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# RECENT DEVELOPMENTS IN DETERMINING CRITICAL LOADS FOR SULPHUR AND NITROGEN DEPOSITION IN WESTERN CANADA

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Integration

Environment Canada

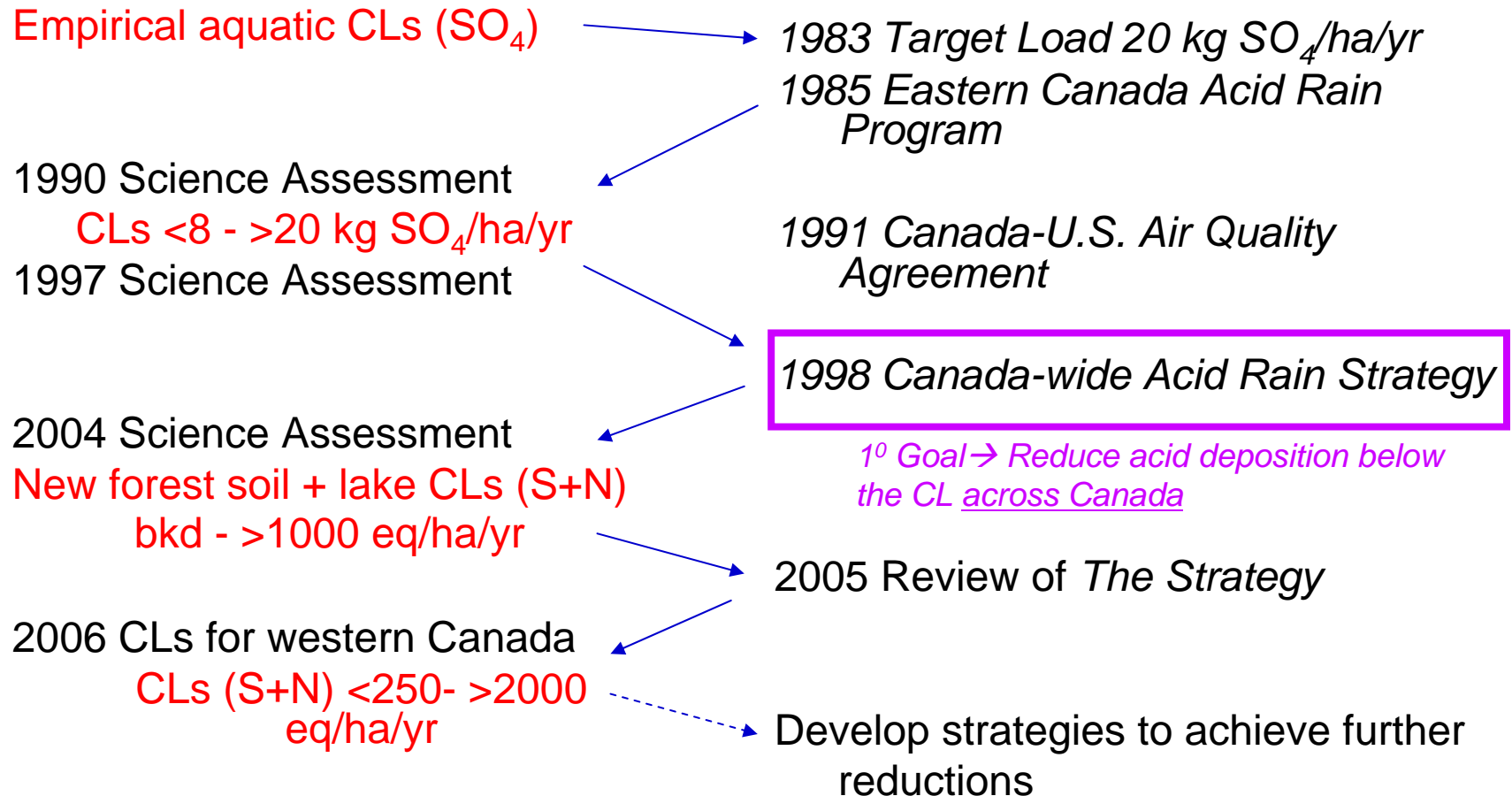
