

# PRE-FLOODING ASSESSMENT OF AQUATIC ECOSYSTEM C CYCLING

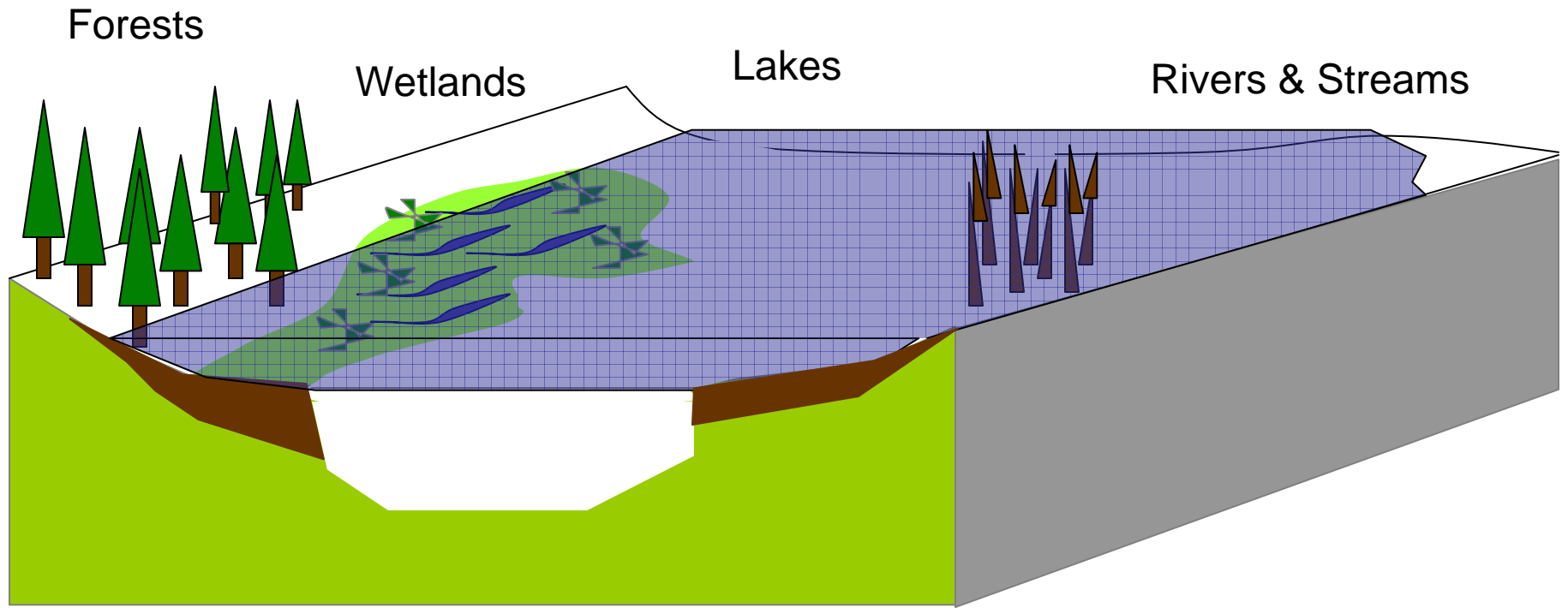
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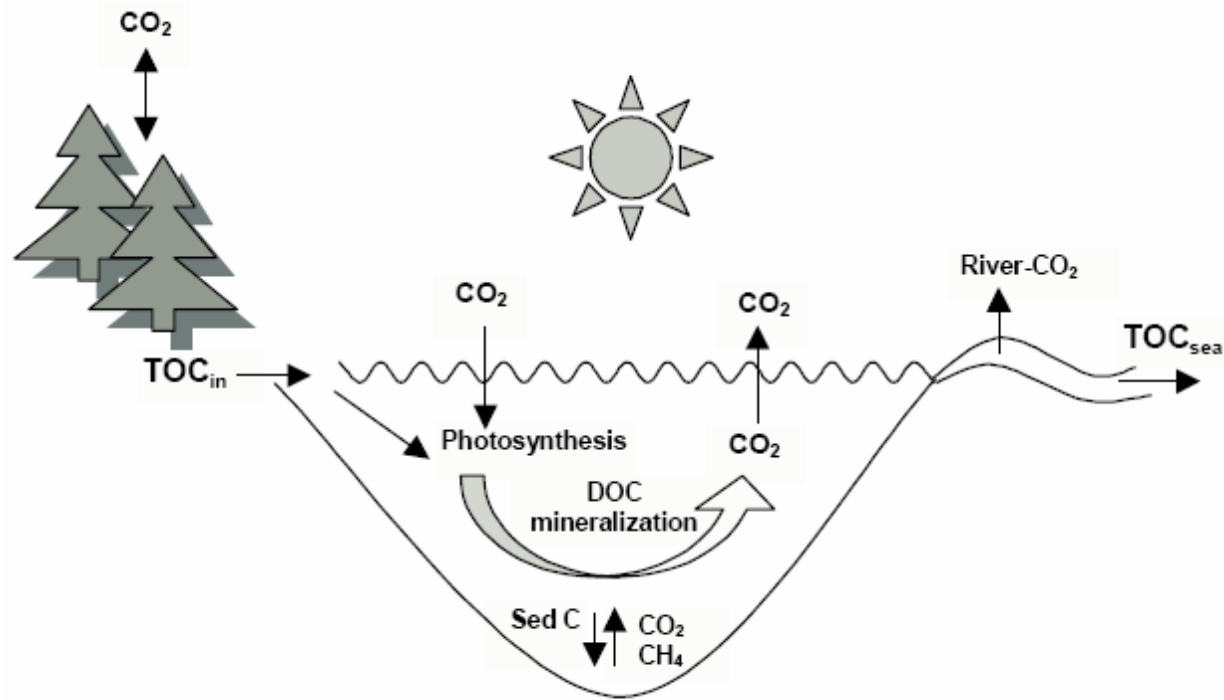
# Setting

- ¼ of the worlds' largest reservoirs are found in the Boreal region of Quebec
- Equivalent to 50,000 km<sup>2</sup> of Boreal forest, wetlands and peatbogs.
- Loss of tens of thousands of lakes, rivers and streams and their replacement for huge, continuous bodies of water



Eastmain I = 650km<sup>2</sup> reservoir

# Carbon cycling in freshwaters



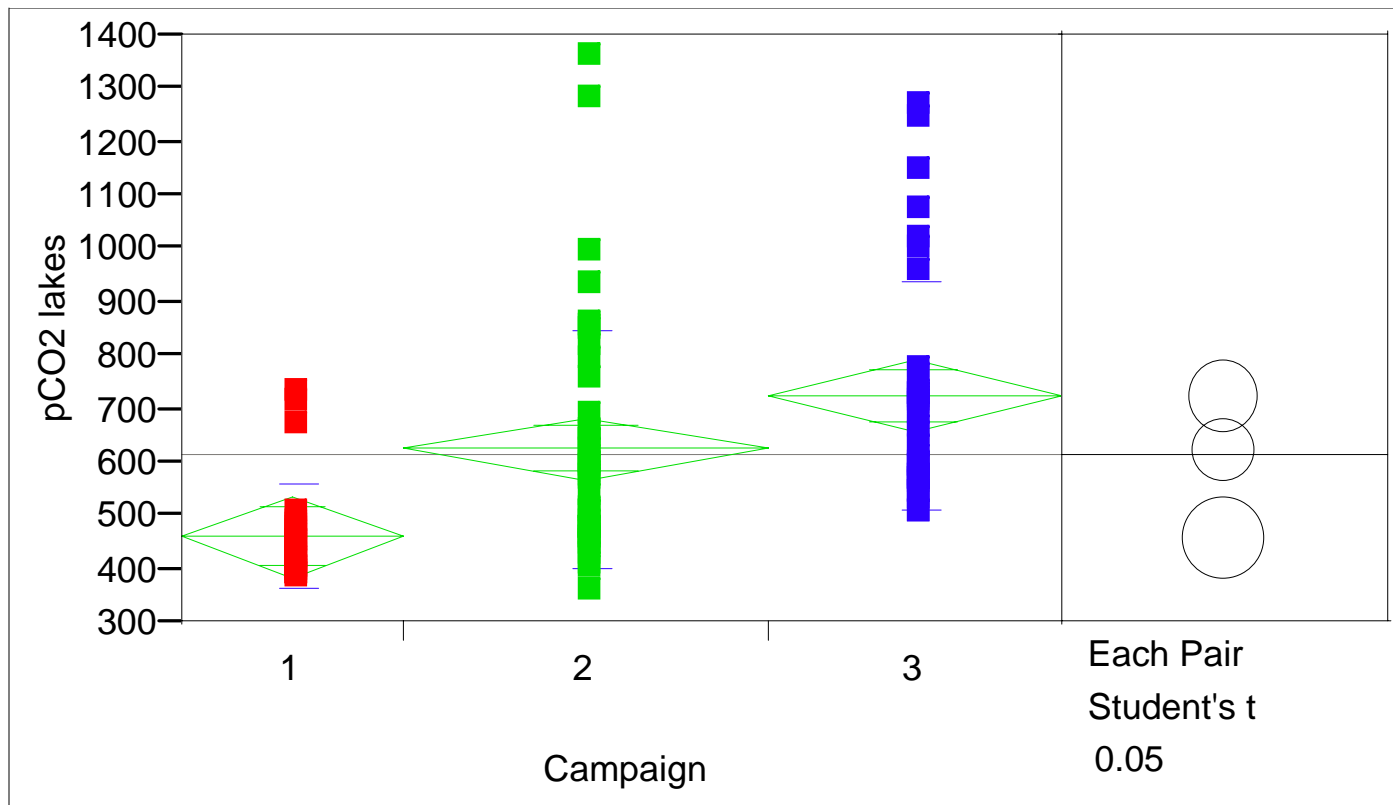
[Algesten, 2005]

