

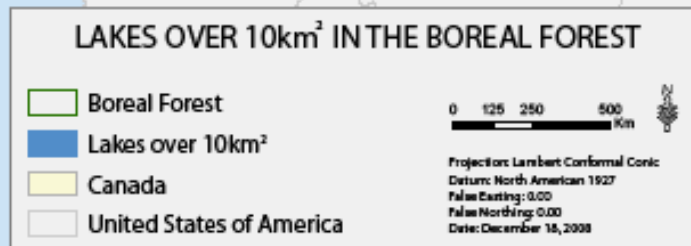


Future Threats and Prospects for Canadian Freshwater: A Scientist's Worst Nightmare

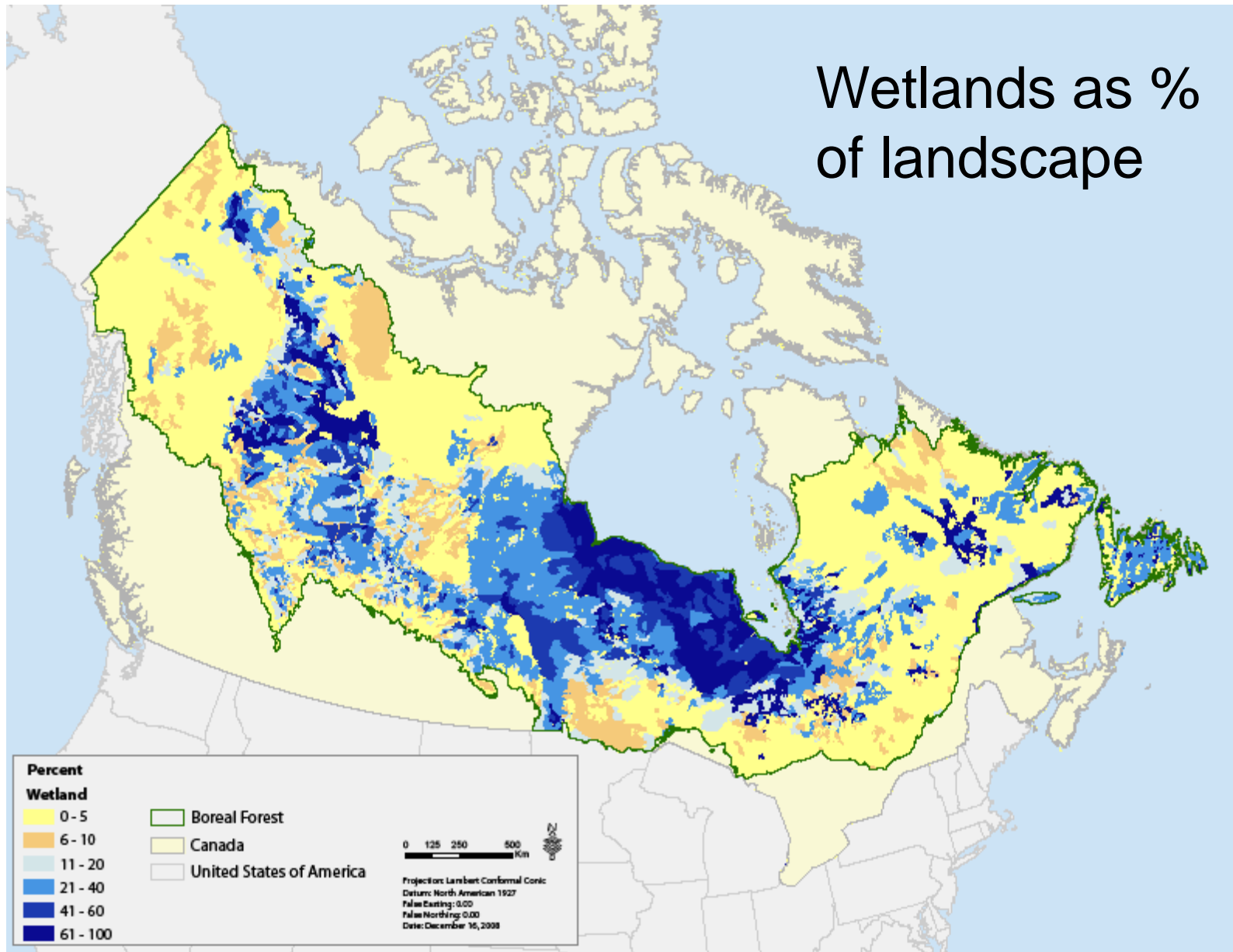
**D W Schindler
University of Alberta**

Climate warming x human activity x natural variation

➤ 60% of
Global
standing
water is in
Boreal regions



Wetlands as % of landscape

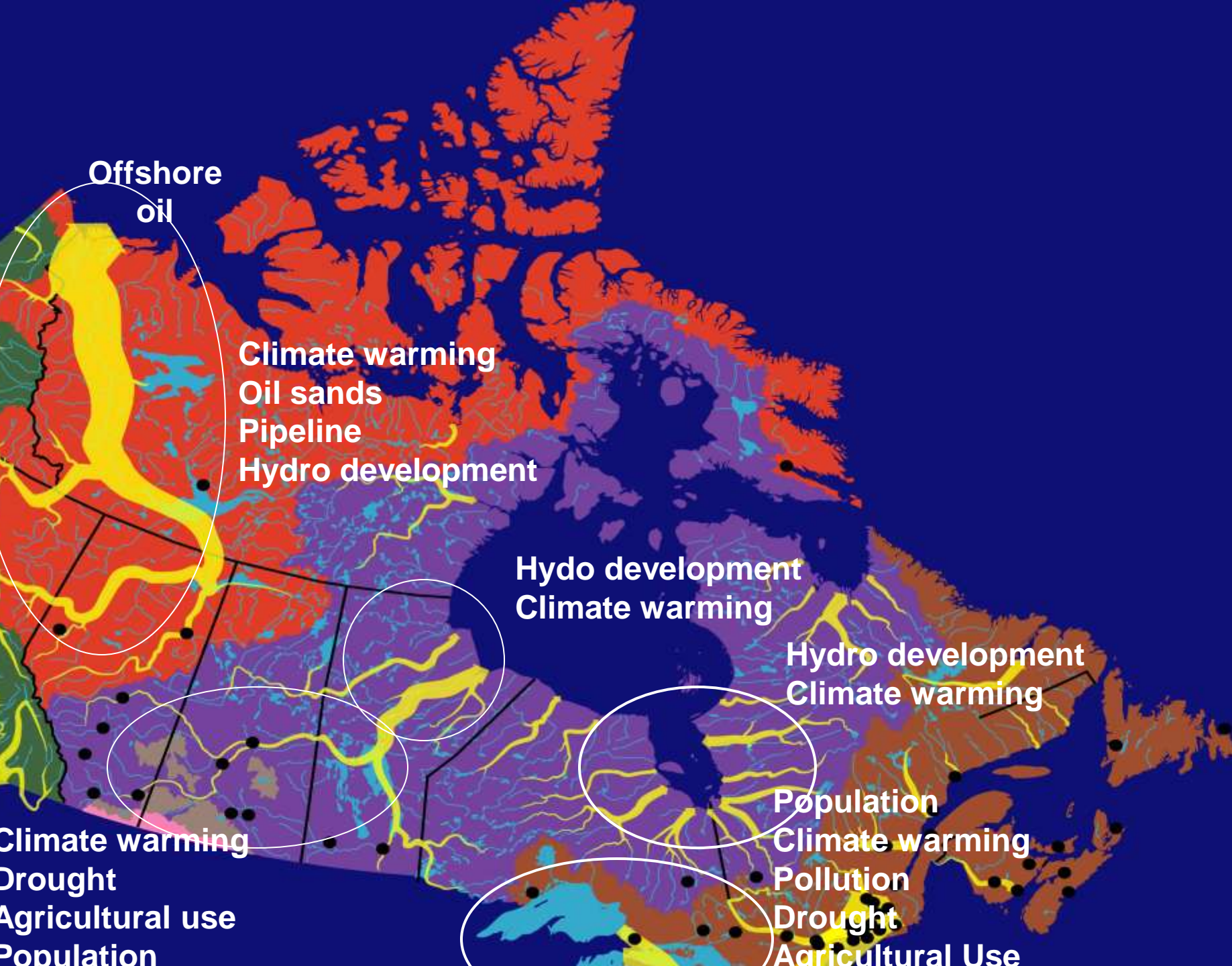


Renewable Freshwater Resources

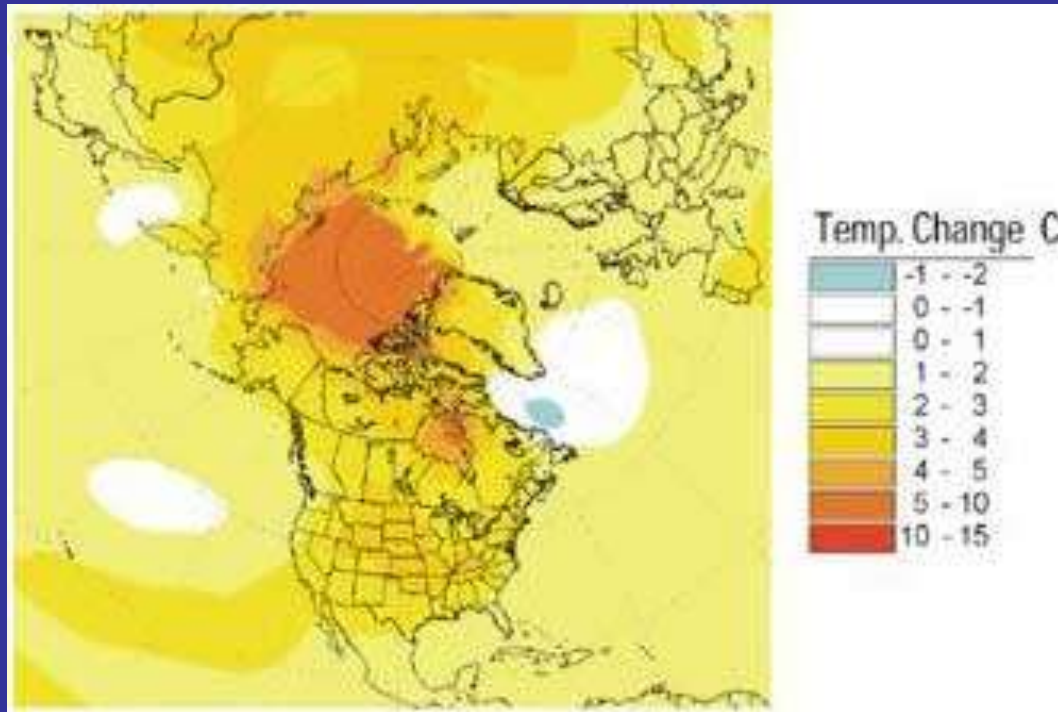
Top 5 Countries

	% of global supply
Brazil	12.4
Russia	10.0
Canada	6.5
USA	6.4
China	6.4

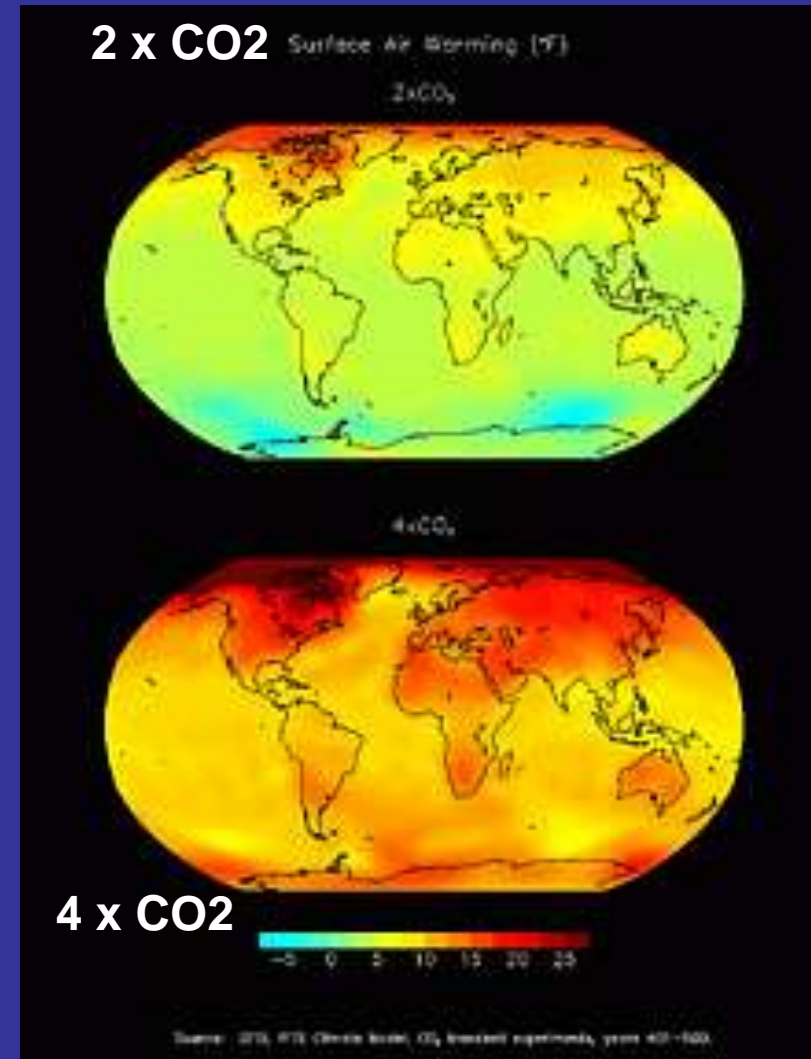
Sprague 2006



N. America in a “Greenhouse Dominated” World?



Current



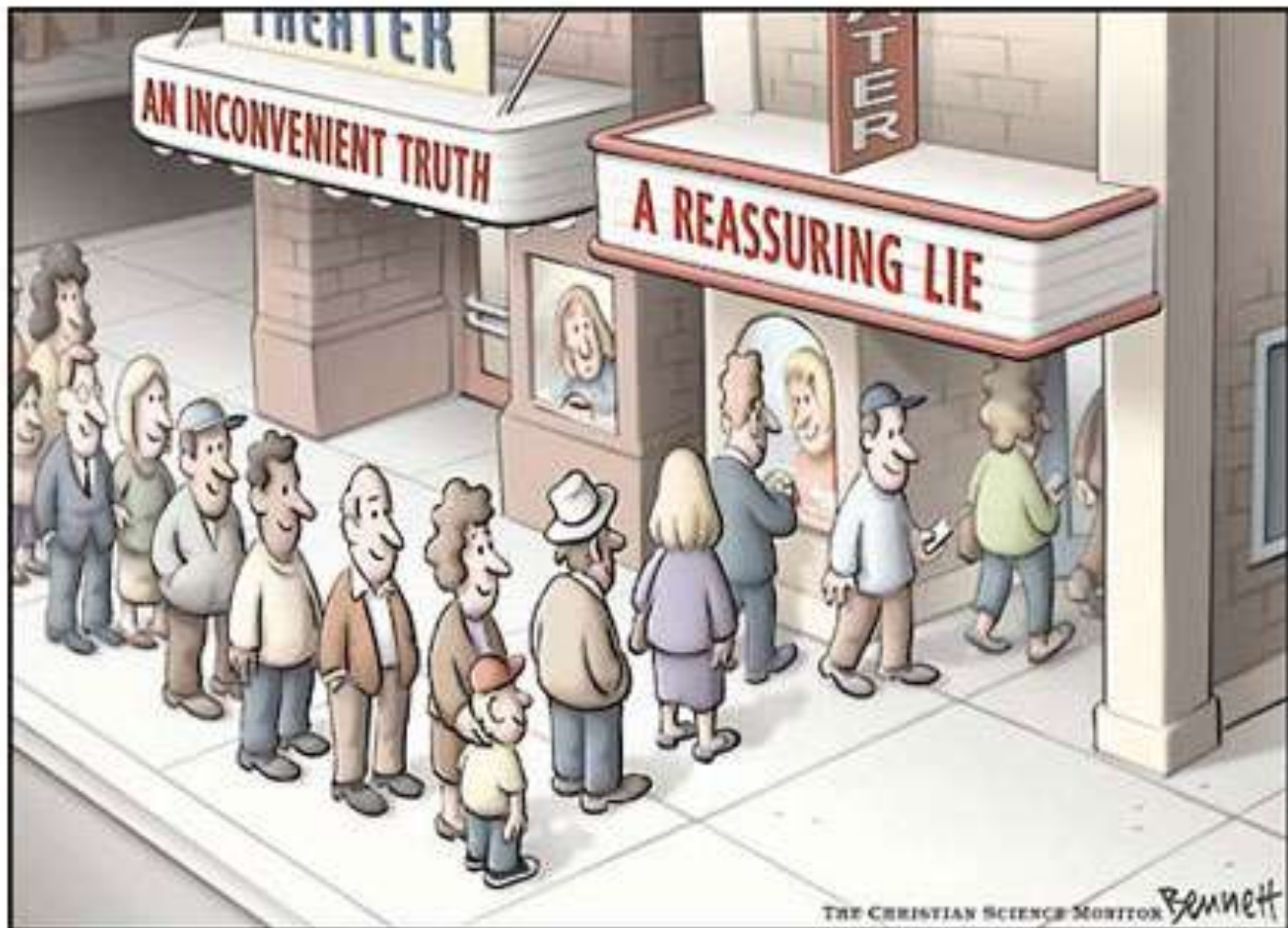
Some recent signs that climate warming has been underestimated by the IPCC:

- **Accelerated sea level rise –**
Rohling et al. Nature Geoscience 2009
- **Greater insect damage : higher forest fire**
Kurz et al. Nature 2008
- **Greater ocean acidification**
Proc. Royal Society of London 2005
- **Longer period of high atmospheric CO₂**
Archer et al. Ann. Rev. Earth Planet. Sci. 2009
- **Accelerated loss of polar ice**
NOAA, NASA websites, many papers
- **Changes in biotic distribution, abundance, breeding**
Post et al. Science 2009
- **Accelerated melting of permafrost, greater C content**
Tarnocai et al. 2009 Global Biogeo Cycles.

AHA! EMAILS
THAT PROVE
CLIMATE CHANGE
IS A HOAX!!!

M. WUERKER POLITICO

MISSING THE:
DYING FORESTS,
RISING OCEANS,
GROWING DESERTS,
MELTING ICE CAPS,
OCEAN ACIDIFICATION,
SHRIVELING OZONE,
RETREATING GLACIERS,
& RISING TEMPS
... FOR THE E-MAILS

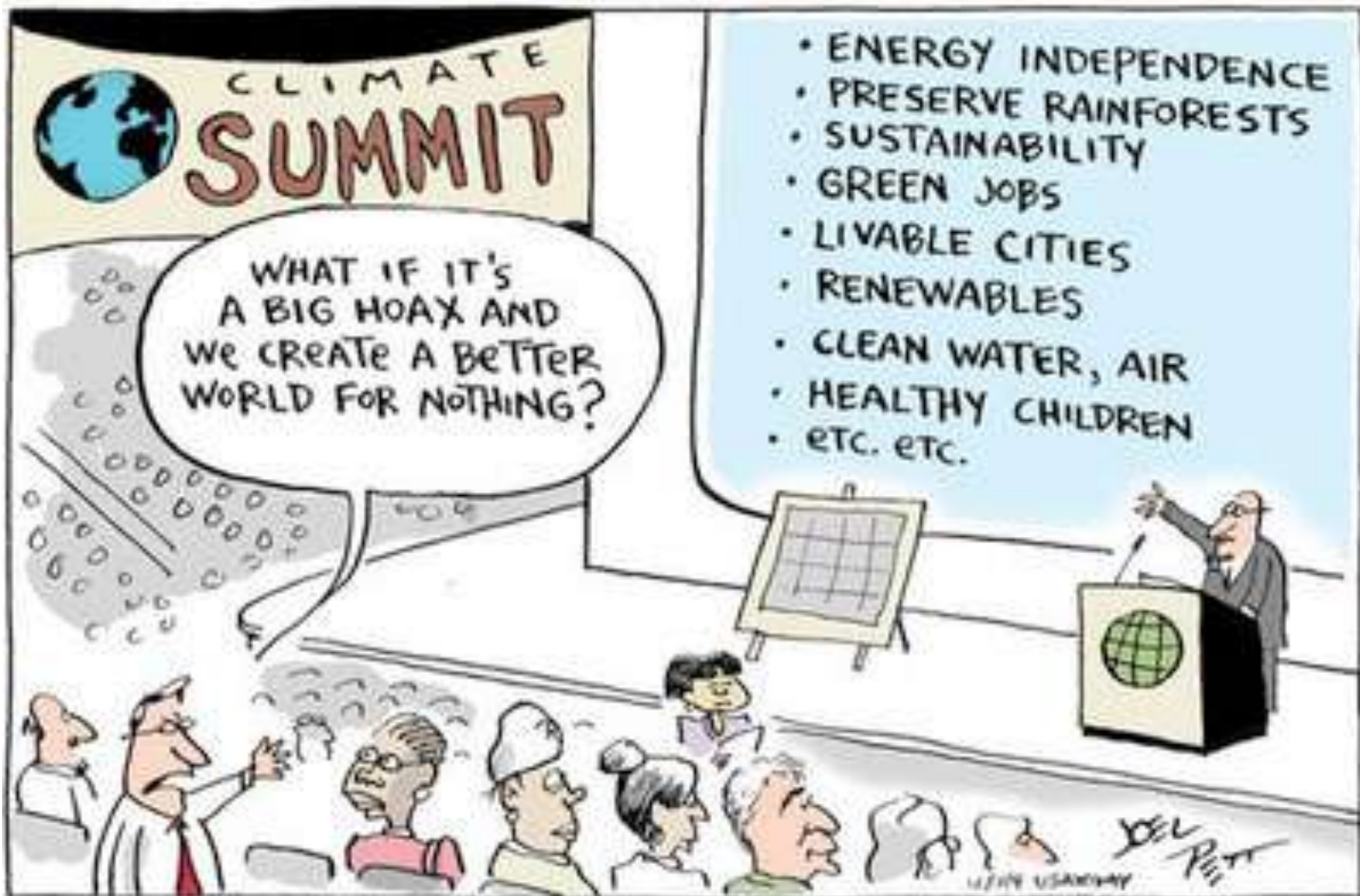


EXXON
MOBIL
30021012 \$

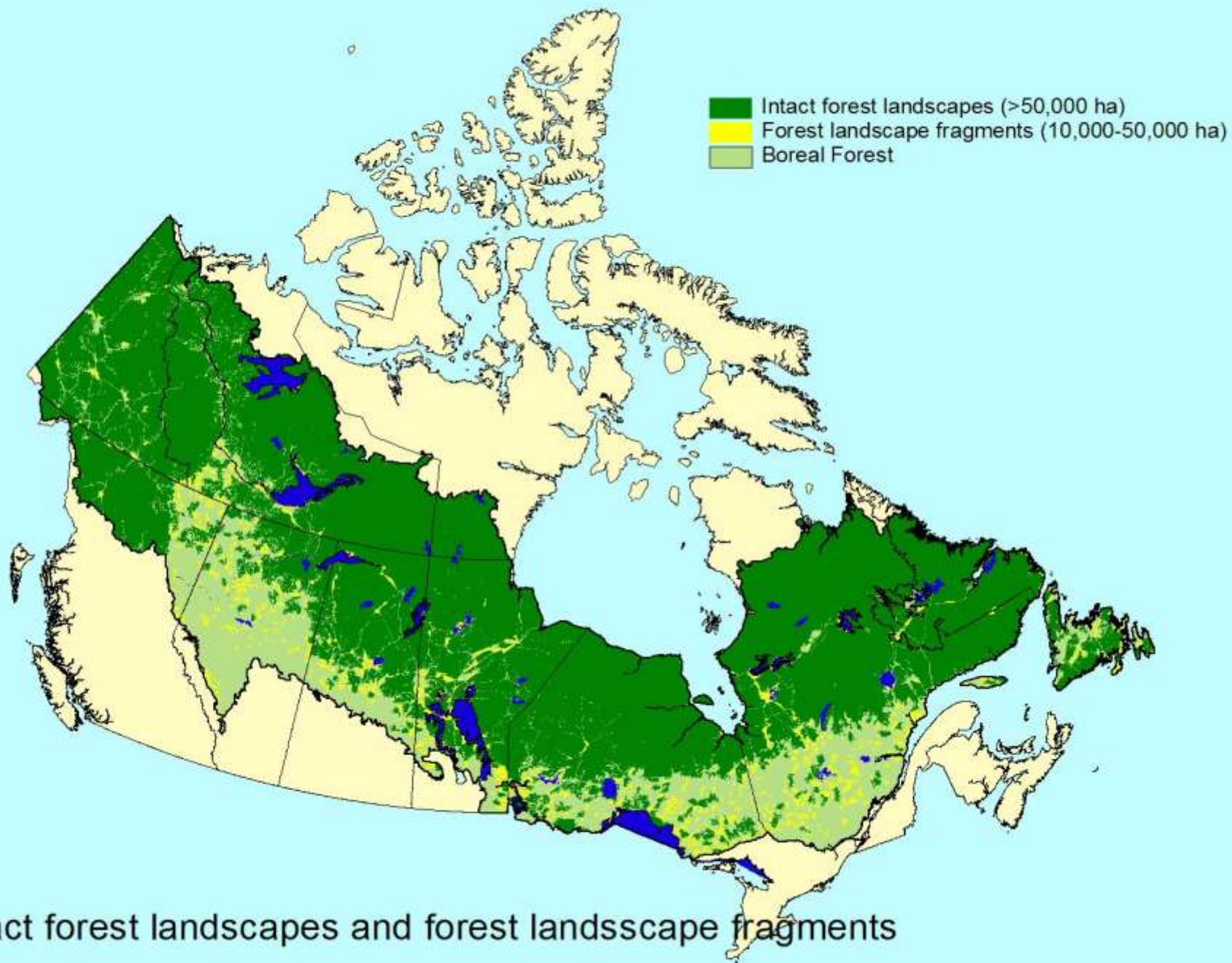
Sunshine

I HAVE BEEN INFORMED FROM
A RELIABLE SOURCE, THAT THIS
"GLOBAL WARMING" IS JUST
NOTHING BUT JUNK SCIENCE!





