Assessing the Relationship between Dinosaur Diversity and Outcrop Characteristics

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Introduction

Here we investigate the relationships between dinosaur sampling and geology. Previous work has produced conflicting results and often relied on proxies for geological data. Other studies focus on geographically small regions, whose broad applicability is unclear. Here we assess dinosaur sampling, and the resulting diversity recovered, in light of available outcrop area in the United States.

We address two questions:

- Is there a relationship between outcrop area and dinosaur fossil discovery?
- Is there a relationship between outcrop area and perceived dinosaur diversity?

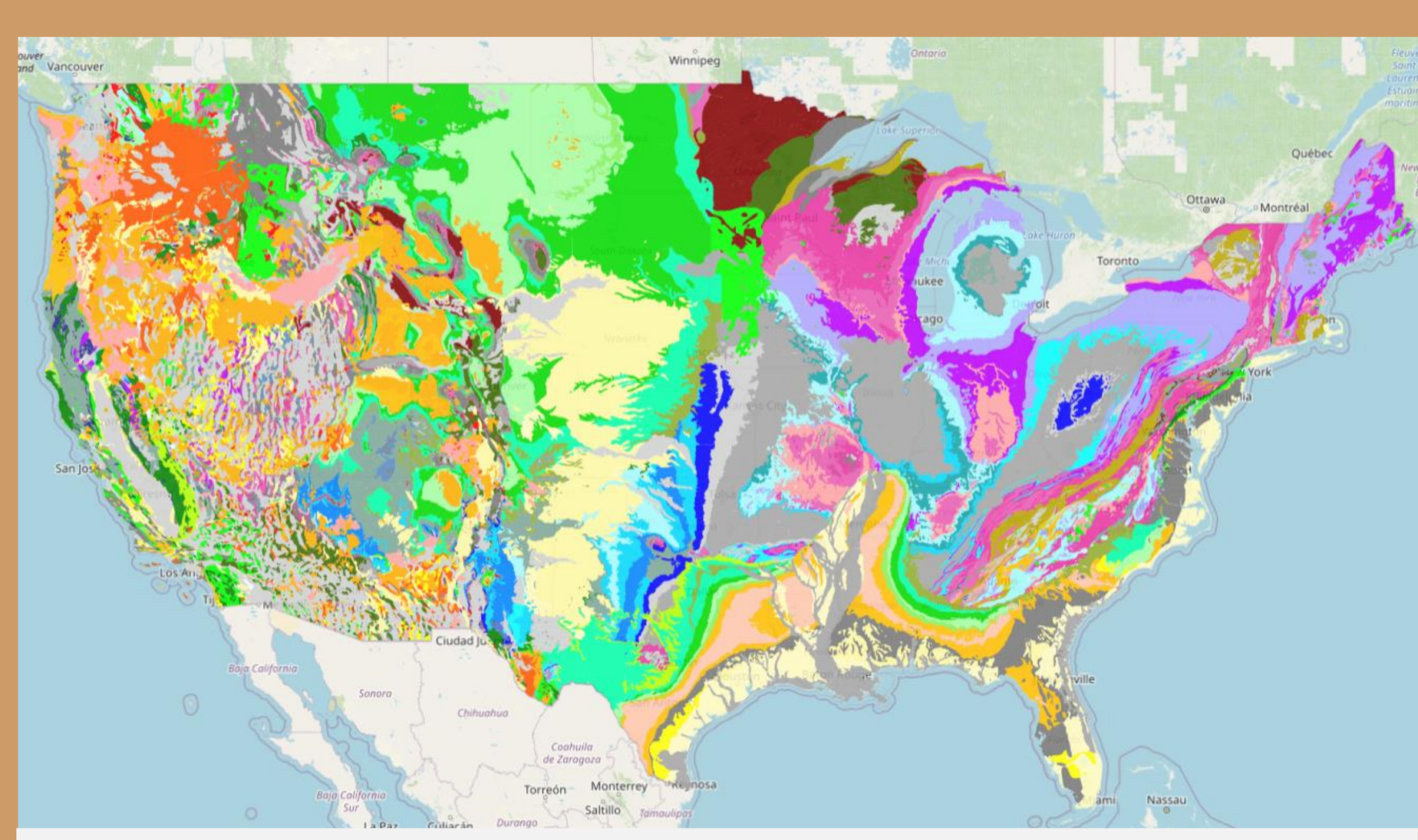

Fig. 1: Map of coterminous US showing geologic outcrops by time interval. Mesozoic outcrops are in shades of green.

