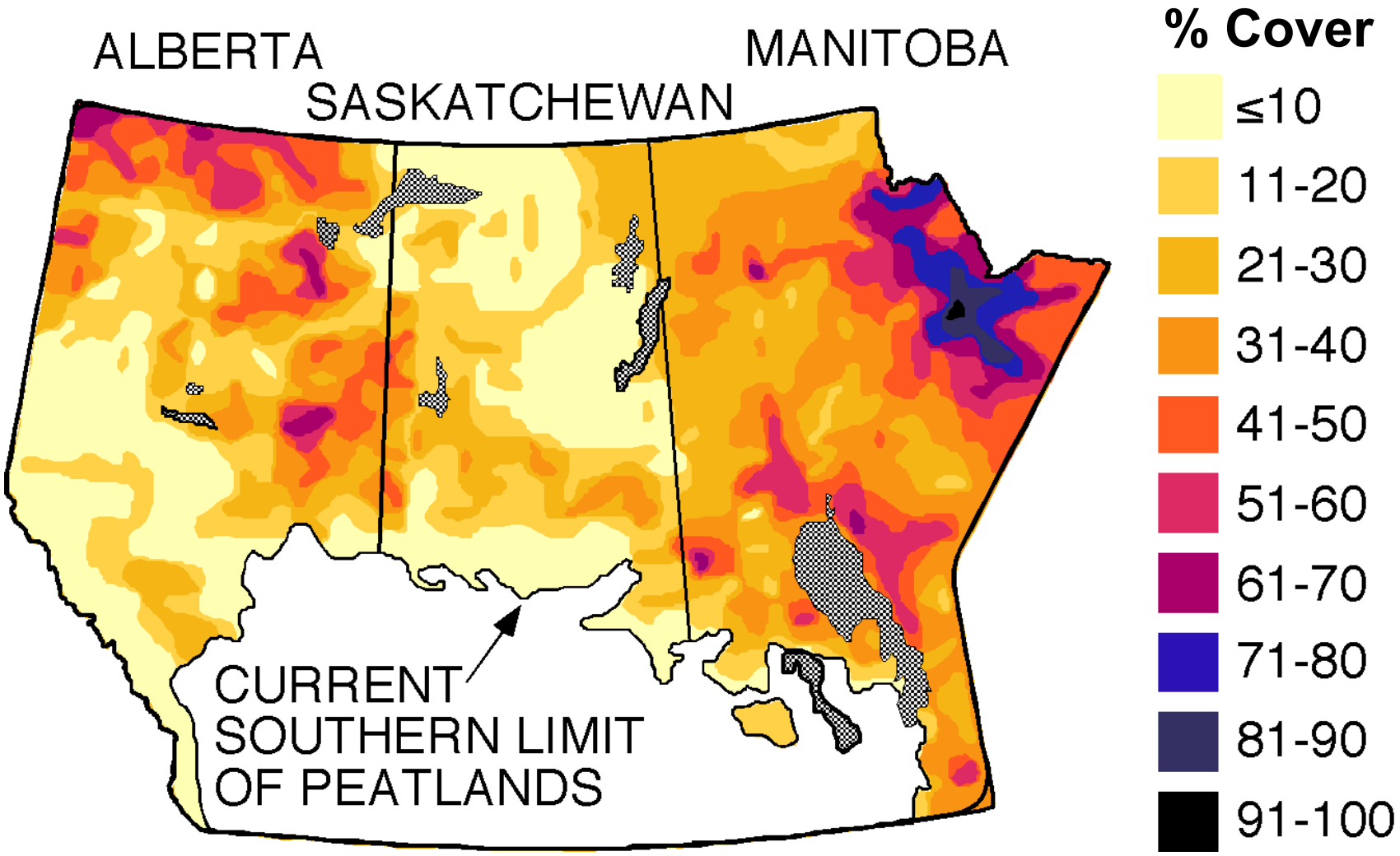


Where are Peatlands Globally?



Global Peatland Distribution
Gore, A.J.P. (1983) Ecosystems of the World 4A: Mires, Swamp, Bog, Fen and Moor: General Studies. Elsevier

Peatland Distribution



Total peatland area = *365,160 km²*

Area of Alberta = 661,848 km²

Vitt et al. (2000)

Global Carbon Pools (Pg of C; 1 Pg = 10^{15} g)

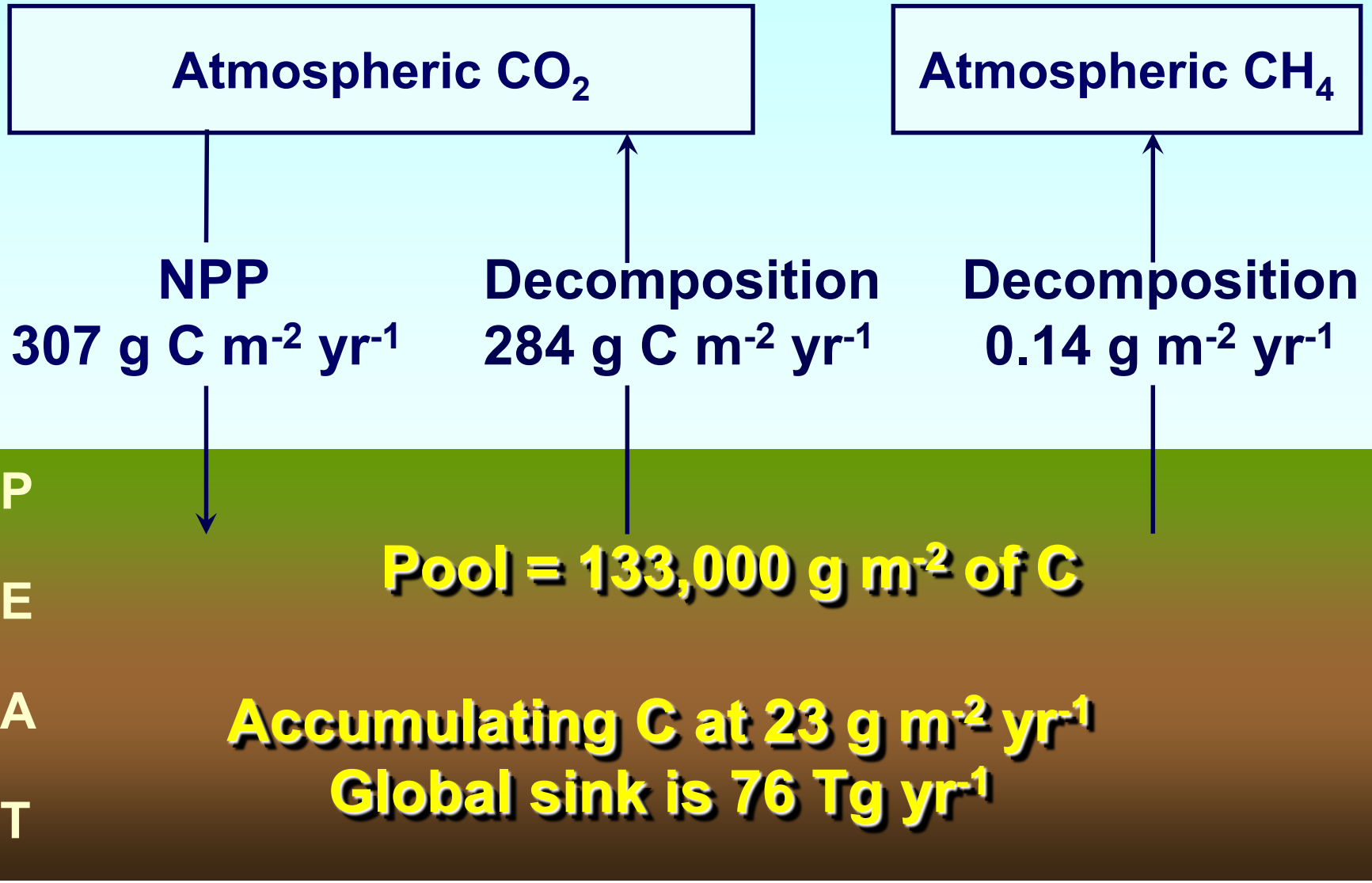
Atmosphere	720	750+	820	860 (in 2021)
Land plants	560			
Non-peatland soils	670			
Peatland soils	455	2000	2000	290 - 455
Boreal forest and tundra soils	375			
Oceans	38,000	40,000	40,000 deep 800 surface	
Coal, oil, gas			10,000	