# Objectives

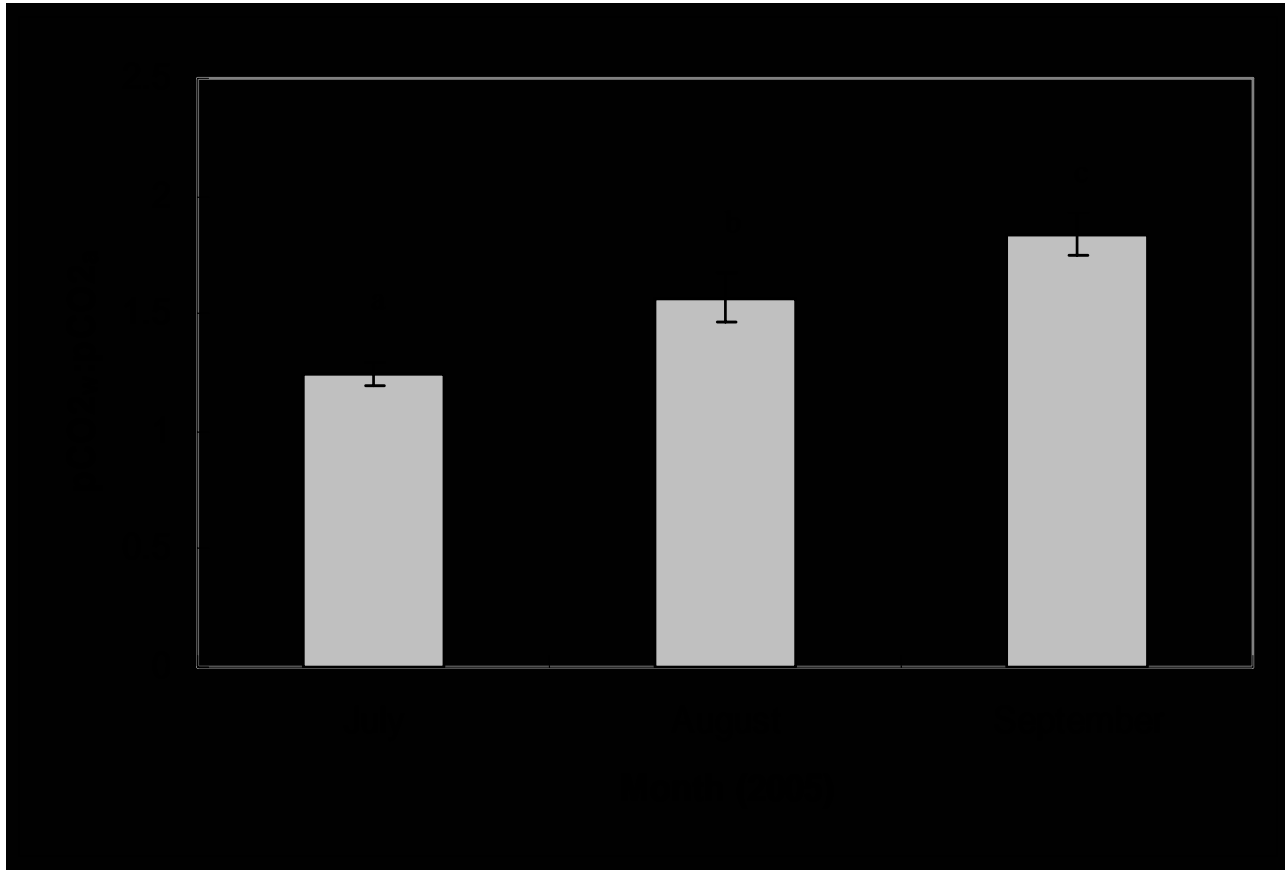
- Determine  $p\text{CO}_2$  dynamics as a function of lake physical-chemical characteristics
- How are  $\text{CO}_2$  patterns related relative to similar models in other parts of the world
- Flux estimates and the discrepancies observed between patterns in  $\text{CO}_2$  and  $\text{O}_2$ .
- Assess the relative magnitude and variability of  $p\text{CO}_2$  in both lakes and their inflowing rivers, and to explore the connections that may exist between them
- Determine the inter-annual variation in  $p\text{CO}_2$  and its synchrony relative to changes in DOC, hydrology...

Lake  $p\text{CO}_2$  dynamics as a function of physical and chemical characteristics

# CO<sub>2</sub> concentrations in lakes sampled in 2005

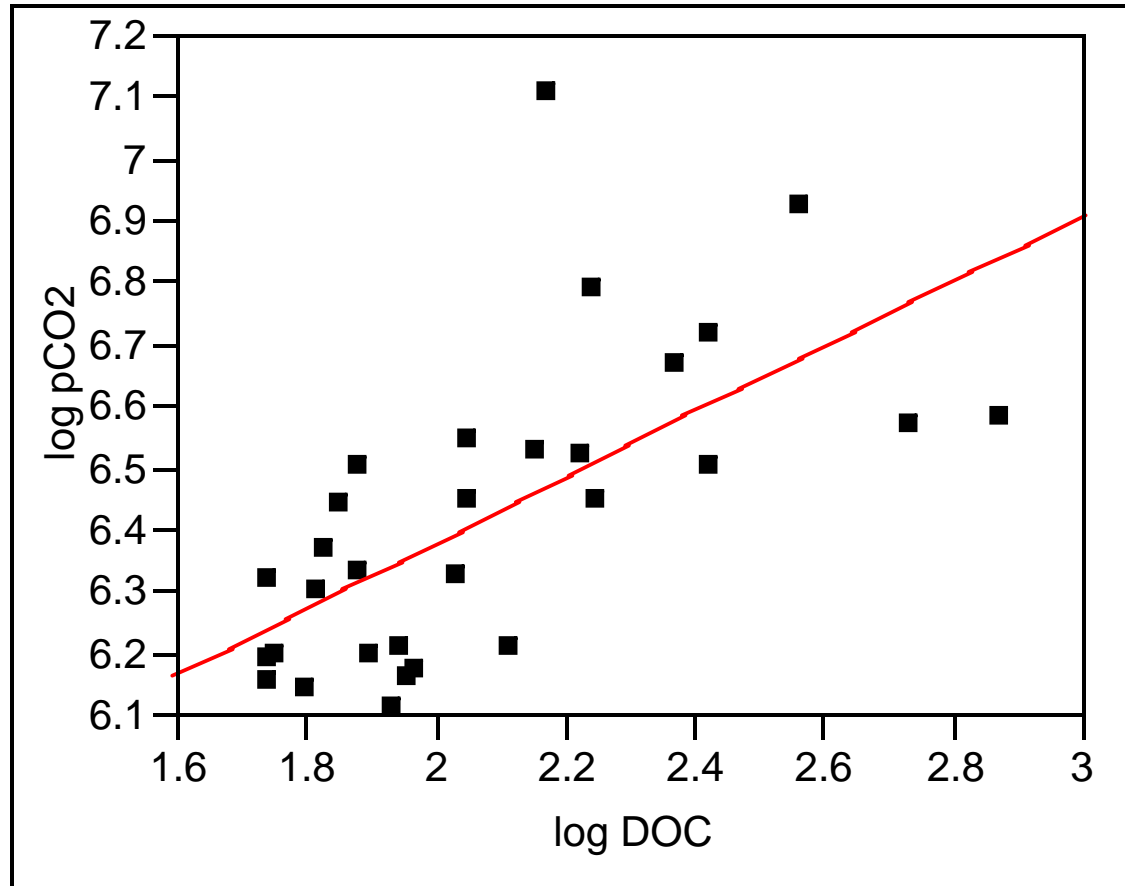


Degree of  $p\text{CO}_2$  over-saturation in the Eastmain lakes.