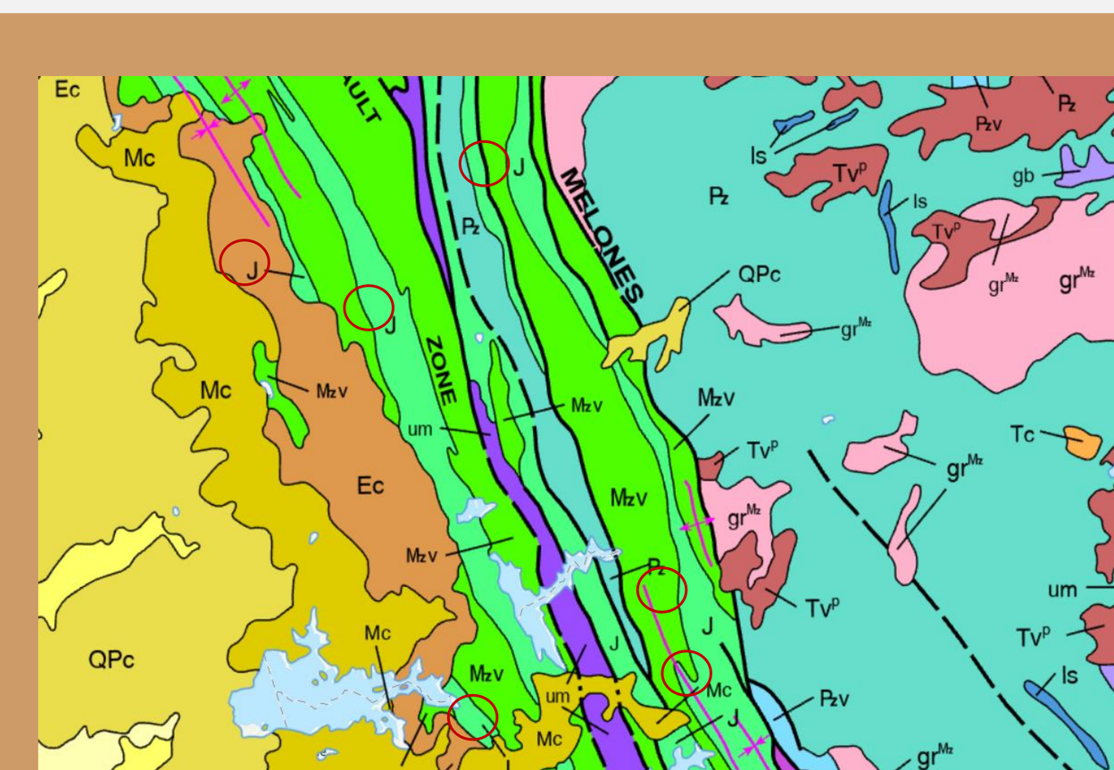

Fig. 2: Close-up of bedrock geology from state map of California, showing typical mapped resolution. Outcrops labeled 'J' and 'K' are relevant to this study.

Methods

Geological data: We confined the study to the United States (US) because it represents a large, varied area with a long history of dinosaur collecting. The State Geologic Map Compilation Geodatabase of the United States Geological Survey includes scaled, digitized data for outcrop area. We captured data on all sedimentary rocks of Mesozoic age, for both marine and terrestrial rocks (because dinosaurs have been found in both). For mapped outcrops that included multiple strata, the area was divided evenly among the components.

Dinosaur Data: We obtained data on non-avian dinosaur collections and occurrences from the Paleobiology Database (PBDB). We collected and vetted data on diversity for each stratum, counting every potentially distinct taxon at the species (or other lowest identifiable) level, including form taxa where appropriate (i.e., ichnotaxa and ootaxa).

Data Assessment: We used bivariate plots of the data to assess and visualize relationships between sampling (occurrences, collections, diversity) and geology (outcrop area, sedimentary environment).

