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Cenozoic biodiversity: goals, challenges and future prospects

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Understanding biodiversity is a major goal of modern science. Biologists document living diversity; study the factors that maintain it, and the effects biodiversity has on ecosystem services. Paleontologists try to understand these same issues by examining biodiversity in the geologic past, and how this history correlates to changes in past environments. Both research agendas are driven by concerns about how biodiversity can be sustained into the future, despite human impacts on biodiversity, including climate change.

Measuring biodiversity is a major challenge. Generally only a subset of the total diversity that exist(s/ed) at any one location can actually be recorded, due to rarity of many species, or (for fossils) species that were not preserved. Taxa occurrence data not collected for biodiversity studies is also frequently incompletely recorded. Incomplete, inconsistent taxonomy; and for fossils also incorrect geologic ages for observations are other major sources of error. Several different methods are used to correct for these problems, such as subsampling occurrence data or using expert-compiled taxonomic catalogs. No method is normally fully satisfactory, but, depending on data quality, can often yield useful approximations of actual (usually relative) diversity.

Assuming that diversity has been accurately estimated, a second challenge comes in comparing diversity to possible causal factors. A common approach is a statistical comparison between diversity and environmental data series. Whether this is a meaningful exercise depends on the underlying statistical model, and whether this is similar to the processes that we are trying to understand. If for example, we suspect diversity to respond largely only when environmental thresholds are crossed, a linear regression test is not very informative. Our understanding of possible processes is however still primitive, and a poor guide to model selection and analysis. Scale is also important (temporal, geographic, taxic). Long-term trends in diversity and environment for example may show different patterns, and be due to different processes, than diversity responses to shorter-term environmental change. Much paleodiversity research in recent years has looked at Phanerozoic trends, with data binned to ca 10 my long intervals. This seems too long: for comparison, it is doubtful we would have discovered much of what we now know about interactions and processes in Cenozoic paleoceanography and paleoclimates if our data was only at this temporal resolution.

Given such challenges in data quality and methods, we need urgently to pay more attention to the relatively high resolution, well preserved Cenozoic records of biodiversity and paleoenvironments. While not perfect, these are perhaps the best fossil/environmental records available to understand how diversity on earth is maintained, and how much is at risk as humanity alters the planet.