From: Gorham (1991), Schlesinger (1991)

From: http://www.whrc.org/carbon/ - 2004

From: - http://cdiac.esd.ornl.gov/carbon_cycle.html - 2007

The Average Global m^2 of Peat Today



From Gorham (1990,1991,1995)

Fire in the Boreal Forest

https://brighterworld.mcmaster.ca/articles/peatlands-pose-complex-wildfire-risk/

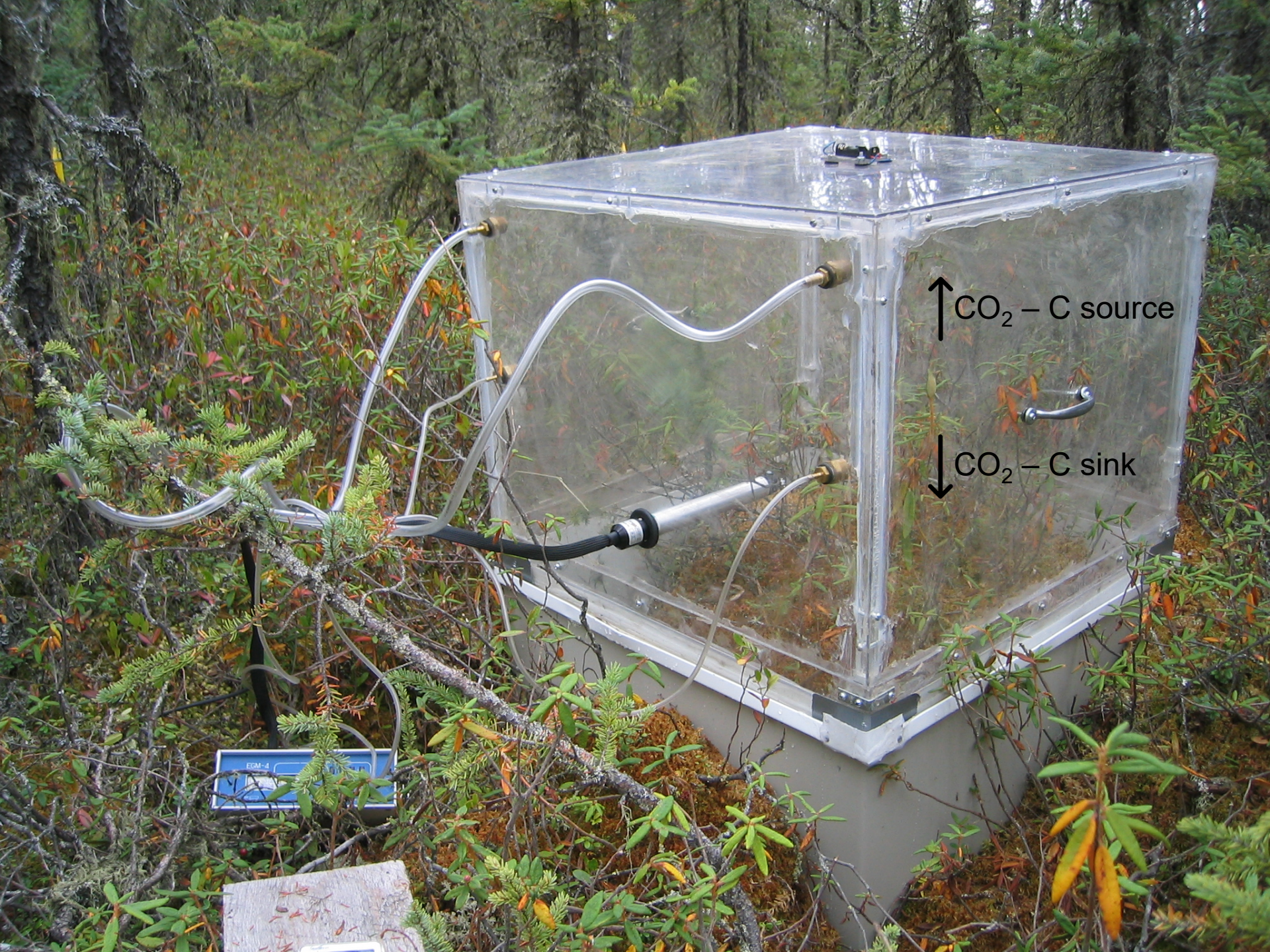

How does C cycling change after fire, especially with regard to
CO_2-C source/sink relationships?

Chronosequence Approach

10 peatland sites, from 1 to 102 years since fire
All bogs in Alberta reasonably accessible by road

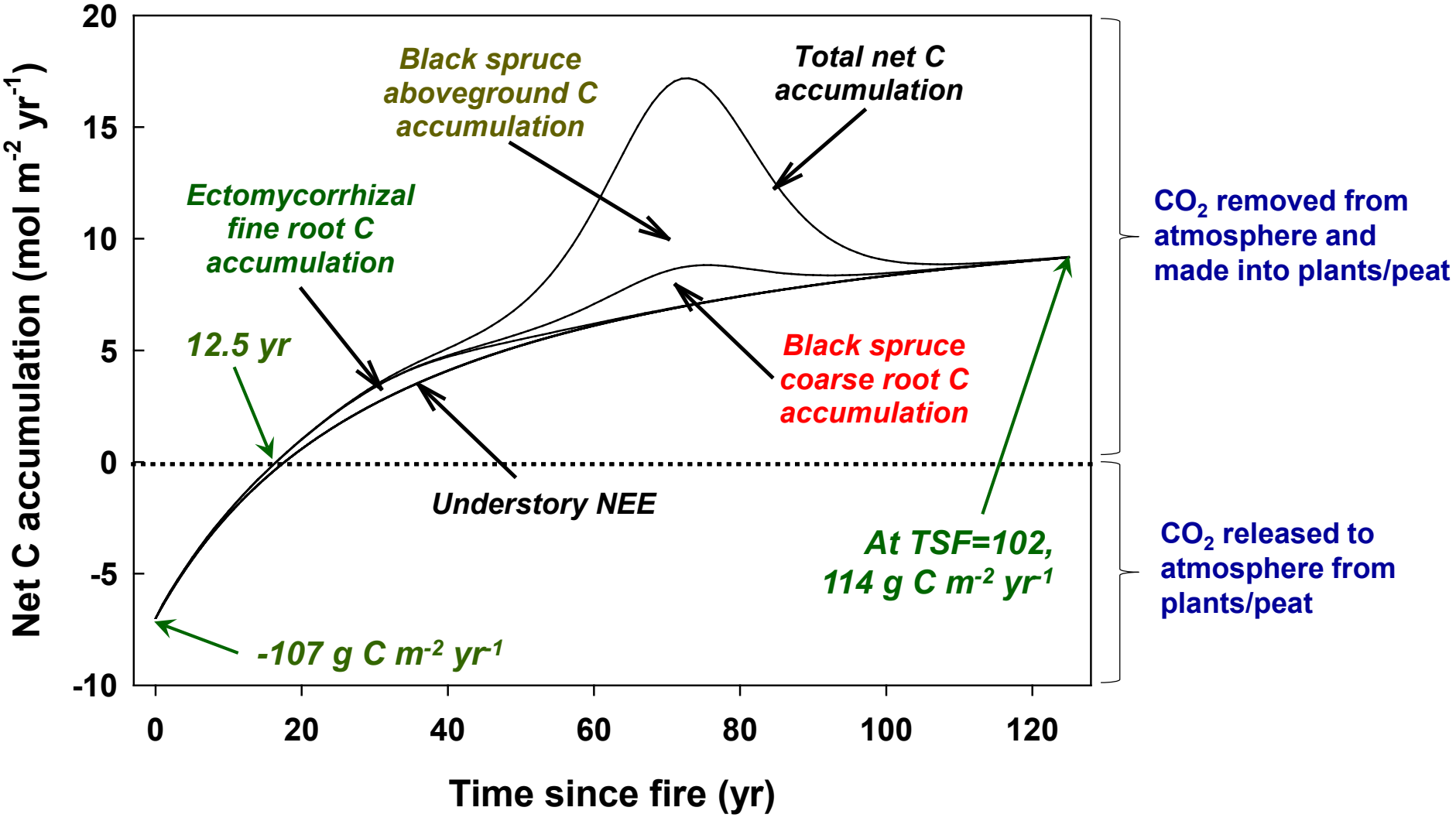
Measure/characterize:

- ***Sphagnum* NPP**
- **Shrub and tree NPP**
- **Decomposition**
- **Vegetation composition**
- **Surface water pH and chemical composition**
- **Water table depth**
- **Peat depth**
- **Peat/air temperature**
- **CO_2 fluxes using the closed chamber technique**


CO_2 – C source
CO_2 – C sink


CALIFORNIA INNOVATIONS

Regional Bog C Sink

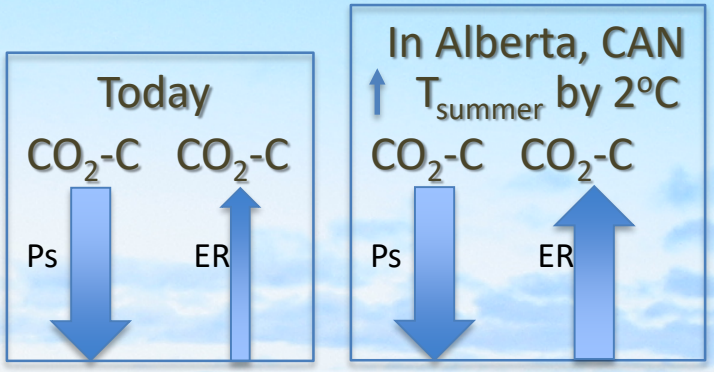


Average Alberta bog C sink is (77 g m^{-2} yr^{-1})

Wieder et al. 2009, Global Change Biology

Summary

860 Pg C as CO_2-C
415.95 ppm on January 25, 2021 at Mauna Loa
419.19 ppm on January 25, 2022 at Mauna Loa



290-455 Pg C globally as peat

Ps = Gross photosynthesis
ER = Ecosystem respiration
= Plant respiration + heterotroph respiration

OR

3% of Earth's land area;
30% of earth's soil C

Decrease in fire return interval from 123 yr to 61 yr results in loss of regional C sink

Class of 100 students (world soil C) with $1,000 total
3 students (peat people) $100 each
97 students (mineral soil people) with $7.22 each

Global Change Biology (2009) **15**, 63–81, doi: 10.1111/j.1365-2486.2008.01756.x

Postfire carbon balance in boreal bogs of Alberta, Canada

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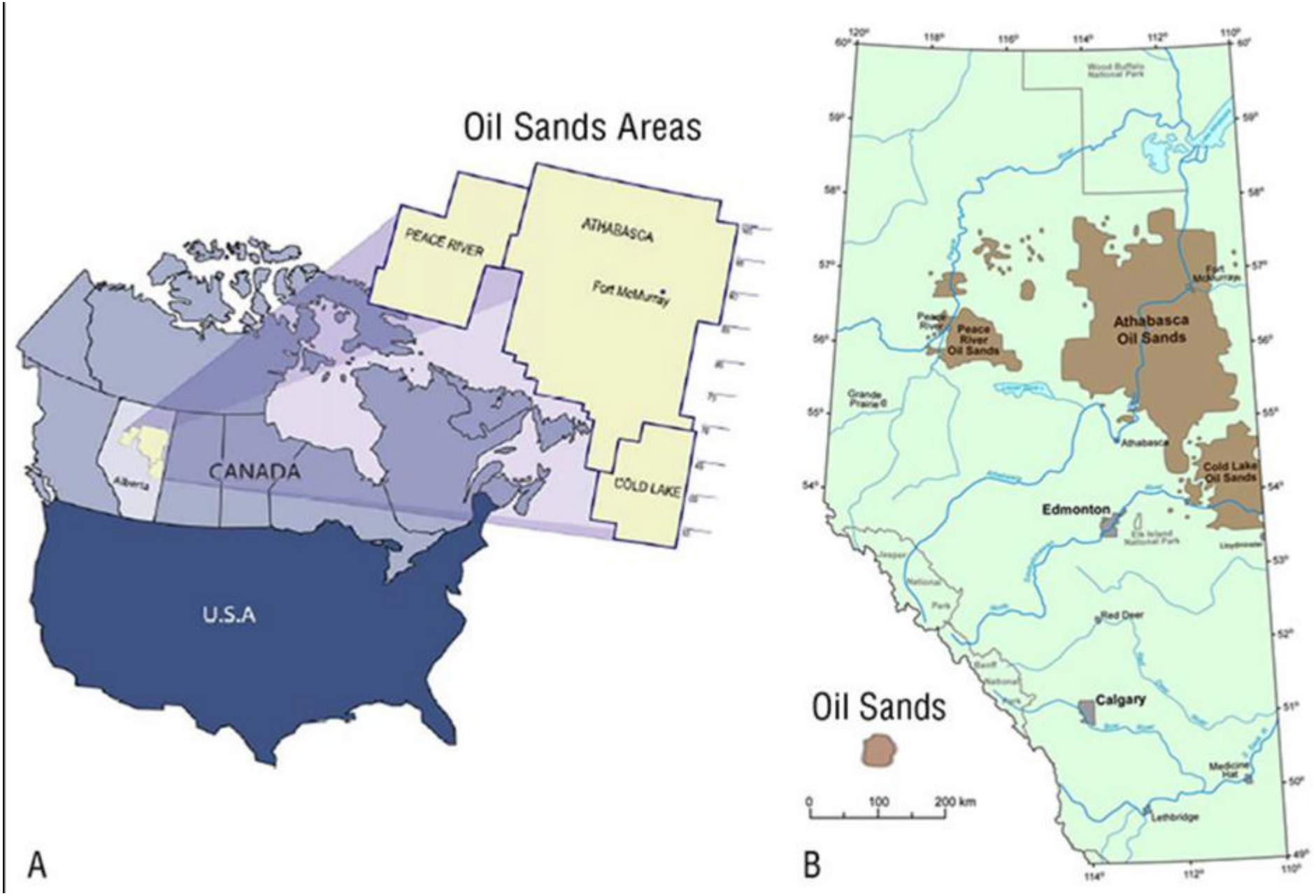
Photos by Kim Scott