The degree of saturation increased throughout the summer with significant differences observed between months ( $p < 0.05$ ).

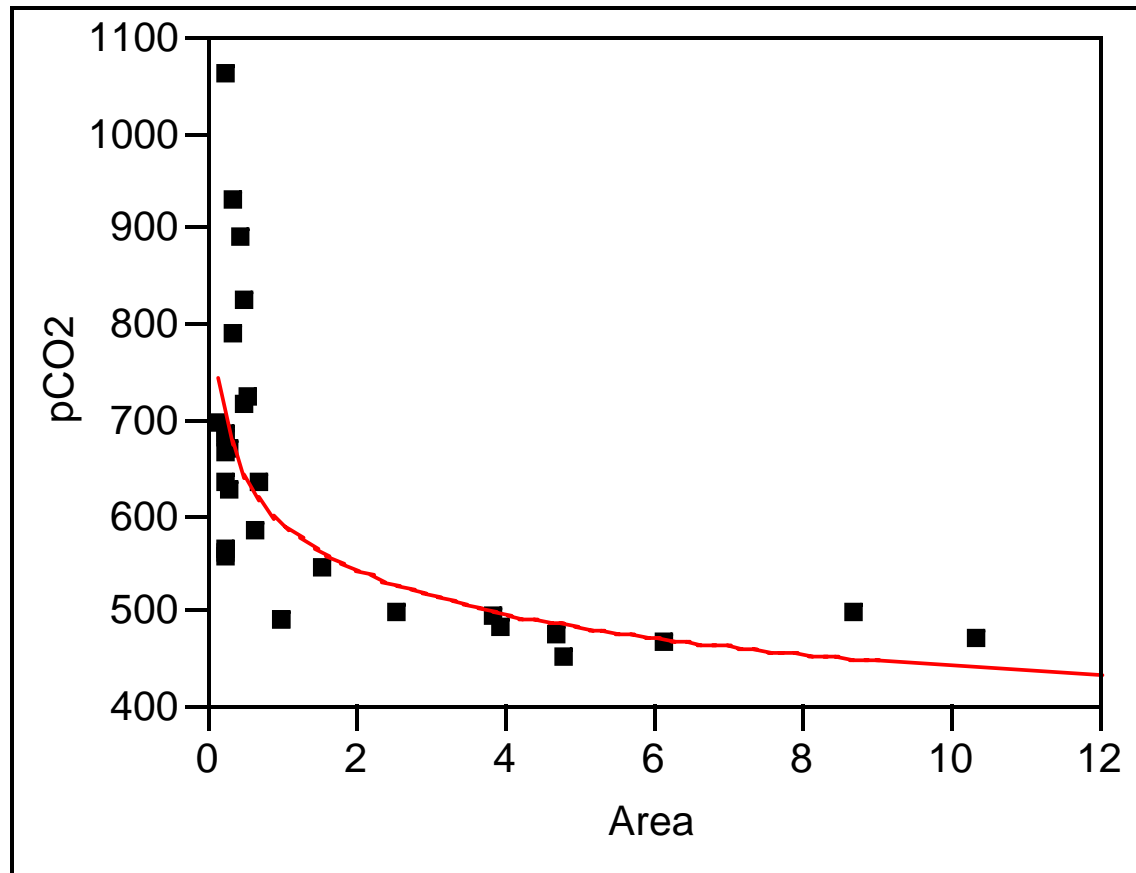
## Relationship of mean $p\text{CO}_2$ to DOC



$$\log[\text{CO}_2] = 5.26 + 0.55 \log[\text{DOC}]$$

$$R^2=0.56; p<0.0001$$

Relationship of mean  $p\text{CO}_2$  to lake area.

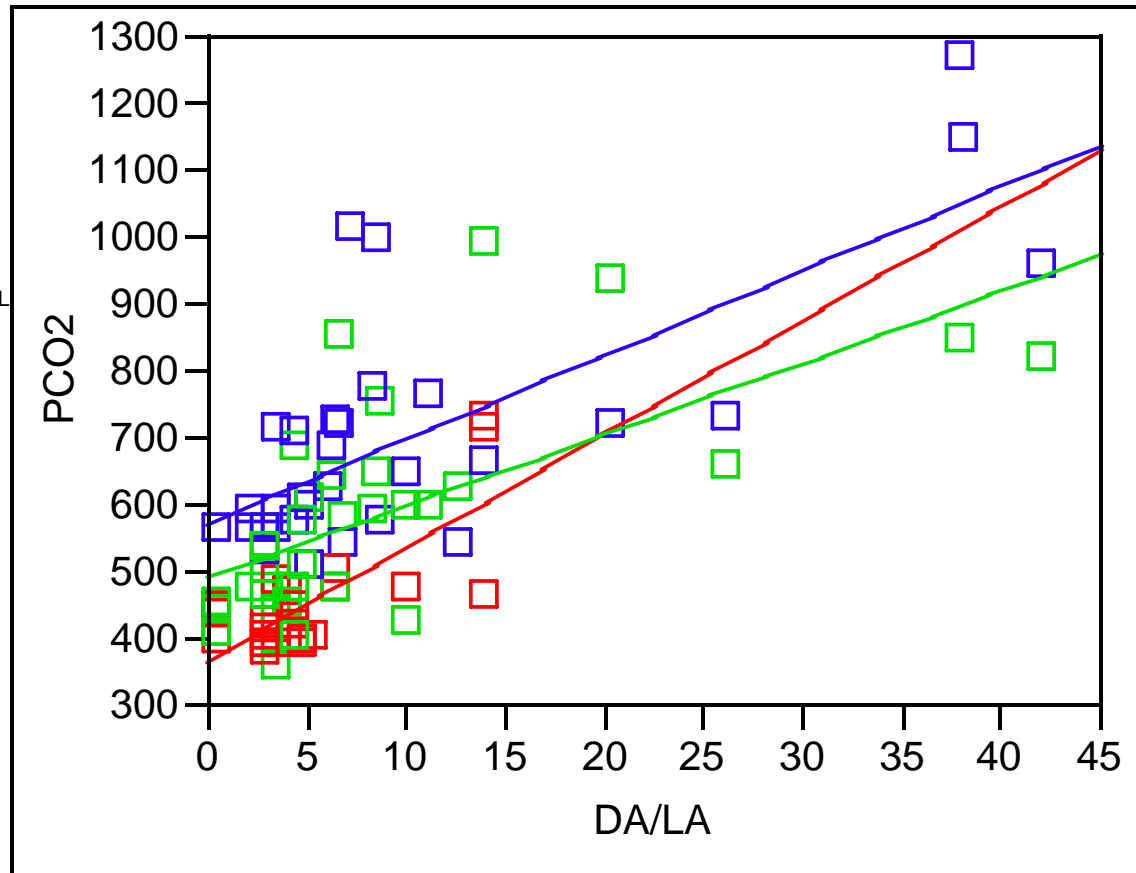


$$\log[\text{CO}_2] = 6.39 - 0.13 \log[A]$$

$$R^2=0.49; p<0.0001$$

# Relationship of mean $p\text{CO}_2$ to drainage ratio.

Linear Fit  
 $\text{PCO}_2 = 478.14583 + 13.711305 \text{ DA/L}$

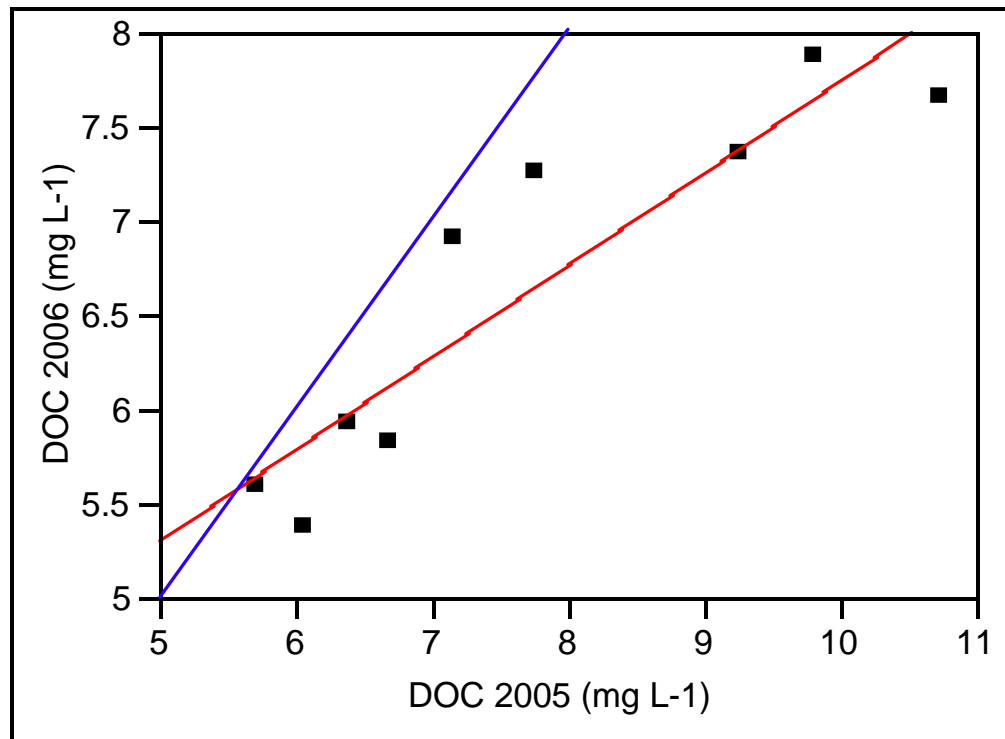


$$[\text{CO}_2] = 528.23 + 10.23 [\text{DA:LA}]$$

$R^2=0.49; p<0.0001$

Change in DOC concentrations between 2005 and 2006 for the nine reference lakes.