Results

Fig. 3: Map of US dinosaur collections in the PBDB, plotted via Fossilworks (N = 2730).

Dinosaur fossils are widely distributed among US Mesozoic outcrops (Figs. 1, 3) and clearly concentrated in terrestrial strata.

There is some tendency for strata with larger outcrops to yield more fossil collections and occurrences (Fig. 4).

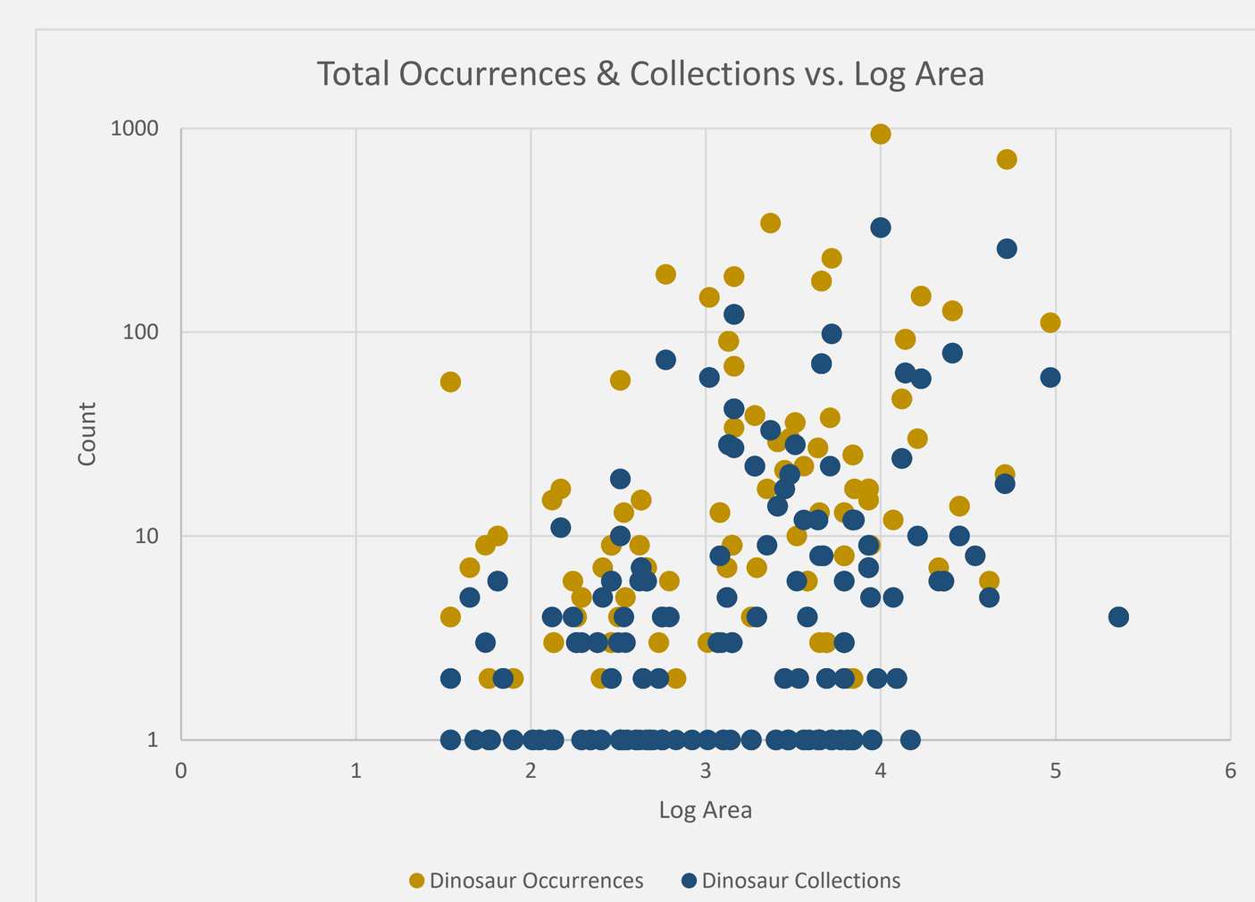

Fig. 4. Plot of dinosaur collections (blue) and occurrences (orange) versus log outcrop area for all strata.

