How predictable is extinction?

Forecasting species survival at million-year timescales

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Foundational assertion of conservation paleobiology

By studying the past,
we can better predict the future.

What are we predicting?

Extinction is hard to predict, but is important to conservation decisions.

Predicting extinction

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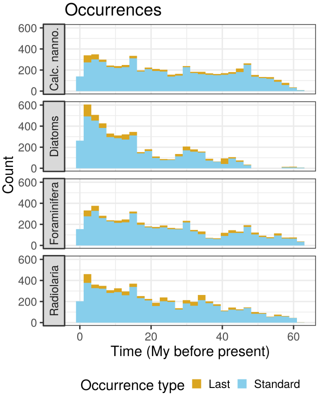
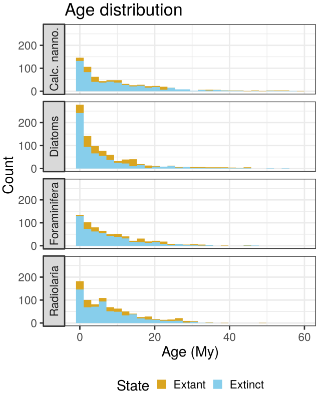
- A taxon's global geographic range can change over time.
- What happens to extinction risk as a taxon changes geographic range? How is extinction risk impacted if that taxon's global geographic range has recently increased or decreased?

Data being analyzed: Neptune database




(UCL)



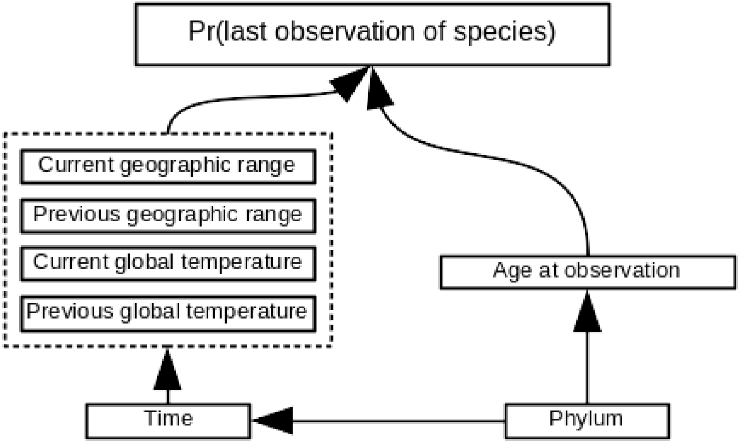


Global occurrences from Deep Sea Drilling Program and Ocean Drilling Project.
– Lazarus. 1994. Math. Geo.; Spencer-Cervato. 1999. Palaeo. Elec.

How we're analyzing the data

- Encoding the past
  - Change in geographic range between current observation and previous observation.
  - Average global temperature at time of previous observation (Mg/Ca elemental ratio).
  - Age in millions of years at time of observation.
- Explore model adequacy using posterior predictive distribution.
- Estimate out-of-sample predictive performance using k-fold cross-validation.

A conceptual model for predicting extinction

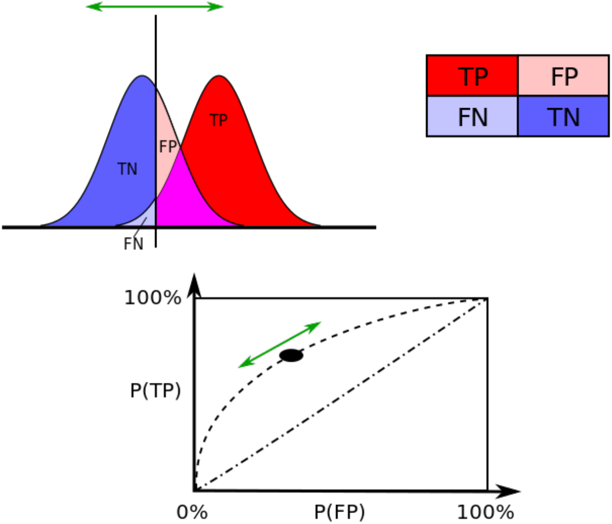


Measuring performance: confusion matrix

		True condition	
	Total population	Condition positive	Condition negative
Predicted condition	Predicted condition positive	**True positive**, Power	**False positive**, Type I error
	Predicted condition negative	**False negative**, Type II error	**True negative**

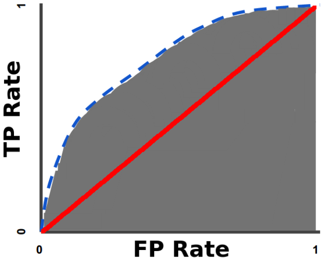
(wikimedia)

Measuring performance: Receiver Operating Characteristic



(wikimedia)

Measuring performance: AUC ROC

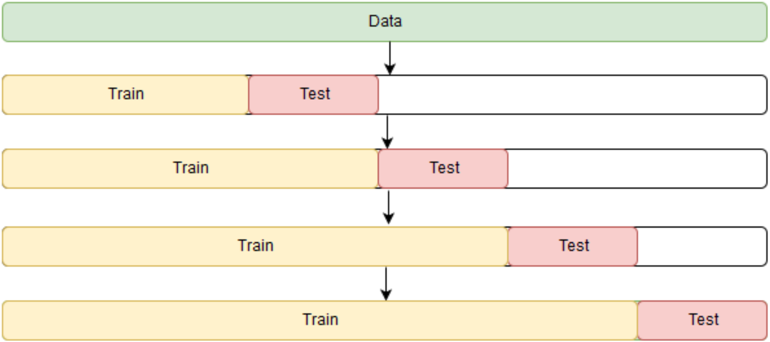


(https://goo.gl/91nEpM)

The area represents the probability of correct ranking of a random “extant”-“extinct” pair.