**Julian Aherne (Trent U.)**

**Shaun Watmough (Trent U.)**

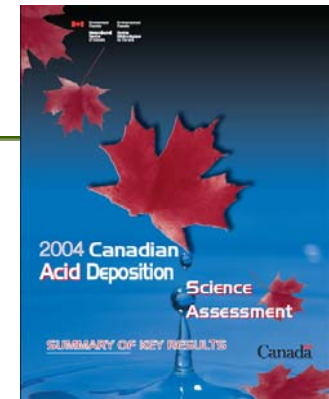
**Dean Jeffries (EC)**

NADP Science Meeting,  
Boulder, CO  
September 12, 2007

# The Critical Load and Acid Rain Policy

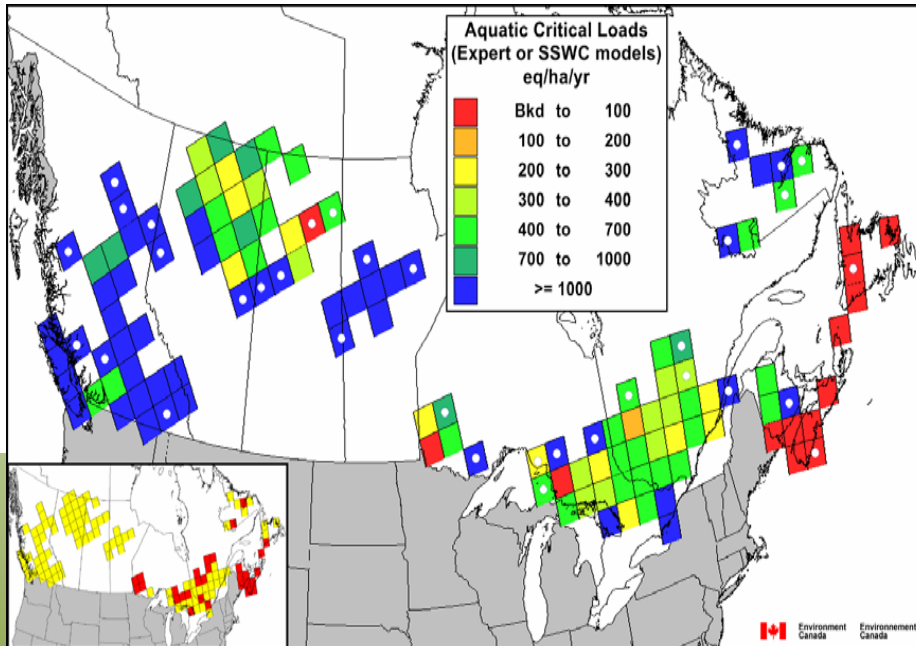


# 2004 Canadian Acid Deposition Science Assessment Aquatic and Terrestrial