

Insights from the past: unique opportunity or foreign country?

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The events of the past are widely recognised as having invaluable potential for contextualising the present, predicting possible futures, and guiding decision-making. Understanding past conditions, how those conditions have changed through time, and the consequences of those changes together form an integral component of academic and practical disciplines as diverse as statistics, psychiatry, education, medicine, political science and finance [1–3]. Indeed, the forgetting of past experience and associated shift of socio-cultural baselines, a phenomenon known as historical or social amnesia, is understood to have dangerous implications for politics, policy and human rights [4].

Conservation is a mission-oriented “crisis discipline” [5–7], which urgently requires robust evidence to inform both applied research and best-practice environmental management and policy. The recent growth of the “conservation evidence” initiative has encouraged more systematic and standardised use of available data to inform conservation decisions, including not only rigorously collected quantitative ecological datasets but also qualitative and anecdotal data, as well as “non-standard” conservation data types such as social science datasets [8, 9]. Many of the key current-day environmental concerns that conservation

biologists and practitioners are faced with have precedents in the past. In particular, the fossil record and other long-term environmental archives can provide rich and unique insights from the history of life across deep time (i.e. geological or evolutionary time) about topics of direct relevance for understanding anthropogenically-mediated biodiversity loss today, such as: “natural” baseline patterns of species diversity and ecosystem composition, structure and function; species and ecosystem responses to environmental change (e.g. past climate change); extinction dynamics and drivers, and correlates of extinction vulnerability and resilience; patterns of recovery after extreme events; and the existence and identity of ecological boundary conditions and tipping points [10–15]. Quaternary environmental archives, representing the most recent interval of geological time (near time or “Q-time” [16]), also contain information about the effects of prehistoric and historical human interactions with biodiversity across centennial or millennial scales, and can potentially permit finer-scale reconstruction of the spatiotemporal dynamics of species declines that may take decades, centuries or even longer to run their course [17, 18]. As many of the drivers and processes associated with current-day biodiversity loss also occurred in the past and have historical signatures, data from the past have the potential to provide important reference baselines on conservation-relevant parameters, and to make predictions about the direction, magnitude, and effects of ongoing and future environmental change. Long-term past biodiversity baselines might also constitute a unique source of data to inform sustainable long-term conservation goals and projections [19].

Ever since their inception, the relationship between the past and the present has been central to geology and palaeontology. Indeed, these disciplines have

never been static and restricted only to consideration of deep time. The gradualistic views of eighteenth century geologists such as James Hutton on form and process in geomorphology, which was developed into the hugely influential nineteenth century Doctrine of Uniformity by Charles Lyell, proposed that the present is the key to the past, with the earth having been shaped entirely by regular geological forces that are still operating today at the same rates [16, 20, 21]. Uniformitarianism strongly influenced Charles Darwin's thinking, as evidenced by his ideas on coral reef formation as well as his evolutionary theories, and even contemporary catastrophists developed alternative theories about earth history based on comparison between modern and ancient geomorphological features, such as recognition of a prehistoric Ice Age by Louis Agassiz [20, 22]. More recently, palaeoecologists and palaeobiologists have interpreted fossil data using modern analogues and many of the principles of modern ecology [23–25], such that “a palaeoecologist is not simply a palaeoscientist whose data may be of interest for ecology but is primarily an ecologist working on another time scale, with different methods” [24].

Conversely, conservation has traditionally focused less on the past and whether it might be the key to the present. Conservation biology is a relatively young scientific discipline that only became established in the 1980s [5, 6], and which originally relied almost exclusively on modern data about populations and ecosystems. The potential importance and usefulness of long-term environmental data for informing conservation has become widely recognised in recent decades, for example with consideration of past data now being incorporated into guidelines made by the International Union for Conservation of Nature [26] and projections made by the Intergovernmental Panel on Climate