Climate warming is not the only reason to change!



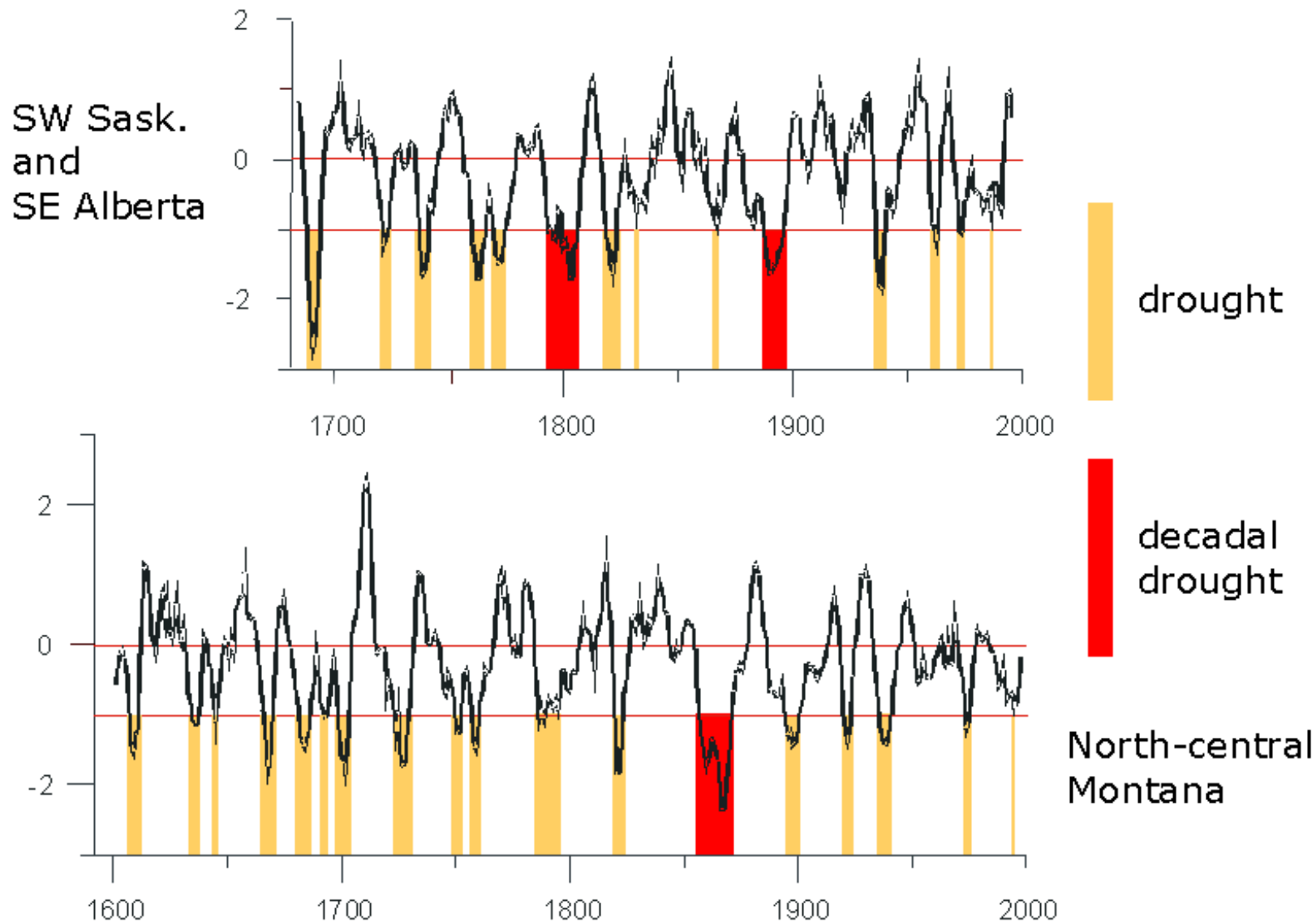
Tree Rings (Dendrochronology)

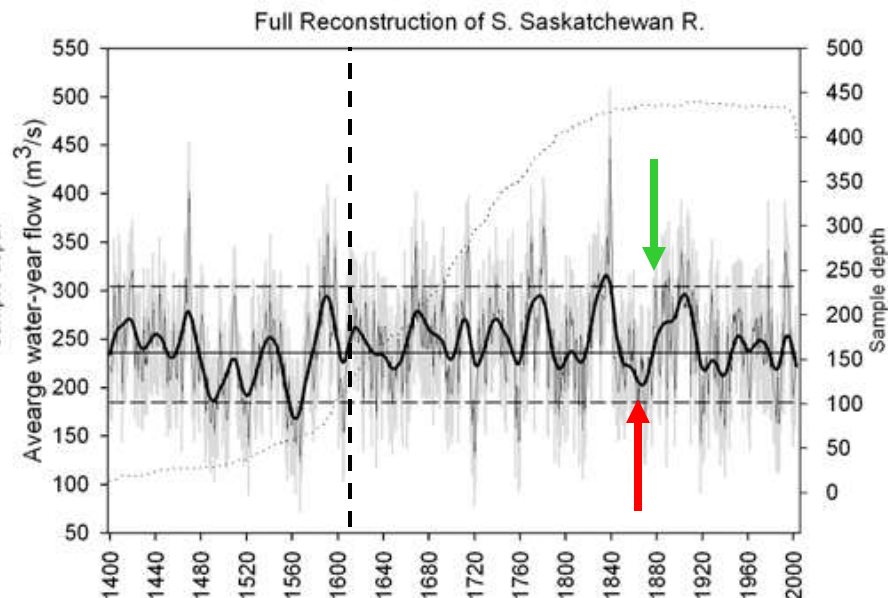
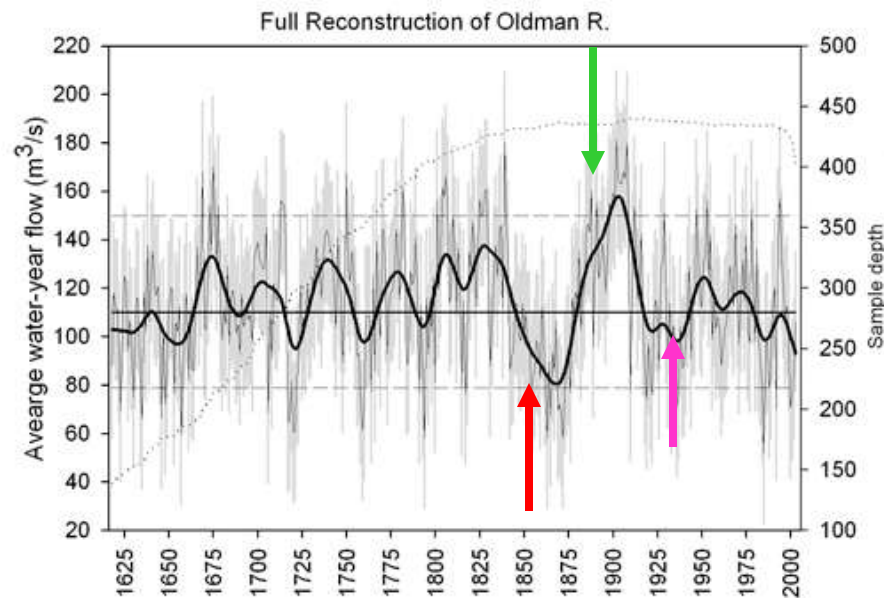
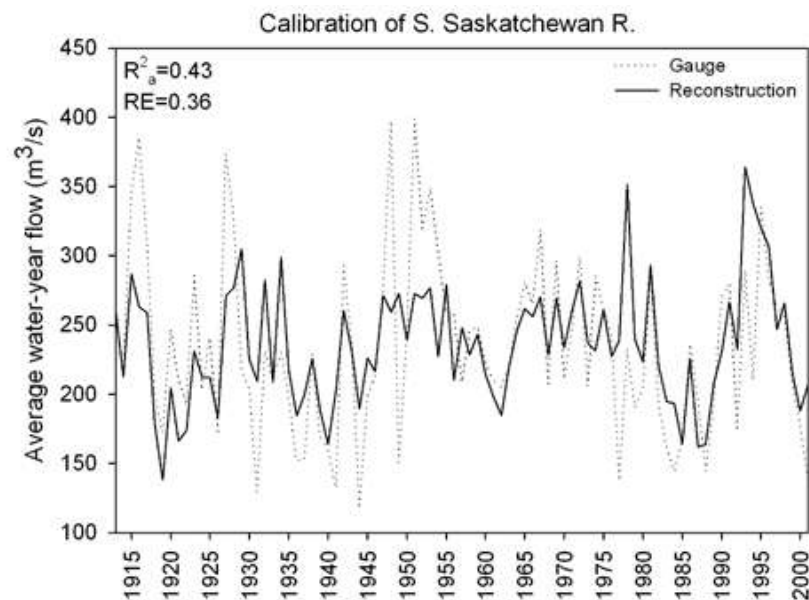
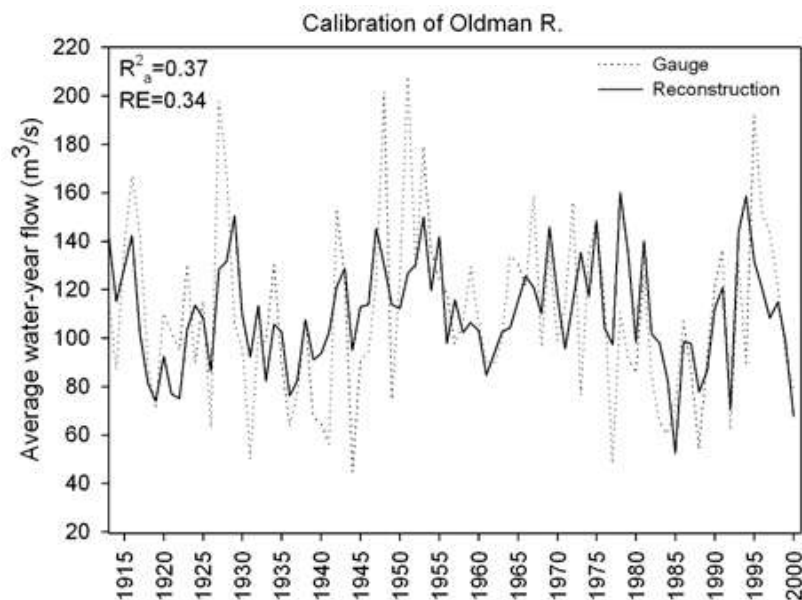


<http://www.ltrr.arizona.edu/sngc/images/fbsm/scardts.jpg>

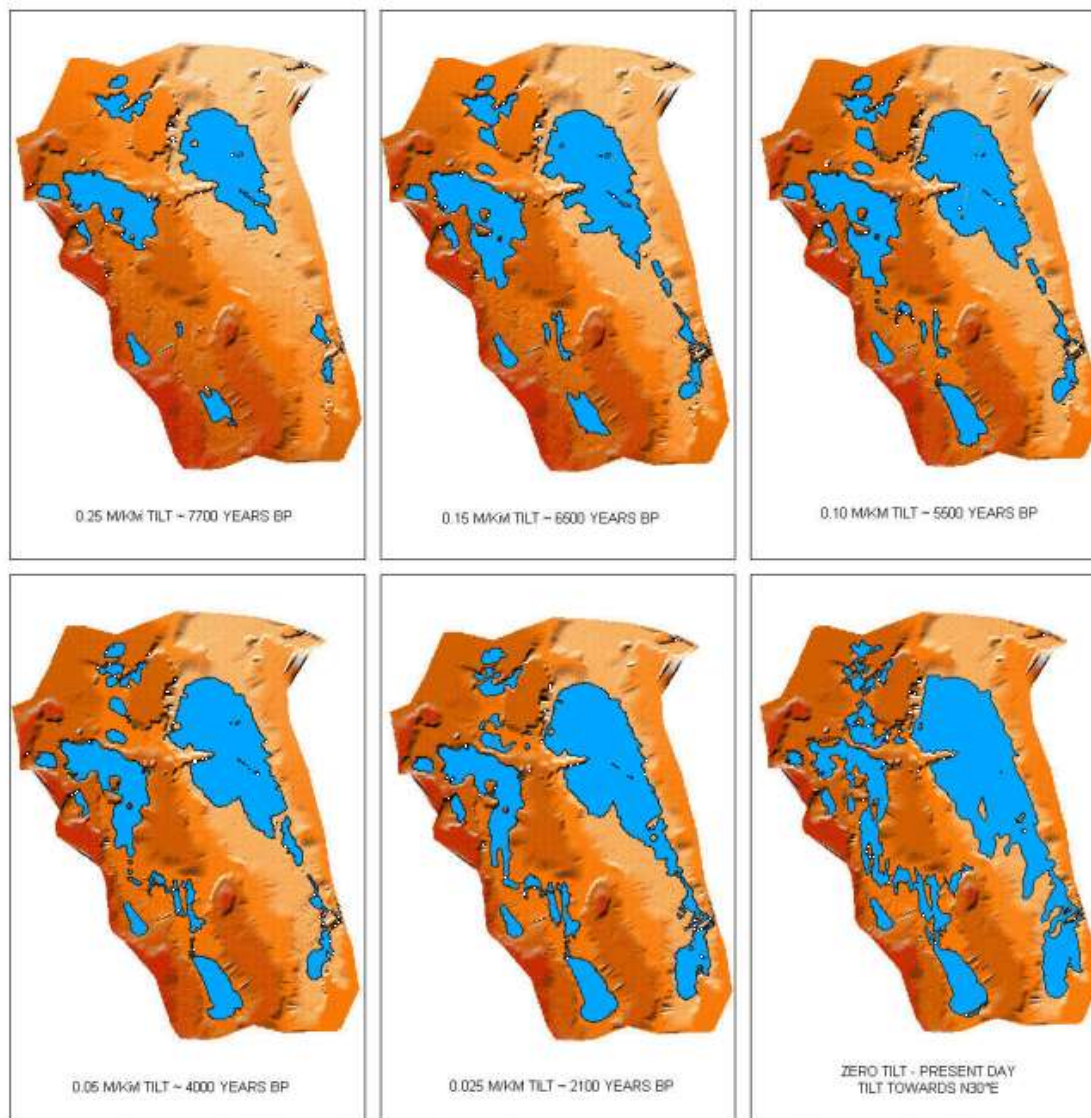
Reconstructed Regional July PDSI

(Sauchyn and Skinner, 2001)





HOLOCENE EVOLUTION OF THE MANITOBA GREAT LAKES REGION



**M. Lewis et al.
2009. Aquat.
Ecosystem
Health**

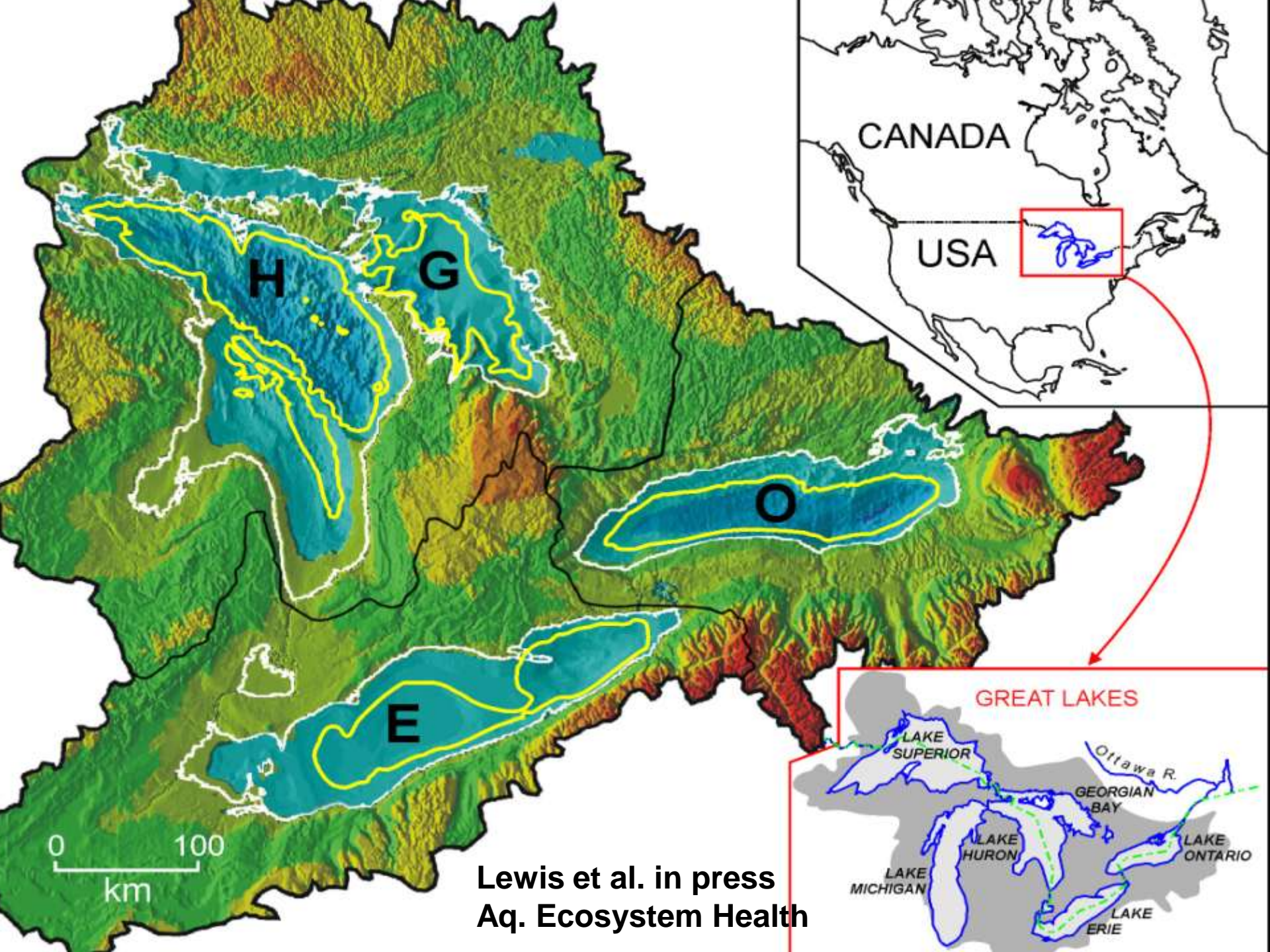
SIMPLIFIED MODEL BASED ON ISOSTATIC REBOUND WITH EQUAL TILT THROUGHOUT

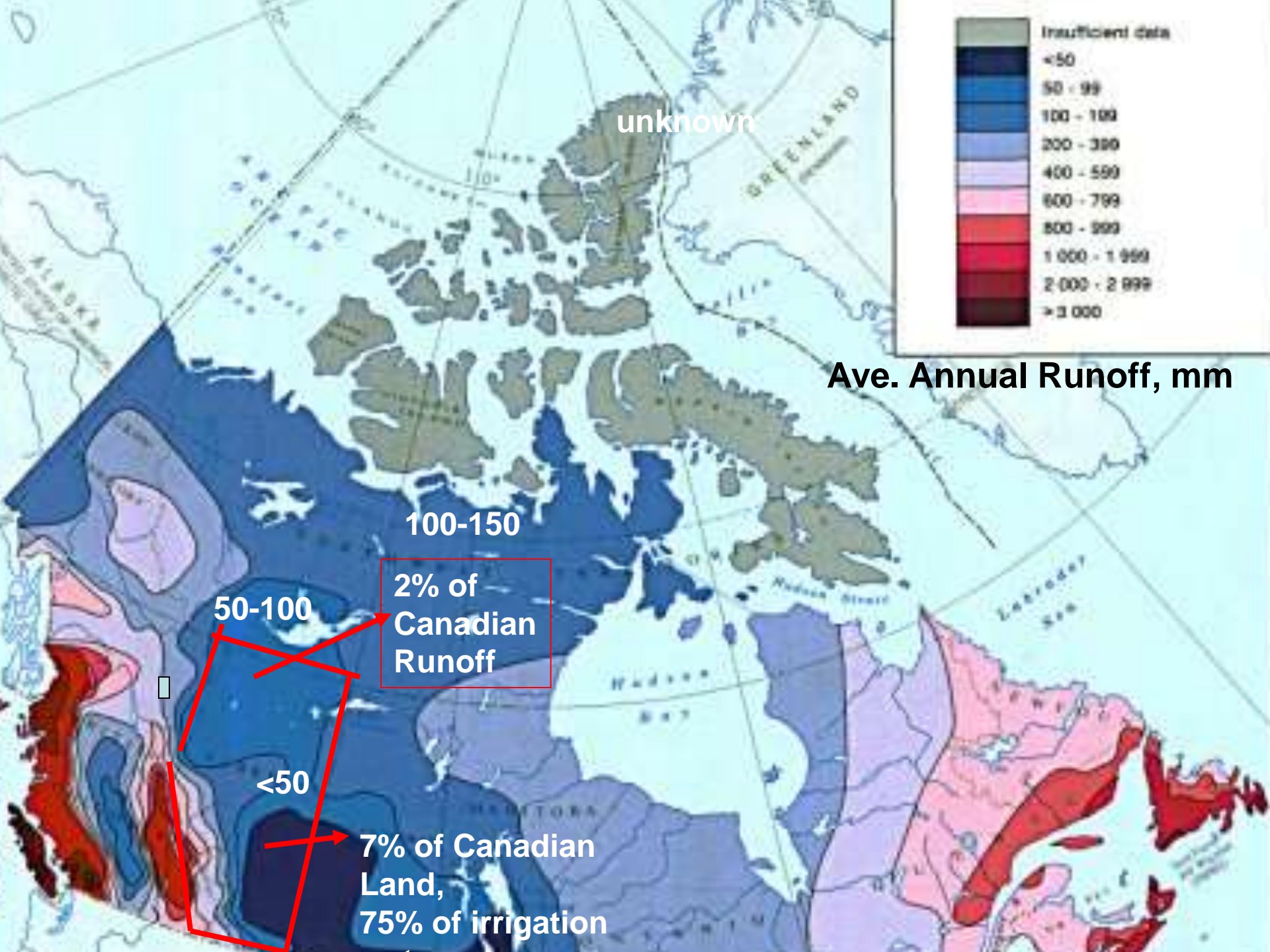


RECOMMENDED CITATION: Matile, G., Lewis, C.F.M., Nielsen, E., Thorleifson, L.H. and Todd, B.J. 1996, Holocene Evolution of the Manitoba Great Lakes Region; Manitoba Energy and Mines, Open file OF96-8.