CLs (eq/ha/yr)

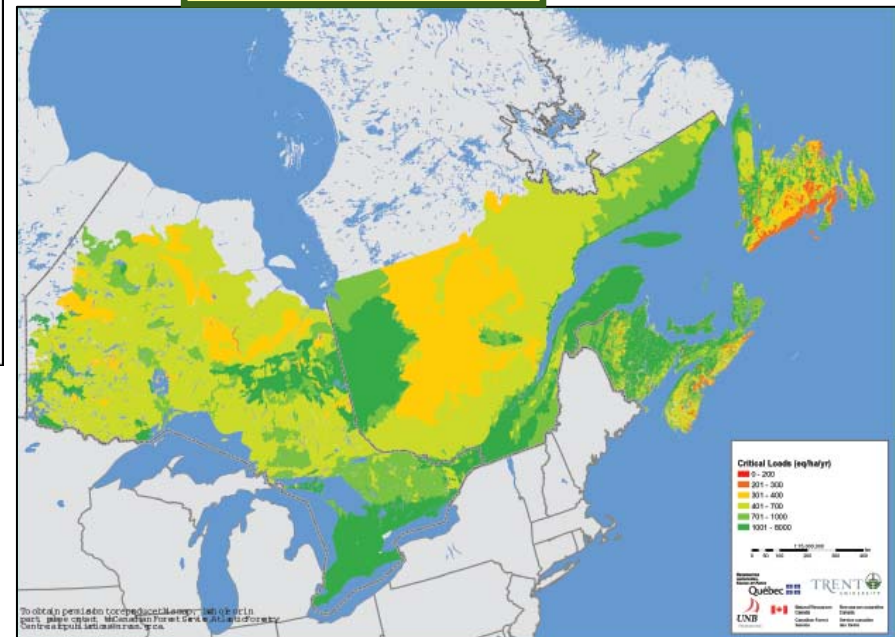


Jeffries and Ouimet (2005)

**Terrestrial**

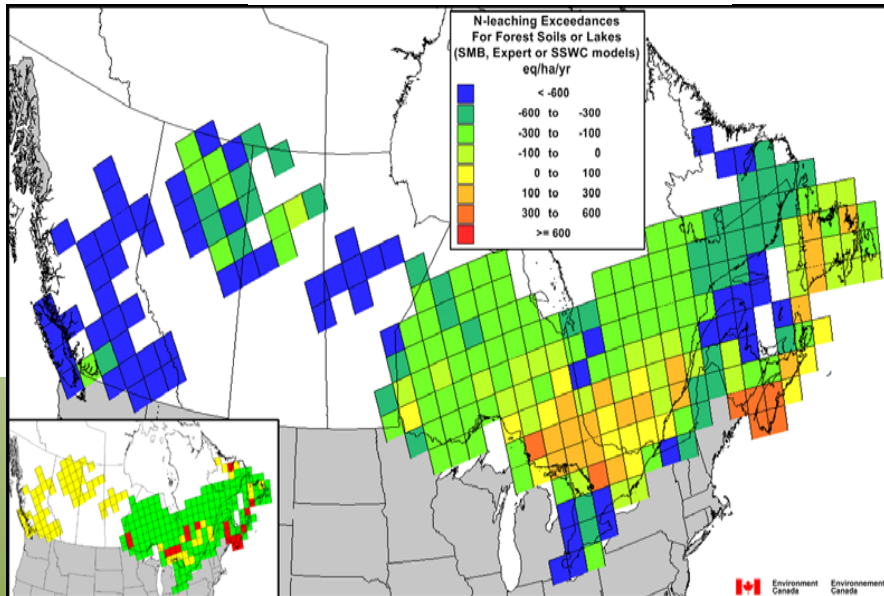


**Aquatic**



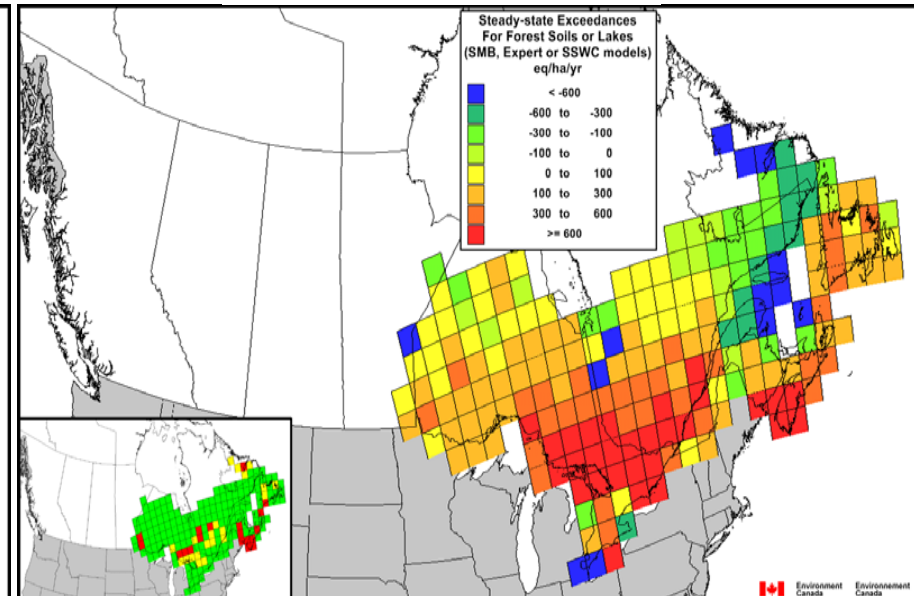
# 2004 Canadian Acid Deposition Science Assessment Combined Exceedances of Aquatic and Terrestrial CLs (eq/ha/yr)