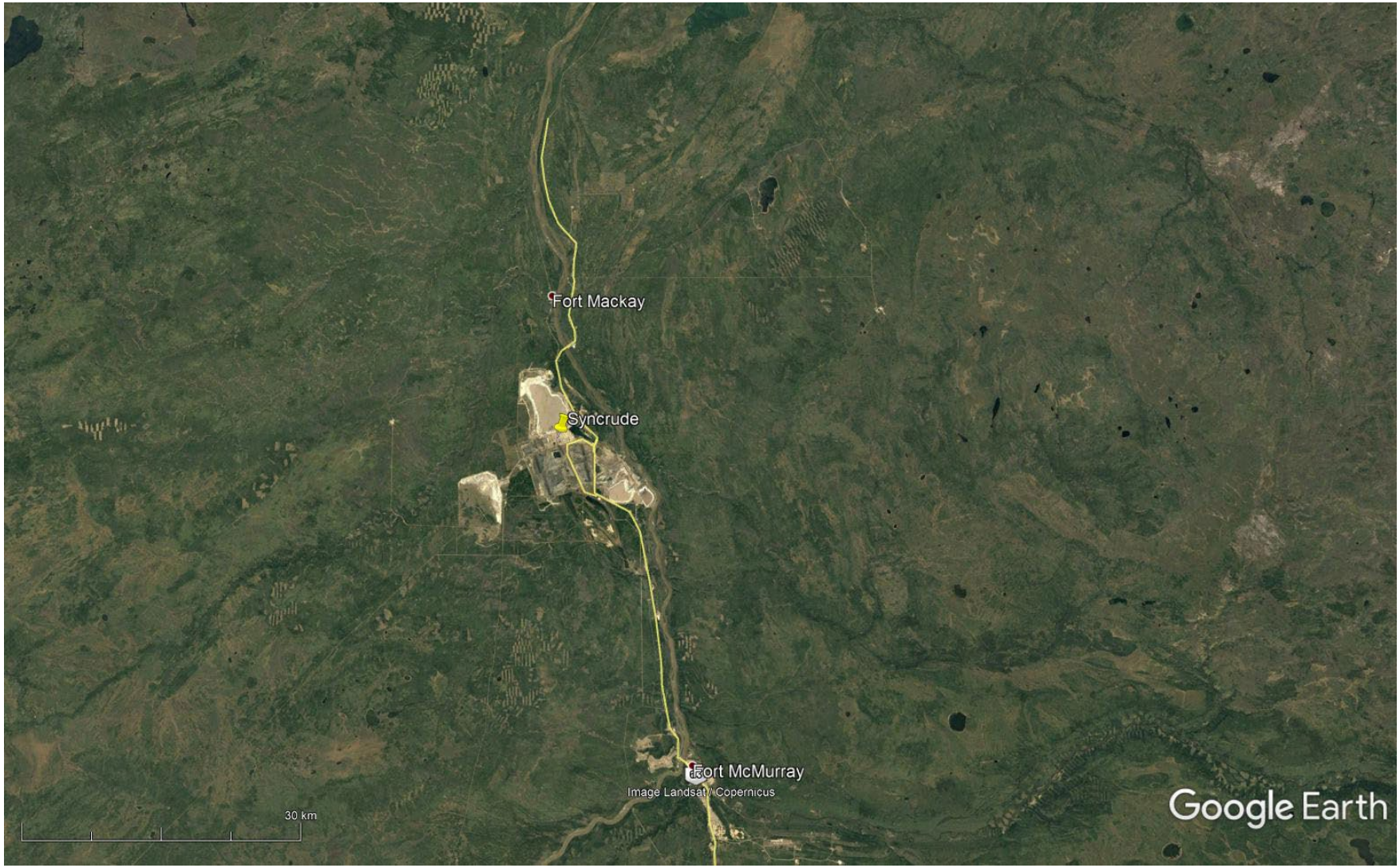


https://explorer.aapg.org/story/articleid/46497/oil-sands-tapped-as-major-resource

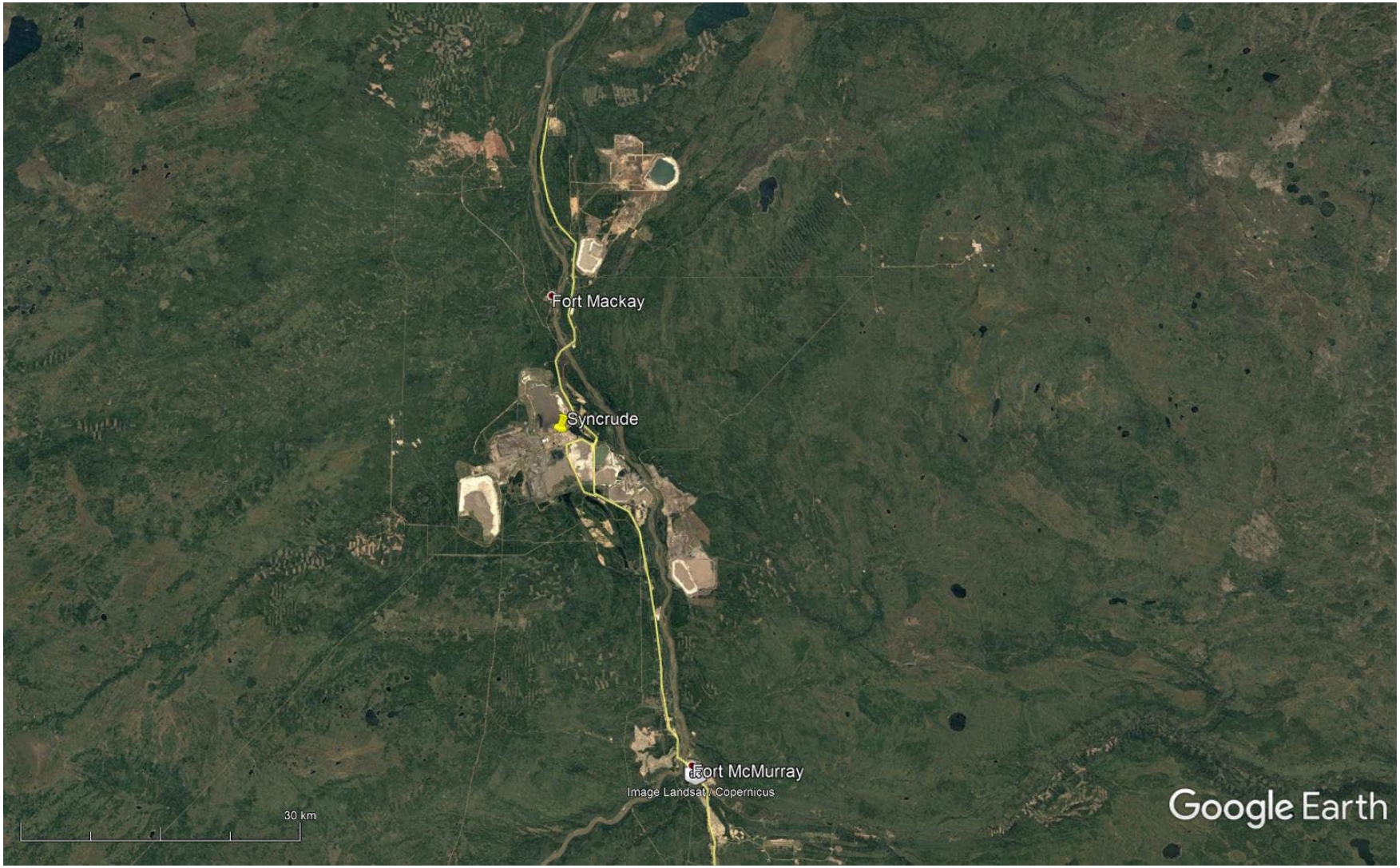
1984


Fort Mackay
Syncrude
First bridge across Athabasca River completed in 1965
Fort McMurray
Image Landsat / Copernicus
30 km
Google Earth