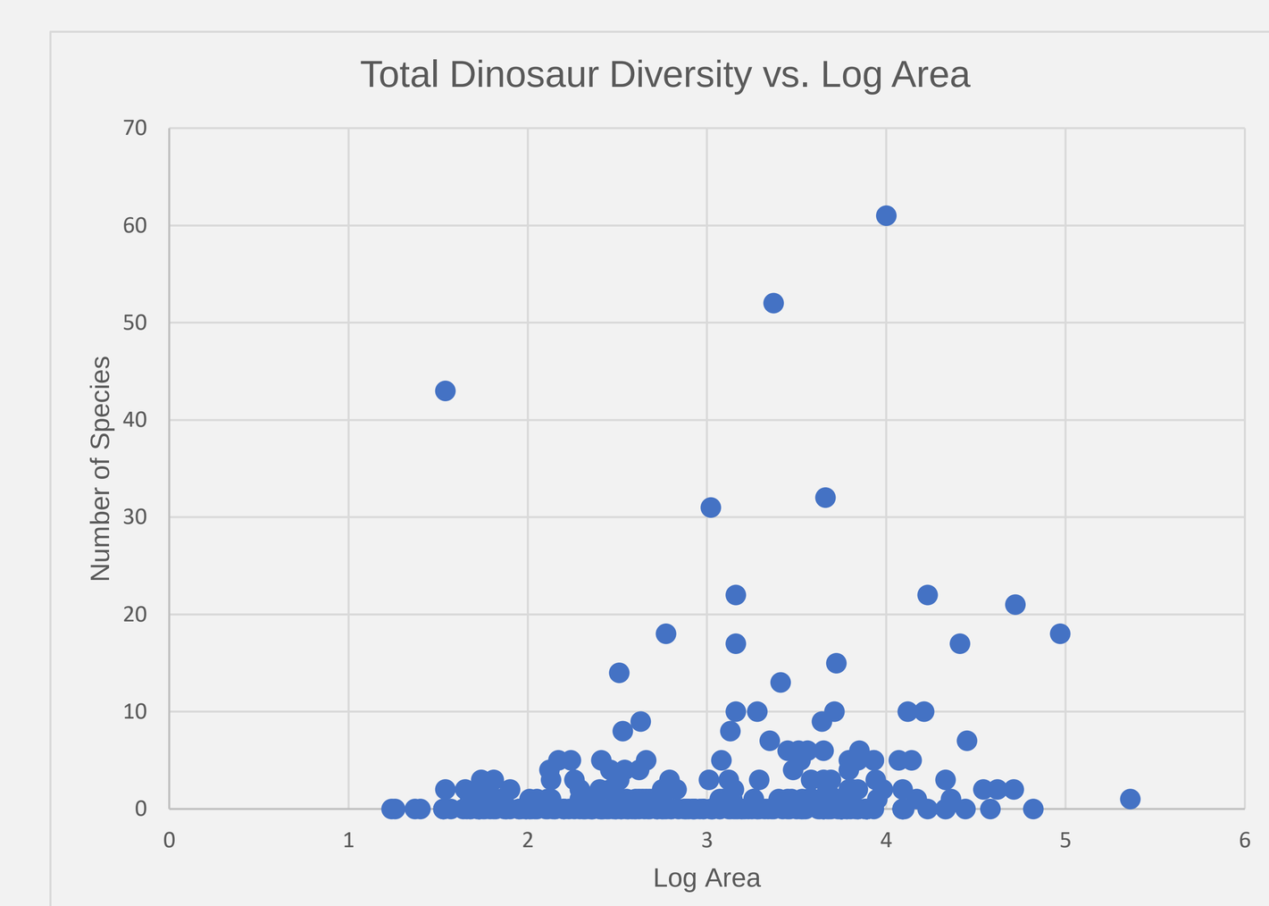

Fig. 5. Plot of dinosaur diversity versus log outcrop area for all strata.

However, little pattern is evident between outcrop area and diversity (Fig. 5). When terrestrial and marine outcrops are separated (Figs. 6–9), the latter show very little relationship between area and any sampling variables.