Manitoba
Energy and Mines



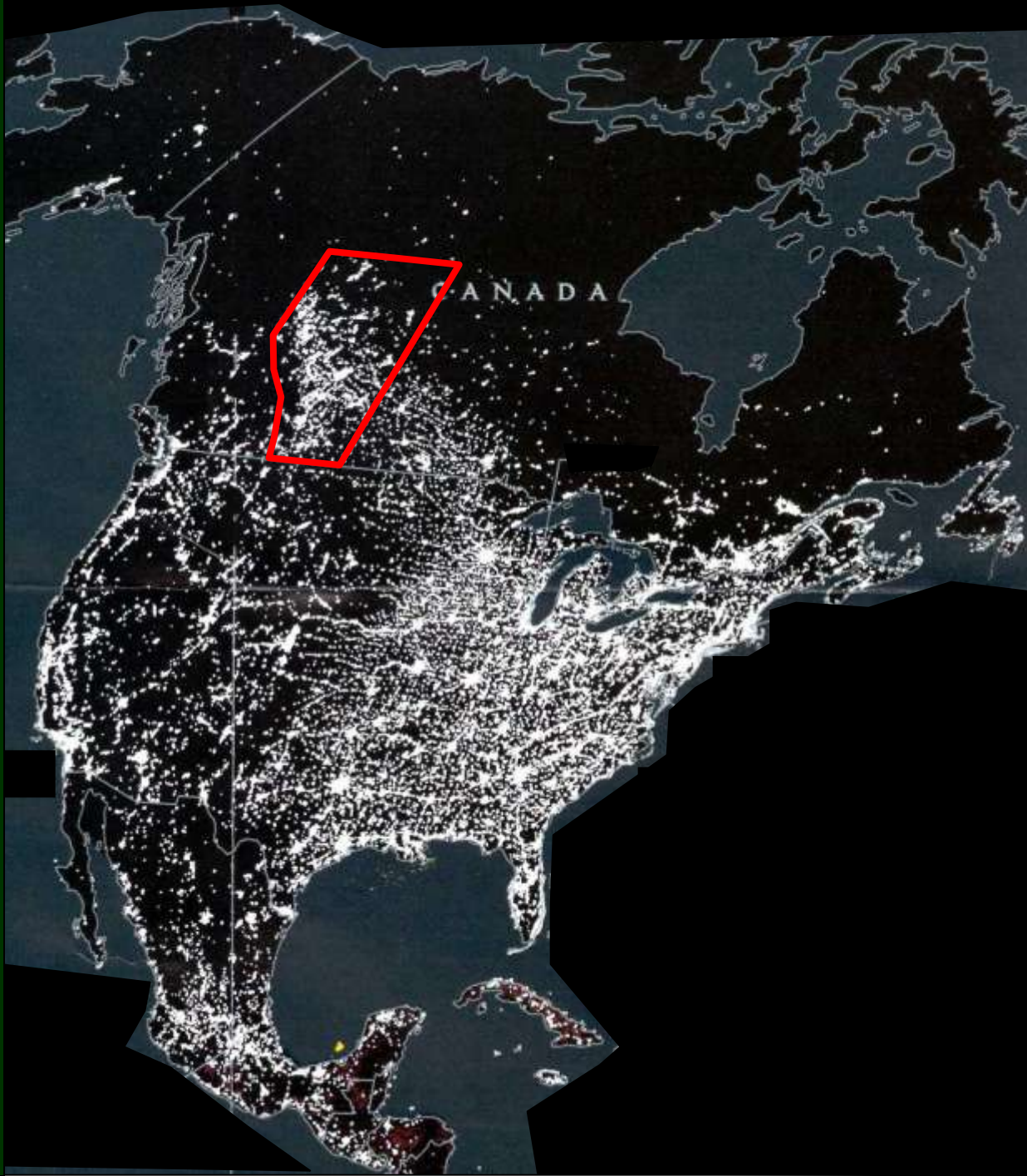


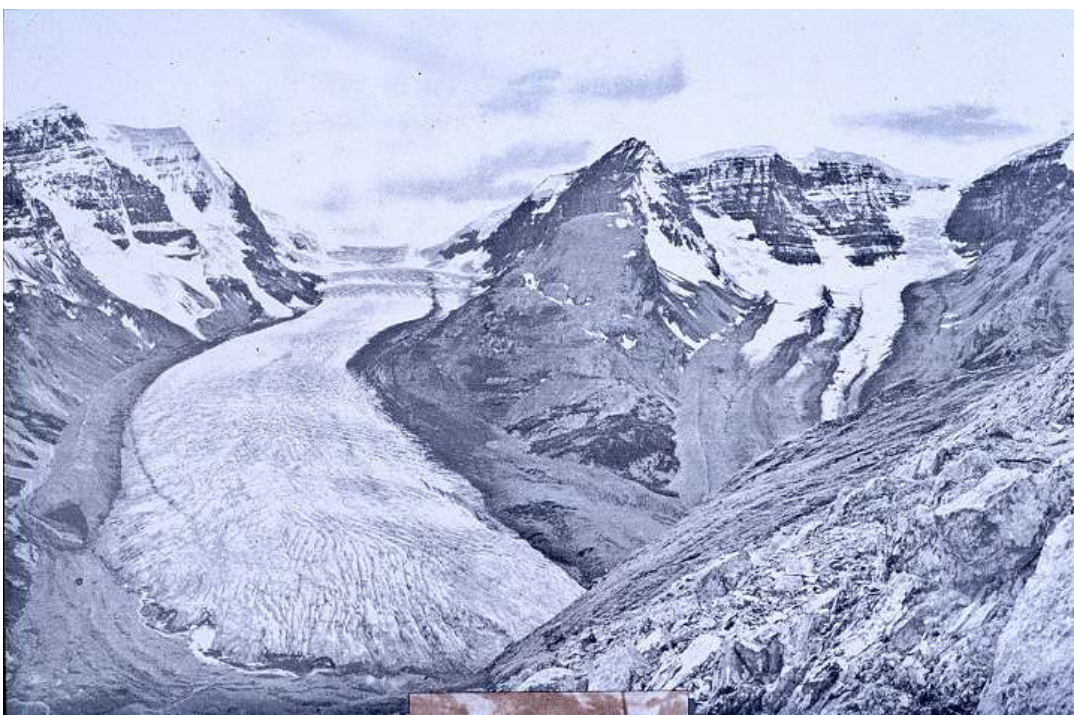


Human Population (millions)

	Canada	Saskatchewan	Alberta
1901	5.4	0.09	0.07
1931	10.4	0.92	0.73
1971	22.0	0.93	1.67
2001	31.1	1.02	3.1
Population Increase	6X	11X	44X

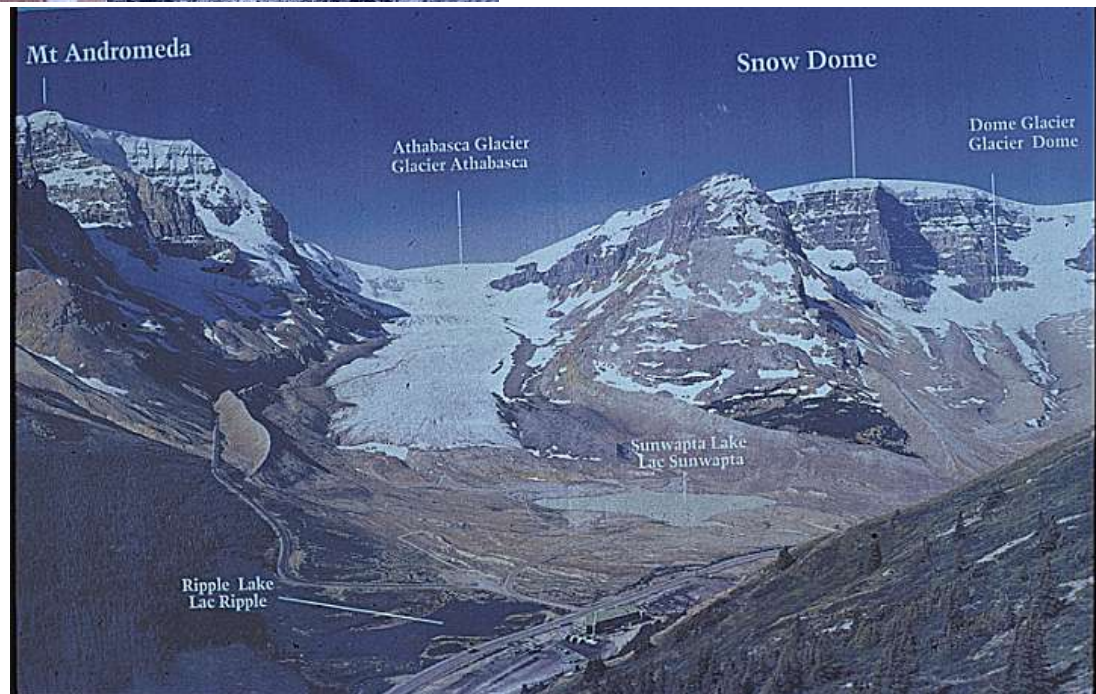
Source: Statistics Canada Annual Statistics 2003, Human Activity and the Environment



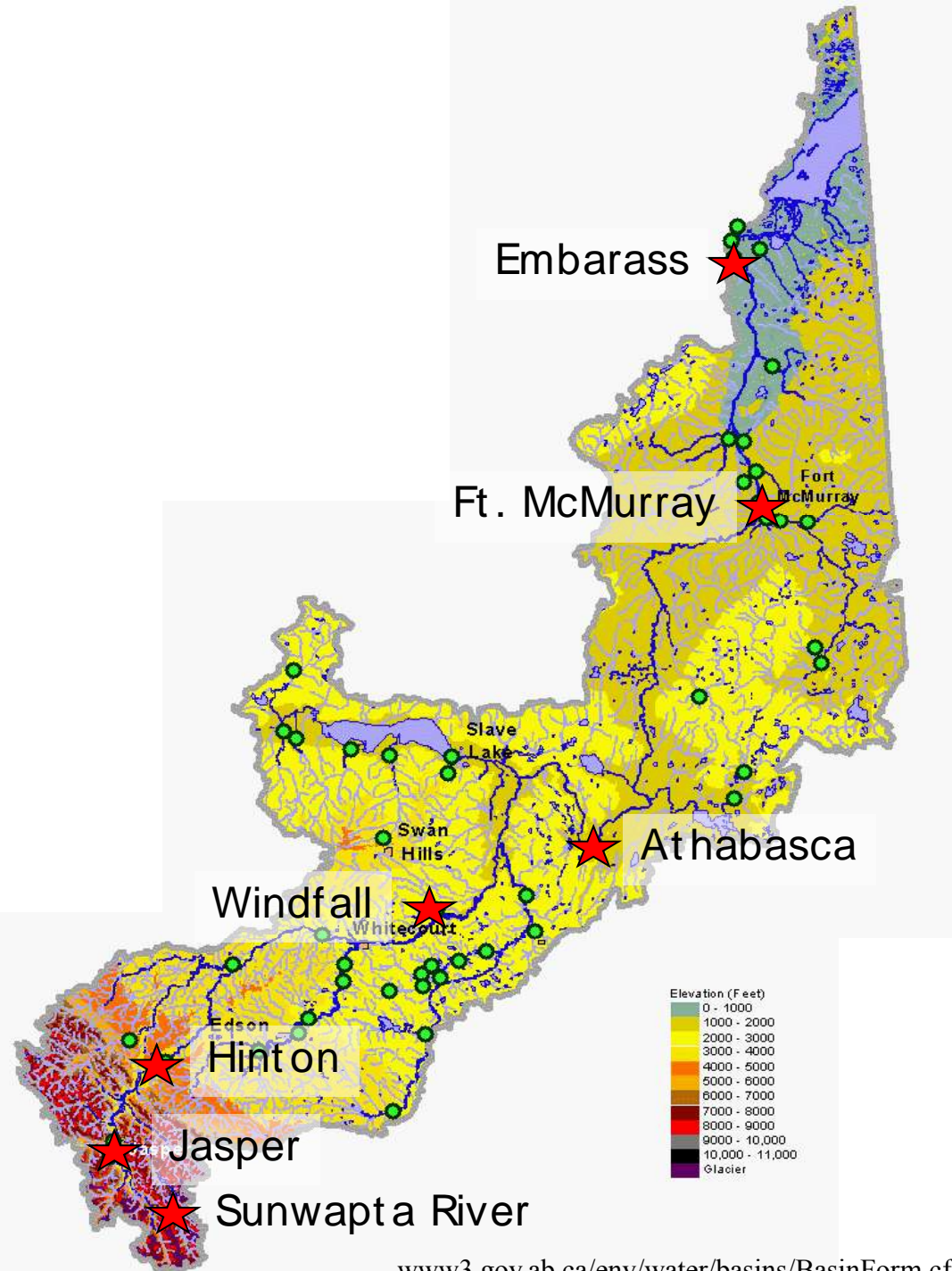


Athabasca Glacier

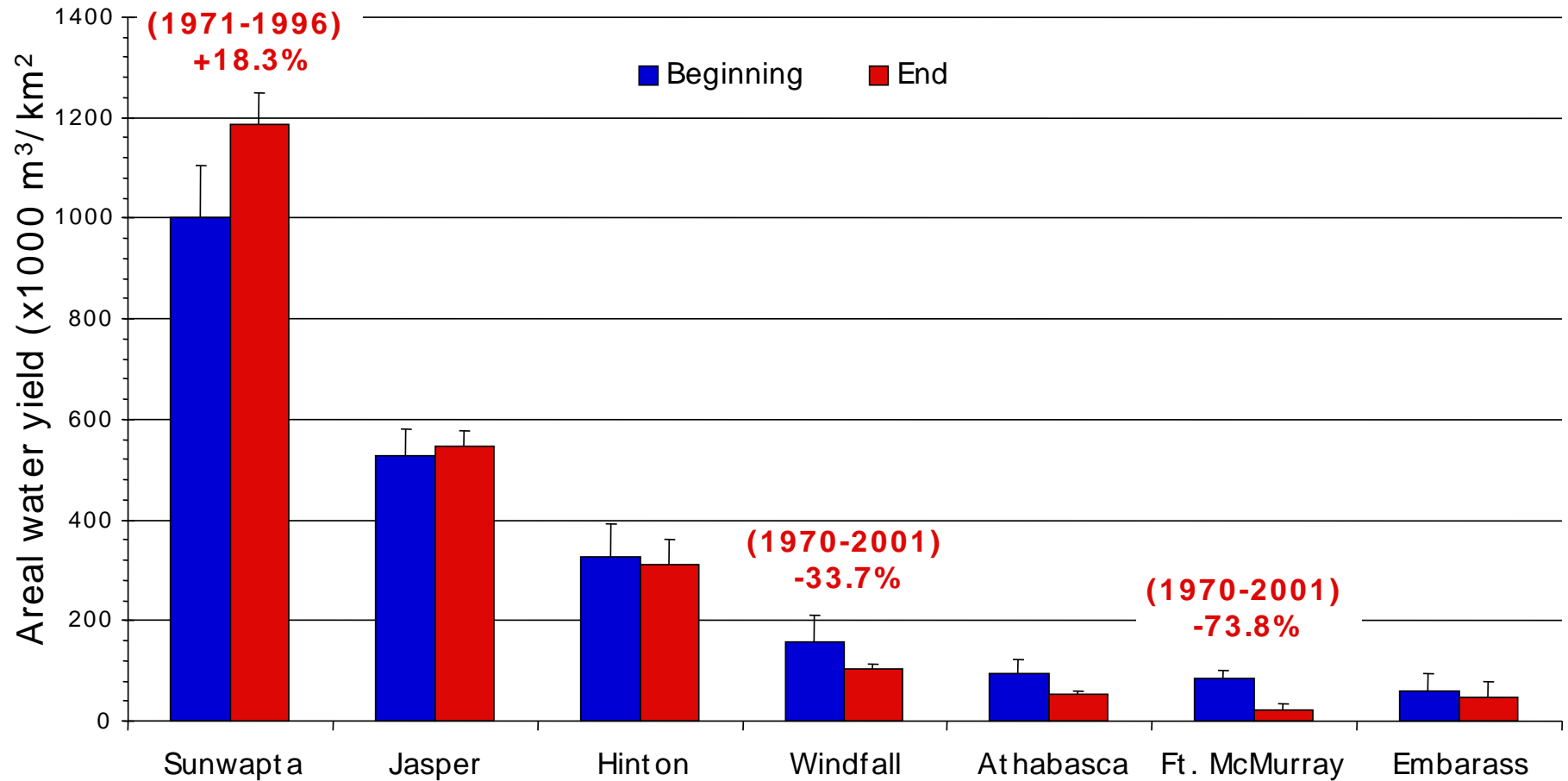
1919



1993



Athabasca River drainage basin subcatchment areal water yields (May – August, 1971-2001)



Donahue unpublished

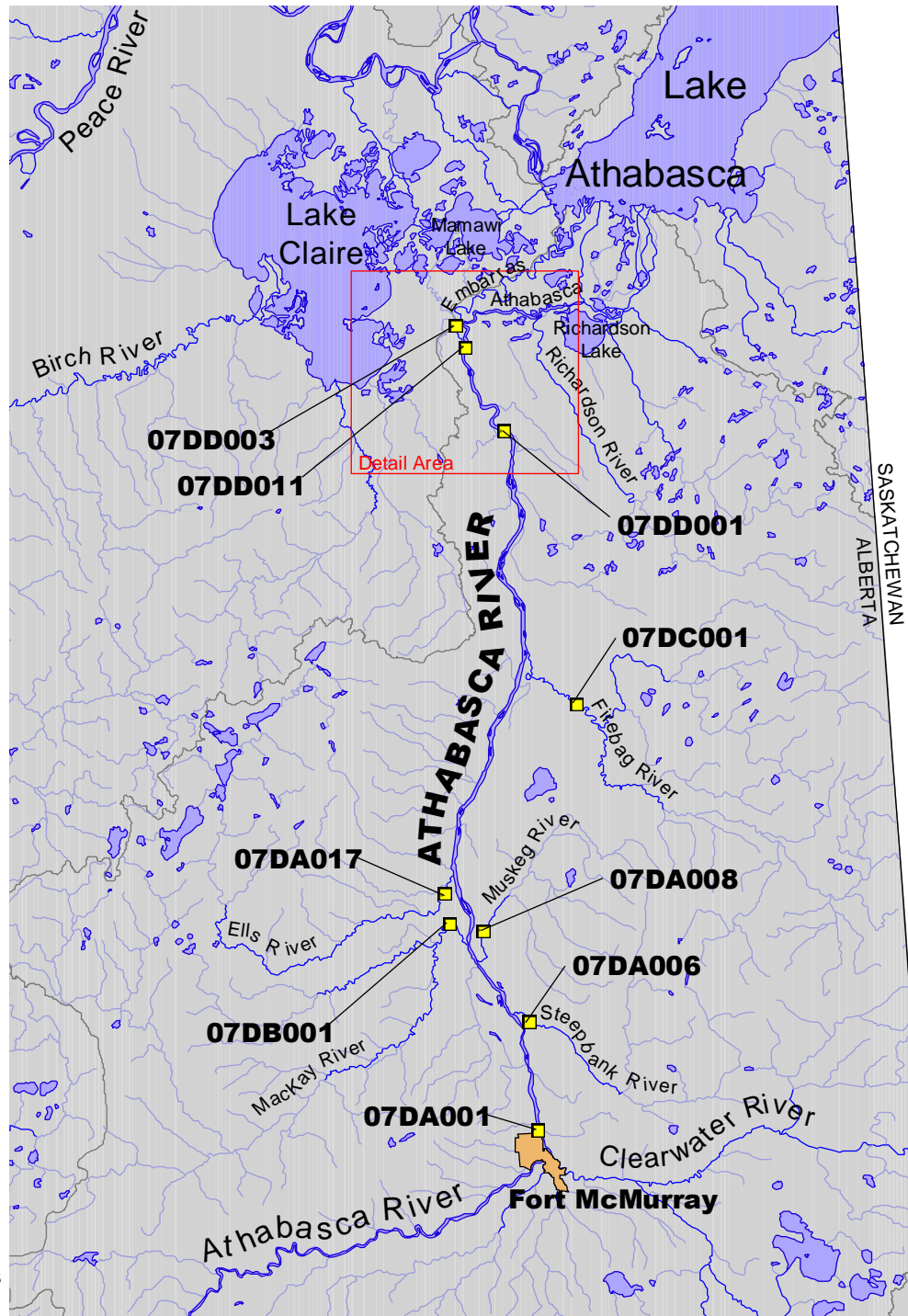
Destruction of Alberta's Boreal Forests and Waters By Tar Sands Developments

D. W. Schindler

Area, thousands km²

Alberta	662
France	505
Sweden	450
Norway	386
Germany	357
UK	249
Oil Sands	140
Greece	131





Tar Sands Extraction- Major Environmental Issues

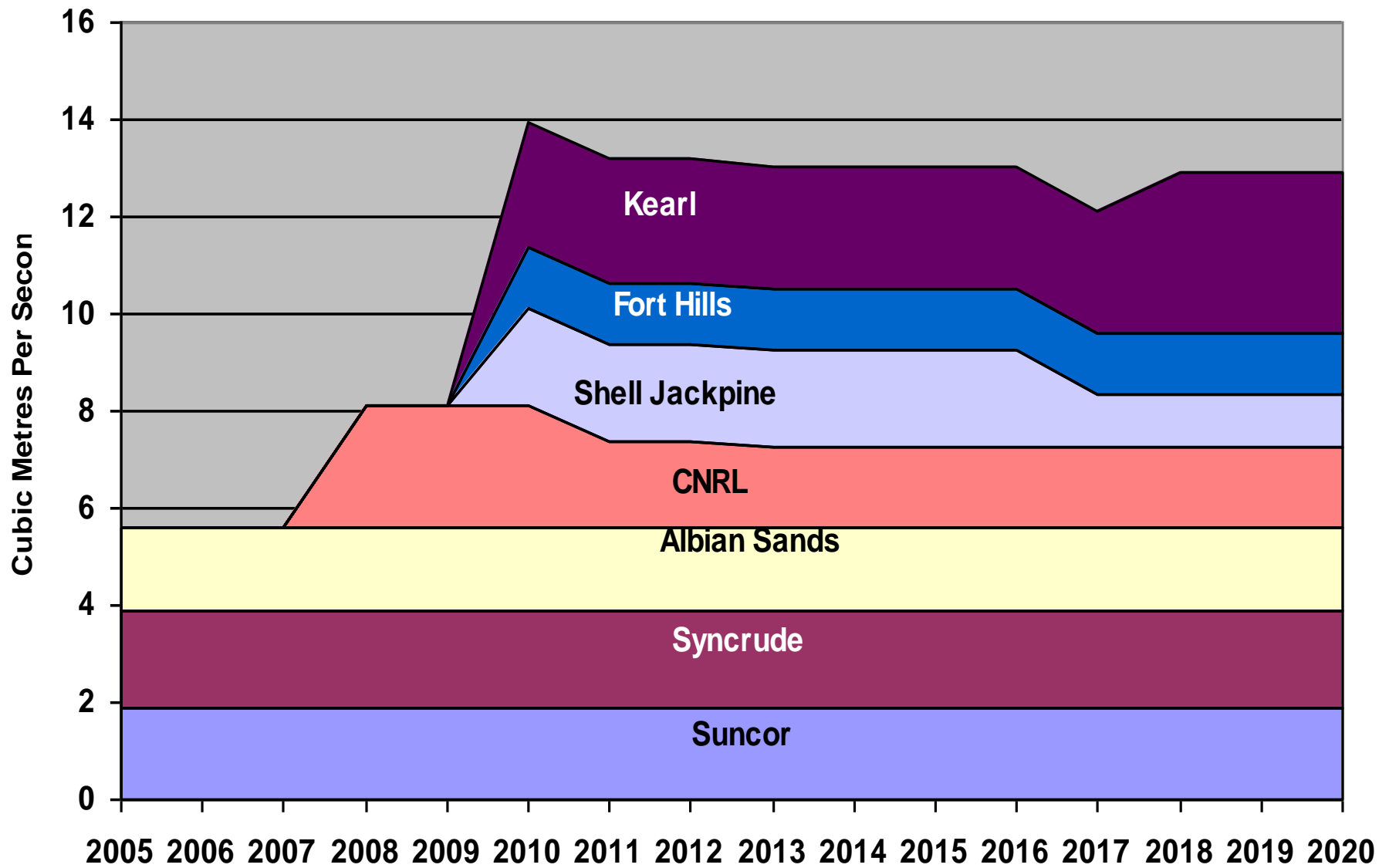
- **CO2 emissions**
- **Water removal**
Water pollution- PAHs, Mercury, Arsenic, etc. etc
- **Lack of reclamation**
- **Boreal forest destruction**
- **Biodiversity loss**
- **Air pollution problems**
- **Violation of First Nations subsistence space**
- **Lack of cumulative effects assessment**
- **Incompetent monitoring**



