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ABSTRACTS

(by alphabetical order of first author)

Emerging palaeoecological records from Nuku Hiva, Marquesas Islands: natural processes and anthropogenic impacts

Melinda S. ALLEN
Department of Anthropology, University of Auckland, Private Bag 92019, Auckland, New Zealand ms.allen@auckland.ac.nz

The Marquesas Islands, with their rugged topography, lack of coral reefs, and high variance climate, presented Polynesian colonists with considerable challenges, while natural and cultural processes throughout prehistory continuously re-shaped Marquesan landscapes and ecological relations. Since 2003, the "Marquesan Human Palaeoecology" project has been assembling a variety of palaeoecological records. Our aims are to understand the dynamics and co-evolutionary outcomes of interactions between human populations, Marquesan landscapes, and both native and introduced biota. Our focus has been on Nuku Hiva, the largest of the Marquesan islands (330 km^2), and our data sets are palynological and archaeological (geoarchaeological, anthracological and zooarchaeological). In this talk, I briefly review our key study sites, recent research highlights, and on-going initiatives. Of general interest are newly emerging records of three large-scale environmental processes, with implications for both human and non-human populations: 1) shoreline dynamics; 2) climate variability; and 3) anthropogenic impacts on native plants and animals.

Prehistoric landscape and vegetation changes in the Society islands: initial human Settlement and impacts

J. Stephen ATHENS[1] & Janelle STEVENSON[2]
[1] International Archaeological Research Institute, Inc., 2081 Young St., Honolulu, HI 96826, USA JSAthens@iarii.org
[2] Department of Archaeology and Natural History, College of Asia and the Pacific, The Australian National University, Canberra ACT 0200, Australia
janelle.stevenson@anu.edu.au

Pollen coring and archaeological sampling investigations for paleoenvironmental research were undertaken on Moorea and Maupiti during July of the present year. In Moorea, three cores were obtained from Lake Temae, a relatively large brackish water coastal lake separated from the sea by a coral sand ridge. Cores of 17.4, 12.37, and 12.0 meters were obtained. Pollen sampling was also undertaken in water-saturated deposits at three coastal archaeological locations. The goal of these investigations is to obtain a high resolution pollen and dating records from which to establish baseline information on 1) pre-Polynesian vegetation, 2) the timing of earliest Polynesian settlement, and 3) impacts to vegetation and possible landscape changes through time following Polynesian settlement. The investigations on Maupiti resulted in the recovery of a short 1.4 meter core in coastal waters, and also pollen sampling from a soil exposure. Whether the Maupiti investigations prove productive will have to await laboratory results.

Aedes mosquitoes and navigators: sailing together across the South Pacific

Hervé BOSSIN
Medical Entomology Laboratory, Institut Louis Malardé, B.P. 30, 98713 Papeete, Tahiti, French Polynesia hbossin@ilm.pf

Fifteen species of mosquitoes have thus far been recorded in French Polynesia. Amongst them, *Aedes polynesiensis*, and *Aedes aegypti* are important vectors of infectious diseases. *A. polynesiensis* is present in most islands of the Polynesian triangle (Fiji, Samoa, Cook, French Polynesia). It is the most important vector of nonperiodic filariasis wherever it occurs and a secondary vector of dengue. *A. aegypti*, present in most tropical and subtropical regions worldwide is the primary vector of dengue including in the Pacific region. Although the site of origin of *A. polynesiensis* is not known with certainty, it is quite evident that this mosquito has been widely distributed by Polynesians from its original center. *A. polynesiensis* is an extremely adaptable, plastic and variable species. A semidomestic species, it displays an extremely wide range of breeding habitats. Its original breeding places were probably tree holes, which it still uses widely wherever it occurs. It is very commonly found in coconut shells and husks, is frequently found in outrigger canoes, and it also breeds in artificial containers of various types. A peculiar feature of the species is its

ability to breed underground, in crab burrows. This tolerance and plasticity in utilization of breeding sites is undoubtedly largely responsible for the success of the species and its wide dispersal by Polynesians in the South Pacific. Females have become adapted to man for their blood source. The original hosts were undoubtedly birds, and possibly bats, since these were the only warm-blooded vertebrates available. The present report will compare and contrast the timelines and possible modes of spread of both *A. aegypti* and *A. polynesiensis* across the Pacific. We will also describe how multidisciplinary, transversal studies linking mosquito genome and population genetic studies with Polynesian history and origin could shed light on the site of origin of *A. polynesiensis*.