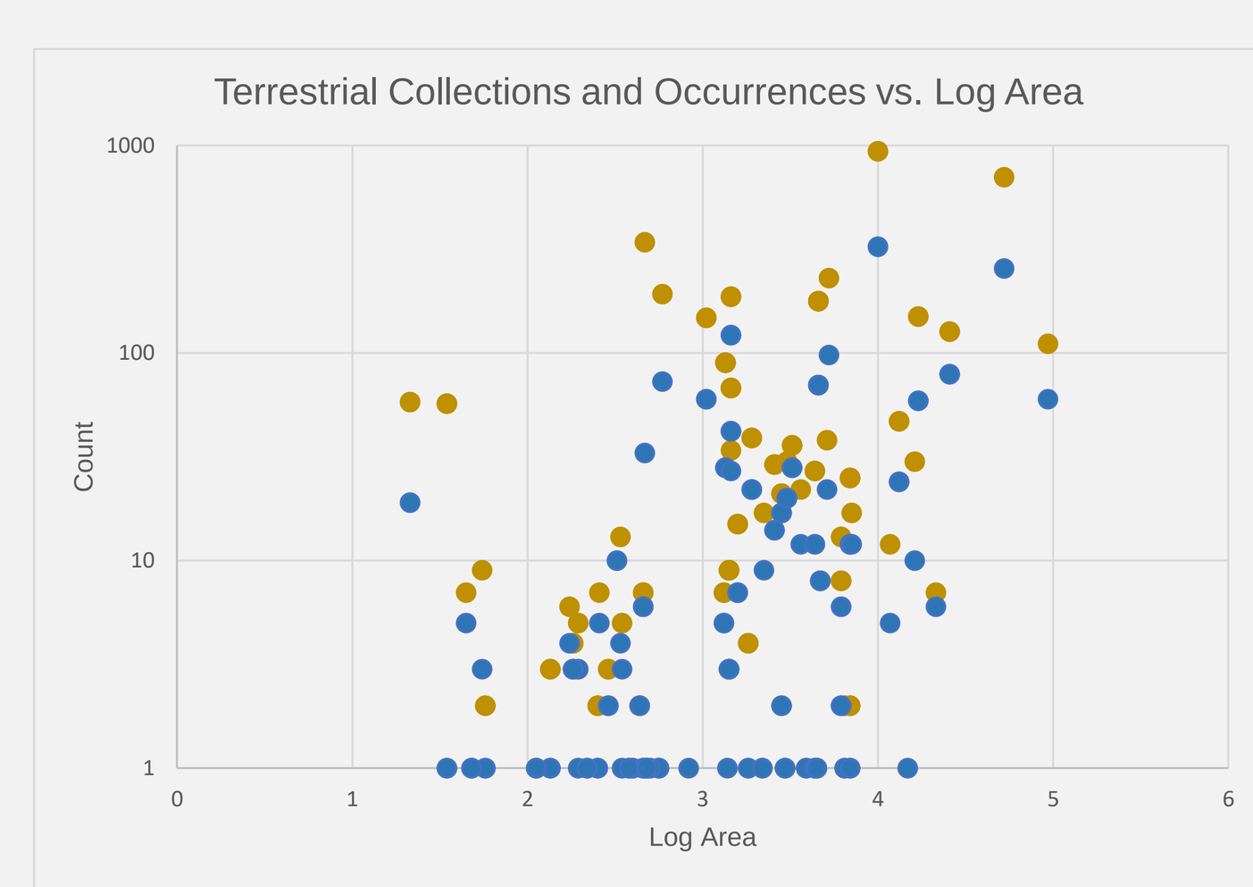

Fig. 6. Plot of dinosaur collections (blue) and occurrences (orange) versus log outcrop area for terrestrial strata.