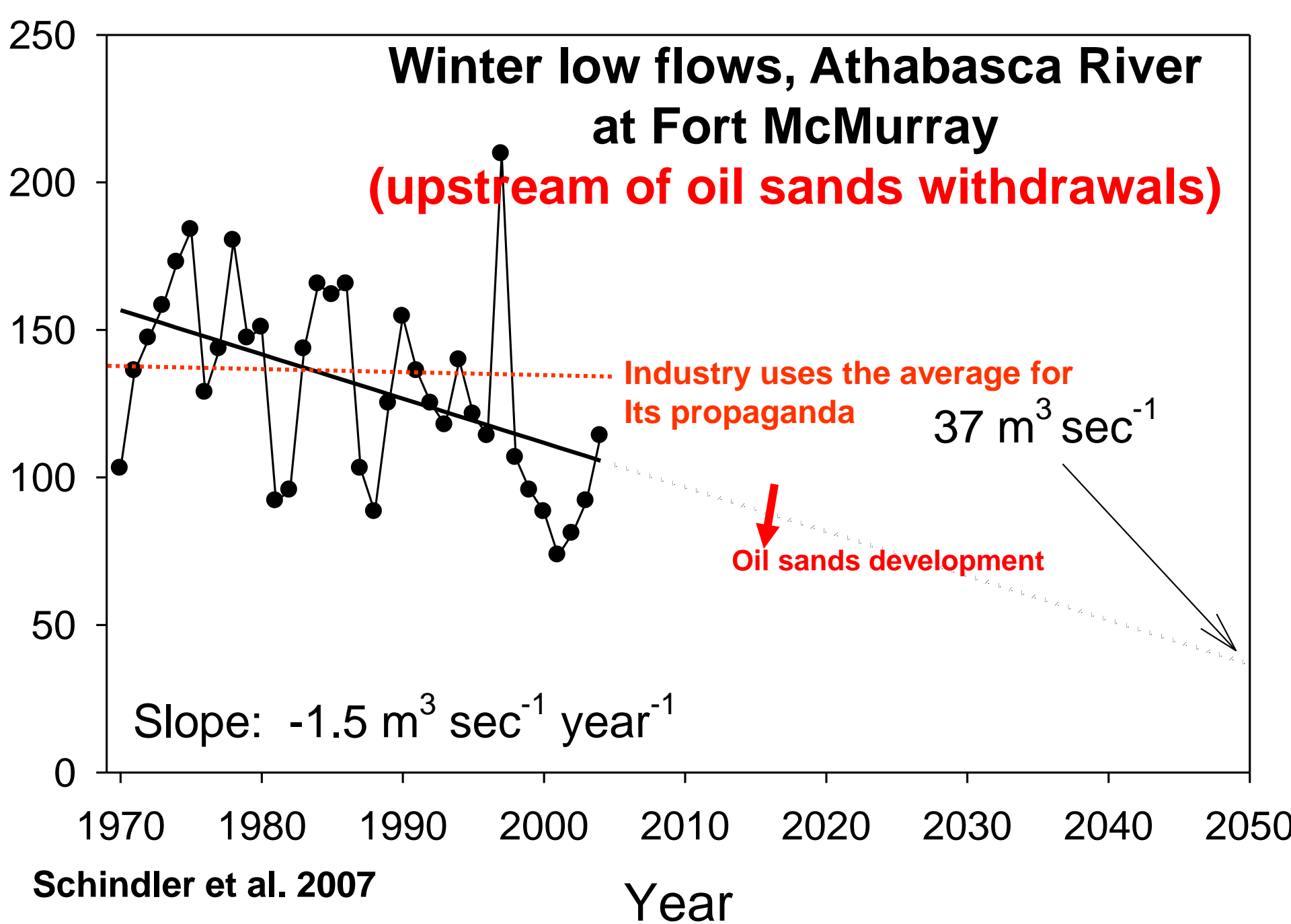
Photograph by Peter Essick



**Oil Sands-
Scraping Bottom?**
National Geographic Mar 2009



Projected maximum water diversions by oil sands mines, Athabasca River Basin
Source: AMEC 2007





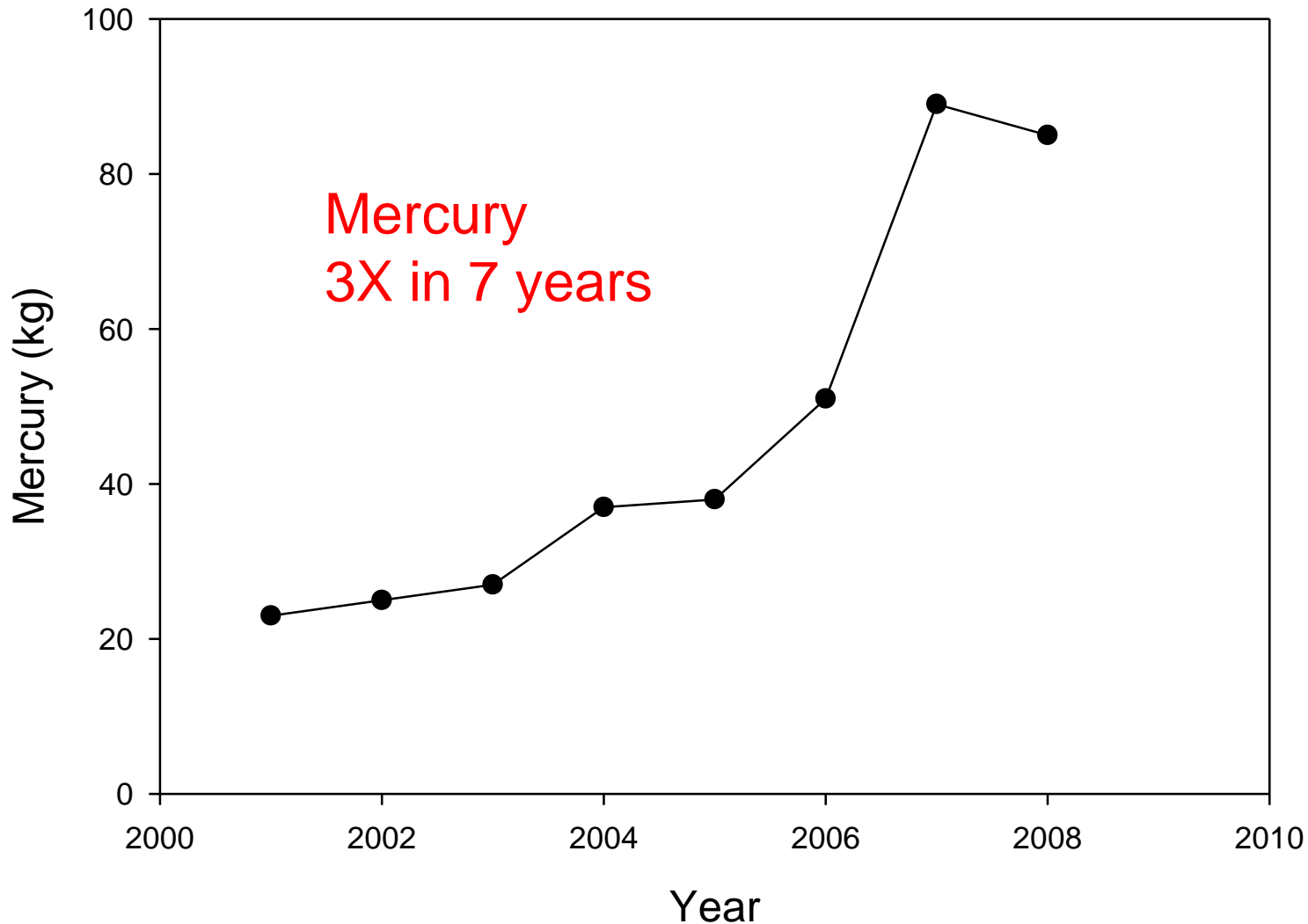


New industrial development (Petro Canada/UTS Fort Hills) along the eastern bank of the Athabasca River, on 12 August 08 .

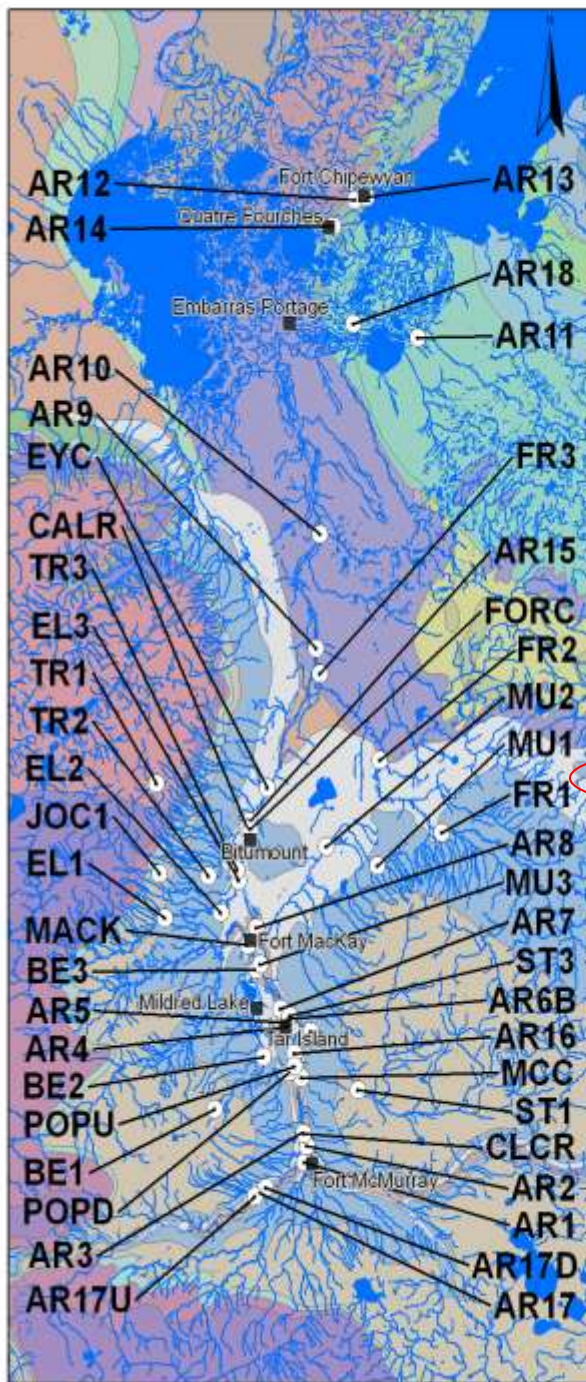
- **Based on two reports from the 1970's/early 1980's, emissions of large amounts of particulates & metals have likely been occurring for about 30 years and perhaps since the late 1960s.**
- **Contaminants in snow have not been reported since.**



NPRI airborne emissions from the oil sands industry



Environment Canada's National Pollutant Release Inventory also shows high and increasing emissions of many toxic substances.



Athabasca Sampling Sites 20090325

○ Athabasca Sites

■ Places

FORMATION

- Clearwater Formation
- Grand Rapids Formation
- Granite gneiss
- Manitou Falls Formation
- McMurray Formation
- Middle Devonian
- Waterways Formation

0 10 20 30 40 50



KILOMETERS

Projection: NAD 1983 UTM Zone 12
Spatial Data: NRCan NTDB
<http://geogratis.cgdi.gc.ca>
Alberta Geological Survey (AGS)
<http://www.ags.gov.ab.ca/GIS>

Feb-Mar 2008

Samples of snow
taken from 31 sites.

Athabasca River and its
tributaries sampled at 37 sites,
upstream and downstream of
development.

June-Aug 2008

Samples of Atha. R. and its
tributaries at 47 sites.

**A study deliberately
designed to test the
contributions of
natural sources of
contaminants vs.
industry**

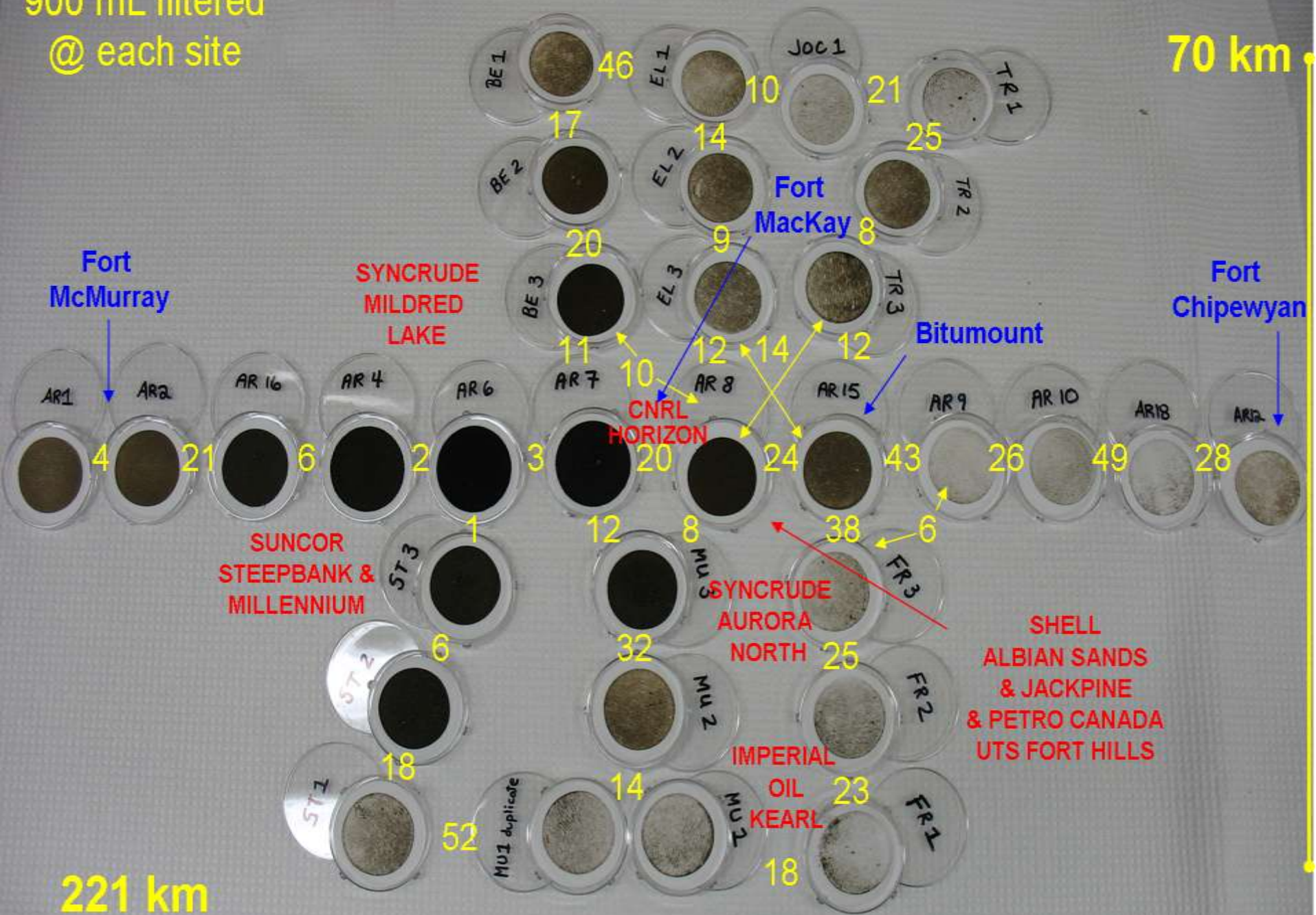
MU 3

**Snow profile,
Muskeg River,
March 2008**



900 mL filtered
@ each site

70 km



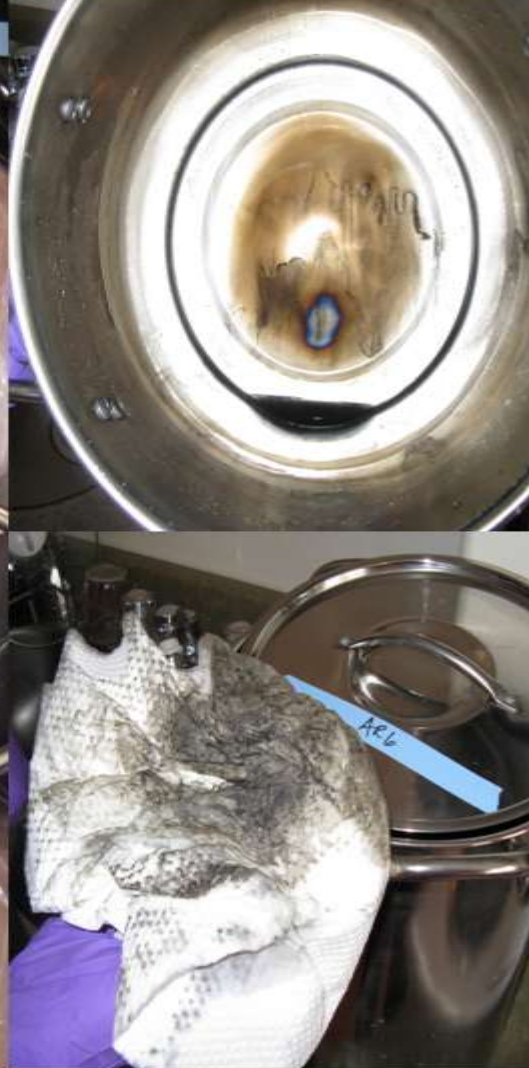


Unimpacted
Site AR1

Melted Snow



Impacted
Site AR6, near upgraders.
Note oil on surface of
snow water.



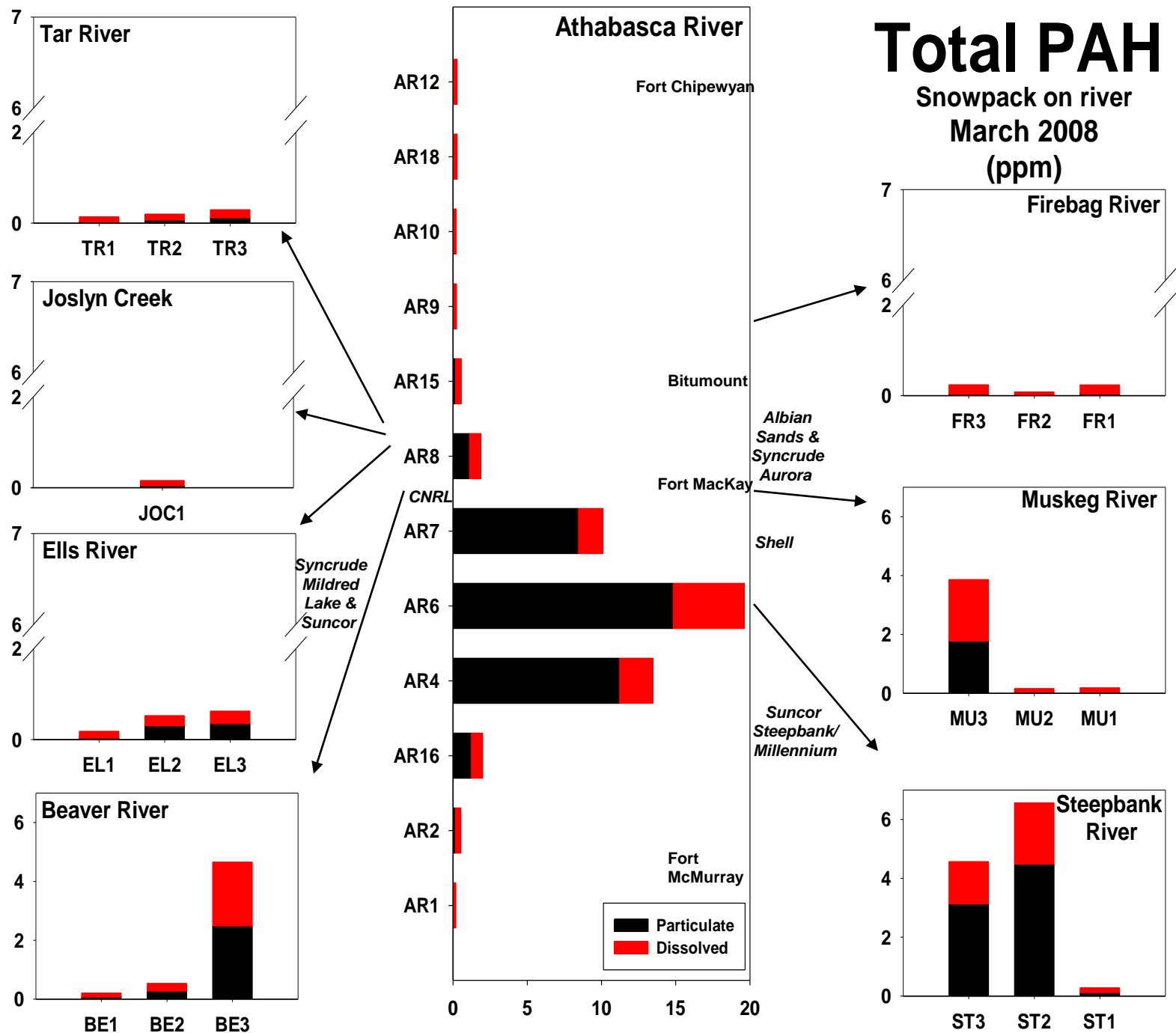


Fig 8

Total Mercury

Snowpack on river
March 2008
(ppt)