The complex roles of alien animals as pollinators, seed dispersers, and seed predators: examples from Hawaiian forests

Donald R. DRAKE
Botany Department, University of Hawaii, Honolulu, HI, 96822, USA
dondrake@hawaii.edu

Animals play direct roles in the reproduction of most tropical forest plants through pollination, seed dispersal, and seed predation. Following human colonization of the Pacific Islands, most of the native fauna in the islands' forests has become rare, extirpated or extinct, and a diverse array of alien species has invaded and proliferated. As a result, plants today are interacting with very different animal communities than they were during most of their evolutionary history, and the implications for plant reproduction are poorly understood. Several case studies from Hawai'i highlight the expected and unexpected roles that alien animals play in the reproduction of forest plants. Honeybees (*Apis mellifera*) are important flower visitors in many forest types, and may now be the only flower visitors for some native plant species. Japanese white-eyes (*Zosterops japonicus*) may be effective pollinators of some plant species rarely visited by native birds, but they are nectar robbers of other species. Alien birds such as Japanese white-eyes and Kalij pheasants (*Lophura leucomelanos*) disperse seeds of some native plants that are no longer dispersed by native birds. Ship rats (*Rattus rattus*) are seed predators of many species, but they disperse seeds of others. The roles of these alien animals are further complicated by the fact that they are sometimes involved in the reproduction of invasive alien plants and sometimes compete with native animals for plant resources. Similar patterns occur on islands throughout the Pacific and other oceans. A thorough understanding of the roles of alien species in plant reproduction is necessary if we are to anticipate and avoid unexpected effects that may arise following their removal on islands.

Large-seeded tree species may decline as seed dispersers cease to play a functional role in island forests: an example from Tonga

Donald R. DRAKE[1] & Kim R. McCONKEY[2]
[1] Botany Department, University of Hawaii at Manoa, Honolulu, HI, 96822, USA dondrake@hawaii.edu
[2] E-64 Sainikpuri, Secunderabad 500094, India, kimmcconkey@yahoo.co.nz

Seed dispersal is a critical process in forest dynamics. The guild of seed-dispersing animals on most Pacific islands is naturally depauperate because of island isolation, and has been further depleted by the extirpation and extinction of native vertebrates following human colonization. In Tonga, we combined measurements of subfossil remains of extinct birds and field observations of existing species to find that diaspores of many tree species that were formerly dispersed by native pigeons (Columbidae), may no longer be dispersed by birds. Instead, their only remaining option for dispersal may be flying foxes (fruit bats). However, the effectiveness of flying foxes as dispersers has been hypothesized to depend on their population densities being adequate to cause aggressive interactions among foraging individuals in fruiting trees. We quantified the proportion of seeds that *Pteropus tonganus* dispersed beyond the canopy of fruiting trees, over a range of sites that differed in flying fox abundance. The relationship between ecological function (seed dispersal) and flying fox abundance was non-linear and consistent with the density-dependence hypothesis. For most trees in sites below a threshold abundance of flying foxes, the animals dispersed < 1% of the seeds they handled. Above the threshold, dispersal away from trees increased to 58% as animal abundance approximately doubled. Hence, flying foxes may cease to be effective dispersers long before becoming rare. We also found that flying foxes were the most important--and often the only--seed dispersers for all 14 large-seeded tree species we assessed. Given the dependence of large-seeded tree species on large-bodied dispersers, long-term forest composition may shift toward smaller-seeded tree species on islands where pigeons and/or flying foxes are not maintained at functional densities.

Lost microcosms in argon capsules? A land snails and other losers perspective

Olivier GARGOMINY[1] & Philippe BOUCHET[2]
[1] Service du Patrimoine Naturel, Muséum national d'Histoire naturelle, 36 rue Geoffroy Saint-Hilaire, 75005 Paris, France gargo@mnhn.fr
[2] Département de Malacologie, Muséum national d'Histoire naturelle, 55 rue Buffon 75005 Paris, France pbouchet@mnhn.fr

