A diatom-based model for total phosphorus in the Lake of the Woods (LOW): Combining Minnesota lakes with LOW sites

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Introduction

The perception that water quality has deteriorated in the Lake of the Woods (LOW) in recent years has led to increased efforts to collect and analyze water quality data in the Rainy River Basin. However, verification that conditions have worsened is hampered by a lack of long-term chemical or biological data. In the absence of historical data, paleoecological techniques can be applied to fill in data gaps, and to quantify long-term changes in water quality that pre-date existing monitoring records. This poster describes the development and performance of a diatom-based model for reconstructing historical phosphorus concentrations in LOW.

Study region

The remains of diatom algae were enumerated in the surface sediments of 145 Minnesota lakes (Reavie et al. 2005) and 17 LOW sites (Pla et al. 2005, Rühland et al. in prep). The Minnesota lakes are located in four ecoregions, and the Twin Cities metropolitan area (Figure 1).

We developed and tested two models for possible use in reconstructing total phosphorus concentrations in LOW:

Figure 1. Map showing the geographic location of the Lake of the Woods in northwestern Ontario, relative to the Northern Lakes and Forests (NLF), North Central Hardwood Forests (CHF), Northern Glaciated Plains (NGP), Western Corn Belt Plains (WCP) ecoregions of Minnesota, and the Twin Cities metropolitan area.

(Inset) The Lake of the Woods sites were located in three major regions of the lake (northwest, eastern and central), and span a large gradient of measured phosphorus concentrations (Pla et al. 2005).

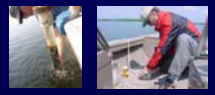
'Full' Model: Following the removal of chemical and biological outliers, this model includes 112 lakes from all Minnesota ecoregions and 16 sites in LOW (total = 128 sites);

'Reduced' Model: Based on similarities in chemistry of the LOW sites and lakes in the NLF ecoregion of Minnesota (Figure 2), this model includes 55 lakes in the NLF ecoregion and 16 sites in LOW (total = 71 sites).

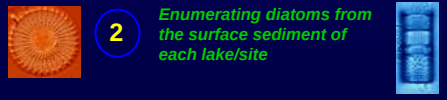
Model development

In the final stages of model development, statistical approaches such as weighted-averaging and/or partial least squares regression and calibration are used to produce quantitative estimates of water quality conditions in surface water from sedimentary diatom assemblages (Birks 1995). However, several steps precede the detailed statistical analyses. These include:

1 *Collecting sediment cores and water chemistry at each site/lake*



2 *Enumerating diatoms from the surface sediment of each lake/site*



3 *Harmonizing diatom taxonomy with other researchers (e.g., Ontario-Minnesota Diatom Workshop, August, 2006)*

4 *Selecting appropriate lakes/sites for the model*

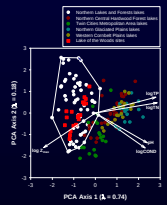


Figure 2. Principal components analysis of water chemistry collected at 145 Minnesota sites and 20 sites in the LOW. The figure shows that the chemistry at the LOW sites is most similar to lakes in the NLF region of northern Minnesota. The 'Reduced' model includes these lakes only.

Model performance

For both models, transfer functions for reconstructing total phosphorus concentrations (log TP) were developed using weighted-averaging partial least squares regression (ter Braak and Juggins 1993). Model performances were evaluated in their ability to predict log TP, with emphasis on the accuracy of predictions of LOW water quality. Despite a higher bootstrapped r^2 for the 'Full' model when all sites were considered, the 'Reduced' model was superior in its prediction of TP concentrations in LOW (Figure 3). Thus, we recommend the 'Reduced' Model be used to reconstruct historical phosphorus concentrations in LOW.

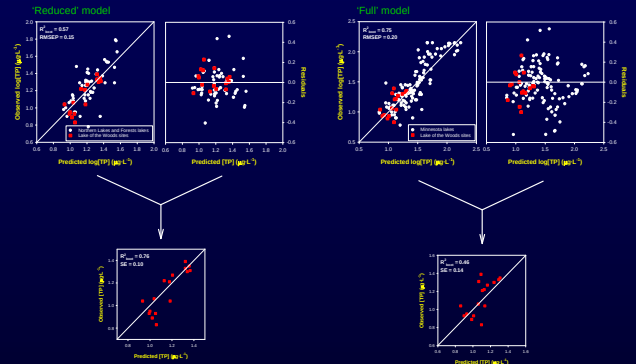


Figure 3. Plots showing performance of the 'Reduced' (left) and 'Full' (right) diatom-based models for predicting total phosphorus concentrations in the study lakes. Upper left plots show observed (measured) versus diatom-inferred log TP concentrations. Upper right plots show the residuals (prediction error) around the 1:1 observed-predicted line. Lower plots show the performance of the models in predicting log TP at the 16 LOW sites. All models were run on square-root transformed species data.

Acknowledgements and References

We thank Bev Clark and Ron Ingram for graphics and/or field assistance. 1) Birks, H.J.B. 1995. Quantitative Paleoenvironmental Reconstructions; 2) Pla, S., Paterson, A.M., Smol, J.P., Clark, B.J., and Ingram, R. 2005. Journal of Great Lakes Research. 31: 253-266; 3) Reavie, E., Kingston, J., Petersen, M., and Edlund, M. 2005. NRRI Technical Report. NRRI/TR-2005/18; 4) ter Braak, C.J.F. and Juggins, S. 1993. Hydrobiologia. 267/270: 485-502.

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