## Immediate Risk



~0.5 million km<sup>2</sup>

## Long-term Risk



~1.8 million km<sup>2</sup>

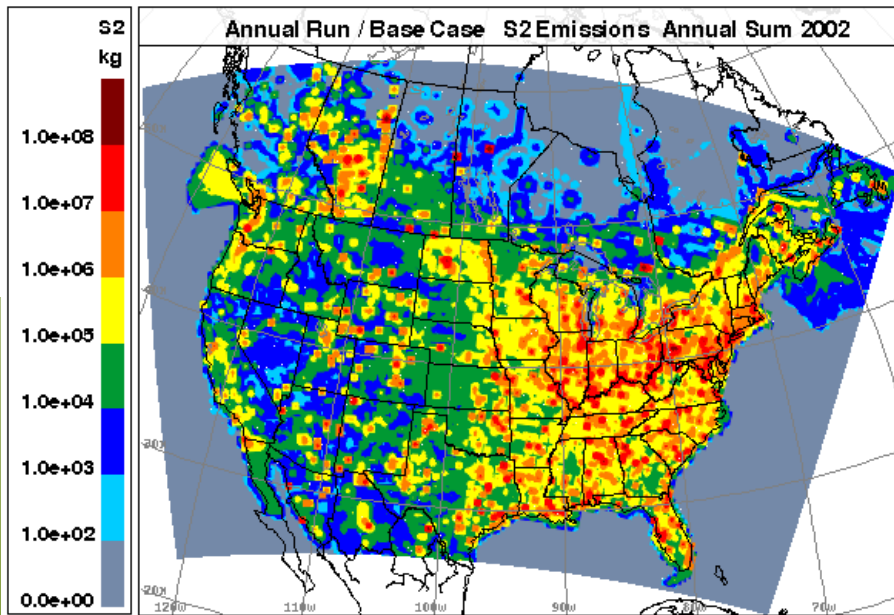
- Information in western Canada too limited to adequately assess risk.