Distance and isolation: what makes Eastern Polynesia a "cold spot" for terrestrial vertebrates has conversely generated a fantastic diversity of land snails, with outstandingly high levels of endemism. Historically, French Polynesia has been home

to about 560 native species or subspecies, 92% of which are endemic. A low island typically had ca. 10 species, often broadly distributed; high islands typically had 30-50 (up to 100) species, mostly endemic to a single island or even a single valley New species are still being discovered in the highlands of the high islands. Shells present in the archaeological record - especially on makatea islands - and museum collections tell a sad story of massive depletion and turn-over in fauna composition: the modern land snail fauna of French Polynesia is ecologically dominated by a dozen or so introduced species. Native endemics occupy relictual distributions threatened by loss of habitat and invasives. Numerous extinctions have already taken place; on some islands, up to 90% of the species are already extinct. With the exception of *Partula*, the land snails of French Polynesia are not on the conservation radar, and even *Partula* conservation has not been very successful, *in situ* as well as *ex situ*. Furthermore *Partula* represent the tip of the mollusc iceberg: they are (comparatively) large and colourful, whereas most native land snails of French Polynesia are minute and drab. Let's be realistic: we will never have an Action Plan for every species of extant land snail, and we are going to lose most of them. It is now time to aim for a biodiversity salvage strategy that would be for the invertebrate fauna of Pacific islands what the *Svalbard Global Seed Vault* is for phytogenetic resources. The technology is there already: argon capsules at ambient temperature.

Adaptive radiation on remote islands: comparison of diversification across the archipelagos of Polynesia

Rosemary G. GILLESPIE[1] & George K. RODERICK[2]
[1] Environmental Science, Policy and Management, 130 Mulford Hall, University of California, Berkeley, CA 94720-3114, USA gillespie@berkeley.edu
[2] Environmental Science, Policy and Management, 130 Mulford Hall, University of California, Berkeley, CA 94720-3114, USA roderick@berkeley.edu

The Pacific Ocean contains more islands than the rest of the world's oceans combined. The most remote high islands are those of Polynesia, notably the Hawaiian Islands, and three archipelagos of French Polynesia: the Society, Marquesas, and Australs. While patterns of adaptive radiation are relatively well known in Hawaii, comparable patterns in the other archipelagos of Polynesia are less well known. First we examine how organisms have colonized the islands, and show that knowledge of dispersal by wind, birds and oceanic drift or rafting, coupled with information about the natural environment and biology of the organisms, can be used to generate broad biogeographic predictions. We then discuss the predictions in the context of the origin, frequency of arrival and location of establishment of dispersed organisms, as well as subsequent patterns of endemism and diversification. We go on to compare patterns of diversification of arthropod lineages across the archipelagos to assess the similarity in species, pattern and rate of diversification, and dynamics of community assembly. The Societies show high endemism, in particular on the youngest high island of Tahiti. The Marquesas also show high endemism, the highest diversity often on the older islands. The Austral Islands are an older, smaller, and lower archipelago; here, the dominant lineages are

often widespread, with taxa endemic to the archipelago rather than an individual island, yet there are large genetic distances between island populations, with sequential colonization of islands. Compared to Hawaii, diversification is less pronounced, and community assembly on the youngest island is most comparable to the second youngest island of the Hawaiian chain.

Visibility of prehistoric colonization in Eastern Polynesia

Terry L. HUNT
University of Hawai`i at Manoa, Honolulu, HI, 96822, USA thunt@hawaii.edu

Recent research in eastern Polynesia has sharpened a focus on the chronology of colonization, leading to a debate over timing and rate of dispersal. Integration of archaeological and palaeo-environmental evidence is critical to resolving a regional chronology. In this presentation, I consider a basis for what "colonization" means in archaeological terms as well as documenting the logic and evidence used to detect the arrival of humans in a new environment. Second, I examine specific criteria to link radiocarbon dating with cultural events of interest. Finally, I explore some possible implications for prehistory, human impacts, and continuing research in the region.

Ecological change in Hawaii and the Pacific as revealed by fossil birds

Helen F. JAMES
Smithsonian Institution, National Museum of Natural History, PO Box 37012, Washington DC 20013-7012, USA JAMESH@si.edu