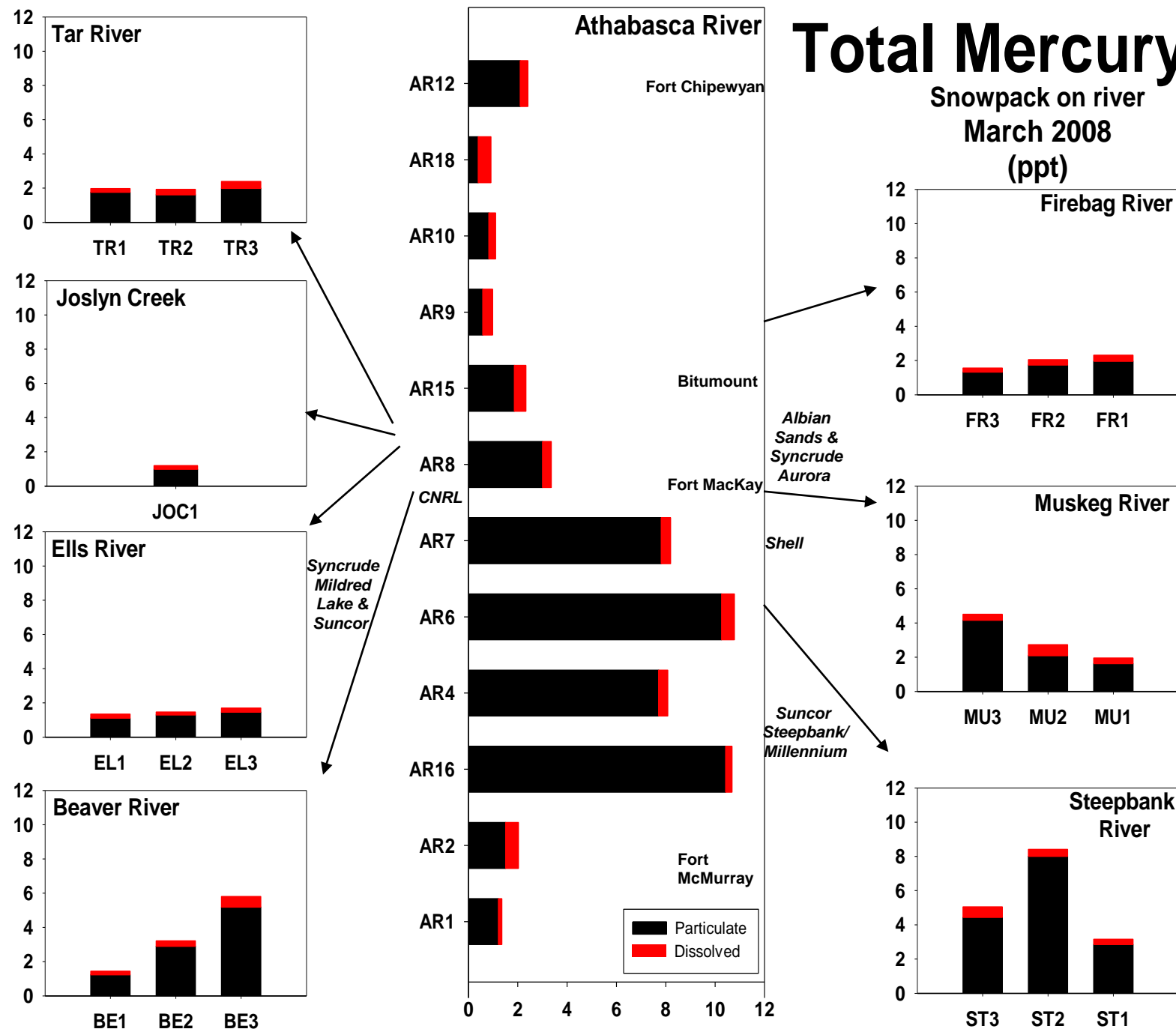


Fig 12

Lead

Snowpack on river
March 2008
(ppb)

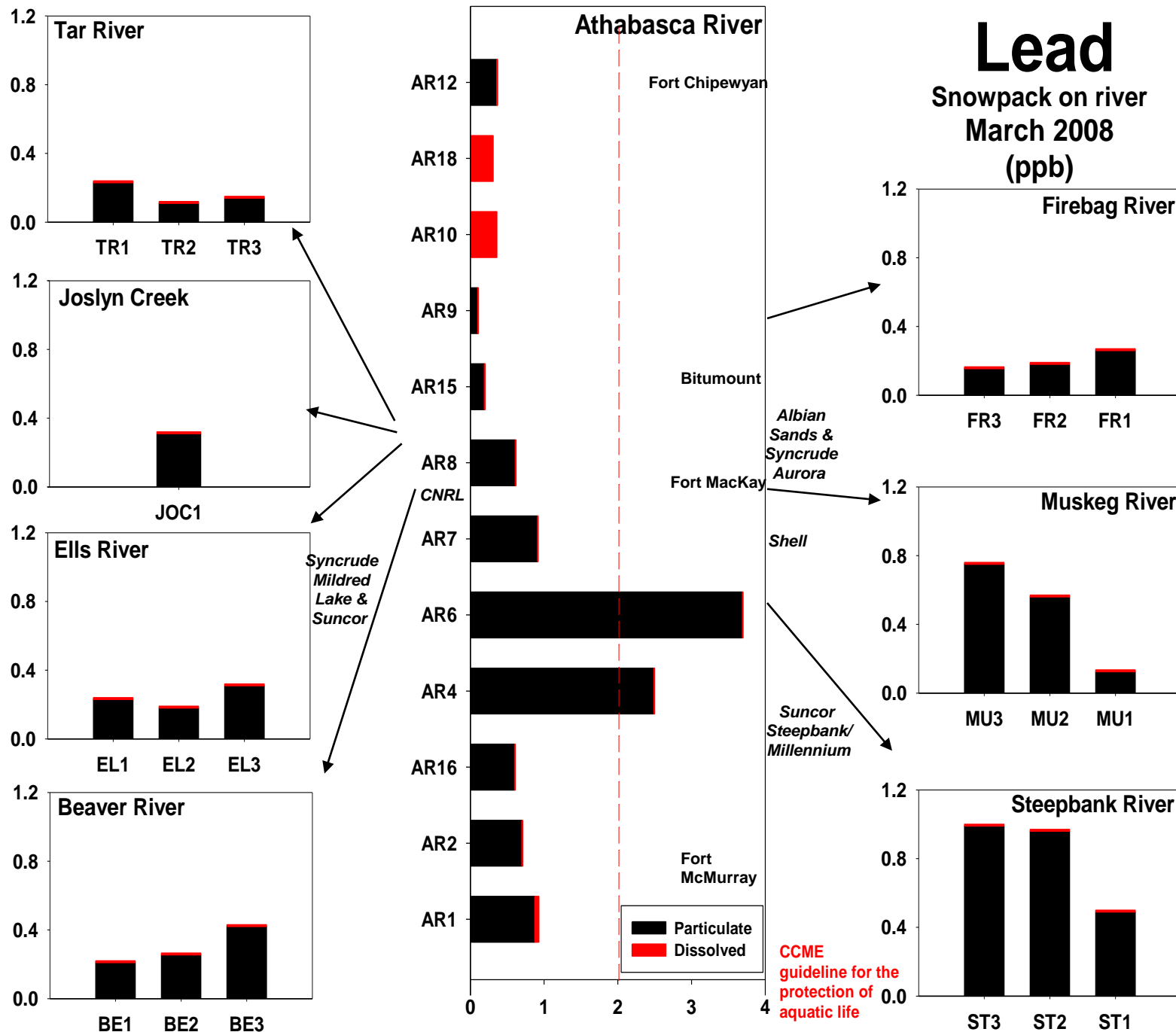


Fig 11

Arsenic

Snowpack on river
March 2008
(ppb)

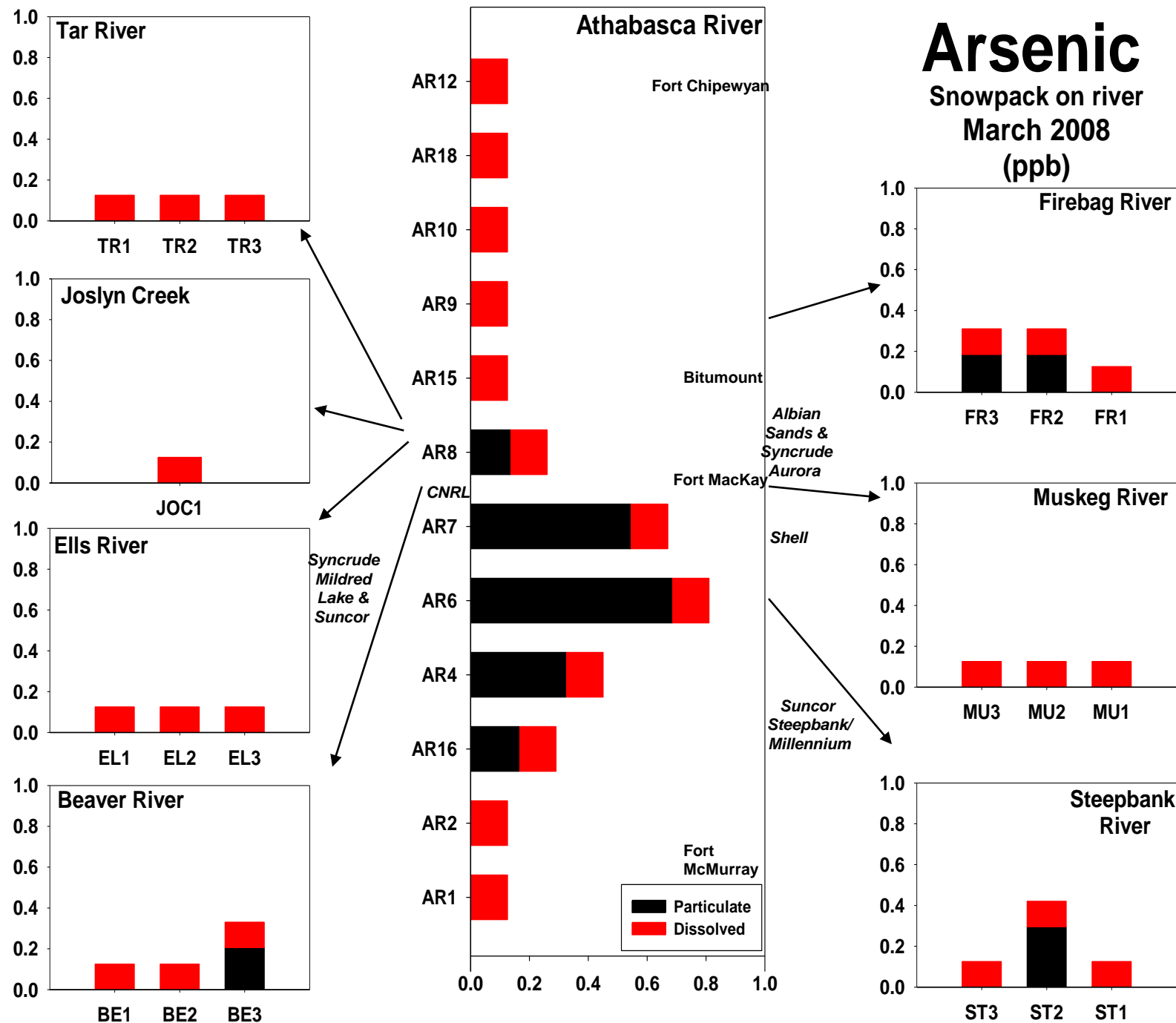
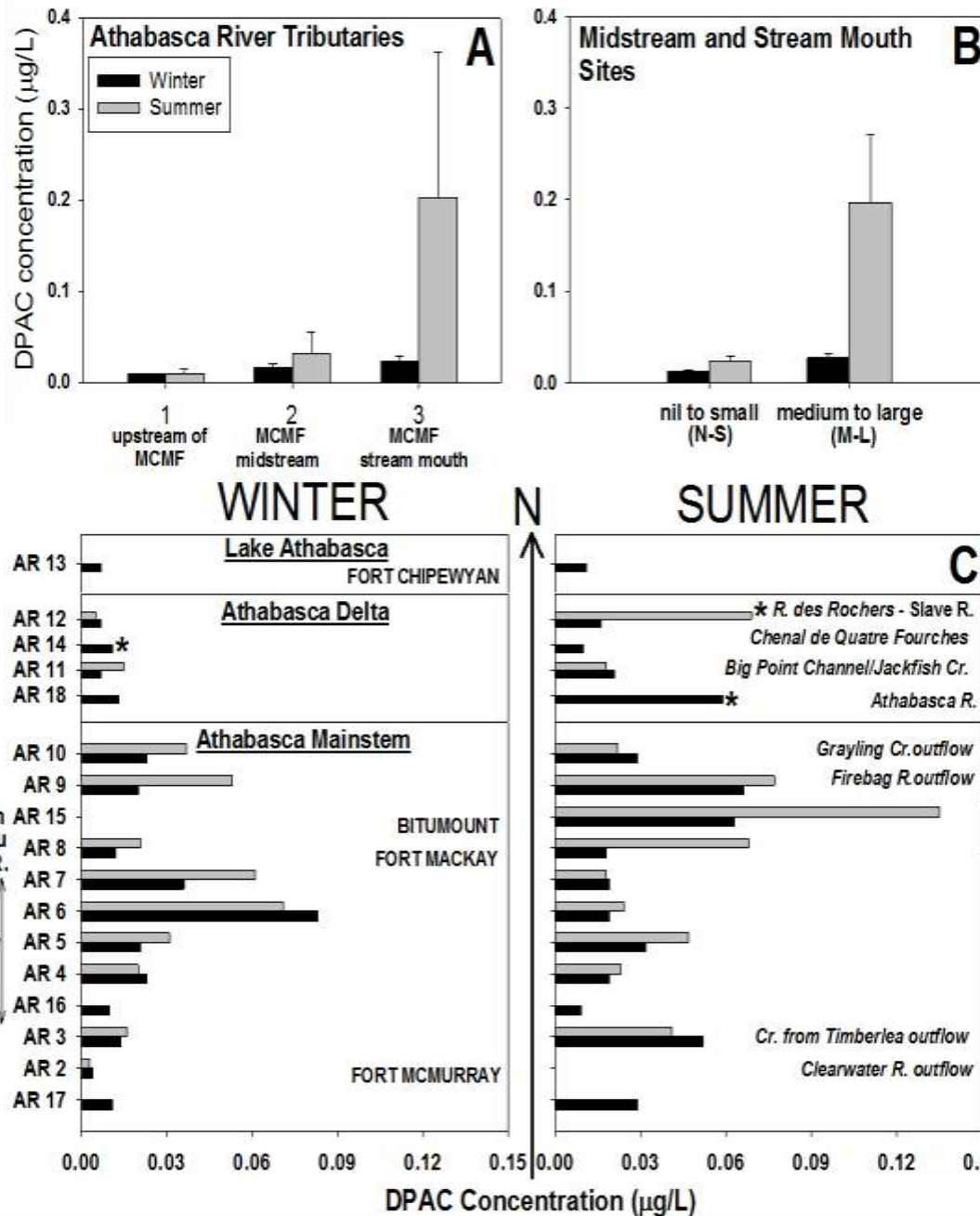


Fig 10

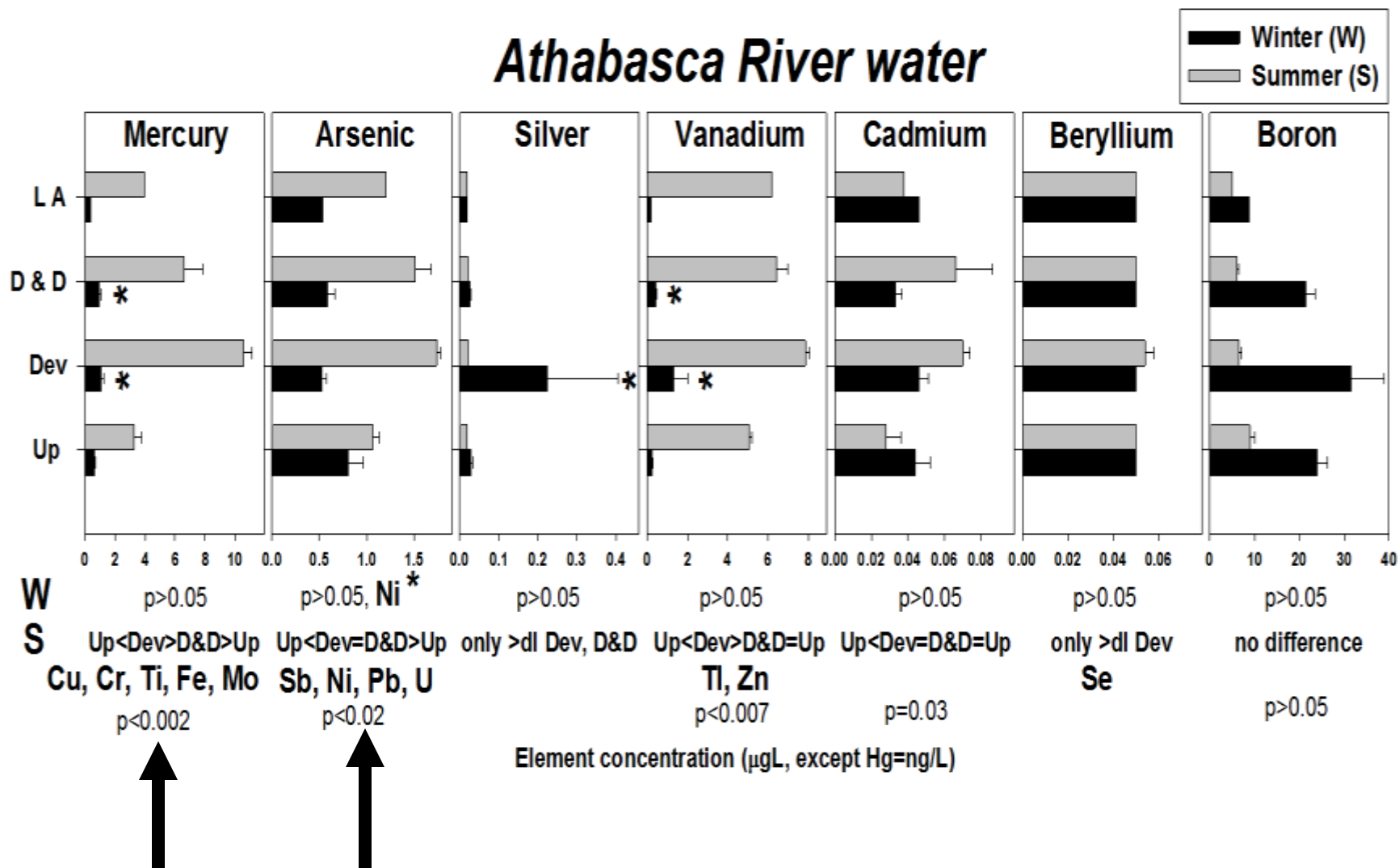
Polycyclic
Aromatic
Compounds in
the Athabasca
River and its
tributaries.



W

CNRL Horizon
TOTAL/Deer Creek In-Situ
Petro Canada Dover MacKay R.
Syncrude Mildred Lake

Athabasca River water



Environment Canada: Where are you? Sec 36(3) Fisheries Act



Suncor's Oil Sands Operation

Mackenzie River Basin Board. 2004. Mackenzie River Basin State of the Aquatic Ecosystem Report 2003.

**Keeping
Waterfowl
Away?**





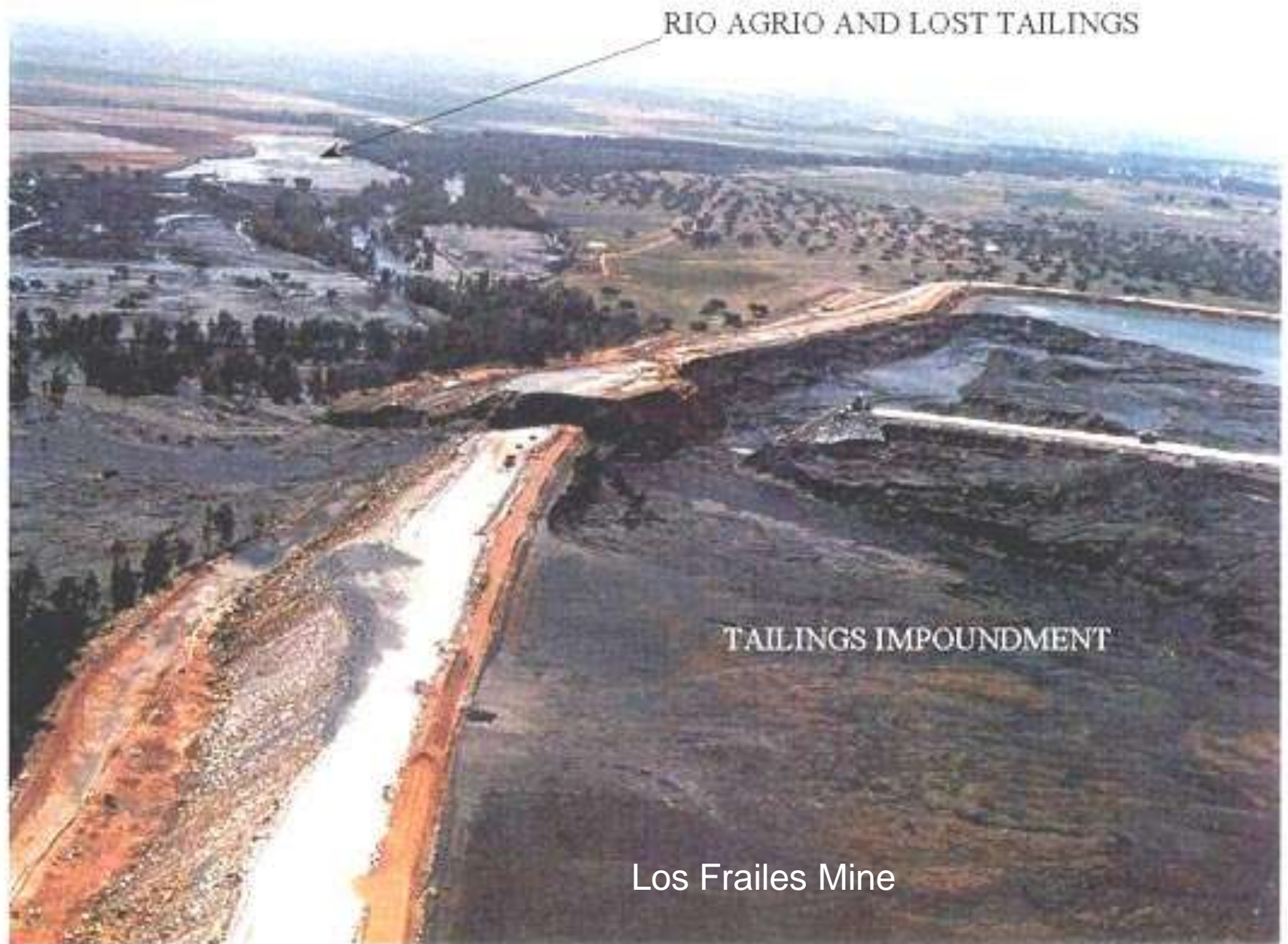


FIGURE 5. Photograph of Dam Breach Looking South (from Eptisa, 1998).