1994


Fort Mackay
Syncrude
Fort McMurray
Image Landsat / Copernicus
30 km
Google Earth

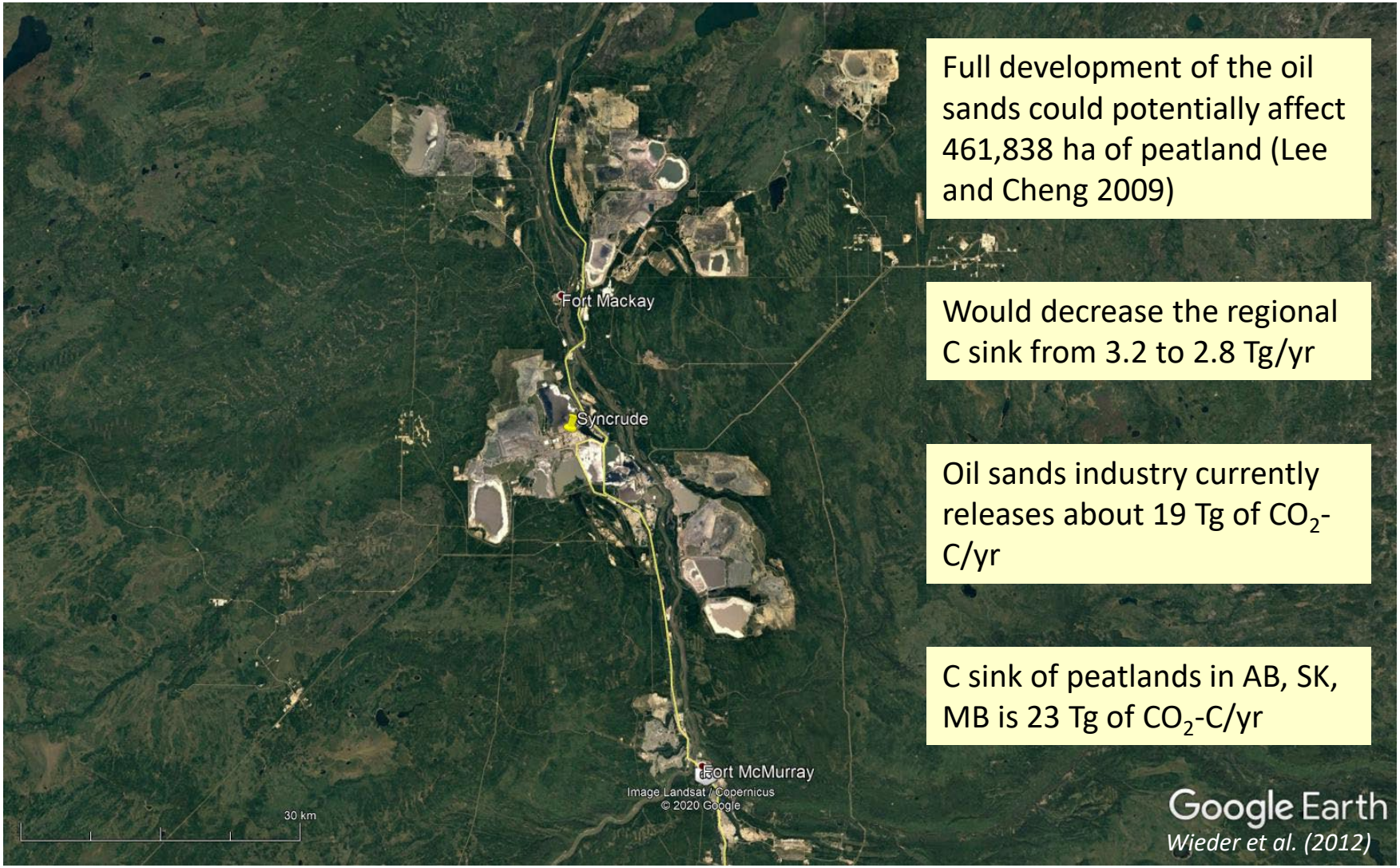
2004


Fort Mackay
Syncrude
Fort McMurray
Image Landsat / Copernicus
30 km
Google Earth

2014


Fort Mackay
Syncrude
Fort McMurray
Image Landsat / Copernicus
30 km
Google Earth

2020



Full development of the oil sands could potentially affect 461,838 ha of peatland (Lee and Cheng 2009)

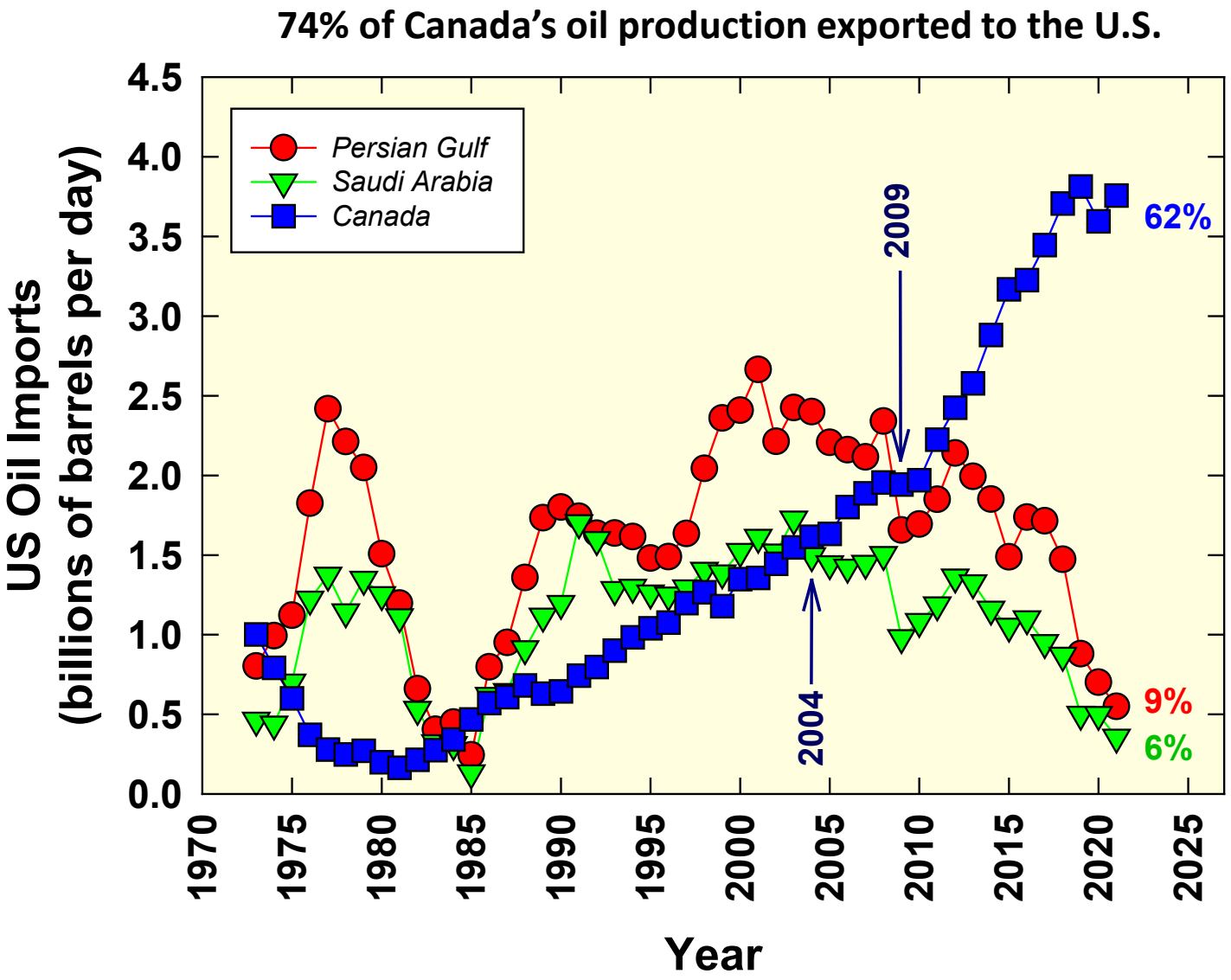
Would decrease the regional C sink from 3.2 to 2.8 Tg/yr

Oil sands industry currently releases about 19 Tg of CO_2-C/yr

C sink of peatlands in AB, SK, MB is 23 Tg of CO_2-C/yr

Wieder et al. (2012)

U.S. Oil Imports



Source: US Energy Information Administration: http://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_epc0_im0_mbblpd_a.htm