The extinction of many species of land birds and extirpation of breeding colonies of seabirds are widely acknowledged consequences of human presence on islands of the eastern Pacific. Recent revelations of arthropod extinctions during prehistory are bringing a fuller appreciation for the scope of human-era ecological changes in the region. Furthermore, recent arguments for a shorter chronology of human presence in the region bring into focus the rapidity of ecological changes that have led to the conditions we observe today. Understanding how biodiversity and ecosystem function have been rapidly altered over a period of centuries leading up to the present can inform our goals for conservation in what are now among the world's most threatened terrestrial ecosystems. With this in mind, I review the radiocarbon record from Hawaiian animal bones in relation to the hypothesized short chronology of human presence in Hawaii, and its implications for the causes of extinctions. I then consider how a breakdown in ecological interactions between species due to the functional extinction of birds (e.g., loss of pollinator services and changes in herbivory, seed dispersal, and seed predation) may affect the structure of modern native plant communities. I consider the importance of taking the past into account when identifying the causes of extinction and endangerment in modern ecological

communities that have recently experienced rapid change, and consequently may be affected by time lag effects. Finally, I consider ecological connectivity between the eastern Pacific Ocean and its islands, in particular with respect to seabirds, and discuss recent research to develop a long-term record of change in trophic structure of the pelagic food chain of the northeastern Pacific using seabird bones from islands.

Human settlement and changing paleo-shorelines of Mo'orea, Society Islands

Jennifer KAHN
Bishop Museum, 1525 Bernice Street, Honolulu, HI 96817-2704, USA
jennifer.kahn@bishopmuseum.org

I present data from recent archaeological fieldwork on the coastal flat of Mo'orea. Auger coring transects running from the base of the colluvial slopes to lagoon shores identified deeply buried subsurface depositional contexts containing stratigraphic records of island biota and zooarchaeological assemblages. Test pit excavations revealed a depositional sequence along the windward coast with deep colluvial deposits up to 2 m in depth, overlying buried paleo-shorelines with calcareous deposits which had abundant anaerobically preserved organic specimens such as fruit and nut casings and wood fragments. Our data demonstrate that initial paleo-shorelines were situated some 100-300 m of the existing modern shoreline. A preliminary chronology for these dramatic landscape changes is outlined with a sequence of AMS ^{14}C radiocarbon dates on short lived species. The case study highlights that the coastal landscape environments we see in the Society Islands today are a result of remarkable human-induced landscape changes initiated soon after first settlement of the islands.

Archaeology and long-term biodiversity dynamics in Polynesia

Patrick V. KIRCH
Class of 1954 Professor of Anthropology and Integrative Biology, University of California, Berkeley, USA kirch@berkeley.edu

Over the past few decades advances in biogeography and phylogeography have greatly enhanced our understanding of how oceanic ecosystems have been assembled over time spans of millions of years. Far less understood are the faster-moving (time scales of decades to centuries) processes whereby these "pristine" insular ecosystems were disrupted, reassembled, and in some cases severely destabilized following the initial arrival of humans between 2900 and 750 years BP. Recent archaeological research, in collaboration with paleo-environmental studies, is making strides in filling this knowledge gap. This paper summarizes the contribution of archaeology and allied disciplines to the understanding of long-term biodiversity dynamics on islands, with special reference to French Polynesia.

Plant introductions and invasions in Polynesian islands : new conservation challenges in novel ecosystems

Jean-Yves MEYER[1], Robin POUTEAU[2], Marie FOURDRIGNIEZ[3] & Ravahere TAPUTUARAI[3]

[1] Délégation à la Recherche, Gouvernement de la Polynésie française, B.P. 20981 Papeete, Tahiti, French Polynesia jean-yves.meyer@recherche.gov.pf

[2] Laboratoire Géosciences du Pacifique Sud, Université de la Polynésie française, B.P. 6570 Faa'a, Tahiti, French Polynesia r.pouteau@yahoo.fr

[3] Moorea Biocode Project, Richard B. Gump South Pacific Biological Research Station, B.P. 244 Maharepa, Mo'orea, French Polynesia mariefourdrigniez@gmail.com ; rtaputuarai@gmail.com

A classical approach for *in situ* conservation is the legal protection and management of native areas of high ecological value (with many threatened species) or of large and unfragmented primary forests. In most of the inhabited islands worldwide, pristine vegetation types have vanished because of increasing human pressures and impacts, and associated animal and plant introductions and invasions. A high number of endemic plant species, many of them becoming extremely rare and threatened, are now found in a matrix of man-disturbed lowland and upland forests. The concept of "novel ecosystems", i.e. with communities dominated by alien species, has recently emerged and is becoming a new paradigm in ecology and conservation biology. The small island of Moorea can be used as an ecological model to study vegetation changes from Polynesian first occupation to European colonization and modern anthropogenic influence. Intensive field surveys were conducted during the "Moorea Biocode Project" (2007-2011) to locate and inventory native and alien plants and map the vegetation using remote sensing and species distribution modelling. Results show that the flora is composed of 310 native flowering plants and ferns *versus* 767 introduced plants, including 182 naturalized species. Almost 35% of the island's vegetation is dominated by monotypic stands of invasive trees (*Falcataria moluccana, Leucaena leucocephala, Spathodea campanulata*) and over 85% of low and mid-elevation forest (< 700 m) is fragmented by alien plants. This is an underestimation of forest alteration, because the small tree *Miconia calvescens*, which is difficult to detect using remote sensing, was not included. Moreover, the future of the remaining 1% of near-pristine habitats (cloud forest on the highest summits and ridges > 900 m asl) is under the potential threat from climate change. New and original conservation strategies have to be urgently sought in order to preserve the native and unique island biota.