# Potential for Acidification Damage in Western Canada

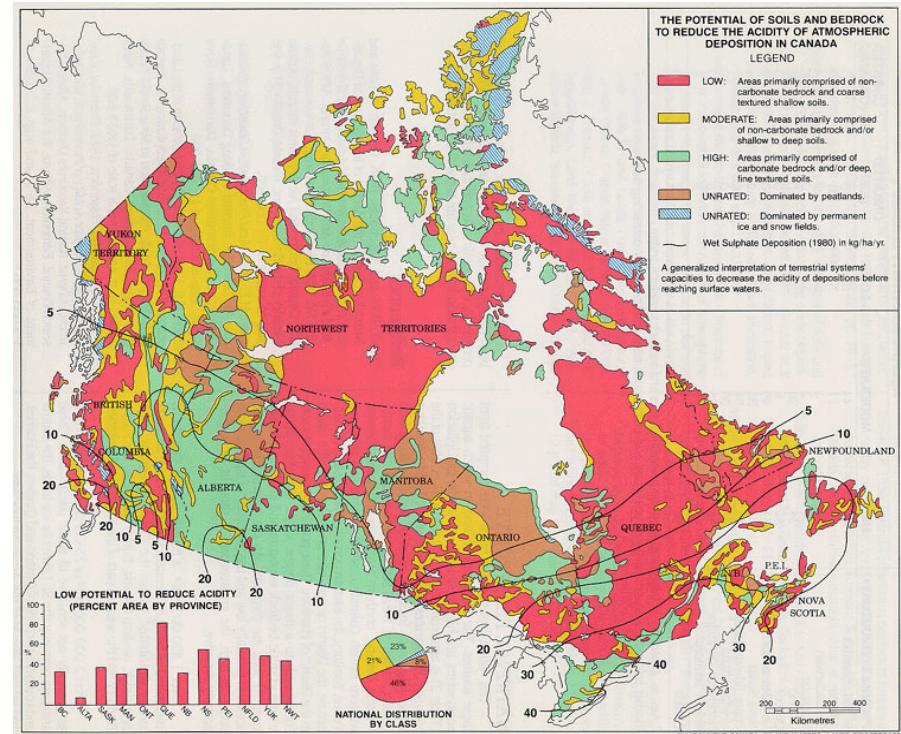
## Distribution

Service Météorologique du Canada  
 Meteorological Service of Canada



2002 CAC SO<sub>2</sub> Emissions (kg/grid cell/yr)

## Bedrock Sensitivity



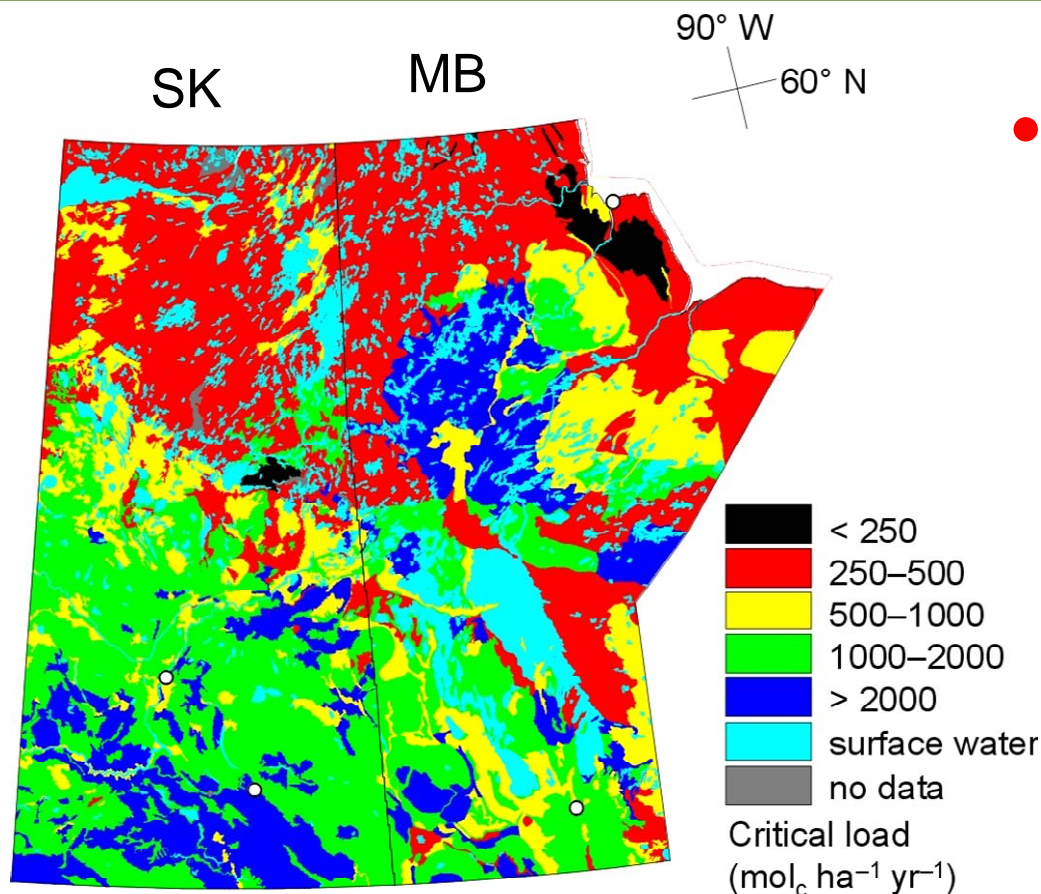
# Development of CLs for Forest Soils in Western Canada