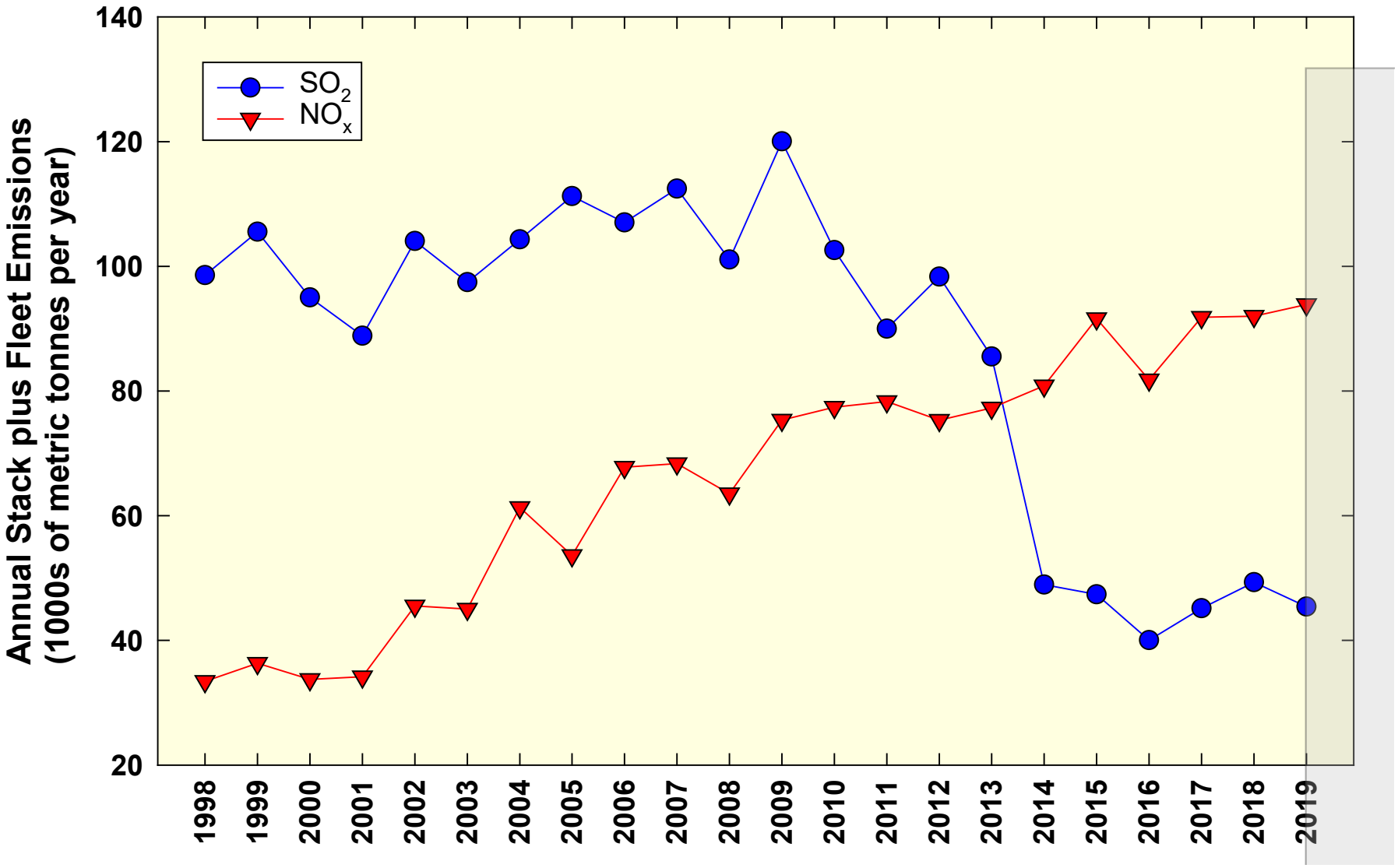
24 hrs/day, 365 days/yr, stopping to refuel or for repair/maintenance

8 L/km (1 gal per 0.3 mi) of diesel fuel

https://twitter.com/imperialoil/status/590570805332987908


SO_x
Photo by Kim Scott

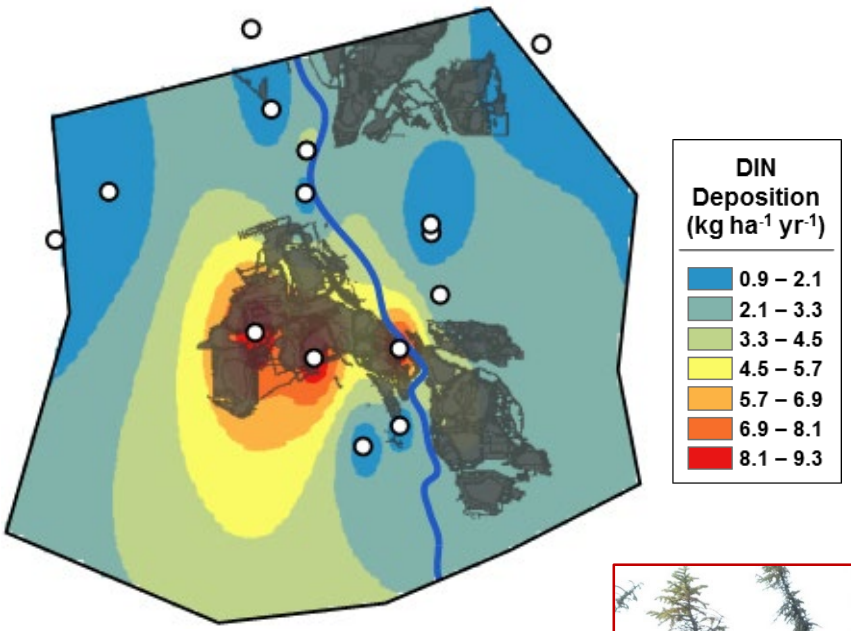
Oil Sands N and S Emissions



Source: National Pollutant Release Inventory

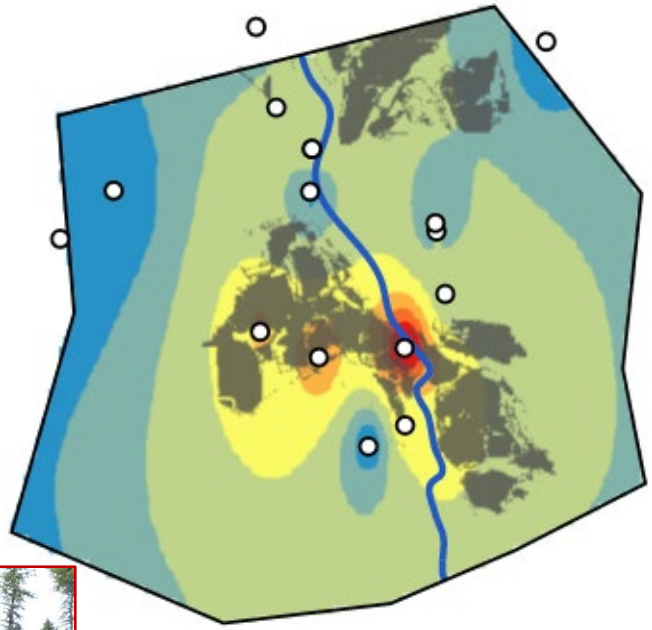
https://www.canada.ca/en/services/environment/pollution-waste-management/national-pollutant-release-inventory.html

Bulk N and S Deposition



DIN Deposition (kg ha^{-1} yr^{-1})

- 0.9 – 2.1
- 2.1 – 3.3
- 3.3 – 4.5
- 4.5 – 5.7
- 5.7 – 6.9
- 6.9 – 8.1
- 8.1 – 9.3



SO_4^{2-}-S Deposition (kg ha^{-1} yr^{-1})

- 1.1 – 2.6
- 2.6 – 4.1
- 4.1 – 5.6
- 5.6 – 7.1
- 7.1 – 8.6
- 8.6 – 10.1
- 10.1 – 12.0

Wieder, et al. *Environmental Science & Technology*, 2016

What are the effects of increasing N deposition on Alberta bogs and poor fens?

Experimental Design

Experimentally add increasing amounts of N to a bog and a poor fen through simulated rainfall; measure responses

7 treatments: nothing, water, 5, 10, 15, 20, 25 kg N/ha/yr

3 reps per treatment; 7.2 m^2 plots
21 plots in bog and 21 in fen


2x6-10
2x6-10
12 D
12D
2x6
Spruceland
Lumber
780-791-3232


BEWARE
OF
DOG


NIPI
(780)791-6411
POTABLE
WATER
NIPI
POTABLE
WATER


13,000 L


25


http://rwieder.clasit.org/research/

What did we Learn?