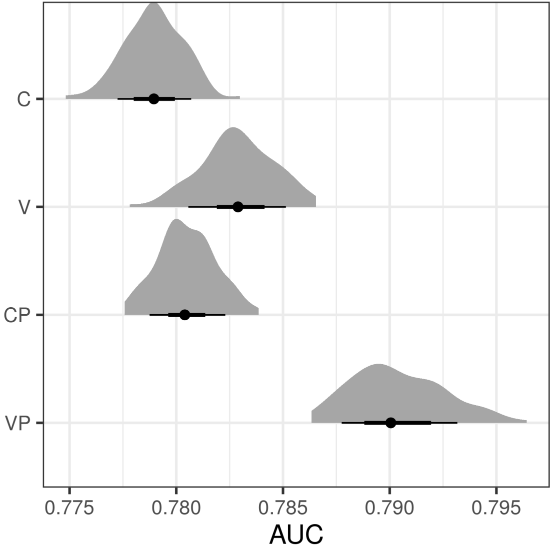
$$\text{AUC} = \begin{cases} 0.5 & \text{non discrimination} \\ 0.6 - 0.7 & \text{poor} \\ 0.7 - 0.8 & \text{acceptable/fair} \\ 0.8 - 0.9 & \text{excellent/good} \\ > 0.9 & \text{outstanding} \end{cases}$$

Measuring performance: k-fold cross-validation



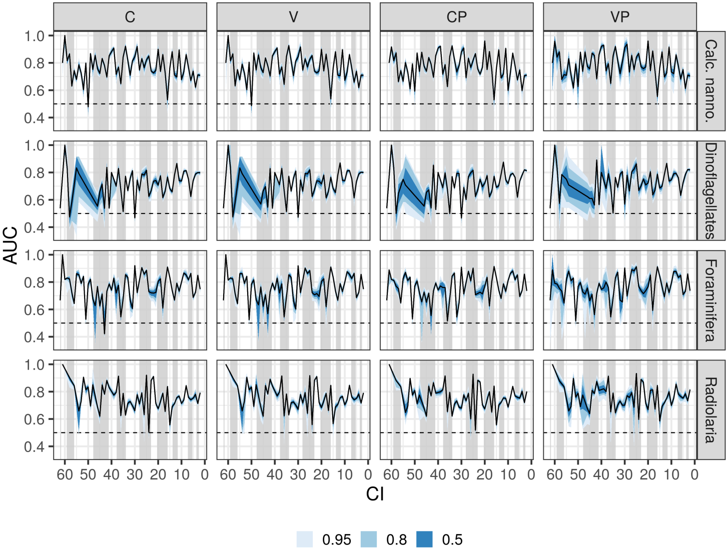
(Ken Williams, https://goo.gl/qLcfL8)

In-sample predictive performance, full dataset

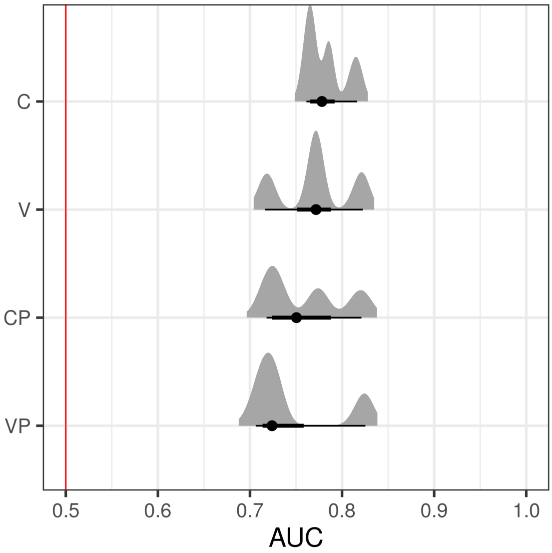


AUC = 0.7-0.8 acceptable/fair

In-sample predictive performance, by time and taxa



Cross-validation results, full dataset



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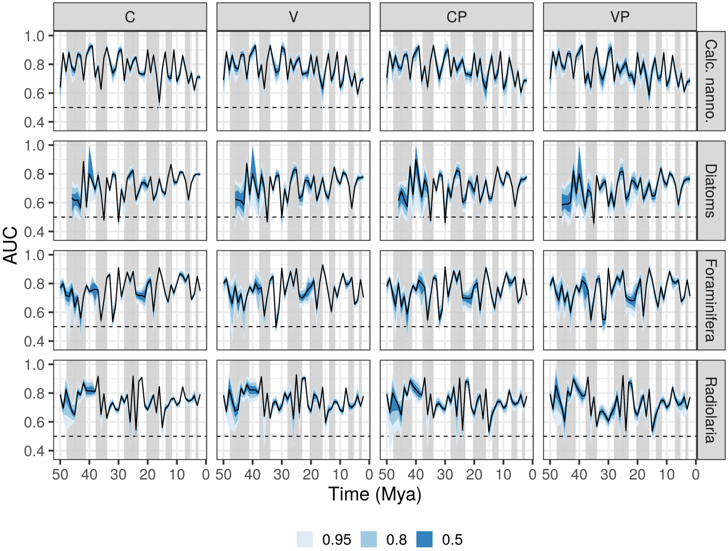
Cross-validation results, by time and taxa



Summary

- The past matters...
  - Our best supported model includes our historical covariates and allows all effects to vary over time.
- But not that much...
  - Models only average/fair expected out-of-sample performance.
- Mechanisms behind changes to geographic range operate at sub-million year scales. Perhaps their effects are weak/masked at million (or greater) year scales.

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GitHub

psmits.github.io/ **trident**

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