$$\text{DOC 2006} = 2.86 + 0.49 \text{ DOC 2005}$$

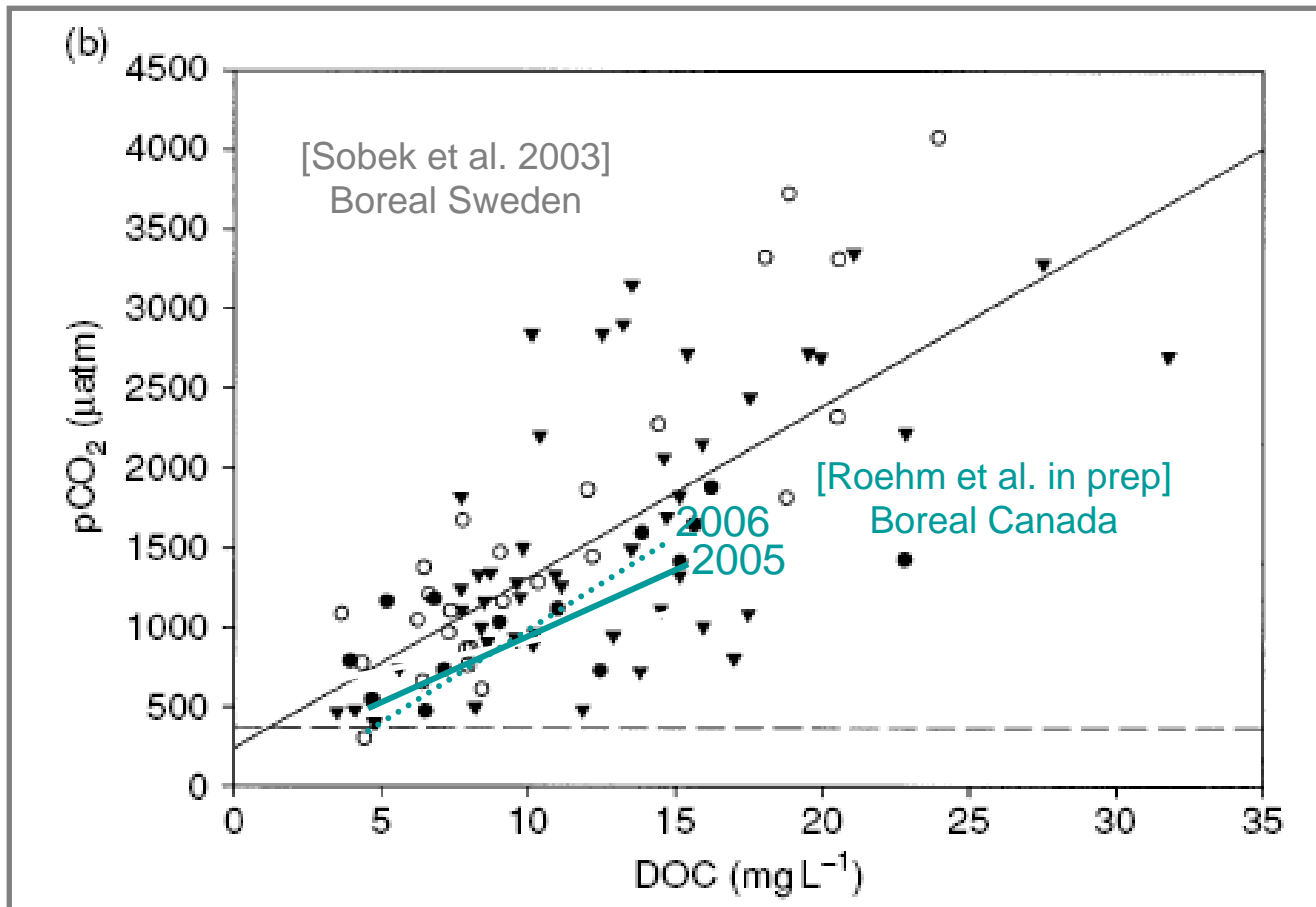


Generally lakes with the highest concentrations in 2005 saw a larger decrease in concentrations in 2006.

This relationship also is positively correlated with lake area.

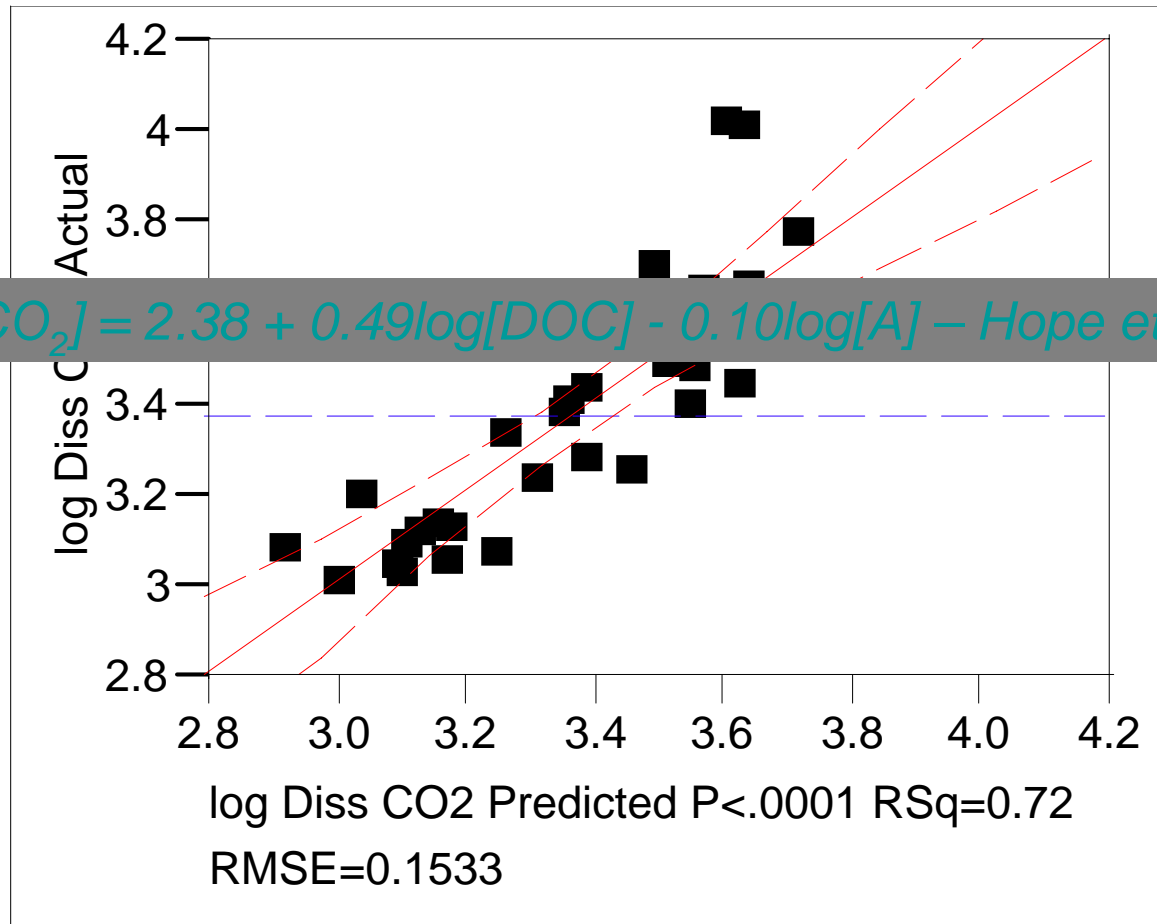
Predictive models of lake  $p\text{CO}_2$

