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EXPLAINING AUSTRALIA'S PLEISTOCENE EXTINCTIONS

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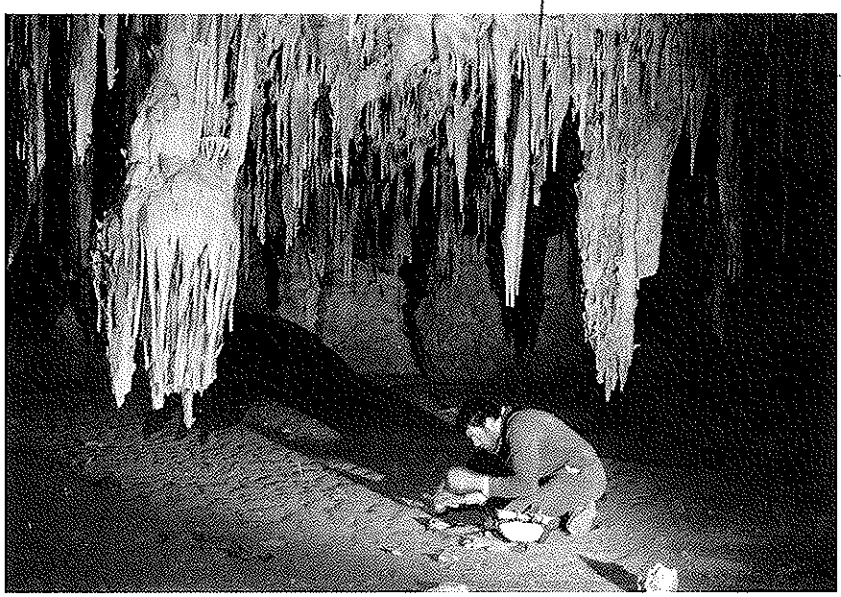

Gavin Prideaux and the skull of an extinct kangaroo. Thylacoleo Caves.

Australia's biota has fared poorly since European settlement. Countless species have been driven or are en route to extinction, and ecosystems have been irreversibly damaged. Deplorable as this is, it was not the first wave of extinctions to sweep across Australia in recent times (geologically speaking). The first people to set foot on the continent around 50 thousand years ago (ka) found a very different landscape occupied by very different animals, which bore little resemblance to those they had seen before. These unique creatures included the rhinoceros-sized *Diprotodon*, marsupial 'lions', giant wombats, short-faced kangaroos, horned tortoises, and giant flightless birds related to geese. These were not the ancestors of modern species, but cohabited the continent with them for at least the last half-million years. By 40 ka more than 90% of larger species (and numerous medium-sized species often overlooked in our fixation with 'megafauna') had become extinct. What could possibly account for the disappearance of such a diverse array of animals?

This question has become one of the longest-debated in historical science. Anatomist Sir Richard Owen fired the first salvo in 1877, arguing that "no adequate cause suggests itself to my mind save the hostile agency of man". A few years later, in 1885, geologist Charles Wilkinson, having seen the effects of severe drought on kangaroos and emus, as well as the diversity of fossil remains, including crocodiles, in the Pleistocene Cuddie Springs deposit (north-central New South Wales), emphasised the lack of "conclusive proof" for a human role. He suggested that "the general cause of the disappearance of these animals since Pleistocene times [was the] want of water". Move forward a century and a quarter, and the debate superficially seems to have shifted little. Surely we must have learned something given the past few decades of intensive research into faunas, people and environments of the late Pleistocene (125–10 ka). Will we ever know what caused these extinctions? And what effects have these had on vegetation patterns and ecosystem complexity?

Until the late 1960s overhunting by people and increased aridity remained the two dominant extinction hypotheses. A third idea, landscape burning by people, was tabled by archaeologist Rhys Jones of the Australian National University and Duncan Merrilees of the Western

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Megafauna

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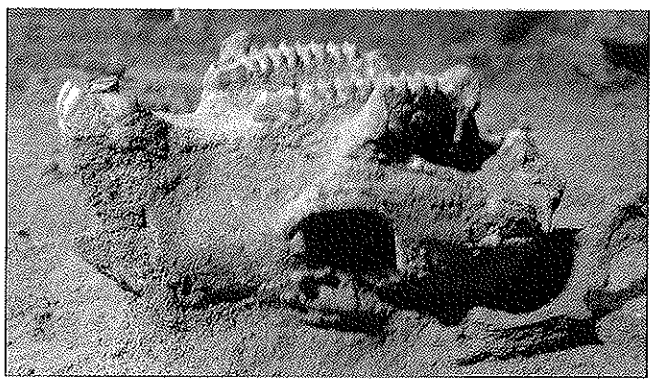
Excavating in Naracoorte Caves

Australian Museum, entirely independently of each other in 1968. Observations by Jones of modern burning practices by Aboriginal people led to his coining the term 'firestick farming', a technique involving repeated burning of vegetation to promote grassy understorey development, facilitating easier hunting, particularly of kangaroos. Jones and Merrilees argued that, when first implemented, this burning regime greatly altered the composition of plant communities, selecting against fire-sensitive food plants, and severely impacting browsing herbivores (consumers of shrubs and leaves of trees). Grasslands spread favouring grazers, including red and grey kangaroos, which have benefited further since European settlement due to the provision of permanent watering points for stock. A number of studies over the past decade have independently supported landscape burning as a likely extinction cause.