## Steady-state Mass Balance Model Approach

- Input-output balance of processes affecting soil acidification
- Critical limit  $\rightarrow$  base cation leaching rate that will protect sensitive forest vegetation

$$\begin{aligned}
 & \text{base cation and chloride deposition} \\
 & \text{base cation uptake} \\
 & \text{critical alkalinity leaching} \\
 \text{CL}(S + N) = & BC_{\text{dep}} - Cl_{\text{dep}} + BC_w - \cancel{BC_u} + \cancel{N_i} + \cancel{N_u} + \cancel{N_{de}} - \text{Alk}_{\text{le(crit)}} \\
 & \text{base cation weathering} \\
 & \text{nitrogen immobilisation, uptake and denitrification} \\
 \\ 
 \text{Exc} = & \textcircled{S_{\text{dep}} + N_{\text{dep}}} - \text{CL}(S + N) \\
 & \text{total (wet and dry) sulphur and nitrogen deposition}
 \end{aligned}$$

# CLs (S+N) for Forest Soils in Saskatchewan and Manitoba



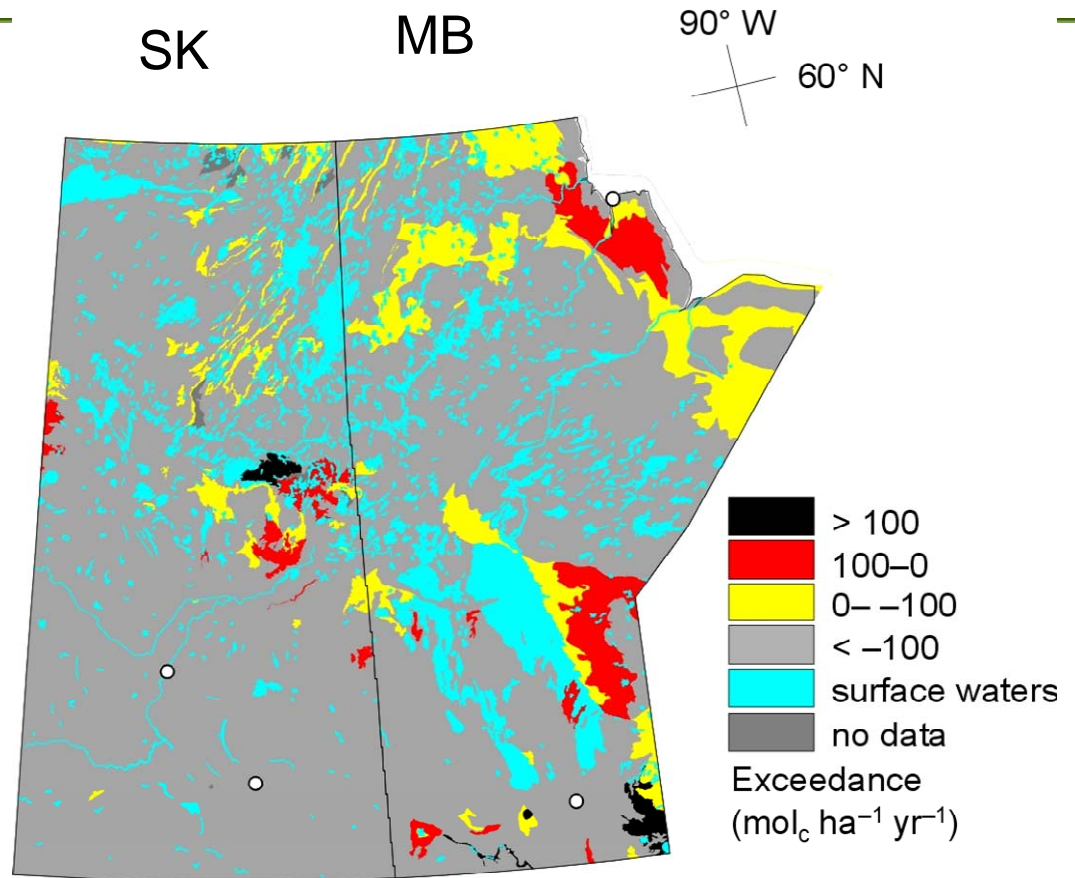
- Lowest CLs (<500eq/ha/yr) found in ~47% of mapped soils in MB and ~36% in SK.