Change [27]. Indeed, there is increasing awareness that loss of historical knowledge is associated with changing socio-cultural perception of what baseline environmental conditions are considered “normal”, a phenomenon analogous to social amnesia and known as shifting baseline syndrome, which has major implications for defining environmental management goals and restoration targets [28]. This change in thinking has led to the emergence of a series of interdisciplinary and synthetic disciplines, conceptually related but distinct from one another, which attempt to utilise environmental archives for understanding modern-day ecological and extinction dynamics, and/or guiding practice and policy. The application of geohistorical data, theories and analytical tools from palaeontology to biodiversity conservation is termed conservation palaeontology [12, 29, 30]. Research into long-term interactions and interconnectedness between humans and their environment throughout history and prehistory, drawing more heavily from environmental anthropology, archaeology and geography, is referred to as historical ecology, a discipline with a longer academic heritage [31, 32]. This term is also sometimes used more broadly to refer to the general use of historical knowledge for ecosystem management [33, 34], and the use of zooarchaeological data to guide conservation has alternately been termed ‘applied zooarchaeology’ or ‘applied palaeozoology’ [35–37]. Two further disciplines, restoration ecology and rewilding, involve research into past environmental baselines to set management targets for restoring anthropogenically degraded ecosystems and/or former species diversity and ecosystem functionality, respectively [38–41]. However, “rewilding” has now become a hugely popular term with a bewildering diversity of meanings, some of which are associated with other

environmental concepts such as connectivity to nature and even activism rather than consideration of past baselines [38, 42–44]. These related disciplines have different goals, scopes and histories, and make use of environmental archives of differing temporal depths, even if terminologies have sometimes been used interchangeably.

However, although the importance and value of integrating past and present is now widely discussed as a novel paradigm in conservation, the reality lags far behind the theory. “Long-term” in ecology is still typically interpreted as meaning decadal to multi-decadal [11, 45], representing “real-time” as defined by Jackson [16]. Only 15% of ecological studies on long-term population declines assessed in one meta-analysis were found to have used data older than 100 years [46], rather than considering longer-term (either near-time or deep-time) archives that have the potential to provide alternative ecological insights on biological processes that can be studied only at different temporal scales. To put this in context, even evidence for the onset of significant human impact on biodiversity dates at least from the early Holocene (>10,000 years ago) and probably much earlier [47]. Scientific and management inferences based solely on baselines from recent ecological systems, from which the most susceptible species may have already become extinct due to past anthropogenic activity, are therefore likely to be biased by “extinction filters” [48]. This should perhaps come as no surprise; in the words of Aldous Huxley, “That men do not learn very much from the lessons of history is the most important of all the lessons that history has to teach” [49].

There are multiple reasons why conservation biologists and ecologists have not yet fully embraced the potential opportunities that could be provided by

studying the past. To cite the well-known opening quote from *“The Go-Between”* by L. P. Hartley [50], from the perspective of many neontologists “The past is a foreign country: they do things differently there”. Most past species assemblages, ecosystems, and environmental conditions differ from those encountered today, with non-analogue communities such as steppe-tundra or “mammoth steppe” widespread into the Late Quaternary [51, 52] and large-scale community reorganisation continuing into the Holocene [53]. Long-term records also reveal a complex picture of constant biodiversity change in response to both past human activity and past environmental change, challenging identification of static baselines or idealised visions of the past that can be used to set current management and restoration goals [15, 54, 55]. Even the Late Quaternary encompasses a bewildering diversity of successive climatic and environmental baseline conditions driven by glacial-interglacial cycling, and which were associated with complex spatiotemporal changes in species distributions and habitat composition [56]. Reconstructing baseline conditions and the ecological processes that regulated them also remains challenging, as demonstrated by the ongoing debate over whether early Holocene Europe was covered by dense closed-canopy forest or by a park-like woodland-grassland mosaic maintained by grazing herbivores [57, 58]. Which baseline should we choose, and is it even possible to determine what constituted “natural” pre-human landscapes? More fundamentally, the scale of biodiversity change across the immensity of geological time can be hard for neontologists to either appreciate or differentiate, with the concomitant risk of grouping everything into a single comparative category called “the past” [24].

The numerous environmental and geohistorical archives that can elucidate past biodiversity states and dynamics are also generally unfamiliar and potentially daunting to researchers not trained in their use, with each archive the focus of a distinct academic discipline and requiring its own specialist investigative and analytical frameworks. These archives are diverse, including the fossil and zooarchaeological records, environmental proxies such as pollen and sedimentological records, and a range of historical sources. Datasets associated with different archives obviously also vary in their quality and potential applicability to modern situations. Given that conservation is a crisis discipline, is there the luxury of time to learn new methods in order to look back into the past?