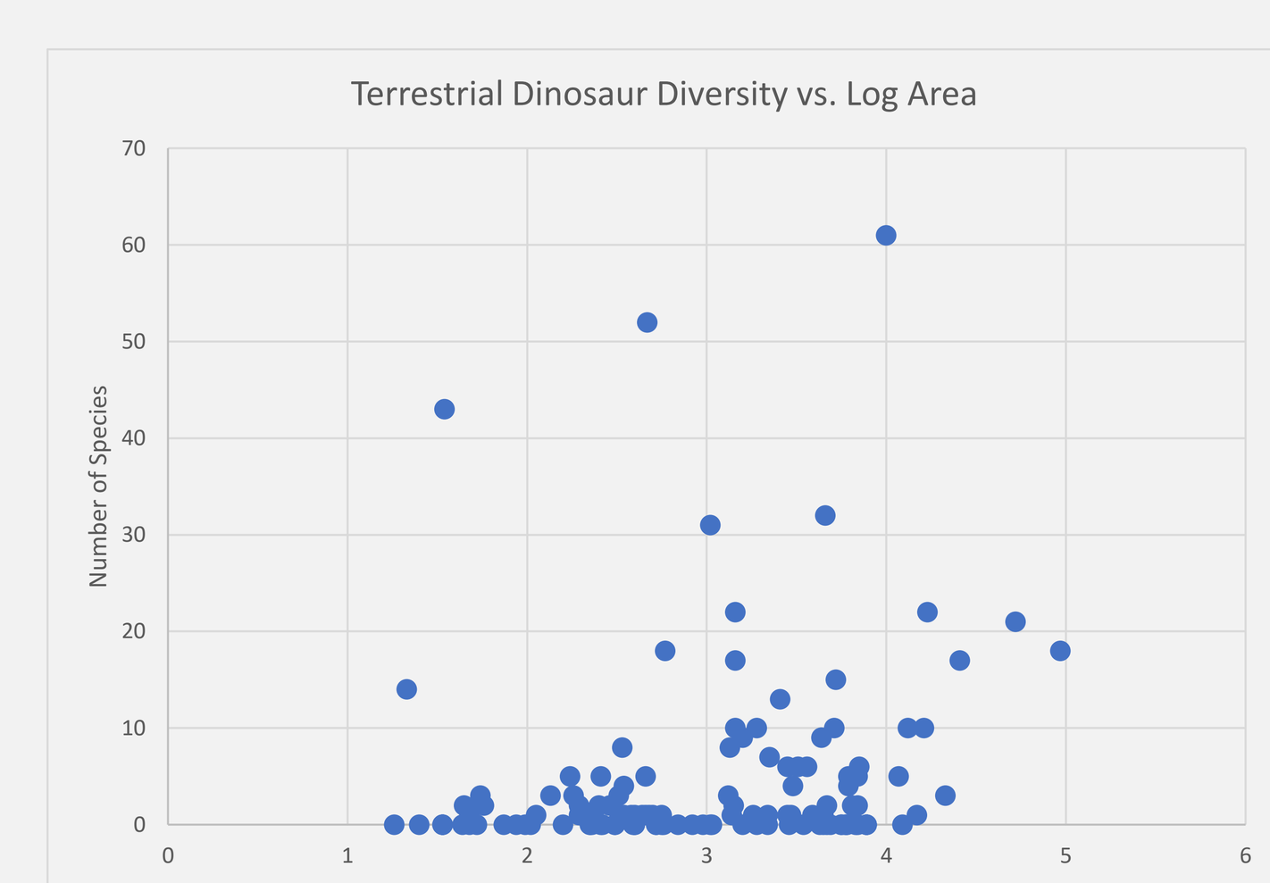

Fig. 7. Plot of dinosaur diversity versus log outcrop area for terrestrial strata.