Los Frailes statistics:

Pond area: 160 ha

Pond volume: 15 million cubic meters

Dike breach release: 7 million cubic meters

1.3-1.9 million tonnes tailings

Area covered 5000 ha

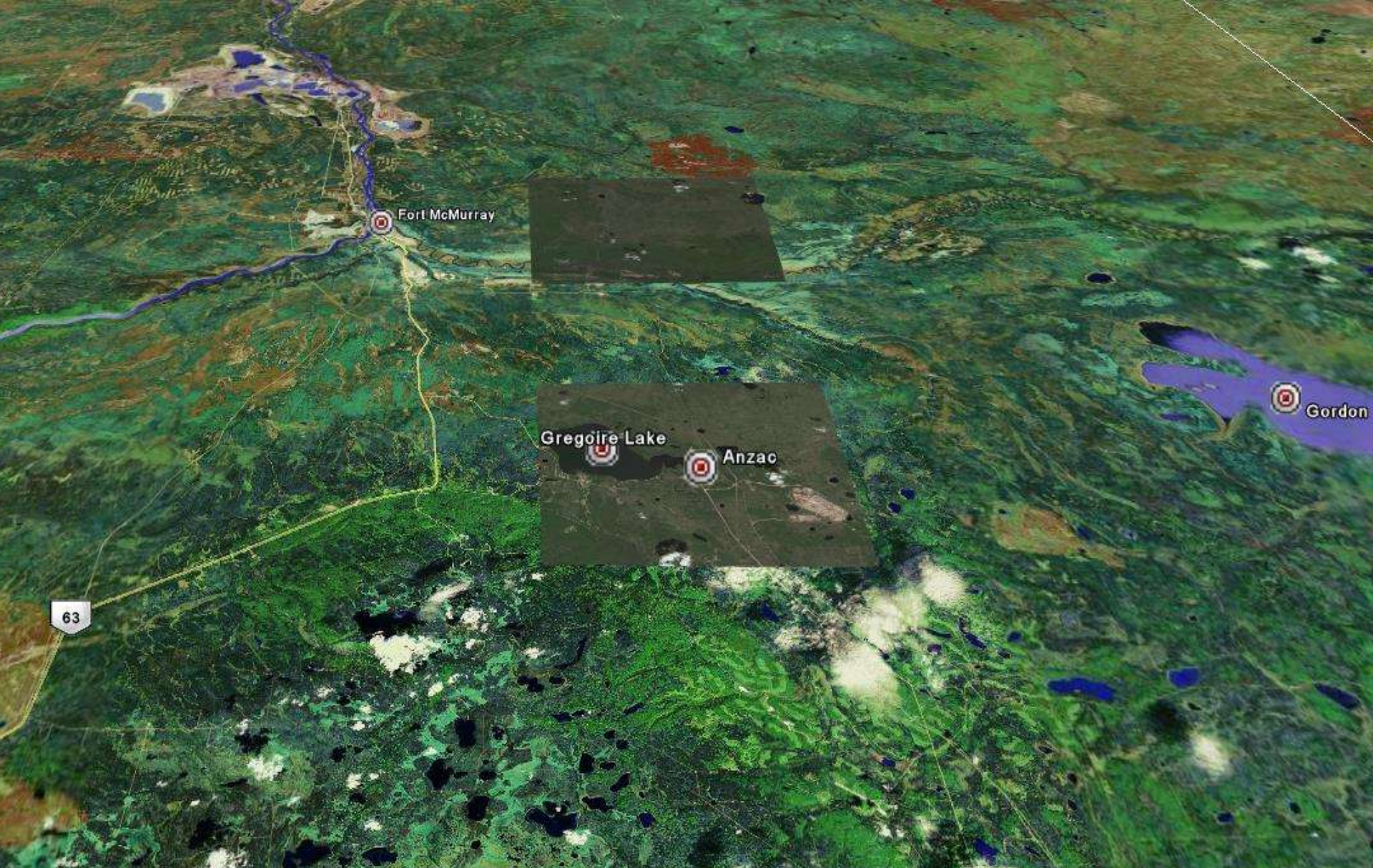
Cleanup costs \$37 million

Mildred Lake statistics:

Pond area: 1300 ha

Pond volume: 400 million cubic meters

Pond leakage: 11 million liters/day



Next slide shows simulation of future development footprint based development of existing leases

Image © 2006 DigitalGlobe
Image © 2006 MDA EarthSat

Google™

52.84° W elev 497 m

Streaming ||||| 100%

Eye alt 46.74 km



Fort McMurray

Gregoire Lake

Anzac

Gordon

63

© 2006 Navteq
Image © 2006 DigitalGlobe
Image © 2006 MDA EarthSat

© 2005

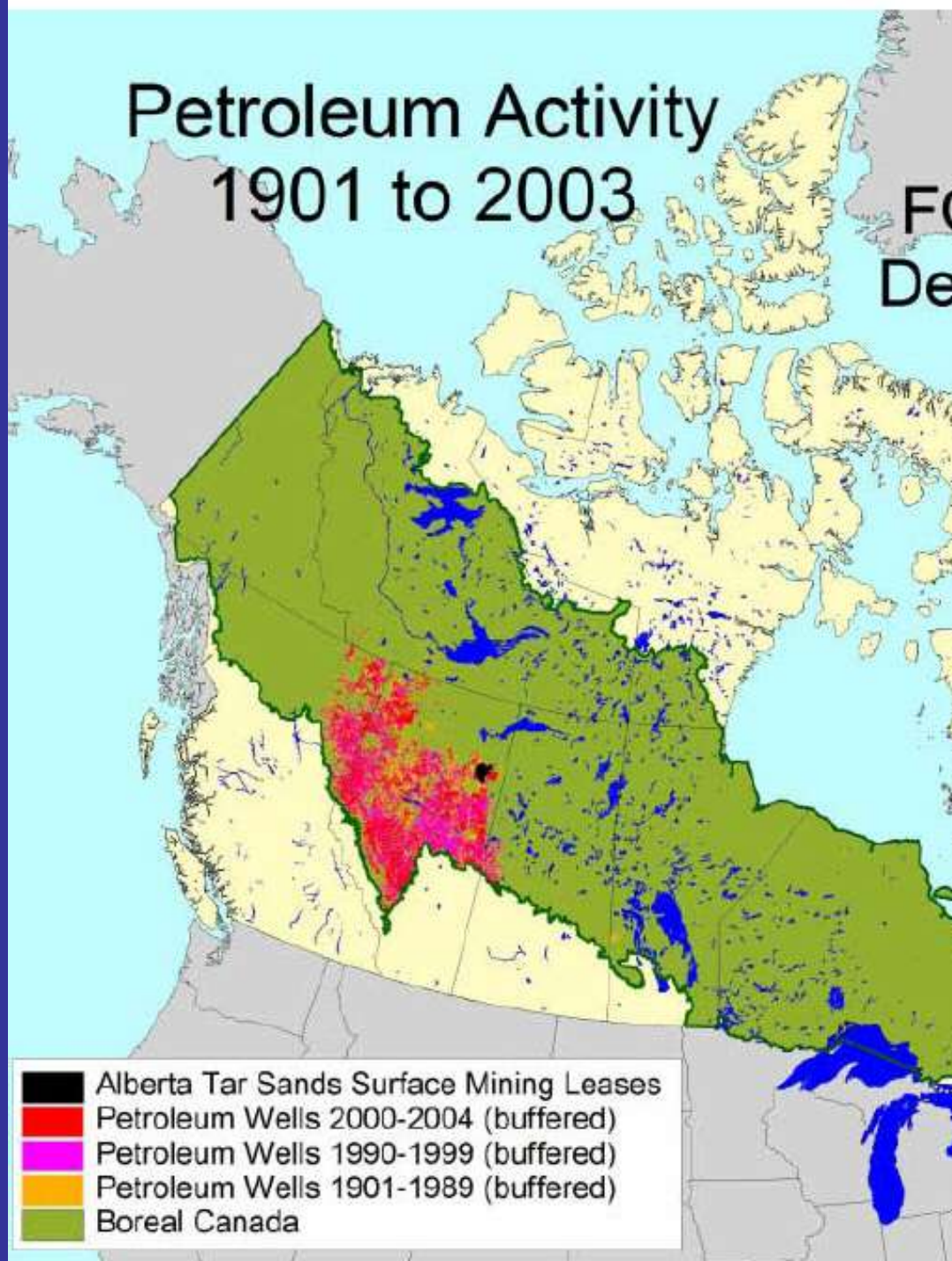
Google

152.84° W elev 497 m

Streaming 100%

Eye alt 46.74 km

Petroleum Activity 1901 to 2003



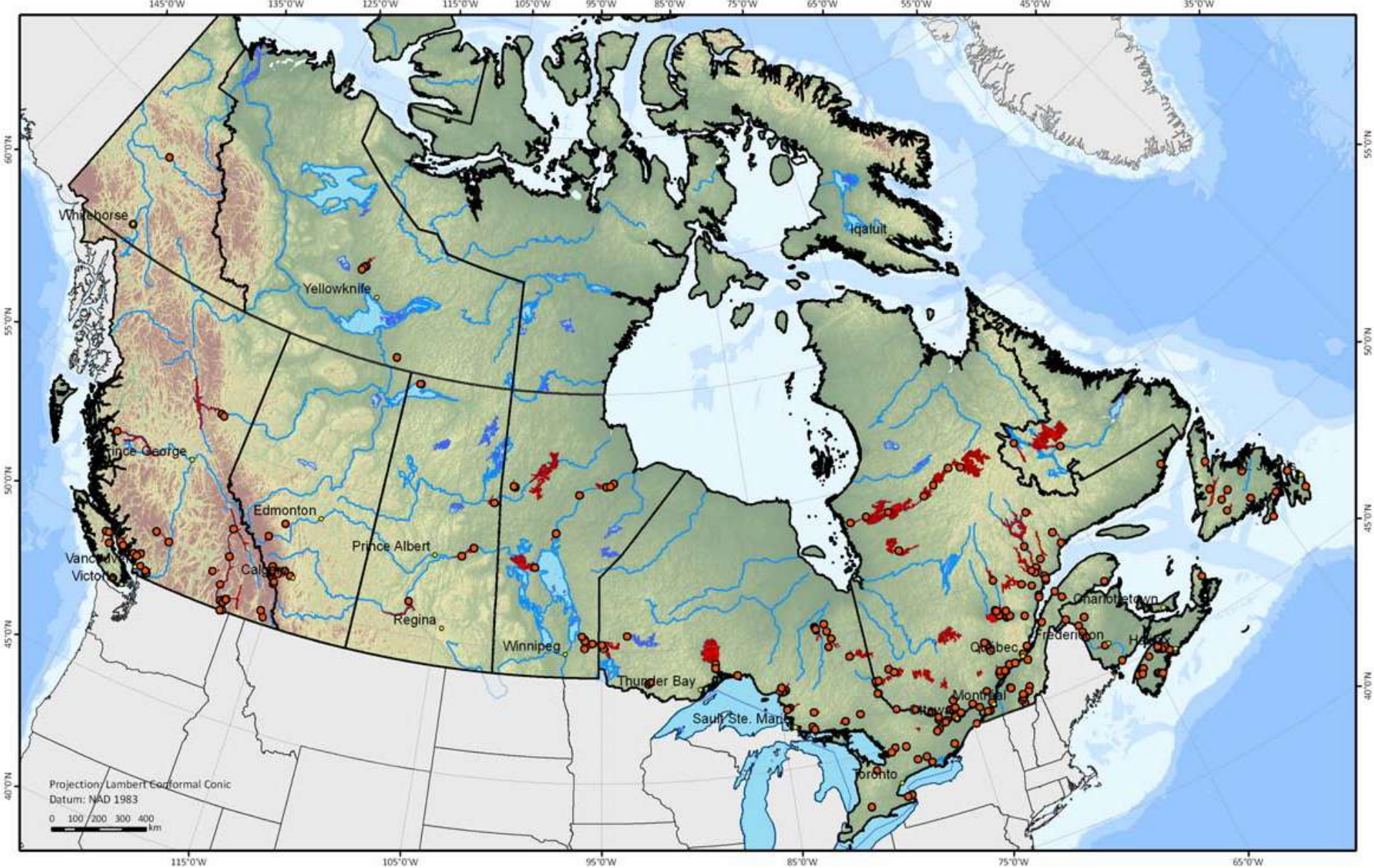
Petroleum Activity FUTURE

FO
Dec



**Global Forest
Watch**

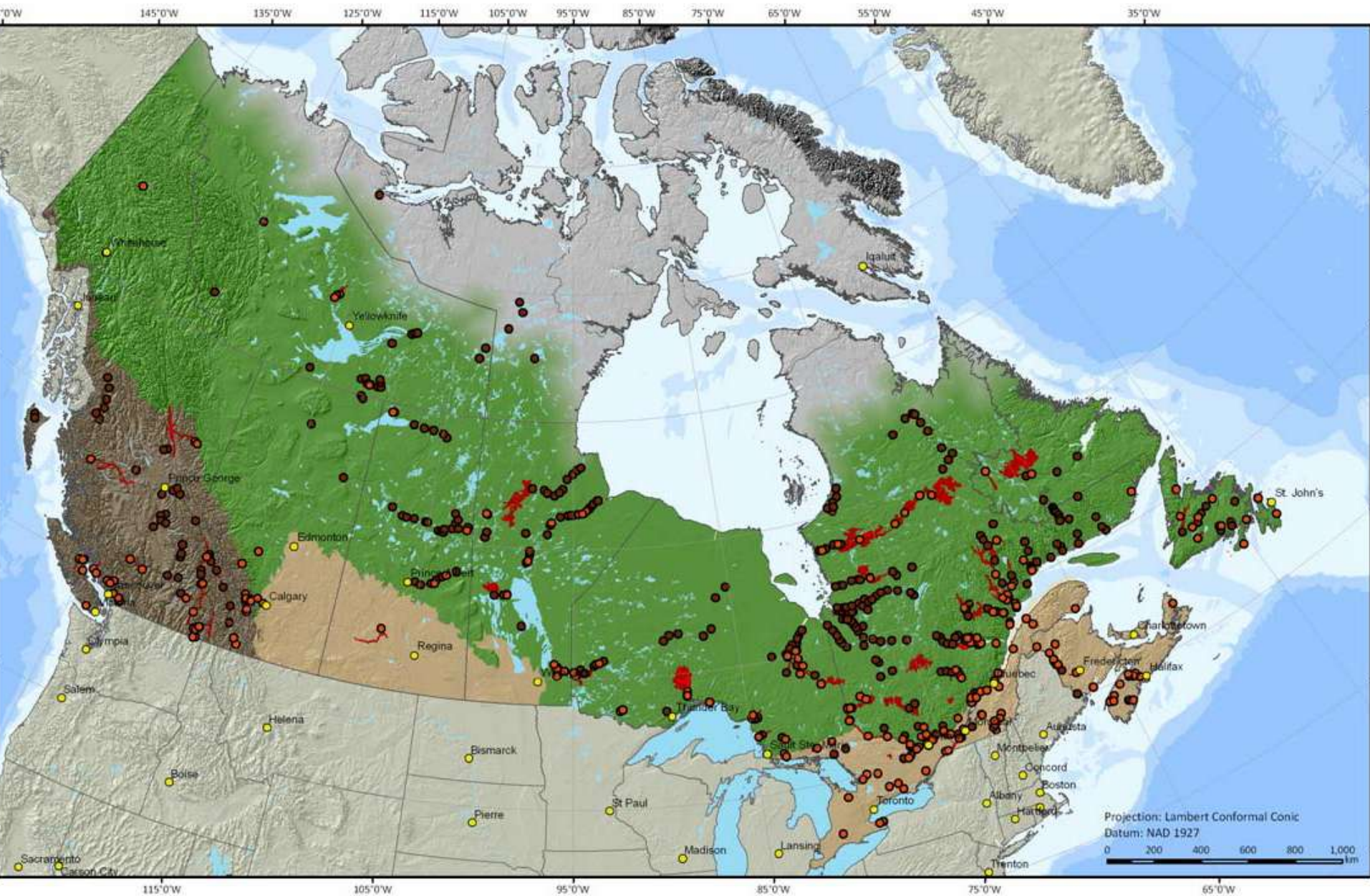




Existing Large Hydroelectric Facilities
in Canada

● Existing Hydroelectric Facilities Existing Hydroelectric Reservoirs

Global Forest Watch (in press)



Existing and Potential Hydroelectric Development in Canada

- Potential Hydroelectricity Facilities
- Existing Hydroelectricity Facilities
- Existing Hydroelectricity Reservoirs

**TABLE 4. LIFE-CYCLE GREENHOUSE GAS EMISSIONS FROM
NON-HYDRO GENERATION TECHNOLOGIES**

	Range (gCO ₂ eq/kWh)	Average
Coal (modern plant)	959 – 1,042 ^a	1,000
IGCC (coal)	763 – 833 ^b	798
Diesel	555 – 880 ^c	717
Natural gas combined-cycle (NGCC)	469 – 622 ^{d,e}	545
Photovoltaic	12.5 – 104 ^f	58
Wind turbines	7 – 22 ^f	14

Sources:
a Spath et al. (1999).
b Gibbins (2005).
c IEA Implementing Agreement for Hydropower (2000).
d Spath and Mann (2000).
e Meier (2002).
f World Energy Council (2004).

Temperate reservoirs

8-60

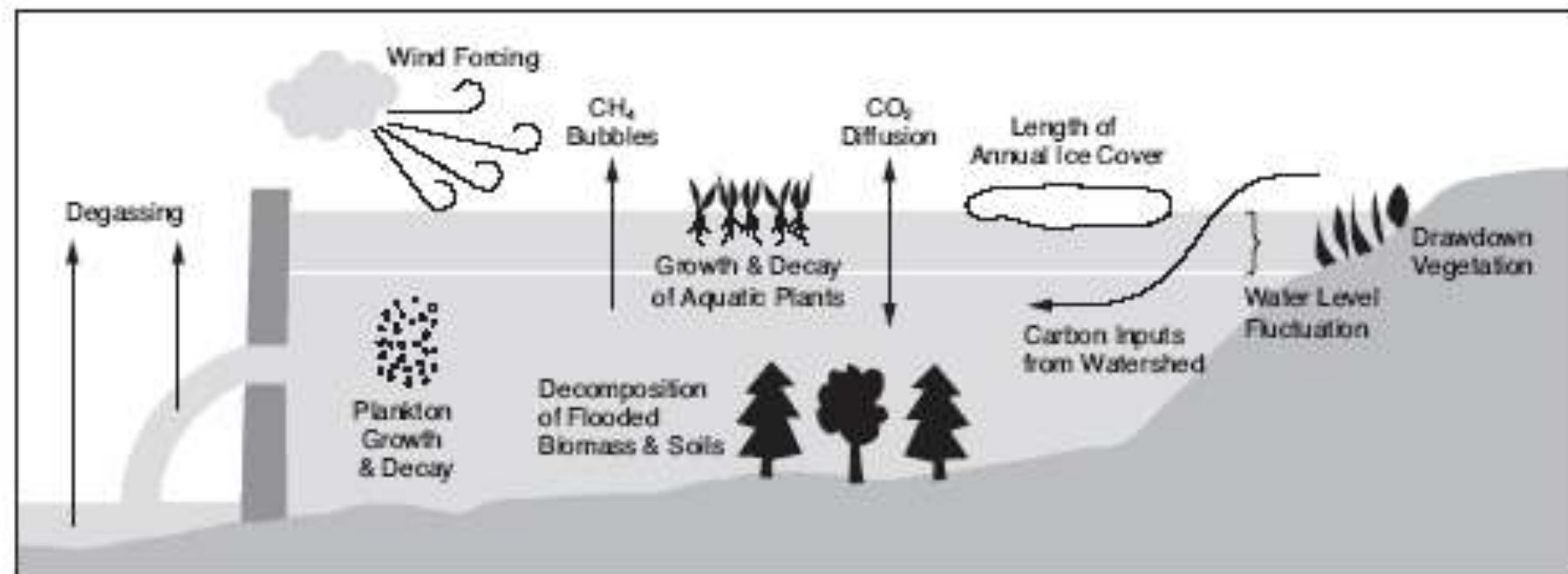
36

Tropical reservoirs

190-18030

>1000

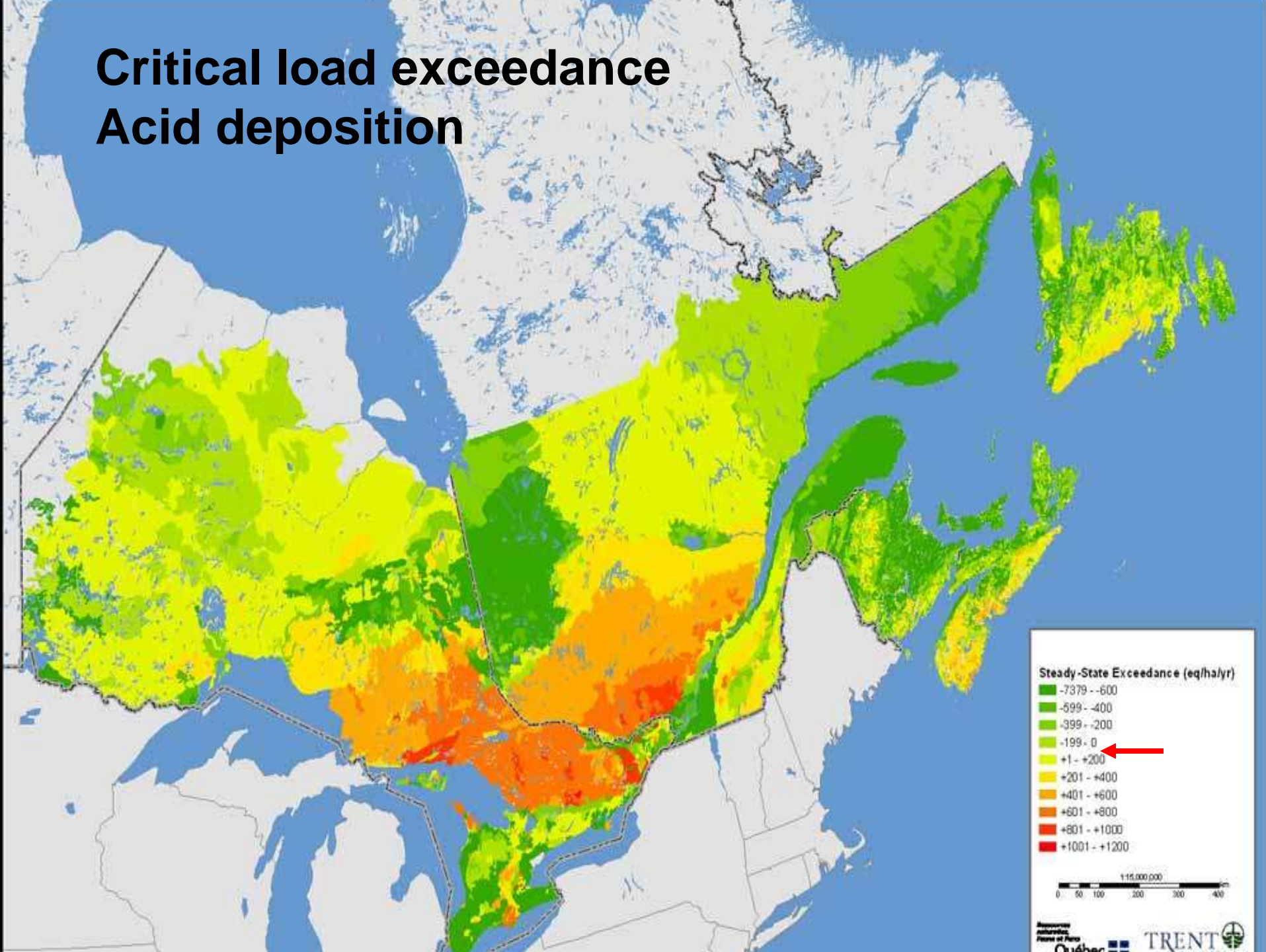
FIGURE 3. SOME KEY FACTORS INFLUENCING RESERVOIR GHG EMISSIONS

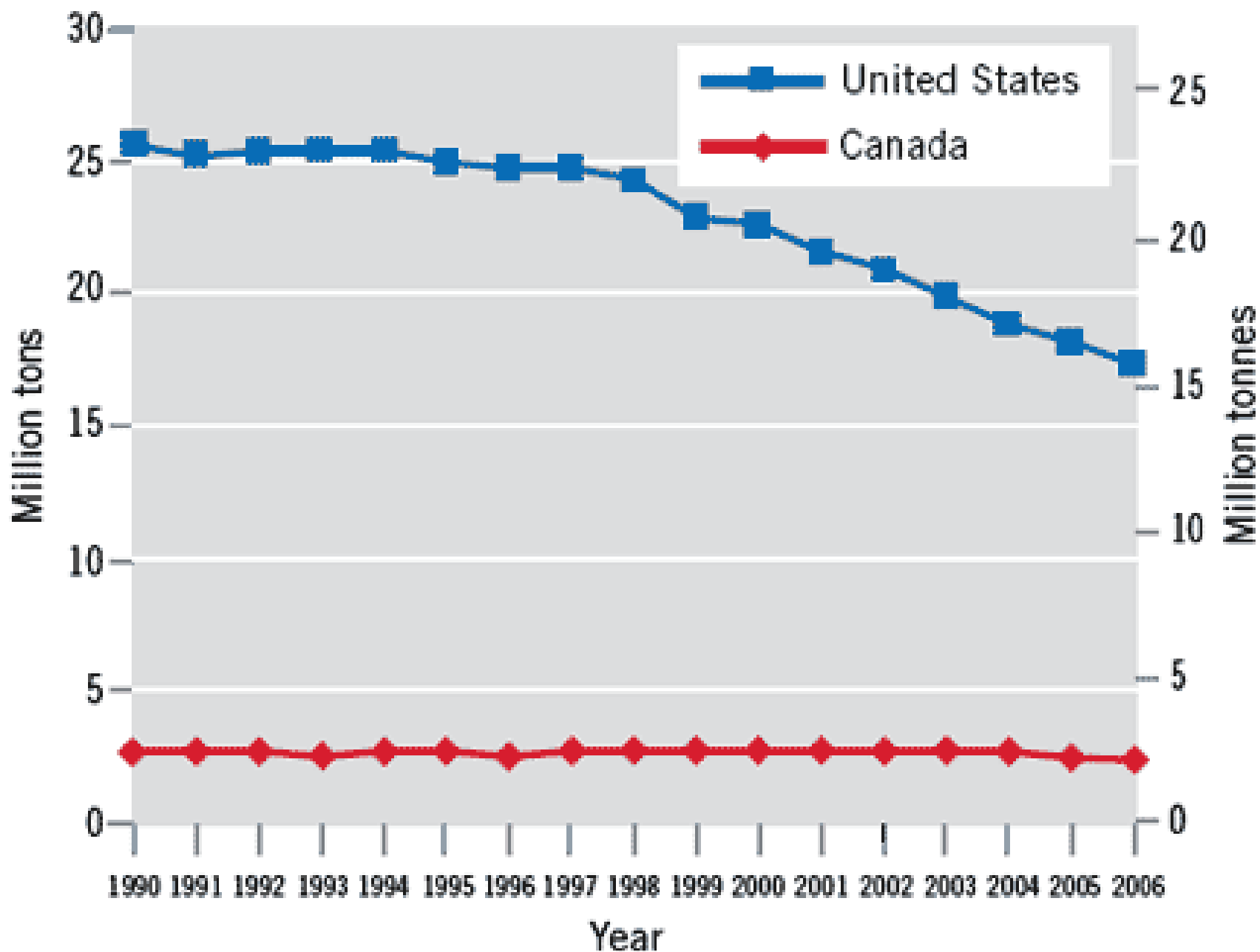


Reservoirs, some Reservations:

- Pollute fisheries with mercury.
- Emit some greenhouse gases.
- Displace people and wildlife habitat.
- Cause channel morphology to change.
- Deprive downstream users of water.
- Deprive downstream fishes of habitat & natural migration routes.