# Models of $p\text{CO}_2$



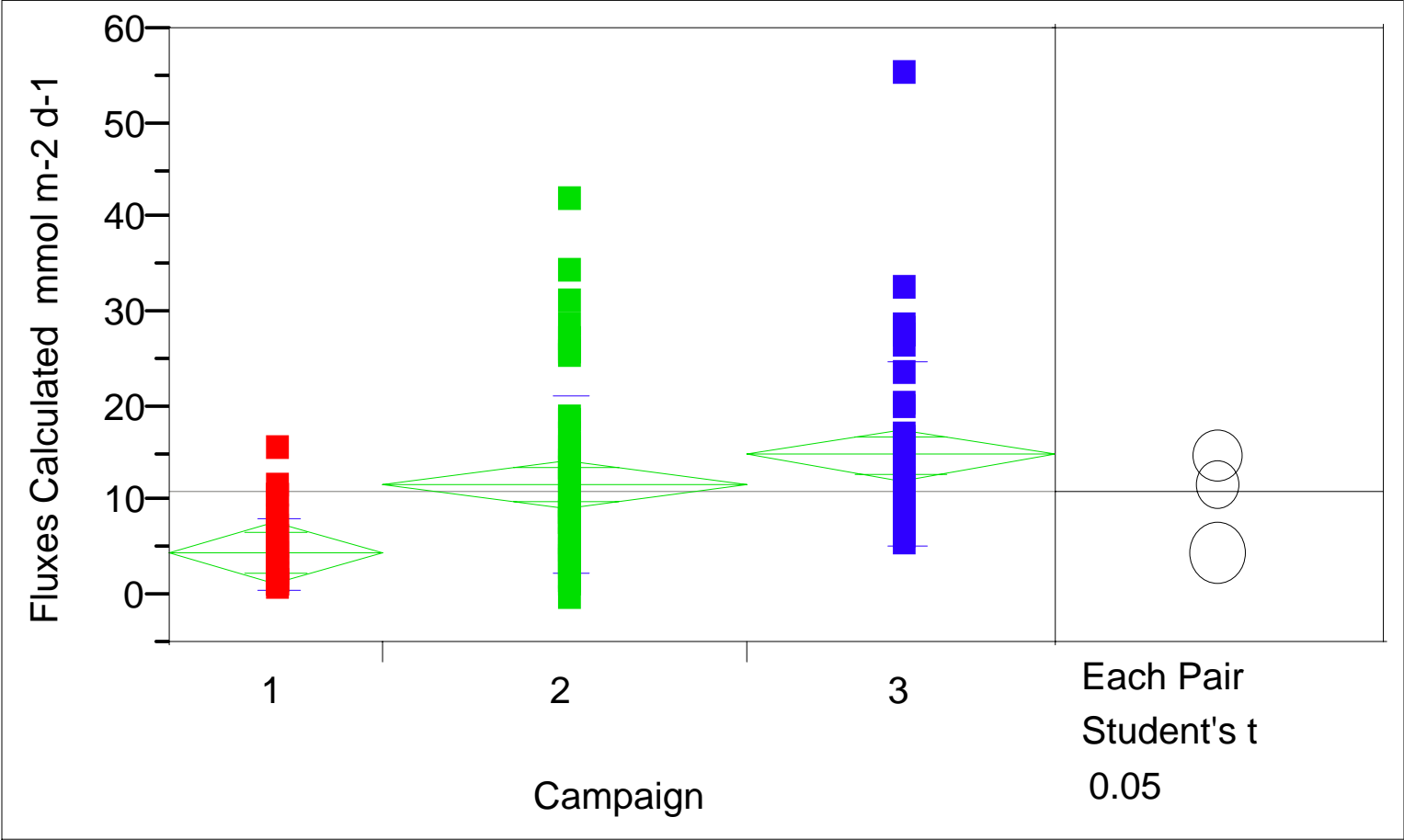
# Mean seasonal dissolved CO<sub>2</sub> concentrations in lakes:

$$\log[\text{CO}_2] = 2.34 + 0.48\log[\text{DOC}] - 0.11\log[A]$$



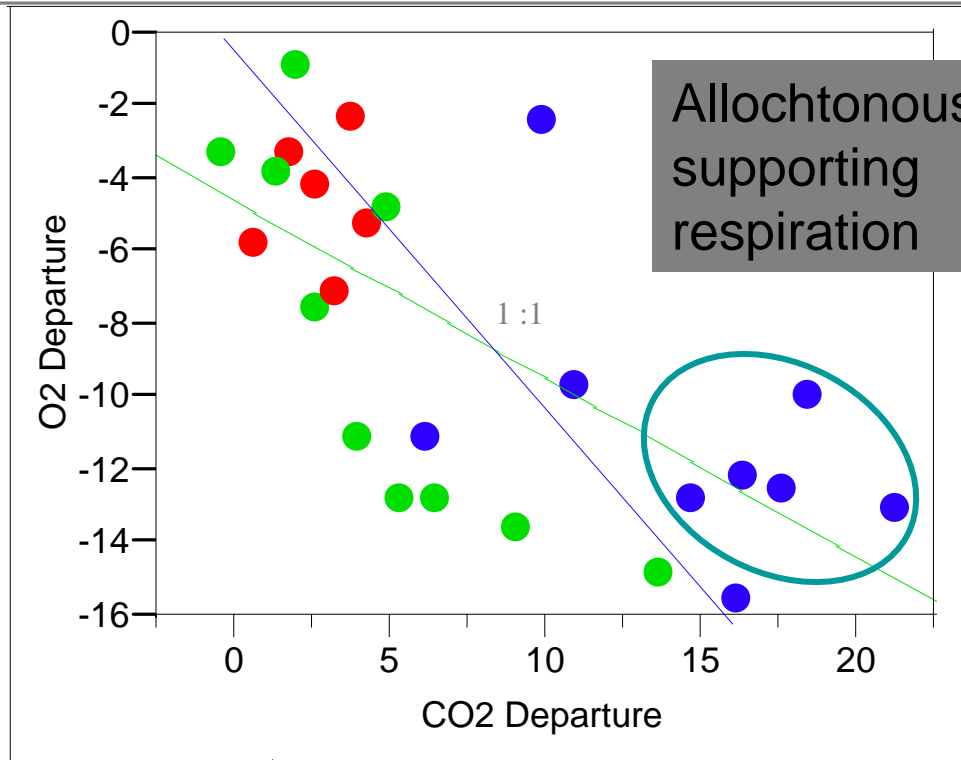
Fluxes estimates of CO<sub>2</sub> and  
discrepancies in CO<sub>2</sub> and O<sub>2</sub> saturation

# CO<sub>2</sub> fluxes calculated from in-situ CO<sub>2</sub> concentrations in lakes sampled in 2005.



# CO<sub>2</sub> and O<sub>2</sub> departures from saturation

Bivariate Fit of O<sub>2</sub> Departure By CO<sub>2</sub> Departure



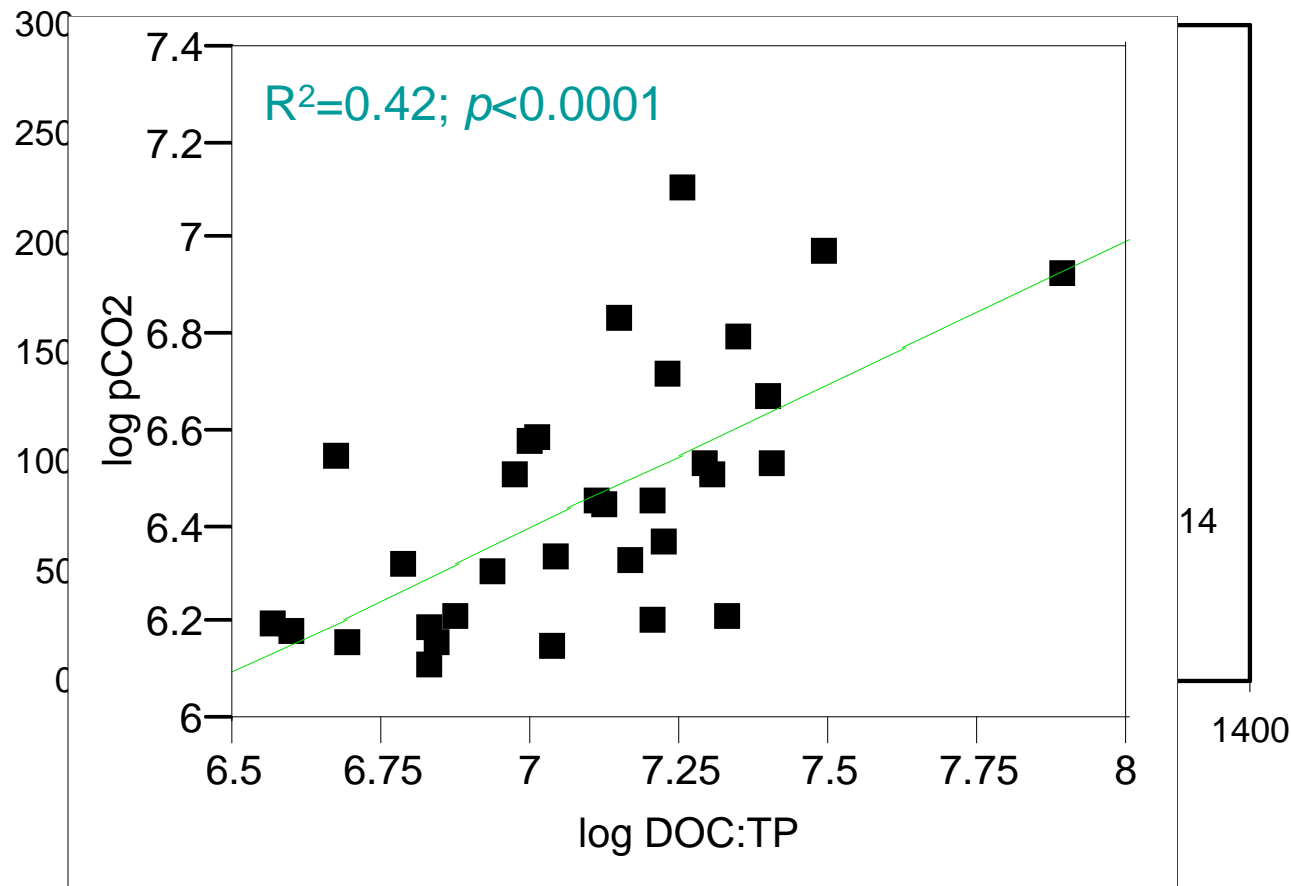
Allochthonous input of DOC supporting higher bacterial respiration