The apparent documentary quality of the fossil record is often interpreted at face value by neontologists attempting to extend the time frame of observations available from the modern era, for example to make direct comparisons between past and present extinction rates [59]. However, palaeontological and neontological data are fundamentally different in many important regards, both quantitatively and qualitatively. Whereas all scientific endeavour is forced to rely on incomplete data, the fossil record encompasses multiple distinct categories of incompleteness and bias associated with both preservation and sampling (organismic incompleteness, ecological incompleteness, stratigraphic incompleteness, and biogeographic incompleteness) [23, 60]. Species concepts, extinction concepts, methods of inferring extinction drivers, survival of evidence, and biogeographic patterns all constitute separate recognised sources of systematic variation between past and present data [61]. For example, species concepts in past and present systems are influenced by different processes of

taxonomic inflation, with neontological studies often diagnosing species on the basis of soft-tissue, behavioural and genetic characters that are unavailable in the fossil record, whereas palaeontological research might instead be more prone to taxonomic elevation and overdescription [62]. The deep-time record is also biased heavily towards marine rather than terrestrial environments [23, 60]. An epistemological gap therefore exists between palaeontology and neontology [60], with data quality, availability and spatio-temporal resolution, and even the units used to think about biodiversity, often differing in key respects. Within the palaeontological record itself, deep-time and near-time fossil data also vary in fundamental respects beyond just temporal scale [23, 63]. Incorporating information from the past into conservation planning therefore requires careful and nuanced consideration.

Whereas neontologists need to understand the issues and deficiencies associated with palaeontological data, it is also important for palaeontologists to recognise that the definition and goals of conservation are complex. In broad terms, conservation biology as an applied scientific discipline aims to understand human impacts on biodiversity and how to design interventions to maximise species persistence in a rapidly changing world [5–7, 64]. However, the discipline draws on diverse backgrounds, including not only biological sciences but also resource management, social sciences, and humanities. The significance and interlinkage of key concerns such as economic development, poverty alleviation, and the financial value of ecosystem services in defining conservation's core goals, and the scale at which concerns and actions should be addressed (from species-level to ecosystem-level to process/functionality-level), are the focus of extensive ongoing debate [65–68]. Furthermore, a “knowing-doing” gap exists

between conservation research and conservation implementation, with scientific recommendations often not translating into practical management and policy [69–71]. Given this diversity of views on values and approaches for conserving diversity, it is important to consider what conservation issues can conceivably be addressed using data from the past. Long-term archives can provide unique and potentially essential insights, but at the same time the past is not a panacea for conservation and must form just one component of a wider toolkit.

The relationship between long-term environmental archives and conservation evidence was the focus of a two-day scientific discussion meeting held in January 2019 at the Royal Society, London, entitled “*The past is a foreign country: how much can the fossil record actually inform conservation?*” This meeting aimed to generate discourse and promote the sharing of data and ideas, foster new collaboration, and provide a call to action to better understand the extent and methods by which data from the past can be integrated into the present to support conservation science and management. What tools, what approaches, and what baselines and thresholds should (or could) be considered? What can the past tell us, and conversely what can’t it tell us? What mistakes might we risk making if we use past data non-critically, and which processes in the past are comparable to those operating today and/or predicted in the future? What is the predictive power of different environmental archives, and how have these archives been used so far in conservation science or management? Ultimately, how can collaboration between disciplines be fostered and improved, and who should be responsible for bringing data from the past into conservation? We consider these issues from the combined perspective of a conservation biologist and Quaternary palaeontologist (STT) and a deep-time

palaeontologist (EES). This special volume presents a series of outputs from this meeting, arranged into four general sections:

- (1) ways in which deep-time data can be used to inform conservation [72–75];
- (2) ways in which near-time data can be used to inform conservation [76–80];
- (3) explicit consideration of concerns, barriers and limitations in the use of past data to inform conservation [81, 82];
- (4) practical ways in which past data can be, and are already being, fed into conservation policy and management [83–87].

We are convinced that the past, although a foreign country, has a vitally important role to play for informing the present and helping to predict the future in the fight to maintain global biodiversity. We hope that this volume will serve as a guide and framework to facilitate future discussion and an improved use of past data in conservation.

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