Colonisations, endemism and history of the marine fauna in the Pacific

Serge PLANES
Centre de Recherches Insulaires et Observatoire de l'Environnement
CRIOBE-USR 3278 CNRS-EPHE, B.P. 1013, Mo'orea, French Polynesia

Understanding distribution of species in space and time remains one of the most challenging questions. In fact, when analysing an ecosystem, a fauna, a genetic structure, we are looking to some instantaneous situation that originate from an history of accidents and equilibriums and will evolve to a future that is often impossible to predict. Reconstruct the past is the first challenge and genetic approach have open new perspectives, and it only from lessons of the past that we can expect to model future development. However, retrieve the past of species and population is not an easy task. Species have been first though speciation processes and further on through colonisation, extinction, recolonisation as well as through drastic changes in population size. The last is of main interest since we can learn from recent changes what can be the future of fauna facing recent global change.
Using the coral reef fish fauna, as well as the pearl oysters we provide examples of analysis retrieving past evolution of population size related to major climatic change. It appears that it is almost impossible to format any general trends and that species and populations are showing very different and unique patterns. Such diversity in histories of populations make even more complicate further generalisation about what to expect in the context of present and near future environmental changes.

A palaeo-perspective into insect diversity on Indo-Pacific islands: long-terms patterns of biodiversity loss and community re-assembly

Nicholas PORCH
School of Life and Environmental Sciences, Deakin University, Burwood Campus, 221 Burwood Hwy, VIC 3125, Australia nicholas.porch@deakin.edu.au

Until recently the Holocene insect record from oceanic islands was completely unknown. Research on a range of Indo-Pacific islands (in Hawai'i, the Australs, Cook Islands and Mascaranes) is now demonstrating that the insect fossil record provides invaluable evidence regarding the nature and history of lowland ecosystems. This presentation will summarise the fossil-based state of knowledge regarding the evolutionary (prehuman) insect faunas of the region and how they are impacted following human arrival in the region. It will focus on aspects of the insect records that provide unique insights into the nature of changing ecosystems of Pacific islands. These aspects include species level identification of a high diversity group, high temporal resolution, continuous sampling and quantification. Together these contribute to a uniquely detailed picture of the nature of prehuman diversity, species introduced by people in prehistory (and more recently), the potential interactions and

impacts of native and invasive species, and the decline of indigenous faunas. The insect record clearly demonstrates that it is impossible to use contemporary evidence alone to reconstruct the evolutionary history of the biota or even the assembly of the modern invasive dominated lowland fauna that we find in the region today.

Burning paths to treelessness: fossil records of plant extinction in Polynesia

Matiu PREBBLE[1] & Jean-Yves MEYER[2]
[1] Department of Archaeology and Natural History, The Australian National University, Canberra ACT 0200, Australia matthew.prebble@anu.edu.au
[2] Délégation à la Recherche, Gouvernement de la Polynésie française, B.P. 20981 Papeete, Tahiti, French Polynesia jean-yves.meyer@recherche.gov.pf

Rapa-Nui was nearly treeless at the time of first European contact in AD 1721. It wasn't until the 1960s that it was recognised from fossil records that trees once flourished on the island. Fossil evidence has since revealed 22 extinct or extirpated plants that would have increased the size of the island's flora to 65 indigenous vascular plants. Humans, climate change and rats have been proposed as the primary causes with all extinctions occurring within the last 1000 years. With 30% of the flora now extinct, how does this compare with other islands in the oceanic Pacific. From recently retrieved and archived fossil and historical records, the extinction rates are much less and rarely exceed 10% of modern floras. Islands in the Austral Archipelago, French Polynesia reveal over 50 extinct or extirpated plant species. In these cases, human activity including forest burning for agriculture over the last 800 years is seen as the primary cause. We ask what are the implications of these fossil archives for interpreting modern plant species diversity, plant rarity or abundance and the overall management of these fragile island ecosystems?