Aherne and Watmough (2006) - Final report available at [http://www.ccme.ca/ourwork/air.html?category\\_id=31](http://www.ccme.ca/ourwork/air.html?category_id=31)



# CL Exceedance (S+N) for Forest Soils in Saskatchewan and Manitoba

- Exceedances occur in ~7% of mapped soils in MB and ~2% in SK.



Aherne and Watmough (2006) - Final report available at [http://www.ccme.ca/ourwork/air.html?category\\_id=31](http://www.ccme.ca/ourwork/air.html?category_id=31)



# Development of CLs for Lakes in Manitoba

## Steady-state Water Chemistry Approach

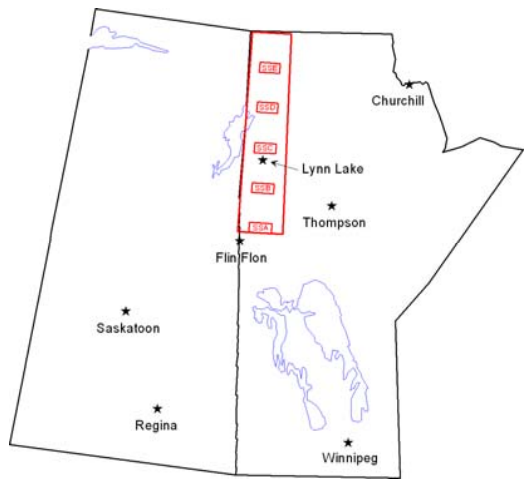
- Critical limit → Acid Neutralizing Capacity of 40 µeq/L (threshold required to sustain healthy aquatic ecosystems).

$$CL(A) = BC_0^* - ANC_{limit} = Q * ([BC^*]_0 - [ANC]_{limit})$$

base cation flux (weathering)                      runoff

- $ANC_{limit}$  for lakes with high organic acids =  $10 + 10.2/3 * DOC$
- Based on water chemistry data from recent survey in NW Manitoba.
- Exceedances estimated for monitored and modelled total S and N deposition.
- Only numerical estimates presented at this time (no map).