Linear Fit

$$[O_2dep] = -4.60 - 0.49[CO_2dep]$$
$$R^2=0.48; p<0.0001$$

Amount of variability in lake  $p\text{CO}_2$  explained by DOC:TP ratio.

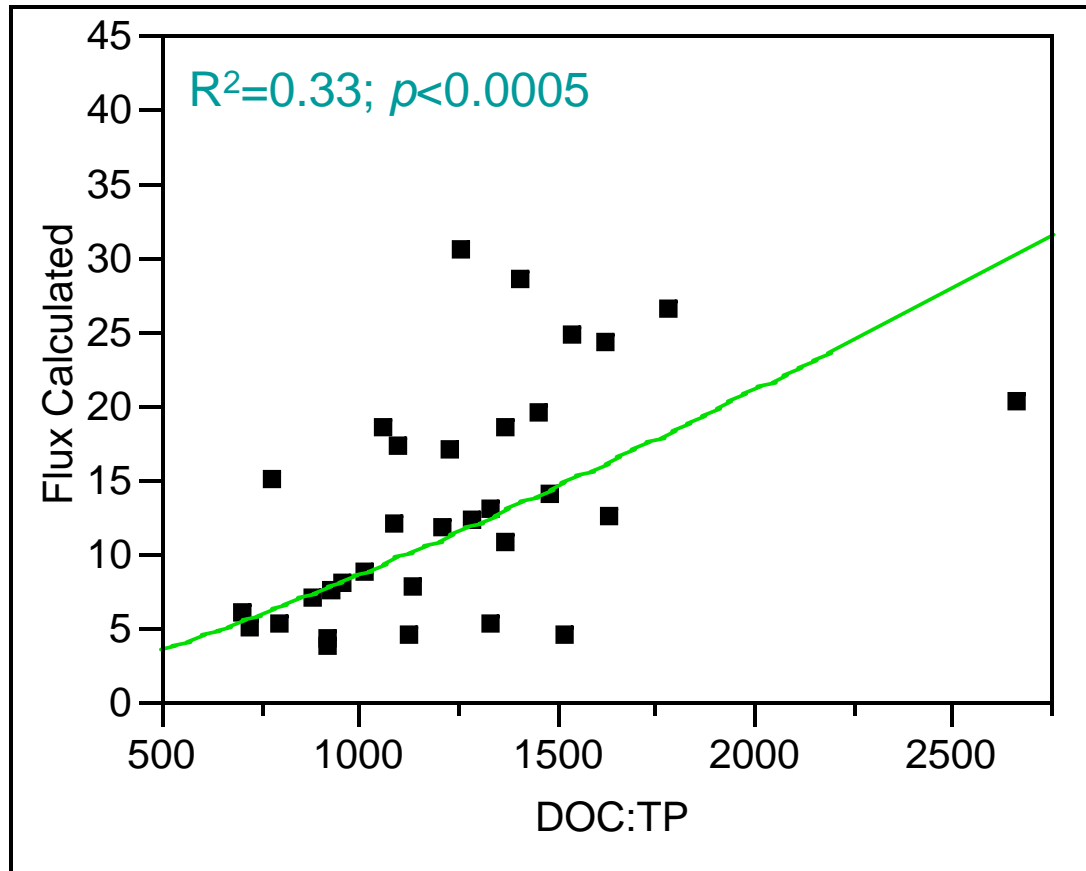
$$\text{Log}[p\text{CO}_2] = 2.17 + 0.60 \text{ log}[\text{DOC:TP}]$$



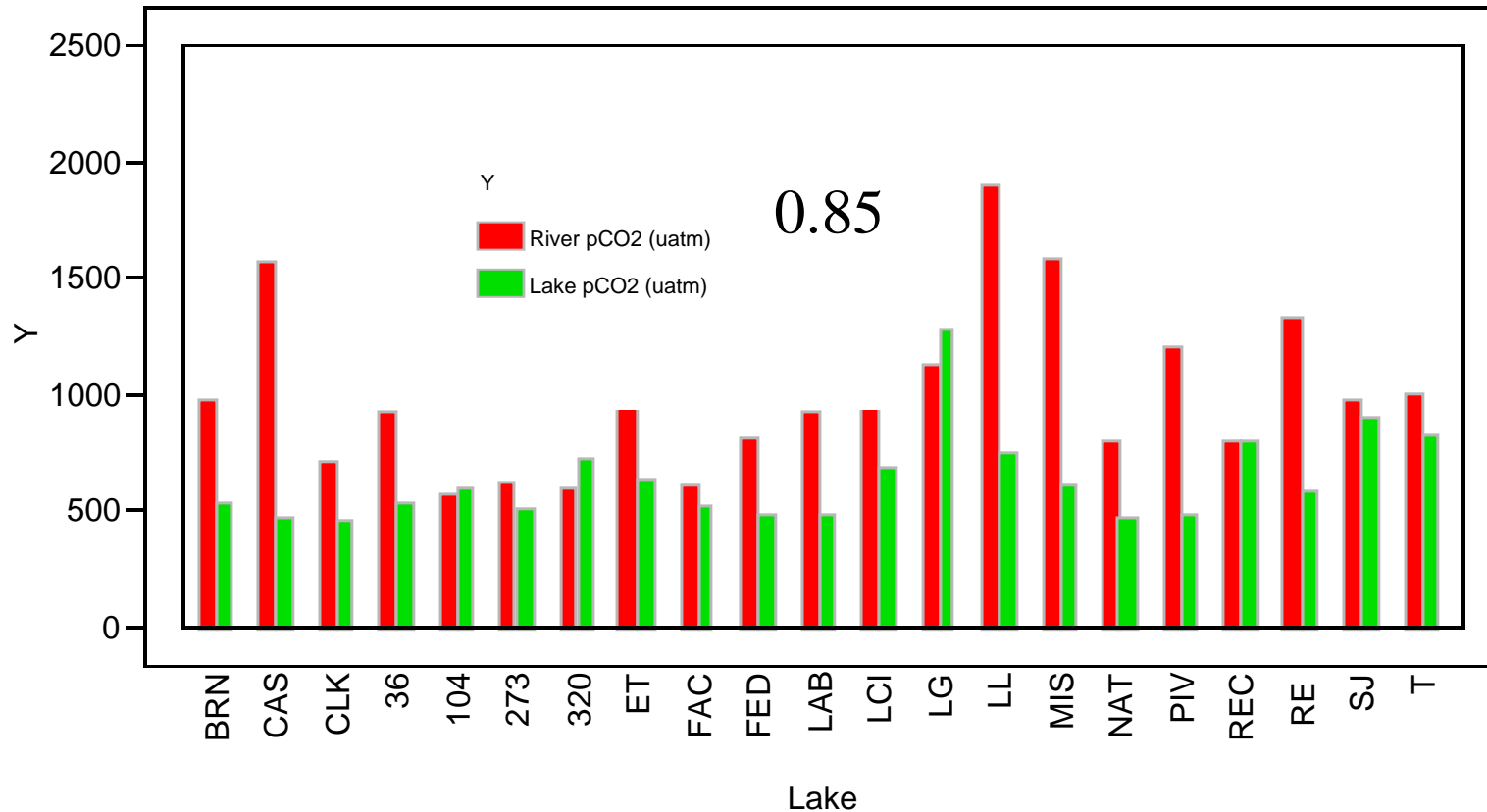
The degree of  $\text{CO}_2$  super-saturation increases with DOC:TP, indicating an external allochthonous supply of C to the system.