Critical load exceedance Acid deposition





Source: EPA and Environment Canada, 2008

NOx emissions

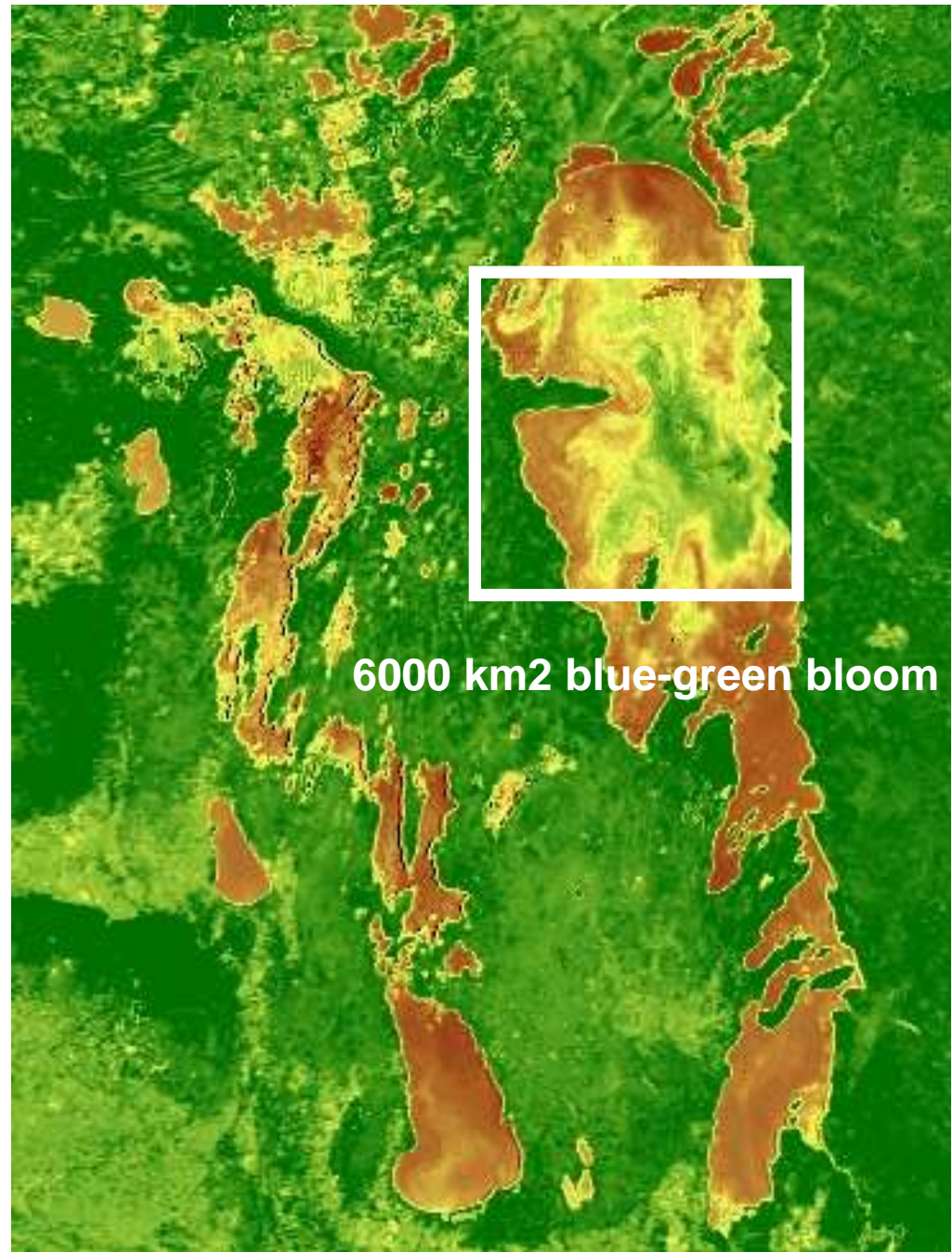


Blue-green N Fixation In Lake Winnipeg

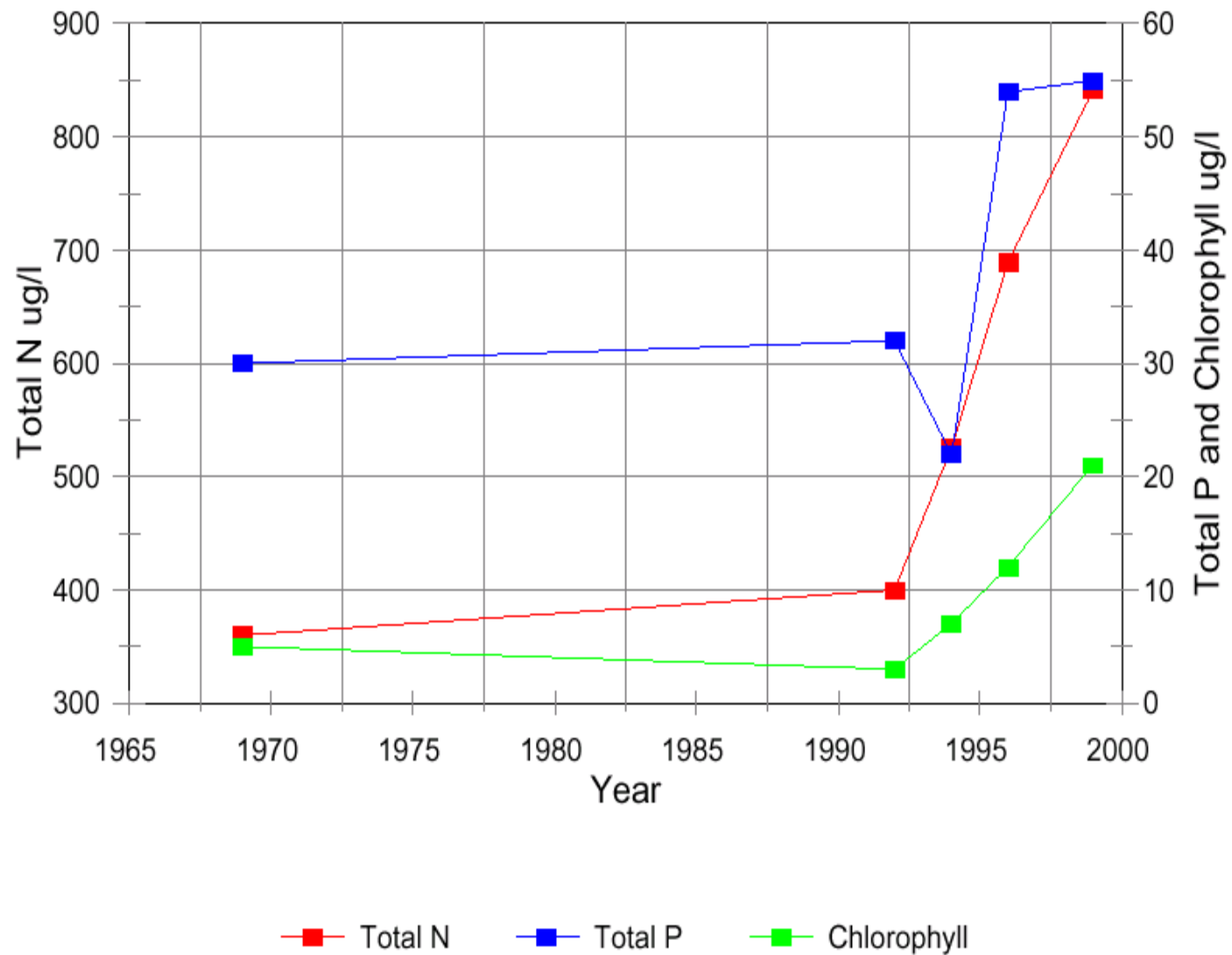
AVHRR NDVI Image

Brown = Low Chlorophyll
High Turbidity

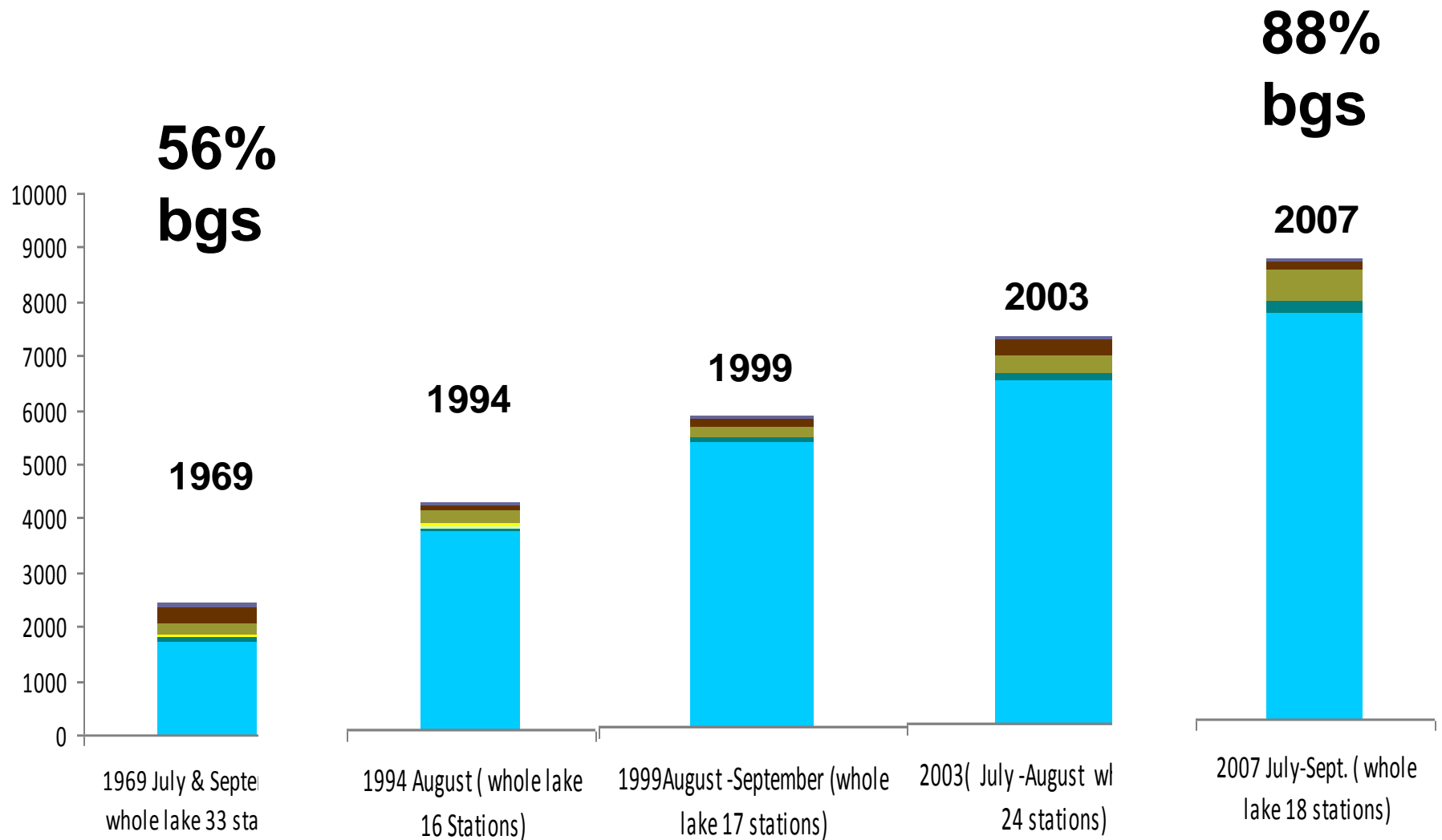
Green = High Chlorophyll



Lake Winnipeg North Basin



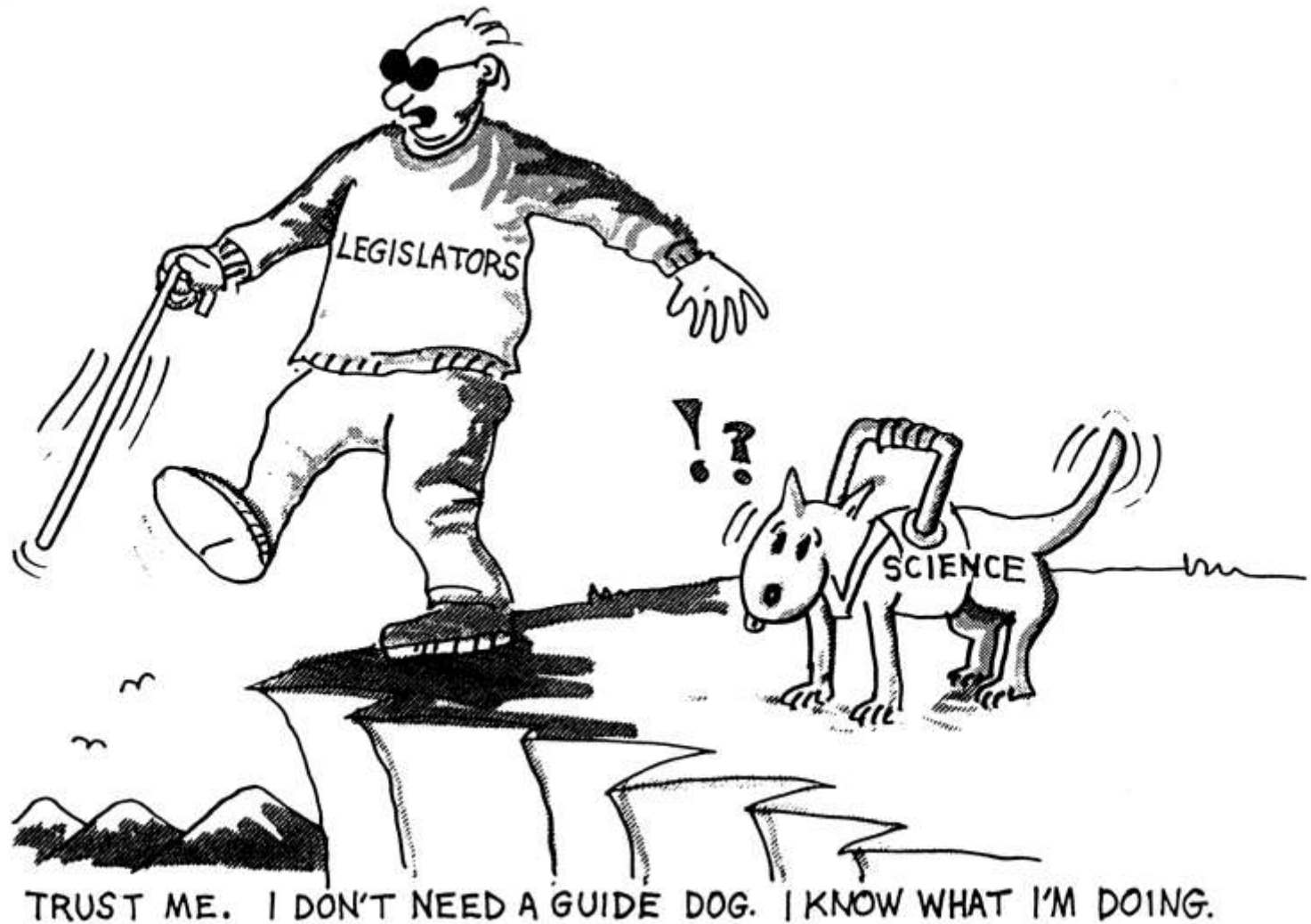
Changes in Lake Winnipeg Phytoplankton over 38 Years. Pale blue = bluegreens. Data from Hedy Kling



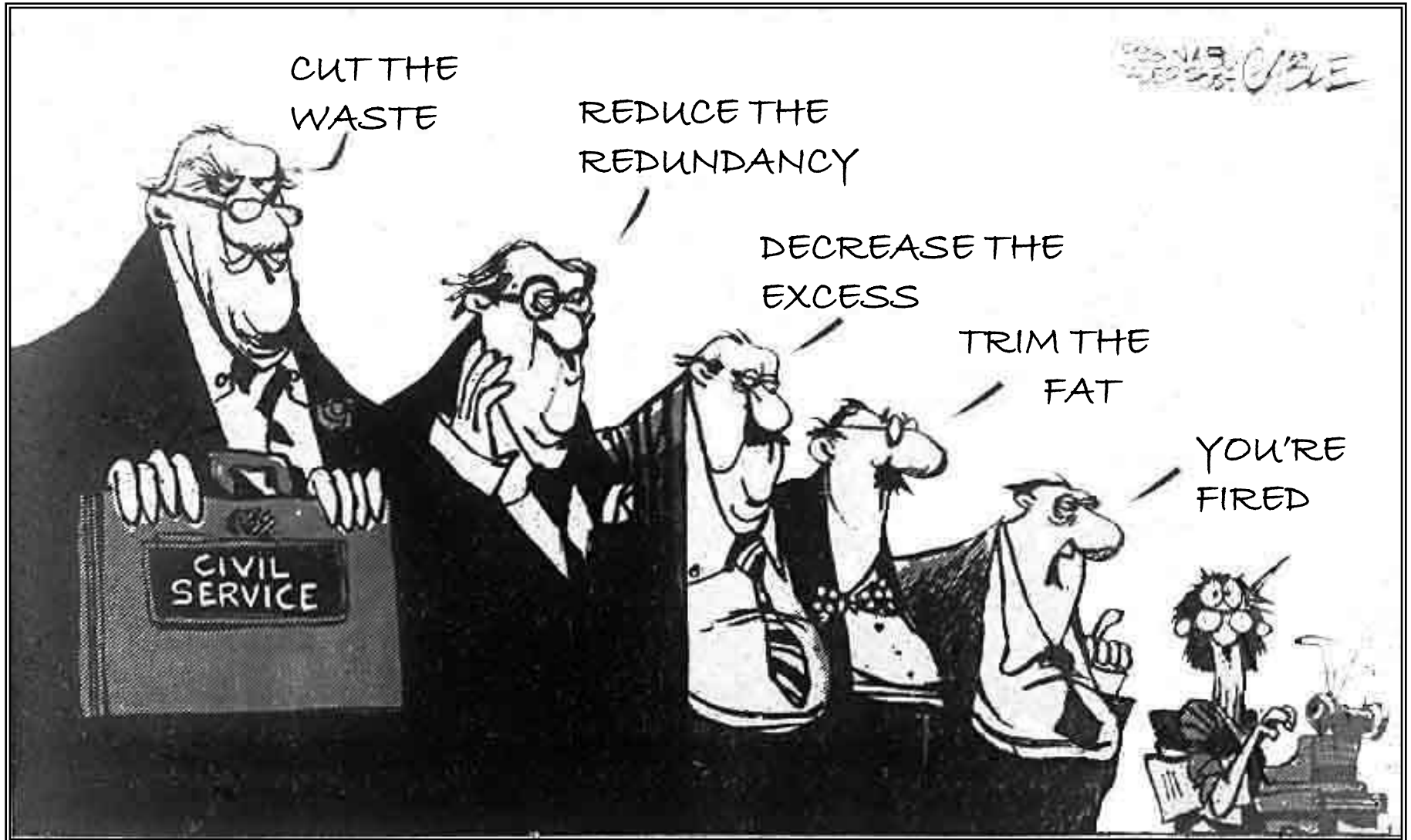




Needed: A better dialogue with decision makers



We must restore federal & provincial government science





Muzzling events of the past few years

1. CBC News. Minister stops book talk by Environment Canada Scientist. April 6th, 2006.
2. Reuters. Canada slashes spending on wildlife protection: CBC. September 19th, 2007.
3. Picard A. Handling of the listeriosis outbreak is a disgrace. Globe and Mail Sept 11, 2008.
4. Smith C. Climate scientist claims Stephen Harper's government has muzzled experts. *The Georgia Straight* 2008.
5. Leak by Environment Canada scientist March 15th, 2010.

Canadian Science Policy the Subject of International Ridicule

Science in retreat. 2008. Nature 451(7181):866.

“... Canada’s researchers have plenty to be proud of, consistently maintaining their country’s position among the world’s top ten....Alas, their government’s track record is dismal by comparison.”

“Canada’s leading scientists can be advocates,urging the government of the day to boost their country into a position of leadership rather than a reluctant follower.”

2010: Canadian government science



Examples of DFO's Bungling

- **Atlantic Cod collapse**
- **The Kemano Salmon Scandal**
- **Salmon Farms**
 - Escaped Atlantic Salmon
 - Sea Lice
 - PCBs
 - Red Tides
- **The near-disappearance of Freshwater Research**
- **Widespread collapse of freshwater and marine fish stocks.**

HAS FEDERAL SCIENCE REACHED THE BOTTOM?

- Most talented senior scientists have left or retired.
- Morale among remaining staff is poor.
- Recruiting talented replacements is difficult
 - Salaries are well below universities.
 - Funding is too low to perform new research.
 - Technical support is low and dwindling.
- Obedience is rewarded, competence is not.
- Reorganization and planning are continuous, but scientific performance is not measured.
- *Time for a new model, the present one doesn't work*

Why Do We Need Government Environmental Science?