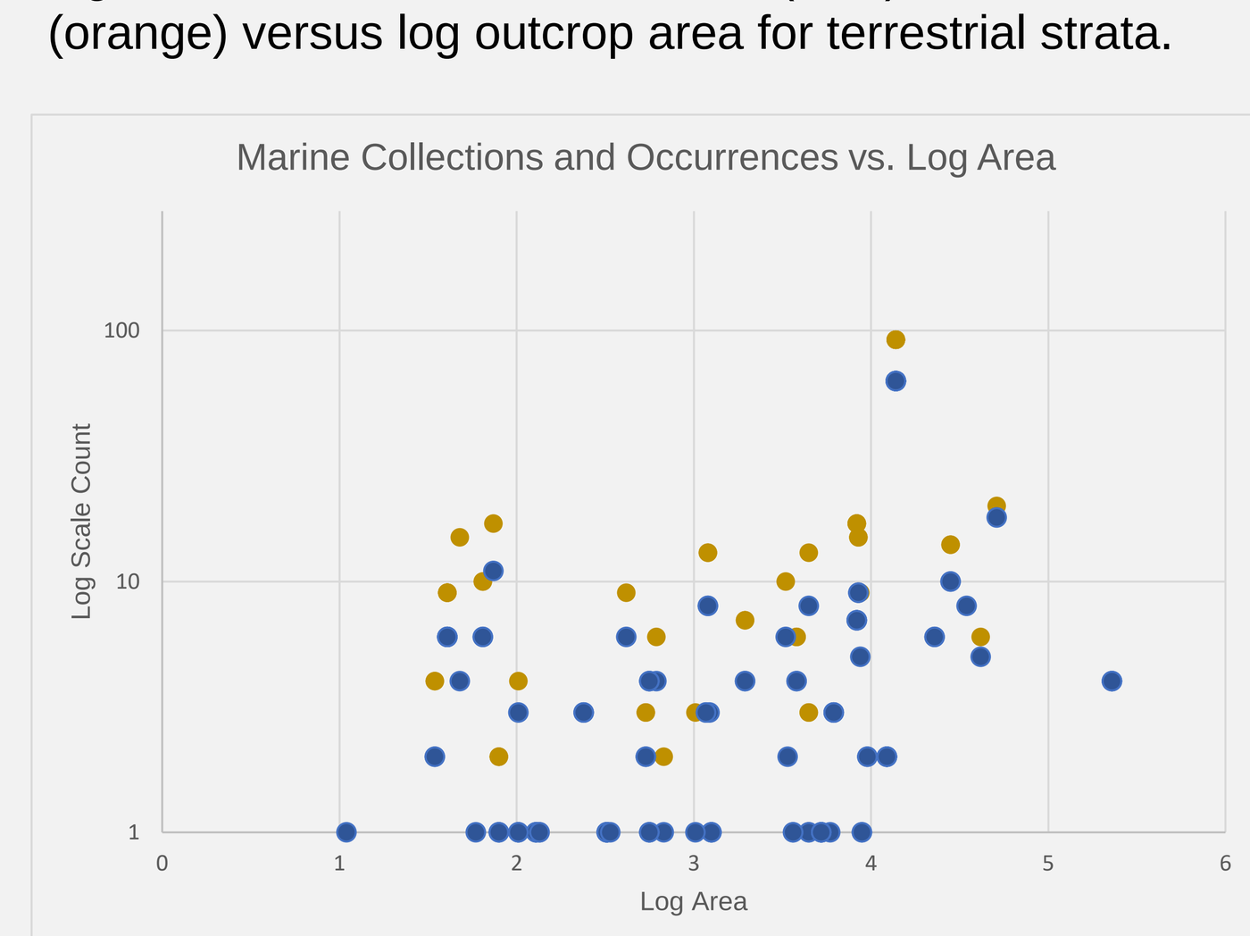

Fig. 8. Plot of dinosaur collections (blue) and occurrences (orange) versus log outcrop area for marine strata. Note: y-scale has been decreased from Figs. 4–7.