Amount of variability in CO<sub>2</sub> flux explained by DOC:TP ratio.

$$\text{Log}[\text{Flux}] = -6.71 + 1.28 \log[\text{DOC:TP}]$$

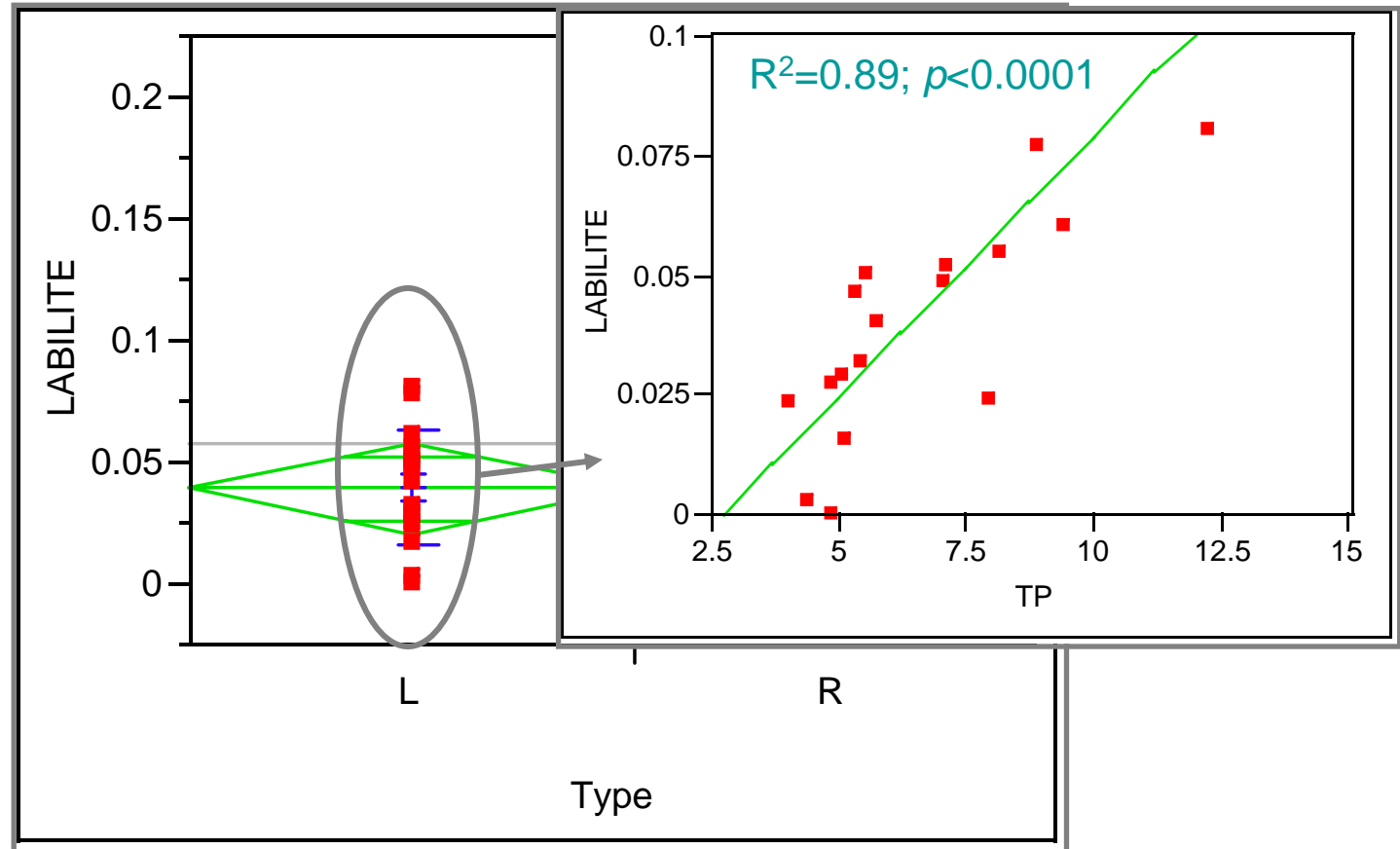


## $p\text{CO}_2$ in lakes and their connecting major rivers.



- The  $p\text{CO}_2$  in the feeding river was 0.85 to 3.5 higher than the lake  $p\text{CO}_2$
- Ratio of  $p\text{CO}_2$  in the rivers to the  $p\text{CO}_2$  in the lakes ( $p\text{CO}_2\text{R}: p\text{CO}_2\text{L}$ ) was negatively and significantly correlated to the DA:LA ( $r^2=0.41$ ;  $p<0.05$ )

# DOC lability



DOC in incoming rivers is significantly more labile!  
Lability in lakes is highly and significantly related to TP

# Conclusions

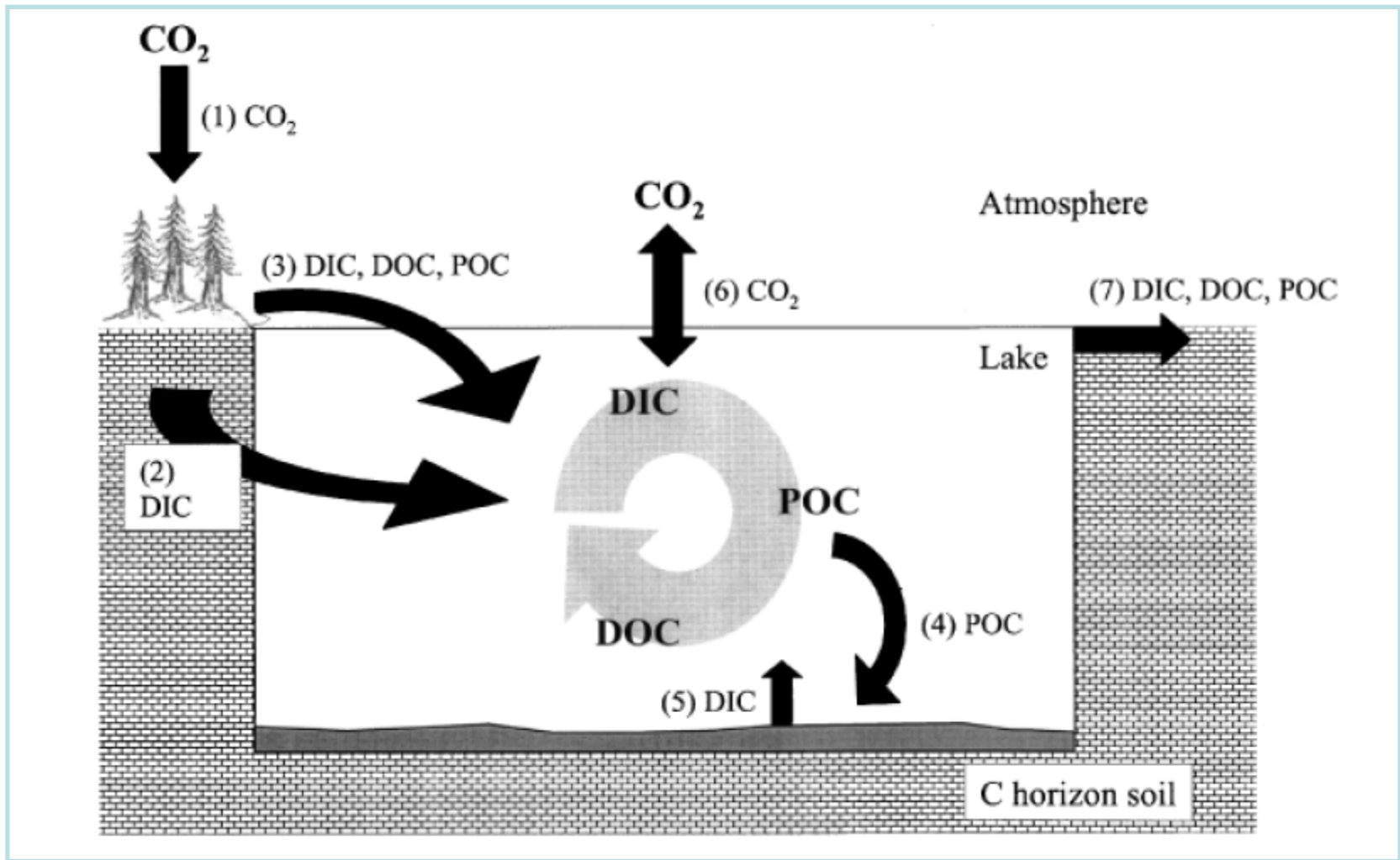
- All lakes and rivers are super-saturated in  $p\text{CO}_2$
- $p\text{CO}_2$  dynamics are strongly controlled by physical and chemical characteristics of the lake and drainage basin.
- Our empirical models show that the prediction of  $p\text{CO}_2$  from DOC alone is similar within Boreal regions. The dynamics change when in a more temperate region.
- BUT our overall predictive model using both DOC and lake area is surprisingly similar to that proposed for more temperate regions.
- $p\text{CO}_2$  and fluxes are strongly influenced by the import of allochthonous C sources.
- The relationship of  $p\text{CO}_2$  in lakes and rivers is complex and non-linear.

