ARE YOUR PALEOECOLOGICAL INDICATORS TELLING THE TRUTH?

Inferring condition from fossil biological assemblages assumes a strong relationship between the variable you want to infer and patterns in the assemblages. In recent years it has become apparent that several species-based indices to infer environmental conditions in paleorecords are providing meaningless results. The following are steps you can take to ensure valid reconstructions. This poster demonstrates a phosphorus inference model based on Great Lakes diatom assemblages, but these methods are easily transferred to many indicators; e.g. foraminifera/sea level, chironomids/oxygen, diatoms/salinity, etc.

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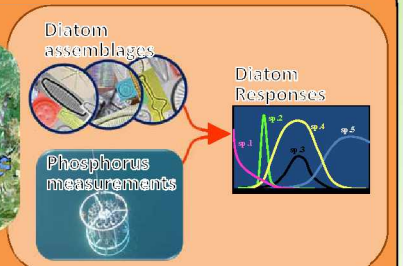
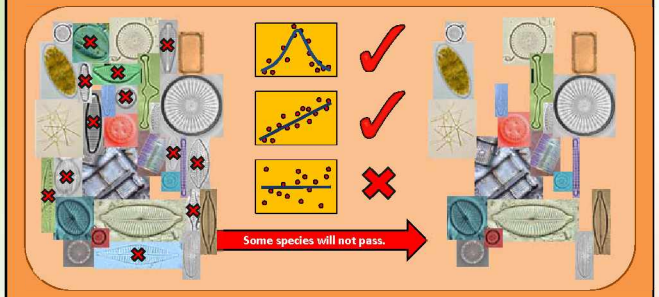
How many species are actually responding along the gradient of interest?



Based on a "training set" of samples from the Great Lakes we collected modern diatom assemblages and associated phosphorus (P) data. Analysis of species distributions along the P gradient provided diatom-P optima. These species-specific P optima are the basis for future inferences of condition from fossil assemblages. To ensure a robust indicator model you must ensure most of your species have significant responses!

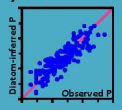


To be useful, a species should have a significant response along the environmental gradient (monotonic, unimodal, etc.). If most of your species have no apparent response to P, your indicator model is not likely to have much power. In the case of Great Lakes diatoms, 67% of the 118 species considered in the model had significant, independent responses along the P gradient, suggesting a meaningful indicator.

This is a good sign!

How bad is autocorrelation in your training set?

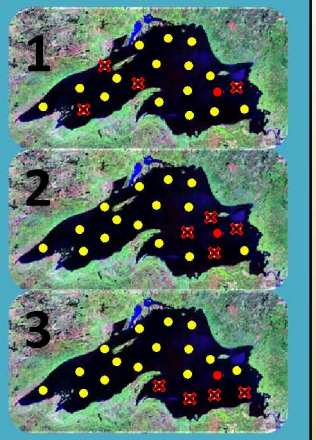
Next, you should thoroughly test your indicator model to ensure your apparent model power is not a result of autocorrelation. A typical model test is to compare observed P with diatom-inferred P in the training set samples. That is fine if no autocorrelation exists, but such is rarely the case!



r^2 = 0.9! Sounds good, right?
It could be a big, fat lie!
Let's find out...

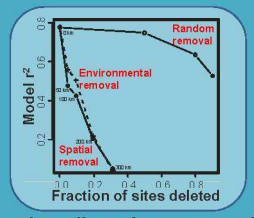
On the right is an example training set for Lake Superior, and the red sample is the one being reconstructed in a single model test iteration. Create multiple models with your training set data, progressively deleting samples:

1. randomly;
2. that are closest;
3. that are environmentally similar (i.e. have the most similar P conditions).



If no autocorrelation exists, all approaches should perform the same way as samples are removed.

Is this the case for the Great Lakes diatom-P model?

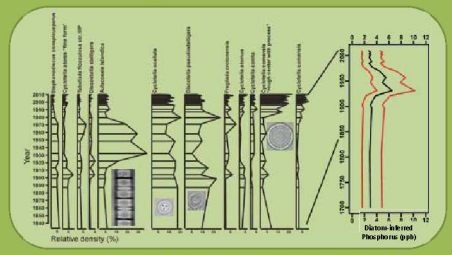


Heck, no!
Iterative model testing indicates that substantial indicator model degradation occurs as samples that are close or environmentally similar are removed.

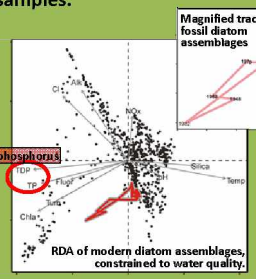
This tells us that autocorrelation is a major problem in our dataset. Our indicator model may still work, but traditional testing methods (r^2, above) are not telling the truth about real indicator power. Further testing is needed...

Are your paleo-inferences realistic?

Here is a diatom paleo-stratigraphy from Lake Superior, with diatom-inferred P on the right. IF TRUE, these inferred data have important implications for lake management.

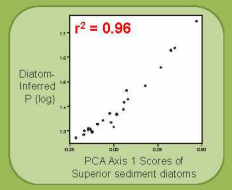


We need to be assured that historical patterns in the diatoms were actually related to historical P. We can gather such information by passively ordinating the fossil samples against the training set samples.



The time track for the fossil assemblages appears to trace a path parallel to the phosphorus vectors, suggesting P historically drove these changes.

This is also a good sign.
Finally, let's regress the diatom-inferred historical P values against the patterns in the fossil assemblages:



96% of the variation in the inferred historical P is explained by the diatoms. This is clear evidence that the indicator model is working as designed. If a strong relationship is not present when testing YOUR indicator model, it is likely that other environmental variables are responsible for historical changes.

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