What about disease? Could a particularly virulent pathogen, brought here by humans, have played a role? This general idea has been proposed as a possible explanation for Pleistocene extinctions on other land masses, which saw mammoths, sabre-tooth cats, giant lemurs, moas and so forth disappear, at different times in different places. In Australia, however, it is difficult to imagine how a disease could account for the disappearance of such an array of unrelated species – more than 60 species including a giant goanna, crocodiles, snakes, turtles, several kinds of birds, echidnas and many marsupials – and then primarily the larger species. Humans would have to have been capable of spreading the disease continent-wide, but be unaffected by it themselves. In his excellent book on Australian mammal extinctions in 2006, Chris Johnson also pointed out that large species in south-east Asia (e.g. tapirs, rhinoceroses, primates) would have been exposed to this disease, but were evidently not susceptible. This leaves us with the relative importance of climatic changes preceding and/or concurrent with human arrival in Australia, and the activities of humans themselves through unsustainable hunting or habitat disturbance, as the most likely culprits (in isolation or combination).

Much of my research over the past decade has tried to address the problem by tracking pre- and post-human changes in the makeup of vertebrate communities through time, and by gaining a better understanding of the ecologies of extinct species. This work mainly involves retrieving large fossil samples from caves. Animals fall into caves through roof openings and are unable to escape. Bones become encased in sediments that enter the cave the same way. Some deposits also incorporate bones derived from regurgitated owl pellets or remains dragged in by mammal predators. Presence/absence data for species along with abundance data within one layer can then be treated as a 'snapshot' of a fauna from one interval in time, and compared with those above or below in the same section, or with other deposits elsewhere. Recent advances have allowed cave deposits to be dated using multiple techniques.

The World Heritage listed Naracoorte Caves in south-eastern South Australia represent the only known locality on Earth with a record of vertebrate life covering the past half-million years. Its value is enhanced by the fact that it is directly comparable with a rainfall record preserved in stalagmites and stalactites. Our work at Naracoorte was the first (2007) to show how an Australian mammal community responded to glacial-interglacial climatic cycling (warm/wet versus



Skull of extinct kangaroo

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Megafauna

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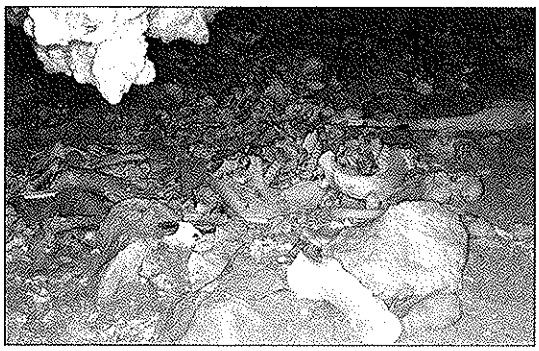
cool/dry times) prior to human arrival. We showed that populations waxed and waned in response to climatic cycling, with forest-adapted species retreating in drier times, while others became more abundant in drier times. Despite these fluctuations, all larger species there before 500 ka were still there at 300, 200 and 80 ka. The fauna was resilient to climatic variations. Extinction of all larger species bar the grey kangaroo by 40 ka cannot be ascribed primarily to increased aridity, especially given that all small- to medium-sized mammals persisted until Europeans arrived. Local climate was relatively cool and moist, and judging from the earlier record, should have been favourable for most larger mammals until 30 ka. The arrival of humans in the region just prior to the extinctions arouses suspicion.

Excavation in Tight Entrance Cave



Ossuary, Thylacoleo Caves

Some of our other work has been concentrated in the Nullarbor Thylacoleo Caves, where pristine Pleistocene marsupial skeletons were discovered by cavers in 2002. Penny Hussey reviewed our findings in the April 2007 issue of *Western Wildlife*. To recap, we discovered that a diverse fauna consisting of 69 vertebrate species, including around 30 different herbivores, inhabited the centre of the now 'Treeless Plain' at around 500 ka. Unfortunately, we have no pollen to indicate vegetation directly, but to support so many species it must have been very different to the modern shrub steppe, and was probably a woodland / shrubland mosaic. Was it wetter than today? Not according to the evidence. Isotope ratios preserved in herbivore tooth enamel and the modern distribution of smaller mammal, bird and reptile species found alongside the larger mammals suggest the climate was similar. Clearly, the large species were well adapted to a dry climate for half-a-million years before succumbing, which rules out aridity alone as the extinction cause. Interestingly, the more palatable plants scattered around the periphery of the Nullarbor Plain today (e.g. myoporums, sandalwoods, quandongs, native apricots) are united by their sensitivity to fire. Perhaps an increase in bushfire frequency and/or intensity changed the vegetation and precipitated the extinction of animal species reliant on fire-sensitive plants. The mystery that needs solving is the cause of this changed burning regime; one possibility is that it was human induced.

We are currently in the process of compiling and analysing data collected from 1996 to 2008 in the aptly named Tight Entrance Cave in the Leeuwin-Naturaliste Region, where we have a record of vertebrates, climate and bushfires (courtesy of charcoal preserved alongside fossils) extending back to 150 ka. The results are exciting in the light of our other research, but until they are published in a scientific journal we won't be letting any thylacoleos out of the bag! However, one thing our Western Australian research does emphasise is just how little we know about the environmental history of the State. In the long-term we hope to generate similar datasets from other regions (e.g., Kimberley, Pilbara, Gascoyne, Goldfields), but ou finding out about potential sites is entirely reliant on landowners, miners, cavers, travellers, explorers, kids, anyone and everyone keeping their eyes and minds open and reporting discoveries to the WA Museum.

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