# Aquatic CLs and Exceedances for Manitoba



## Manitoba Lake Survey: SSWC Critical Loads (eq/ha/yr) and Number of Lakes Exceeded

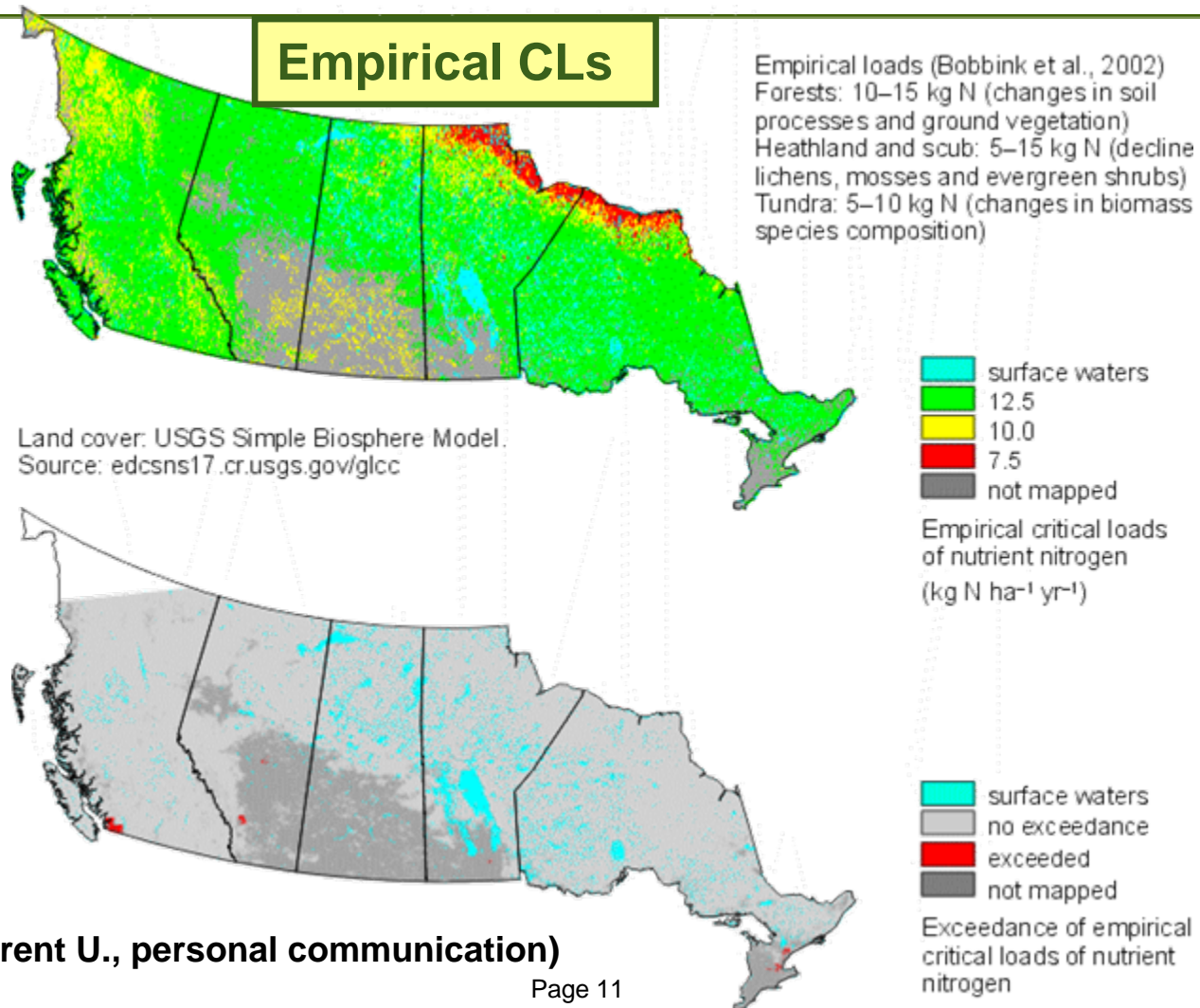
	5 <sup>th</sup> / 50 <sup>th</sup> Percentile CLs		Number of Lakes Exceeded*	
	“Regular” ANC <sub>limit</sub>	ANC <sub>limit</sub> for Org. Waters	“Regular” ANC <sub>limit</sub>	ANC <sub>limit</sub> for Org. Waters
SSA (n=30)	176 / 551	137 / 520	0	0
SSB (n=30)	197 / 497	157 / 492	0	0
SSC (n=40)	98 / 224	118 / 221	3	2
SSD (n=52)	58 / 203	55 / 190	5	4

N

Number consistently exceeded using 3 deposition estimates, i.e., map interpolation, AURAMS and RELAD.

(Dean Jeffries, EC, personal communication)

# Terrestrial CL and Exceedance of Nutrient N (Eutrophication)



(J. Aherne, Trent U., personal communication)

# Ongoing CL Projects

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- Steady-state and dynamic CLs and exceedances (S+N) for lakes and forest soils in the Georgia Basin (British Columbia)
  - Work in support of Georgia Basin Action Plan
  - Contact: Pat Shaw (EC-PYR); Partners: Trent U, UNB, NRCan, UBC
  - Completion date: March 2008
- CLs and exceedances (S+N) for BC, SK, MB and eastern Canada based on modelled deposition
  - Work in support of Sulphur Emission Control Area (SECA) initiative
  - Contact: Joanne Bellamy (EC), Partners: Trent U, UNB, QC MNR
  - Completion date: March 2008
- Steady-state and dynamic CLs and exceedances (S+N) for lakes and forest soils in Fort McMurray (Alberta)
  - Work in support of Alberta's SO<sub>x</sub> and NO<sub>x</sub> Management Framework
  - Multi-agency project





**Thank you**