Setting up and maintaining a field experiment of this scale was challenging

Even at the highest N addition rate, concentrations of NH_4^+ and NO_3^- in bog or poor fen porewater, were unaffected

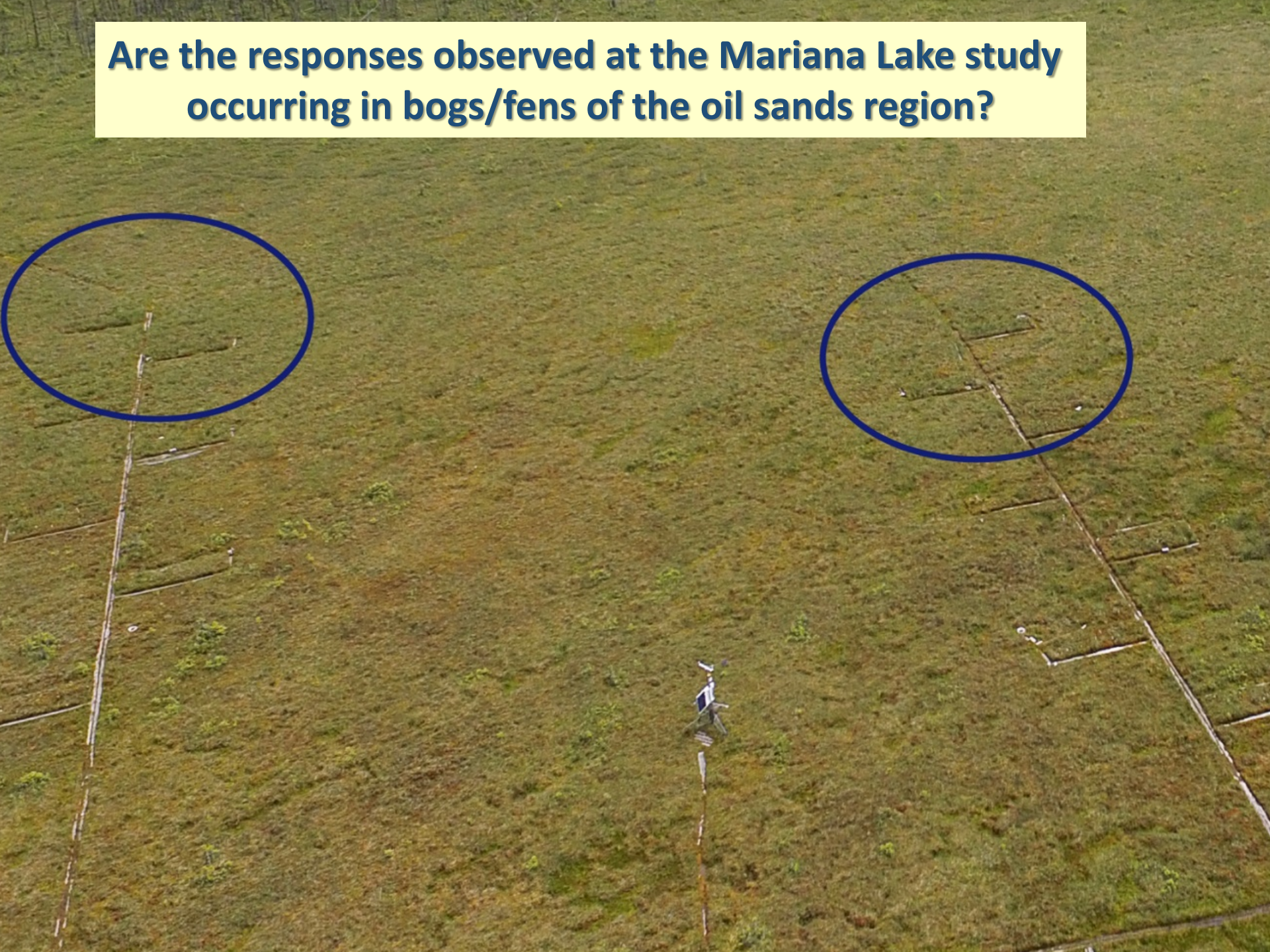
Growth of *Sphagnum fuscum*, the dominant peat-forming moss, was unaffected by N addition in the poor fen, and actually inhibited by N addition in the bog

Increasing N addition led to: a change in relative abundance of *Sphagnum* species, including a decrease in *S. fuscum* cover, an increase in shrub and black spruce growth, and an increase in shrub cover

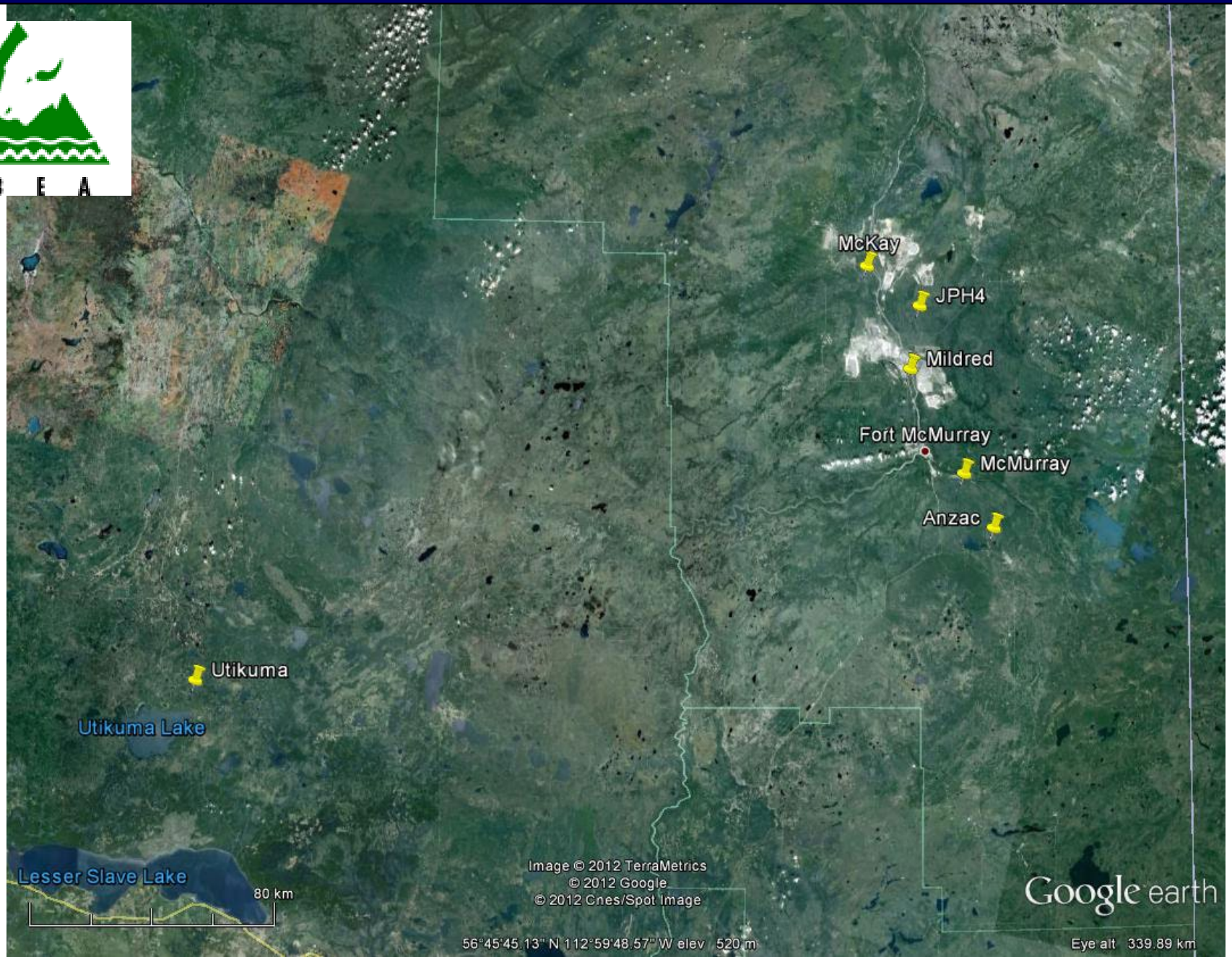
Wieder et al. (2019) Ecological Monographs
Wieder et al. (2020) Science of the Total Environment

