Conservation Biology

Letter

## Look to the past for an optimistic future

Conservation paleobiology provides a framework that allows the fossil record to guide conservation efforts. Scientists now use fossils to successfully reconstruct prehuman baselines of populations, communities, and ecosystems to create conservation targets, contextualize modern-day change, and predict future conservation needs (Dietl et al. 2015; Finnegan et al. 2015; Barnosky et al. 2017). Often, however, the prognosis is rather pessimistic because the fossil record reveals the bleak truth of what has been lost over time through human activity. Meanwhile, earth optimism shows that positivity is critical to maintaining engagement in conservation (Knowlton 2017). How can fossils make positive contributions to today's conservation challenges?

Earth optimism brings a much-needed breath of fresh air to conservation, not least because examples of success can be harnessed to identify effective solutions. A good example of how this can work is through the identification of conservation "bright spots", i.e. areas that are in demonstrably better condition than expected. The approach, originating from successful initiatives in human health and development, was applied to identify coral-reef bright spots by Cinner et al. (2016). They compared the statuses of thousands of coral reefs to an expected state to uncover several reefs that, given their socioeconomic and environmental context, were performing better than expected; this in turn revealed what makes a bright spot bright.

Although powerful, the models have some limitations because models use a subset of the many variables that can affect ecosystems. Possibly more problematic is that they are built on ecosystems with baselines that might have shifted. We propose that the fossil record can be used to more accurately gauge ecosystem status relative to an unshifted baseline.

Our ideas build upon the framework of Symstad and Jonas (2014), who used decade-long variations in North America's Great Plains grassland communities to quantitatively establish the "natural range of variation" as a powerful tool to evaluate current ecosystem state and make conservation recommendations. We propose that the fossil record be used to define the natural range of variation in an ecosystem over time (hereafter, the historic range of variation [HRV]) to identify bright spots and avoid the shifting-baseline syndrome.

Our approach can be implemented using either taxonomic or functional data, depending on the ultimate conservation goal (Barnosky et al. 2017). Modern ecosystems within their HRV can be considered bright spots, whereas dark spots are those that fall outside their HRV. Thus, even if an area is not considered an archetypal conservation priority under conventional standards, confirmation from the fossil record that it sits within its HRV would provide a compelling argument for the area's preservation and study as a valuable component of overall ecosystem diversity. This would fuel conservation optimism by increasing the number of known bright spots globally and help expose the underlying mechanisms that lead to conservation success and failure.

Once bright and dark spots are identified, the fossil record could also provide a more nuanced understanding of ecosystem functioning through time. Many ecosystems, such as lakes, mangroves, marshes, and coral and oyster reefs can be cored and their fossil communities dated and reconstructed with high temporal resolution. Such records have the potential to reveal whether bright and dark spots have been historically stable, existed in alternative stable states, or are inherently more likely to recover or deteriorate following disturbance. They thus offer valuable lessons about resilience and could improve our ability to make future predictions. These data could also reveal the timing and context under which modern conditions became established and how human and natural drivers of change interplay over time. This could help develop location-specific blueprints for recovery or management toward novel ecosystem states, if desired.

High-resolution records that cover all or part of the history of human interaction with an ecosystem can also help elucidate underlying drivers of ecological change. For instance, global and local stressors can be challenging to disentangle because they coalesce on different scales to alter ecosystem functioning in complex ways. This confounds the ubiquitous debates about the relative values of conservation that focus on global as opposed to local problems. These stressors are, however, typically decoupled through time, presenting the

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opportunity to tease apart their relative importance using the fossil record.

Large amounts of existing fossil data can be repurposed to establish HRVs, identify bright and dark spots, and explore mechanisms of ecological change on local scales. However, new data is required, especially from young fossil records (Kidwell 2015), in conjunction with comparable samples from modern ecosystems. Modern and fossil data should be collected and interpreted with care because fossil assemblages are time-averaged accumulations of community members, and modern ecosystems contain many taxa that do not leave a fossil record. However, recent advances have been made in the quantitative interpretation of the fossil record in light of conservation questions (e.g., Dietl et al. 2015; Kidwell 2015), and the flourishing study of ancient environmental DNA will no doubt begin to incorporate missing community members that have poor fossil records. Neontologists and paleontologists must work together to collect and share mutually compatible data, and funding agencies should recognise the benefits of the such interdisciplinary collaborations.

Finally, as conservationists endeavor to maintain positivity, it is worth remembering that fossils have captivated the public for centuries. What better way to be a conservation optimist than to appreciate, understand, and learn from the struggles, survival, and resilience of life over millennia as we look to the future.

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