- Long-term research and monitoring.
- Professionally done EIAs.
- Interdisciplinary research beyond what universities can do.
- Lower cost than private sector.
- More professionally done than private consultants.

Why we urgently need strong links between environmental sciences and policy in Canada in 2010

- **Climate change**
- **The myth of water abundance**
- **Increasing eutrophication**
- **Acid rain continues**
- **Increasing population and industrial development**
- **The oil sands-the world's most destructive project.**
- **Rising “virtual water” exports**
- **Rising tensions with the USA**
- **Industry's propaganda machine is busy**

A Good Start on a National Water Plan

- Uniform federal *regulations* for water management & water quality.
- Abolish FITFIR & water markets, replace with a more equitable system.
- Set aside water first for ecosystem needs & basic human water needs.
- Integrate protection of watersheds and water.
- Recognize value of ecosystem services.
- Strong, federally integrated watershed monitoring programs.
- Choose industries with low net water demand, low potential to pollute water.
- Limit population and industry, especially in dry or overcrowded basins.

Additional Needs:

**Consideration of First Nations rights..
water and watersheds.**

**A more developed and broader boreal
vision.**

A National Water Strategy & Policy.

Solutions-Revisit the FRB Model

- Abolish the business model and multi-layered bureaucracy.
- Put senior scientists in charge of the science agency, not bureaucrats.
- Put government –sponsored science at arms length from the political process.
- Have organizations responsible to taxpayers, not politicians.
- Link departments to university departments.
- Make accurate public communication a priority.
- Develop strong national policies and enforce them.
- Recognize excellence, not obedience.

*The land bears the scars
of minds whose history
was imprinted by no example
of fore bearing mind, corrected,
beloved.*

Wendell Berry

Efficient Irrigation Technology – shifting a fraction of the crops irrigated by flooding fields to sprinkler and drip systems;

Improved Irrigation Scheduling – using local climate and soil information to help farmers irrigate more precisely; and

Regulated Deficit Irrigation – applying less water to certain crops during drought-tolerant growth stages to save water and improve crop quality

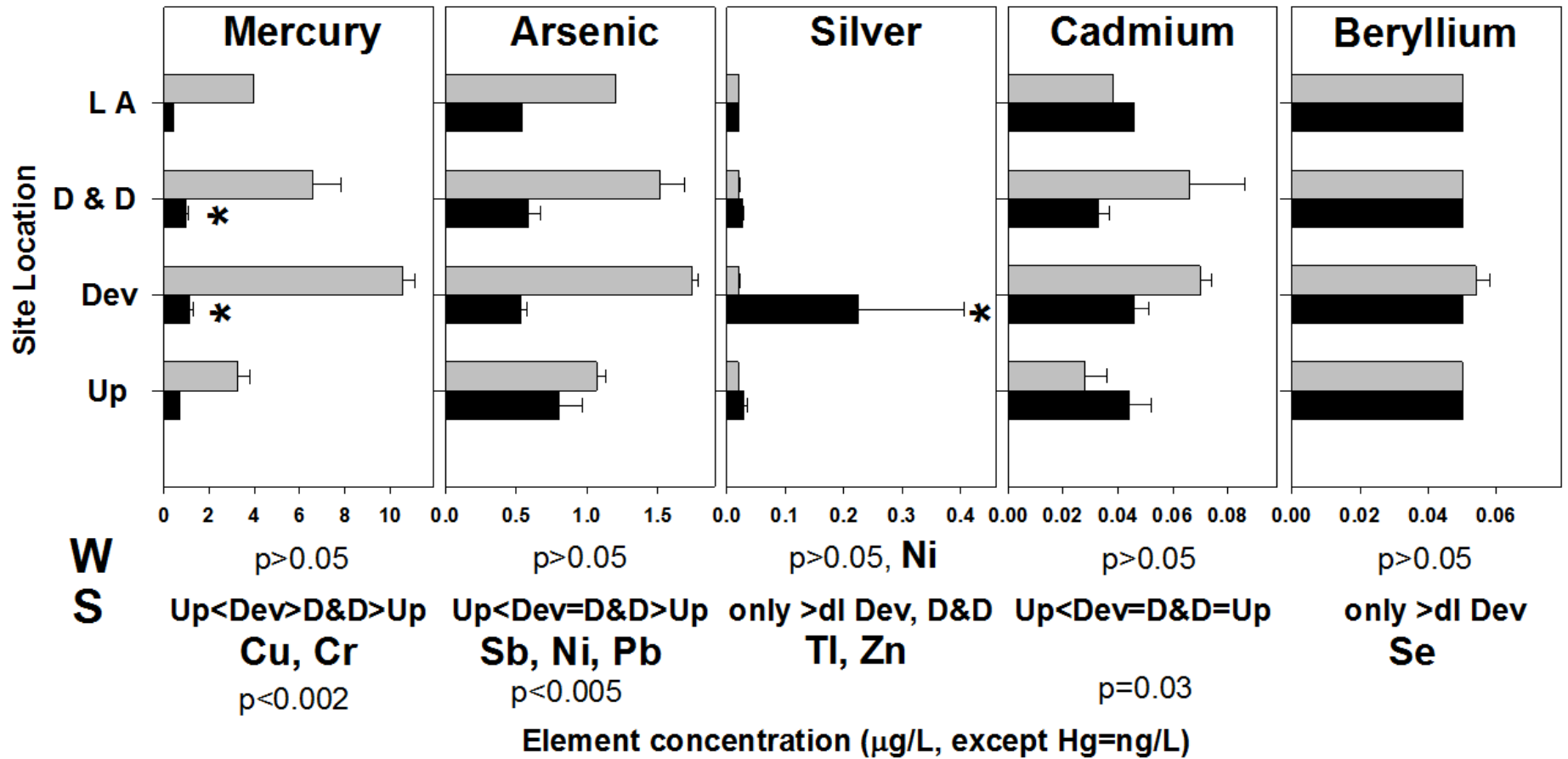
“The failure to meet the most basic water requirements of billions of people has resulted in enormous human suffering and tragedy. It may be remembered as the 20th Century’s greatest failure.”

Peter Gleick 2008

Create protection of adequate instream flows
to conserve aquatic ecosystems
Give priority of water to basic human needs
Integrate water and land use management plans
Develop equitable sharing of water in times
of shortage

Share the Water Ecojustice and Water Matters 2009

Athabasca River water



**“I've seen the future, brother:
it is murder.**

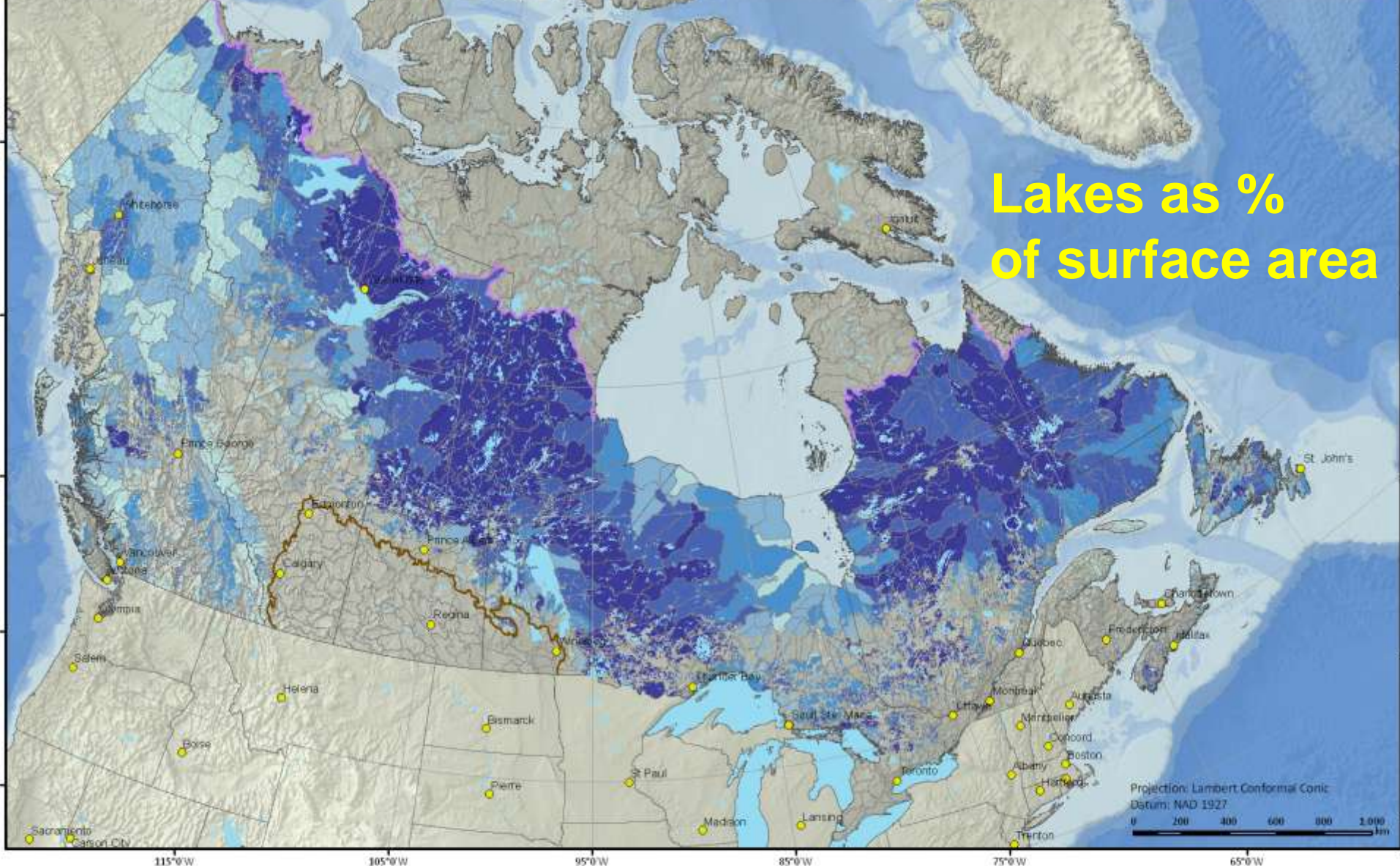
**Things are going to slide,
slide in all directions**

Won't be nothing,

Nothing you can measure anymore.

**The blizzard, the blizzard of the world
has crossed the threshold,
and it has overturned
the order of the soul”**

Lakes as % of surface area



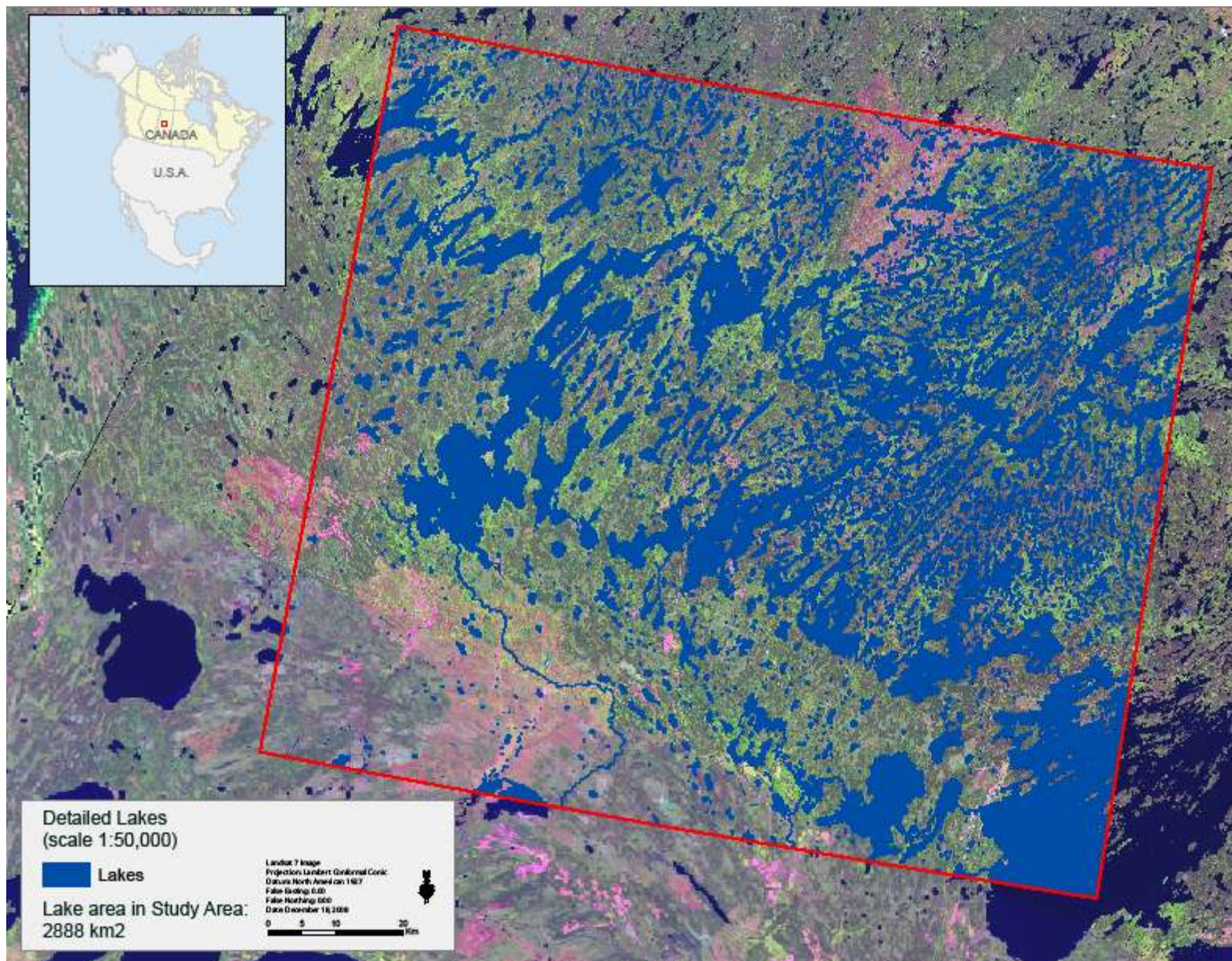
Lakes and Rivers within Canada's Intact Forest Landscapes by Watershed

Percent of Watershed Covered by Lakes and Rivers

- 0% - 1%
- 1.1% - 2.6%
- 2.7% - 5.1%
- 5.2% - 9.7%
- 9.8% - 38.7%

- Forest-Arctic
Ecozones Boundary
- Forest-Prairie
Ecozones Boundary







Southern Lake Winnipeg Climate 4000 yrs ago?

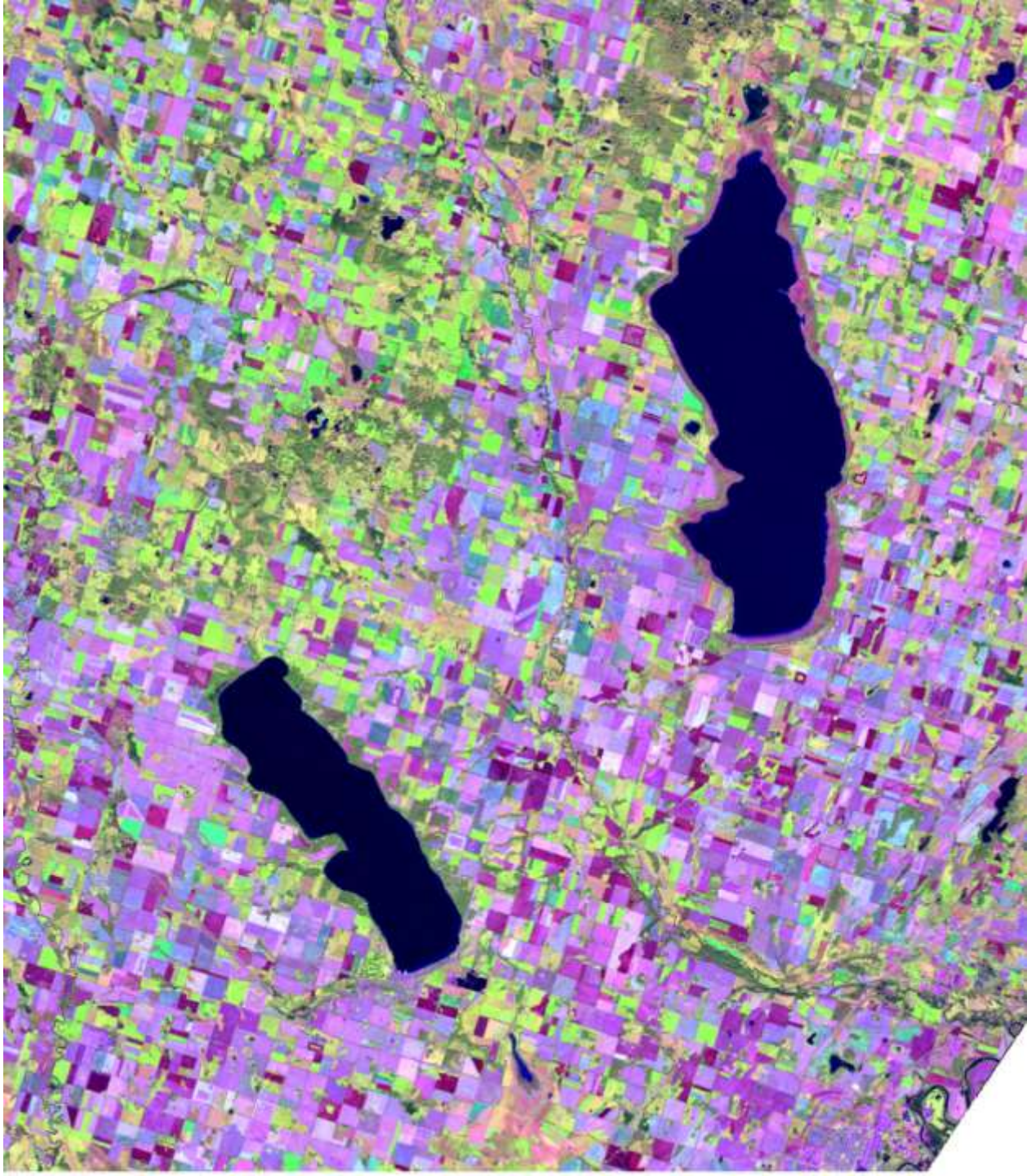
Wooded Fen



Bayley, 2004



Lac la Biche Sept 2005



Boreal Ecosystem Services-2002 dollars

Anielski and Wilson 2009

TOTAL VALUE, ECOSYSTEM SERVICES	\$703 x 10⁹
• Carbon storage	\$582 x 10⁹
• Flood control, water filtering, peatlands	\$77.0 x 10⁹
• Flood control, water filtering, biodiversity, non peatland wetlands	\$33.7 x 10⁹
• Pest control – boreal birds	\$5.4 x 10⁹
• Nature related activities	\$4.5 x 10⁹

Market Value of Boreal Resources

2002 Dollars

Anielski and Wilson 2009

Timber	$\\$18.6 \times 10^9$
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Mining + oil and gas	$\\$23.6 \times 10^9$
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Hydroelectric generation	$\\$19.5 \times 10^9$
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Costs:

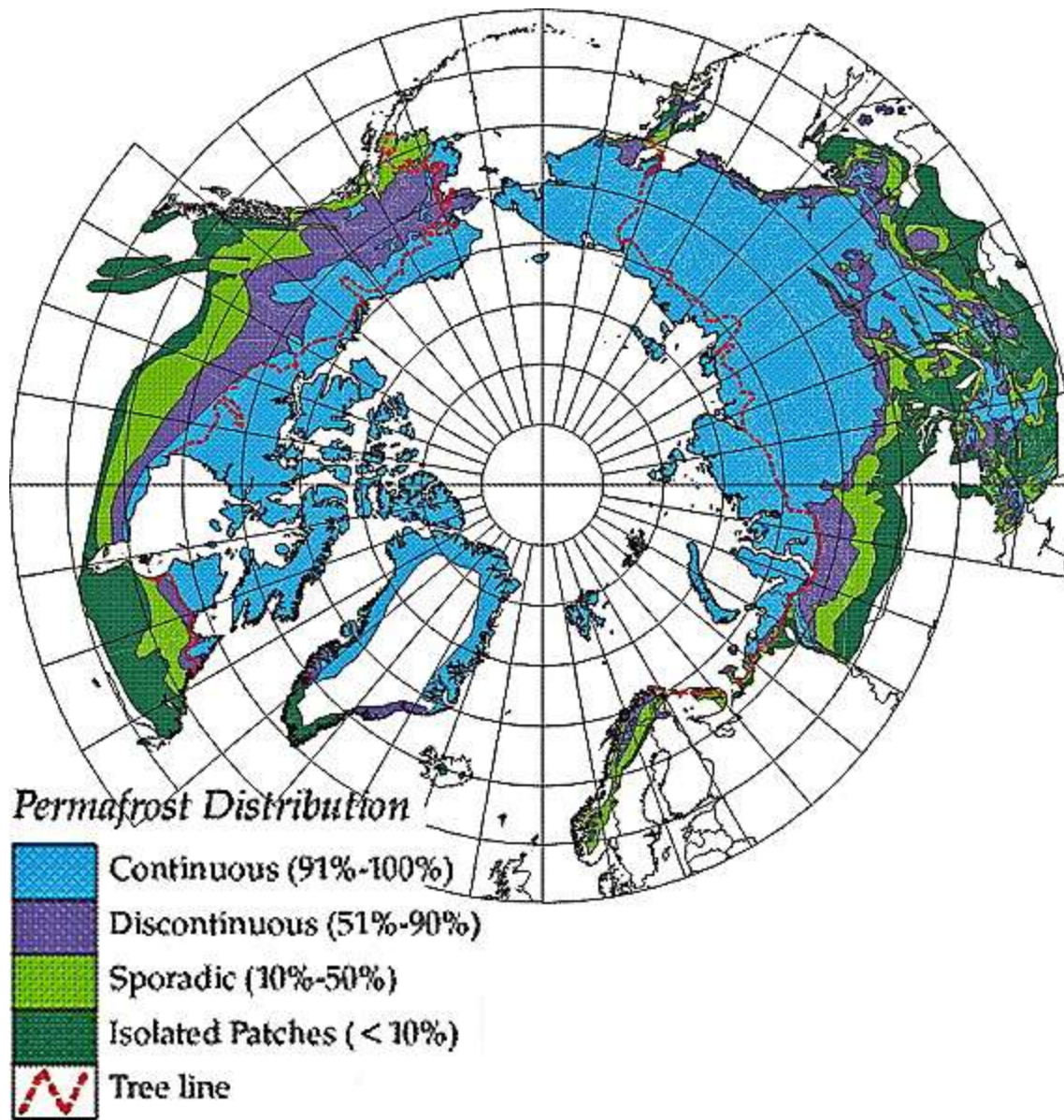
Air pollution	$\\$9.9 \times 10^9$
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Government subsidies	$\\$1.0 \times 10^9$
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Forestry carbon emissions	$\\$0.15 \times 10^9$
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Net value:	$\\$50.9 \times 10^9$
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ESP/GDP = 13.8



16% of global soils are in permafrost. They contain 1672 Pg C (50% global below ground C.).

Permafrost melt is expected to add as much as 400 Pg C to atmosphere by 2100.

Carbon Stores-Boreal, Tropical and Temperate Forests

Biome	Area (x 10 ⁶ ha)	Soil Carbon (Pg)	Plant Biomass Carbon (Pg)	Total Carbon (Pg)
<small>Based on Kasischke, 2000</small>				
Boreal Forest	1,509	625- 1700	78	703- 1500?
Tropical forest	1,756	216	159	375
Temperat e forest	1,040	100	21	121

(One Pg [petagram]=one billion metric tonnes or one trillion kg)

Major Problems with Environmental Impact Assessment

No assessment of cumulative effects of multiple projects.

Short term studies, done by poor methods and inadequate expertise.

No post-development analysis-were predicted impacts correct?

Poor government screening-too many at once.

Hearing panels are small, lacking in expertise.

A new model is needed