Shrub Cover Response

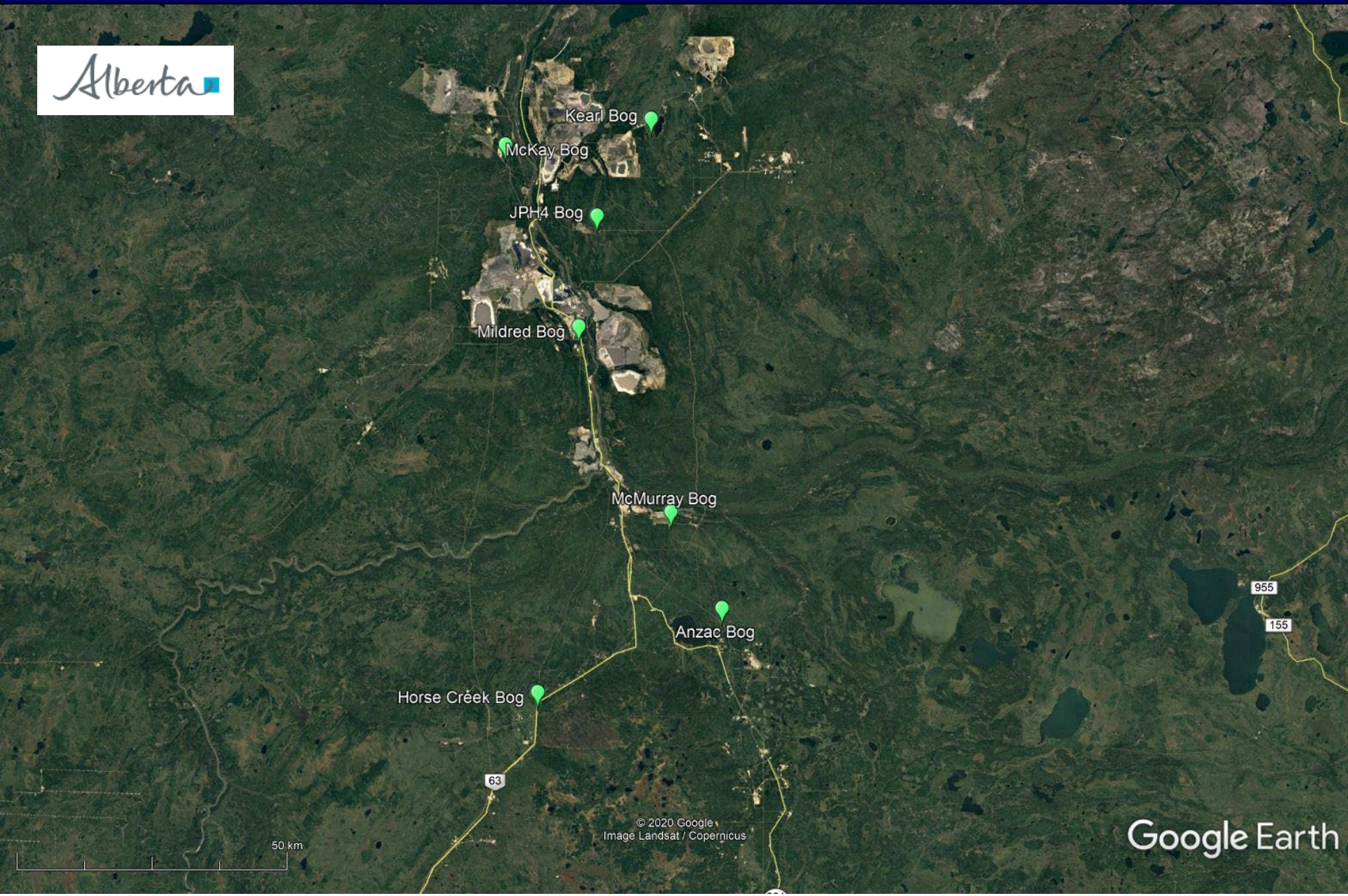
Are the responses observed at the Mariana Lake study occurring in bogs/fens of the oil sands region?



Bog Monitoring Sites Established in 2009



Bog Monitoring Sites in 2019



Environ Monit Assess (2021) 193:208
https://doi.org/10.1007/s10661-021-08929-y

Bog plant/lichen tissue nitrogen and sulfur concentrations as indicators of emissions from oil sands development in Alberta, Canada

R. Kelman Wieder · Melanie A. Vile · Kimberli D. Scott · Cara M. Albright · James C. Quinn · Dale H. Vitt

Received: 22 September 2020 / Accepted: 4 February 2021

Biogeochemistry
DOI 10.1007/s10533-016-0216-6

Effects of altered atmospheric nutrient deposition from Alberta oil sands development on *Sphagnum fuscum* growth and C, N and S accumulation in peat

R. Kelman Wieder · Melanie A. Vile · Cara M. Albright · Kimberli D. Scott · Dale H. Vitt · James C. Quinn · Medora Burke-Scoll

Received: 2 July 2015 / Accepted: 2 May 2016

Environ Monit Assess (2020) 192:743
https://doi.org/10.1007/s10661-020-08645-z

A protocol for monitoring plant responses to changing nitrogen deposition regimes in Alberta bogs

Dale H. Vitt · Melissa House · Samantha Kitchen · R. Kelman Wieder

Received: 20 April 2020 / Accepted: 28 September 2020

Environmental Science & Technology
Article
Published: October 21, 2016
pubs.acs.org/est

Differential Effects of High Atmospheric N and S Deposition on Bog Plant/Lichen Tissue and Porewater Chemistry across the Athabasca Oil Sands Region

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Environ Monit Assess (2021) 193: 766
https://doi.org/10.1007/s10661-021-09555-4

Is bog water chemistry affected by increasing N and S deposition from oil sands development in Northern Alberta, Canada?

R. Kelman Wieder · Melanie A. Vile · Kimberli D. Scott · James C. Quinn · Cara M. Albright · Kelly J. McMillen · Caitlyn Herron · Hope Fillingim

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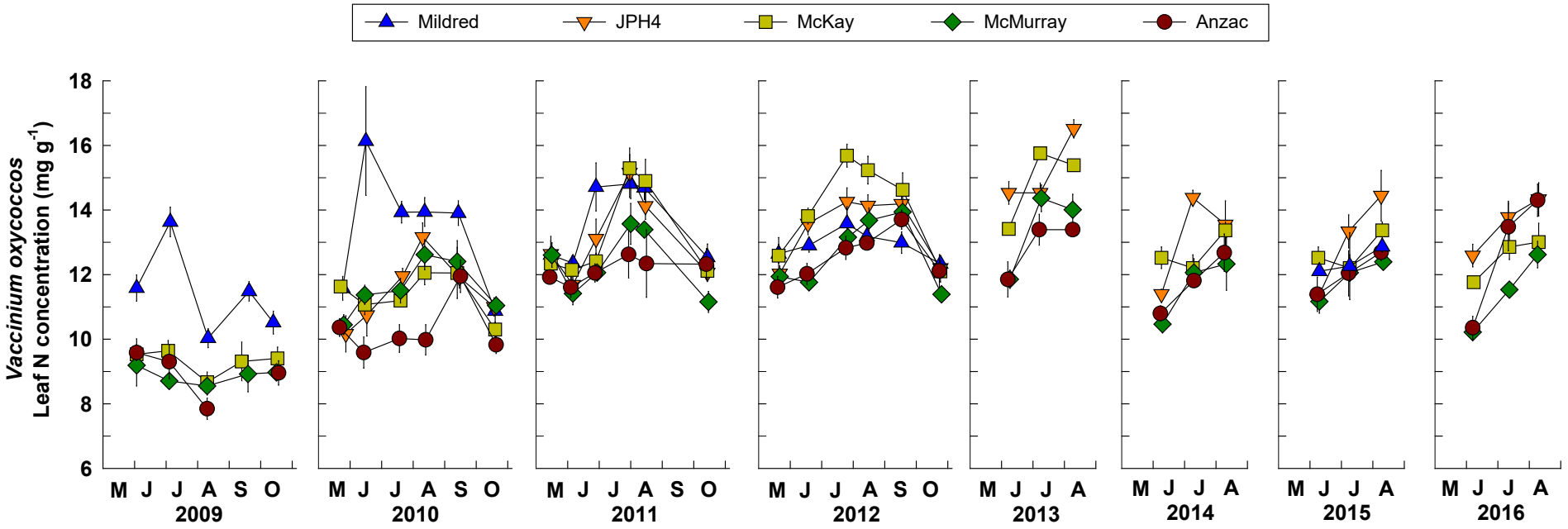
Leaf N Concentrations



QUESTIONS??

Photo by RKW