# Many thanks for your attention!

- Thanks to:
  - Hydro Quebec
  - Catherine Beauchemin
  - The many field assistants...



Hydro-Québec Production  
McGill UQAM  
Environnement Énergie Inc.

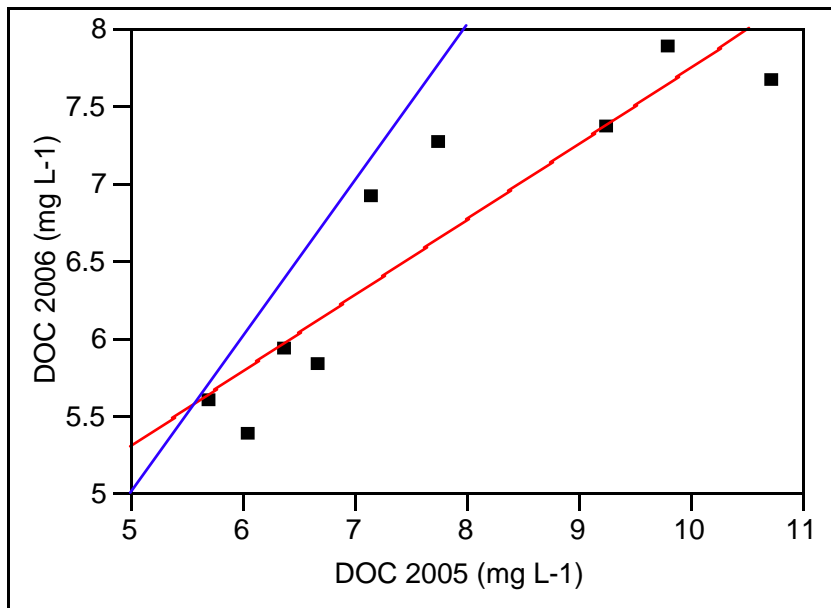




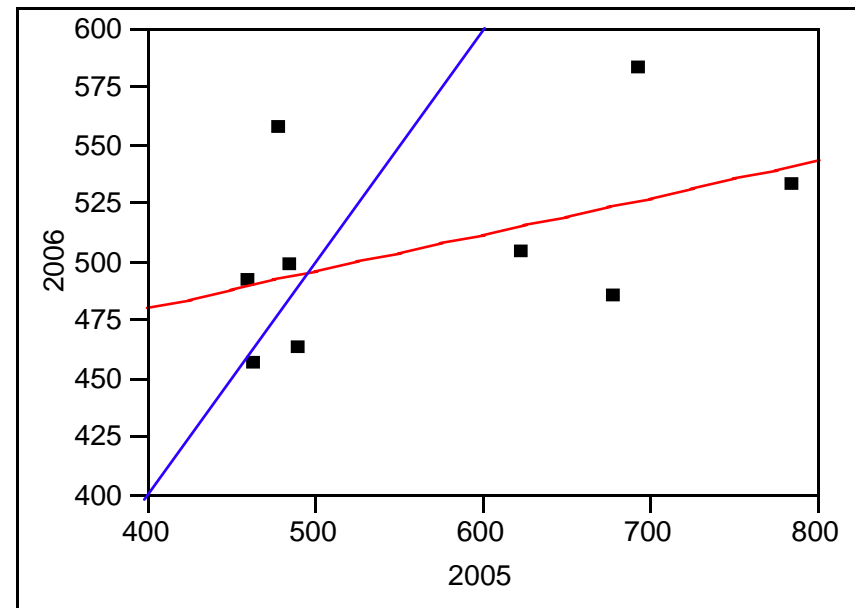
# Conclusions

Change in DOC concentrations between 2005 and 2006 for the nine reference lakes.

$$\text{DOC 2006} = 2.86 + 0.49 \text{ DOC 2005}$$



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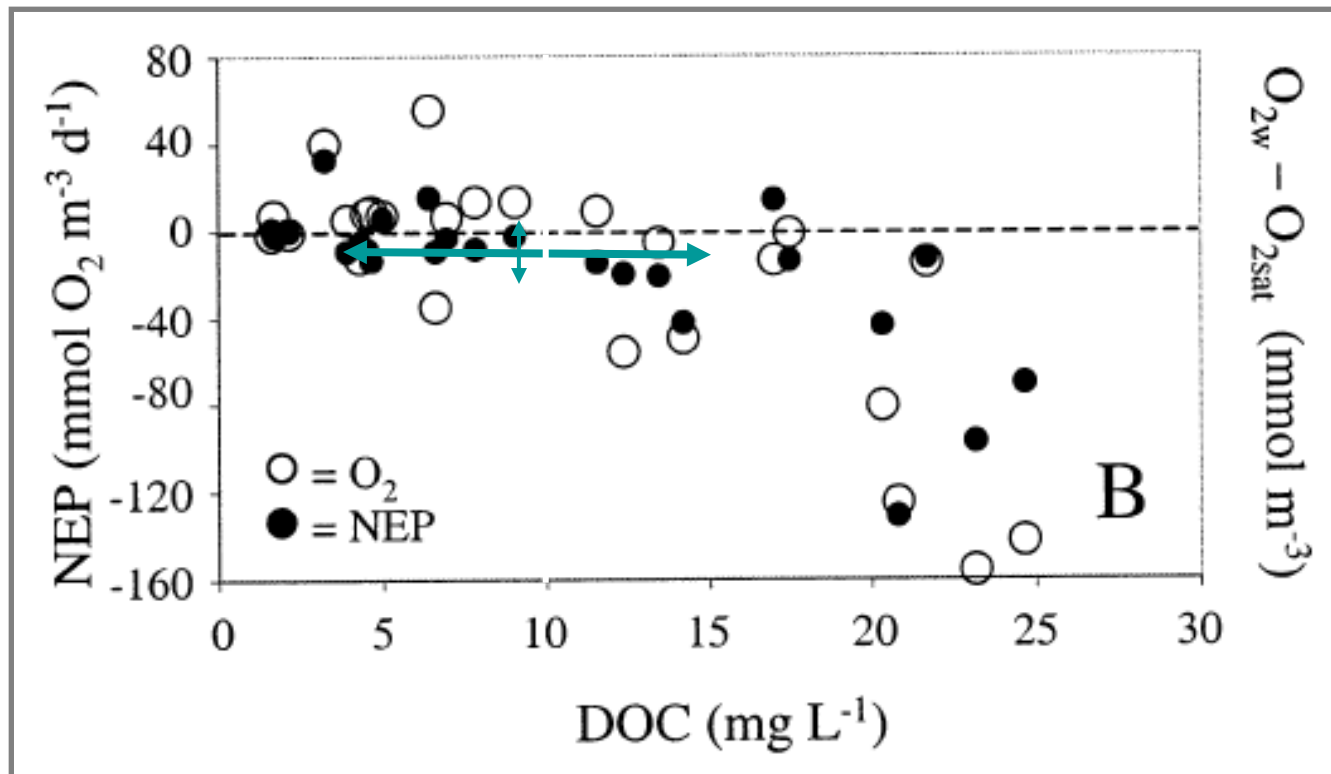


$$\text{pCO}_2 \text{ 2006} = 417.57 + 0.16 \text{ pCO}_2 \text{ 2005}$$

Generally lakes with the highest concentrations in 2005 saw a larger decrease in concentrations in 2006.

This relationship also is positively correlated with lake area.

## O<sub>2</sub> departure from saturation and DOC concentration



Estimates for NEP and direct measures of mean dissolved O<sub>2</sub> minus the O<sub>2</sub> concentration at saturation with the atmosphere (O<sub>2w</sub> - O<sub>2sat</sub>). Below DOC of 10 mg L<sup>-1</sup>, NEP is near zero and dissolved O<sub>2</sub> is near saturation, but above this DOC concentration, NEP becomes negative and dissolved O<sub>2</sub> becomes undersaturated. [Hanson et al. 2003]