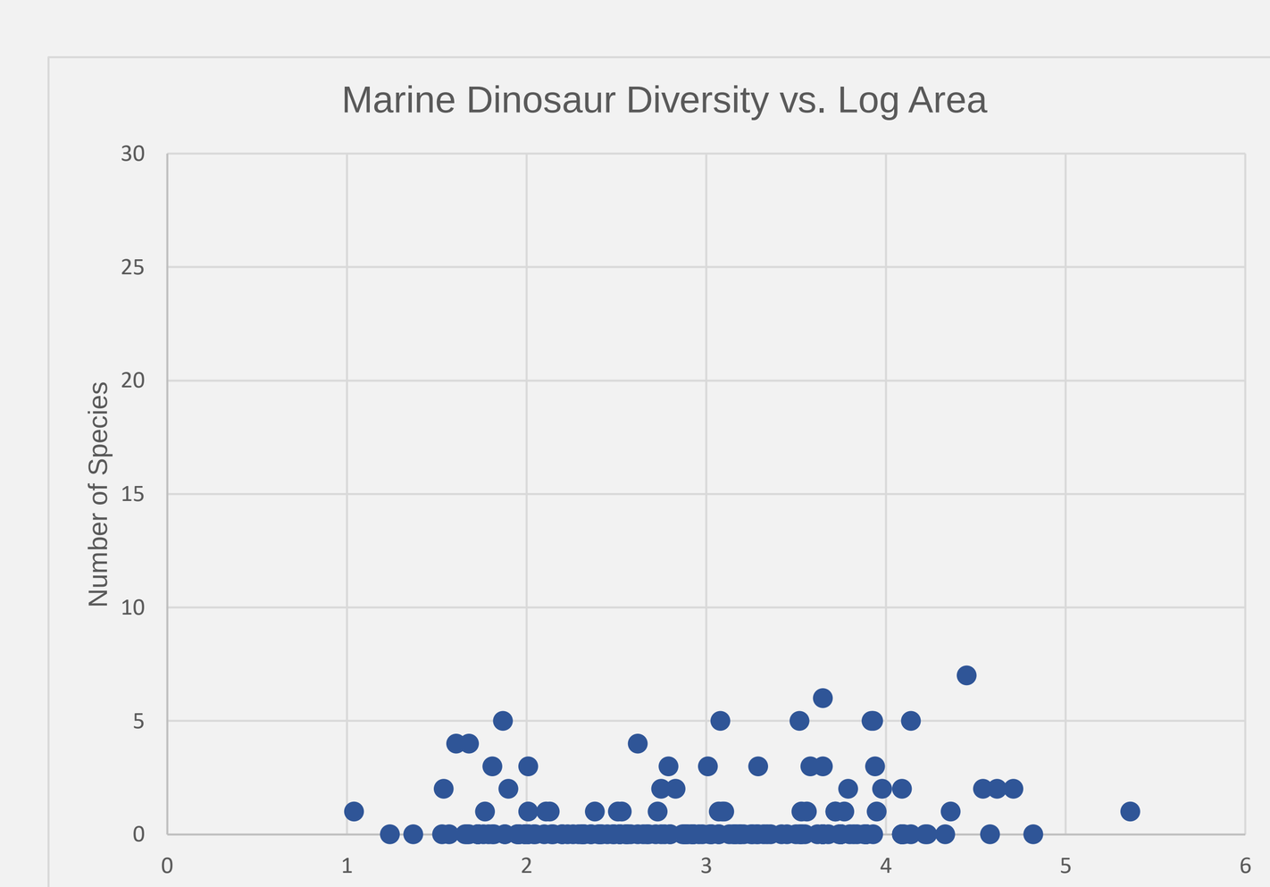

Fig. 9. Plot of dinosaur diversity versus log outcrop area for marine strata. Note: y-scale has been decreased from Figs. 4–7.

Discussion

There is an apparent discrepancy in the results. Whereas larger outcrop areas do tend to produce more collections and more occurrences, they do not necessarily produce more species.

This supports the idea that outcrop area has some effect on the ability to find and collect fossils in the first place. However, diversity may be more strongly controlled by intrinsic properties of the stratum itself, including aspects of its original depositional environment and its general preservational potential. These would not vary with modern outcrop area.

In general, marine beds show little correlation with any sampling variables. In these environments, dinosaurs are rarely preserved, through "sweepstakes"-like events, and so samples are always low regardless of outcrop area.

Conclusions and Future Work

The results suggest that dinosaur sampling is partly controlled by outcrop area, but that diversity is more reliant upon inherent characteristics of fossil-bearing layer. There is no strong relationship between any factors in marine strata.

If these relationships are broadly applicable, then even relatively small outcrops may be sufficient to recover a significant sample of preserved diversity.

One variable that could influence these data is modern-day plant cover, which reduces outcrop exposure and would negatively impact collecting effort. This is especially likely along the East Coast. Future work will add data on vegetation cover, and examine these overall correlations statistically.

Acknowledgements & References

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