What charcoals can tell us: anthracology and its application in the Pacific, case study in New Caledonia

Stéphanie THIÉBAULT[1] & Emilie DOTTE-SAROUT[2]
[1] UMR 7209 CNRS-MNHN, Archéozoologie-Archéobotanique, 55 rue Buffon, F-75005 Paris, France thiebault@mnhn.fr
[2] Archaeology, School of Social and Cultural Studies, University of Western Australia, Perth WA 6009, Australia emilie.dotte@uwa.edu.au

In this paper we would like to demonstrate the potential of anthracology, *i.e.* identification of wood charcoal macro-remains, for the study of Pacific palaecology and its first application in New Caledonia. After a rapid presentation of the discipline we will expose some results yielded by a recent PhD research that applied anthracology to New Caledonian archaeology for the first time. This program involved the creation of a wood anatomy atlas and a specific work was conducted on the methods to be used or developed in regards to tropical and Pacific environments.

The results provide information about the chronology of development for the kanak settlement system in one valley of the Grande Terre, the Tiwaka valley (North-East), at the beginning of the second millennium AD. They also show that these development arose within a forested landscaped, showing only few signs of anthropogenic pressure, although occurring after 2000 years of human presence on the island. Such signs do appear later in the chronology, probably together with the demographic rise and intensification of human occupation of the landscape that characterized the kanak pre-contact period. The approach used and the interpretations of the results will be discussed, as well as the limits and potential of such a type of study for the Pacific islands in general and French Polynesia in particular.

An overview of the bird extinction in eastern Polynesia

Jean-Claude THIBAULT[1] & Alice CIBOIS[2]
[1] Muséum National d'Histoire Naturelle, Département Systématique et Evolution, UMR7205 Origine, Structure et Evolution de la Biodiversité, 55 rue Buffon, F-75005 Paris, France jncldthibault@aol.com
[2] Département de Mammalogie et d'Ornithologie, Muséum d'histoire naturelle, CP 6434, 1211 Genève 6, Suisse Alice.Cibois@ville-ge.ch

In a first part we present different topics on the extinction of birds in Eastern Polynesia : fragility of the species, difficulties to date the extinction, roles of hunting, predators, and habitat changes. However, some extinctions remain difficult to connect to an identified cause. In a second part, we detail the knowledge concerning extinction in the small archipelago of Gambier: of the ten landbird species recorded, only one, the Reef Egret survives today. To conclude, we suggest that more information on extinct species should be given by DNA analysis, comparing bones from Polynesian settlements with identified present species.

Ghost animal-plant interactions in New Zealand: fossil evidence for past pollinators, seed dispersers, seed predators, and herbivory

Janet WILMSHURST & Jamie WOOD
Landcare Research, PO Box 40, Lincoln 7640, New Zealand WilmshurstJ@landcareresearch.co.nz

Fossils of plants and animals preserved in sediments offer a long-term perspective of ecosystem dynamics and species responses to environmental change. Palaeoecology therefore provides an important tool to help ecologists and restoration groups make more informed decisions about managing biodiversity. The relatively recent settlement of East Polynesia means fossil evidence can provide detailed insights into pre-human states that are relevant to the present day, and which can be used to set restoration targets. Long-term records can distinguish indigenous from introduced

taxa, and reveal currently rare species that were once dominant before forest clearance. Past ecological linkages between flora and fauna, now disrupted by deforestation, hunting, and introduced predators, can be uncovered. Most applied conservation palaeobiology studies have focused on reconstructing plant and animal communities. Here we show how other analyses of prehuman ecosystems can provide insight into past animal/plant interactions and lost ecosystem functions, such as seed dispersal, pollination and herbivory. For example, woody seed cases in sandy flood deposits and bird nests preserved in cave sediments have captured distinctive seed predation marks left by introduced rats and native parrots respectively; pollen analysis of extinct bird coprolites from rock overhangs reveal surprising new candidates for the pollination of both common and threatened plant taxa; and multi-proxy analysis (ancient DNA, pollen, macrofossils, seeds) of coprolites from extinct avian herbivores provide evidence of past plant consumption, seed dispersal and potential pollination roles.